Two essays on the women's empowerment in agriculture: an empirical assessment of the WEIA and a theoretical proposal with relationship to time allocation

by

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AN ABSTRACT OF A DISSERTATION

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Abstract

Several authors argue that one mechanism to promote economic growth in agriculture is a sector that is more inclusive and equitable towards women. Thus, there is increasing interest in the measurement and drivers of women's condition and efforts directed at improving their agency, status and power. One measurement strategy center on the novel concept of the Women's Empowerment in Agriculture Index (WEAI). This dissertation is composed of two essays to empirically evaluate women's empowerment and focuses on the WEAI.

The first paper of this dissertation centers on the evaluation of the Women's Empowerment in Agricultural Index and the Abbreviated Women's Empowerment in Agricultural Index (A-WEAI). These tools have been used extensively to measure and track women's empowerment in agriculture and is based on the multidimensional empowerment concept that relies on different indicators to measure the latent concept of women's empowerment. After a quantitative assessment of the indices using the Multiple Indicators Multiple Causes approach (MIMIC), we conclude that holding all other variables constant, the probability of increasing the correlation between the variable women's empowerment and the indicators of the indices is higher under the WEAI than under A-WEAI. Ownership of assets and workload indicators require attention, but due to uniqueness that workload indicator brings to the women's empowerment discussion, the way this indicator is used in the calculation of the indices needs refinement. The paper concludes by proposing a theoretical revision of the links between women's empowerment and time allocation.

Motivated by the finding of the first paper, the second paper proposes a new theoretical framework that is based on Becker's model of allocation of time, but incorporates Sen's and Kabeer's definitions of empowerment, with respect to time allocation. Under this framework, women's empowerment is part of a utility maximization problem, and new relationships and explanations offered to understand some of the apparent contradictory results found in empirical studies. These studies found empowerment contributes to decreasing the allocation of time to leisure. The objective of the paper is not only to propose a different theoretical approach, but to test it empirically using the Bangladesh Integrated Household Survey and modeling time allocation using Two-Stage Least Squares to control for endogeneity of empowerment status. We

conclude, after accounting for the endogeneity in the models, that the Sen model generates more consistent estimates of the relationship between time allocation and empowerment. We suggest data collection strategies to understand the actual freedom of individuals when making time allocation decisions in order to refine assessment of the model. These refinements, combined with our modeling, will assist in rigorous assessment of interventions designed to improve women's welfare.

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Dedication

To my beloved son Nico, my supportive husband Albert, my dear parents Santi and Ceci. Also, to my brother Gio, and all women of my family that were contributors and the motivation for this work.

Chapter 1 - Assessing the Women's Empowerment in Agricultural Index (WEAI) and Abbreviated Women's Empowerment in Agricultural Index (A-WEAI) using the MIMIC approach

Introduction

Following the Millennium Summit of the United Nations in 2000, it was identified that to have sustainable development in rural areas of the world it is essential to guarantee gender equality and rights for women and girls as well as eliminating poverty, achieving zero hunger, good health and wellbeing. Consequently, to investigate and measure the gender gap and the sources of those inequalities, the last decade was dedicated to measuring and monitoring women's empowerment in agriculture.

Research on the measurement of women's empowerment in agriculture has increased and with it the quantity of measurement tools created. To name a few of the new indices for the agricultural sector, there is the WEAI (Women Empowerment in Agricultural Index), A-WEAI (Abbreviated WEAI), WELI (Women's Empowerment and Livestock index), WENI (Women's Empowerment in Nutrition index), and PRO-WEAI (Women's Empowerment in Projects). Although having a variety of indices that can be applied to specific women's empowerment situations sounds desirable, using different versions of the same measurement can compromise the comparability of results to the original index, and limit the ability to monitor projects that have been implemented. Even a greater concern is that every derived new index can fail in its purpose if the original version of the index is not an accurate measurement tool of women's empowerment in agriculture. Therefore, it is relevant to assess the original version of the Women's Empowerment Index in Agriculture (WEAI) to assure its validity and reiterate it as a reliable tool.

Since 2012, IFPRI, the US Government's Feed the Future initiative (FTF) of the United States Agency for International Development (USAID), and the Oxford Poverty and Human Development Initiative (OPHI) of Oxford University, have invested many resources in the creation and implementation of the Women's Empowerment in Agricultural Index (WEAI). The main objective with the creation of the WEAI is to have an accurate, valid and reliable tool that is convenient in guiding agricultural development policy. The WEAI is considered a holistic tool to measure women's empowerment in developing countries using a multidimensional approach.

Created in 2010, and after the elaboration and implementation of questionnaires in different FTF countries, the WEAI index was launched in 2012. Subsequently, FTF countries undertook

population-based baseline survey that collected data to calculate the WEAI. After the baseline surveys were finished, key elements such as the length of the survey, had to be revised to improve the performance of the WEAI. Therefore in 2013, numerous stakeholders, researchers, USAID partners, and representatives of different entities agreed that the WEAI was very resource-intense and some indicators were identified as problematic.

OPHI and the teams from IFPRI and USAID revised the WEAI and as a result, a new version of the index was designed, the Abbreviated WEAI (A-WEAI). In this new version, some indicators were modified, and others were removed. The A-WEAI was administered in Bangladesh and Uganda and has proven to reduce time of the interviews by 30 percent, as well as the financial cost of collecting the data (Malapit *et al.* 2015) compare to the WEAI survey.

Although WEAI has been used in many developing countries to create policies to transform the agricultural sector to a more inclusive and equitable one, few have attempted to assess this index. To the knowledge of the author, only three papers assessed the WEAI, all of the three used qualitative approaches like cognitive testing/cognitive interviewing (Johnson and Diego-Rosell 2015; Malapit *et al.*2016). The third paper evaluated the WEAI in the development sector instead of the agricultural sector (O'hara and Clement 2018). Lastly, a working study done by Min-Barron et al. in 2017 evaluated the A-WEAI index testing the content validity of the index.

This study will utilize a statistical approach rather than a qualitative approach to measure the validity of the WEAI and A-WEAI. In the assessment of the indices presented here the Multiple Indicators and Multiple Causes (MIMIC) modeling approach will be used for the statistical analysis. MIMIC models have been widely used by several authors in the economic and agricultural economics' fields to model institutional changes (McLeod *et al.* 2019), health and women's empowerment relationships in Ghana (Zereyesus 2017), dairy industry performance (Richards and Jeffrey 2000), and cattle farmers intention to improve grasslands (Borges *et al*. 2016). Further, Oliver in 2015 estimated propensity of beef cattle farmers to adopt conservation practices and most recently McLeod *et al.* (2019) modeled the use of information sources by farmers using this model. Also, the MIMIC model corresponds to one of the most important latent models used in the testing of statistical properties of multidimensional indices (Krishnakumar 2008).

This study uses the MIMIC model in combination with household data survey from Bangladesh to estimate correlations between the components of the index (indicators), the women's empowerment variable (the latent variable), and exogenous variables like demographics, socio-economic, and health variables. The purpose of this chapter is to investigate if the modifications of the original Women's Empowerment in Agricultural Index (WEAI) produced a reliable and accurate

index to quantify the women's empowerment in agriculture in reference to its dimensions and indicators. The evaluation of the index would help verify that the WEAI and/or A-WEAI are appropriate tools to measure women's empowerment in the agriculture sector.

Literature Review

The concept of empowerment and different forms to measure it

The literature is so vast when it comes to definitions of women's empowerment to the extent that the concept has become blurred. In "Agency and Empowerment: A proposal for internationally comparable indicators" thirty-two different definitions were documented on the concept of women's empowerment (Alkire 2005). Nonetheless, most of those definitions state empowerment in terms of Sen's agency, that is understanding empowerment as "an actor's or group's ability to make purposeful choices" (Alsop 2006).

It is important to mention that women's empowerment, as well as empowerment in general, is a multidimensional concept. As stated by Mason in 1986, the phenomenon on gender inequality is inherently complex and spreads across different dimensions including the social, economic, and political dimensions among others (Mason 1986). Men and women can be disempowered in one dimension or aspect of life while not in another. If intervention takes place on a certain dimension, empowerment in other dimensions should not be ignored since all aspects must equally meet in an adequate manner. The World Bank, which defines empowerment as: "the expansion of assets and capabilities of poor people to participate in, negotiate with, influence, control, and hold accountable institutions that affects their lives" (Narayan 2002), also adopted this multidimensional aspect of disempowerment concept.

For the purposes of this study, the type of empowerment that will be considered is the one related to the agricultural sector. Empowerment will be defined as the multidimensional process which enables individuals to meet both their practical and strategic needs and increases on individual's political power, self-consciousness and strengthens self-confidence (Mason and Smith 2003).

A methodological challenge remains making the transition from the definition of empowerment to the measurement of it. This methodological challenge is relevant since measuring empowerment can help to diagnose, design and keep track of areas of disempowerment that women are facing in the rural areas. Also, if women's empowerment is being measured, it becomes easier to

think through more concretely and address the problem of empowerment more effectively (Penn 2015). The authors of indices that measure women's empowerment are challenged to answer questions such as which are the indicators of empowerment, or which indicators can be used to track its progress? How can we measure women's empowerment in a way that allows the expected heterogeneities between regions, socioeconomic status, marital status, age, or ethnicities? Before WEAI all indicators were proxies or indirect indicators, and thus did not provide direct measures of empowerment as experienced by individuals. Also, typically women's empowerment has been measured at the aggregate level which does not allow measurement of a specific sector.

Indices and surveys: a chronological review

There are many ways to measure empowerment in the literature (see Alkire 2007 for a comprehensive review). For decades, women's empowerment has been measured using proxy variables like education and income, equity variables like the ratio of girls to boys in education, or the share of women in wage employment in the non-agricultural sector.

Early indices such as Gender-related Development Index (GDI) and the Gender Empowerment Measure (GEM) were introduced in 1995. The GDI is a "distribution-sensitive measure that accounts for the human development impact of existing gender gaps in the three components of the Human Development Index (HDI)" (Klasen 2006). The GDI uses the same indicators of the HDI, namely income, life expectancy and education. The GDI is a sub-index of the HDI. Thus, it is not an independent measure of gender gaps, and can only be used with the scores from the HDI. Using the GDI by itself will not be a complete measurement. In addition, some data is not always readily available in many countries. For example, data on life expectancy are difficult to calculate in the absence of complete vital registration systems since life expectancy is very sensitive to the often-underreported number of infant deaths (Bardahn 1999).

In 1995 the Gender Empowerment Measure (GEM) was developed. The GEM measures the extent to which women have gained economic and political power, instead of focusing on the impact of gender inequality in human development (HDI). It attempts to measure the roles of women as agents in society. Even though the GEM index has been used year after year, it only takes into account a small group of women in society (Bardhan 1999). Only those that belong to elite groups or are in positions of power, such as political positions, are measured. This tool does not provide an accurate assessment of empowerment because it does not include most women in poor and developing countries. Debate has arisen over whether or not GEM and HDI have been influential in

promoting gender-sensitive development. Some of the major criticisms of both include: 1) they are highly specialized and difficult to interpret, 2) often they are misinterpreted, and suffer from large data gaps, 3) they do not provide accurate comparisons across countries, and 4) they try to combine too many development factors into a single measure (Alkire 2013).

Another alternative measurement that was created to quantify women's empowerment was the Gender Parity Index (GPI). This index is commonly used to assess gender differences by dividing the value of an indicator for girls by that for boys. A value of less than one indicates differences in favor of boys, whereas a value near one indicates that parity has been more or less achieved. In its simplest form, it is calculated as the quotient of the number of females by the number of males enrolled in a given stage of education (primary, secondary, etc.) (Klasen and Schüler 2011). This index has been used to design policies that have encouraged girls to attend school and has led to achieving equality in primary education between girls and boys in the world. Yet the problem of women's disempowerment persists. The criticism of the index is the over emphasis on the educational aspect of empowerment (Alkire 2013). Even though education is crucial to raise levels of empowerment, it should not be the sole aspect to take into consideration when trying to measure empowerment. Domains like health, economic, social and political participation should also be measured according to the definition of empowerment.

A more complex measurement of women's empowerment was created in 2005 by Parveen and Leonhäuser (2005) called Cumulative Empowerment Index (CEI). This index is a composite of six empowerment indicators combining both quantitative and qualitative data to get a comprehensive view of women's empowerment. The quantitative part represents five categories (e.g., 1 = Very low, 5 = Very high), and the scores are obtained from empowerment indicators from a survey. Even though the CEI is based on a multidimensional concept, it does not allow for heterogeneities between different groups such as: sectorial (agricultural sector and non-agricultural sector), ethnic, generational, socioeconomic, or regional.

In 2010 the Gender Inequality Index (GII) was proposed to address some of the shortcomings of the GDI and GEM. GII surveys a broader population and covers gender inequalities in more sets of domains (education, health, economic opportunity, and political opportunity), but the index is very complex to understand. Permanyer believes that simplicity is required for analysts, policymakers, or practitioners to convey a clear message, but the GII has been criticized for its complexity as well as for a lack of comprehensiveness. The index seems to include unnecessary dimensions and omits relevant ones (Permanyer 2013).

Other approaches to measure empowerment have been nationally representative surveys such as the Demographic and Health Surveys (DHS). These surveys include a range of questions about decision-making, such as who decides about the use of female-earned income and who, within the family, has the final say about a range of decisions (for example, decisions about the woman's own healthcare, large and daily household purchases, visits to family or relatives, and what food should be cooked each day) (Alsop *et al.* 2006). Although DHS provides a direct measure of decision making within the household, the domains in which decision-making is measured are typically confined to the household and domestic sphere. These questions do not adequately cover other dimensions of a woman's life, particularly decisions in the productive and economic spheres. Nor do they consider measures of empowerment other than intra-household allocation of decision-making powers (Alkire 2005; Narayan-Parker 2005).

As indicated by Malhotra and Shurley (2005), the progress of women's empowerment is infrequently tracked over time and the context-specific nature of their empowerment poses a challenge in terms of consistency and comparability in the indicators used across social settings. Therefore, there was a need to create a women's empowerment index that was survey based, and focused on women's daily decision-making, control over productive resources and income, leadership, and time allocation.

In 2012, the WEAI was created with the objective to overcome all the criticisms of previous indices. The WEAI measures empowerment considering women as agents, that have action not only inside their households but also outside of them. The index is specialized in agriculture, it is easy to interpret, its results are cross-culturally comparable, and it is applied to a broader population (female and males, rural and urban, educated and non-educated agents). In addition, the index tracks progress over time since it is calculated every five years using a comprehensive database that is collected from a household survey. Lastly, the index serves as a diagnostic tool to identify key areas in which women (and men) lack empowerment so that programs can focus on multidimensional solutions.

The WEAI underwent a revision before the second wave of data collection and as a result two tools originated: 1) an updated version of the WEAI, known as WEAI 1.1; and 2) a shorter version of it known as the Abbreviated WEAI (A-WEAI). The WEAI 1.1 contains the same indicators and questions as the original WEAI, except for the autonomy module. The A-WEAI was piloted in August and September of 2014 and now data from Bangladesh and Uganda are available.

The last adaptation of the WEAI was launched on April 2018, and it is called the pro-WEAI index. The pro-WEAI, based on the concept of empowerment as a process (Kabeer 1999), is

organized into domains that are more explicitly based on measuring three types of agency: intrinsic agency (power within), instrumental agency (power to), and collective agency (power with). Based on the Naila Kabeer concept of empowerment, the pro-WEAI index contains twelve indicators within three dimensions and will be used to assess empowerment in project settings to monitor project outcomes (Malapit *et al.* 2019). An assessment of this new index would also be beneficial to the measurement of Women's Empowerment in other contexts.

Different approaches to assess the WEAI and the A-WEAI

During the last six years, there have been qualitative studies that tried to assess the WEAI or the A-WEAI using different approaches, and in different contexts. For instance, Johnson and Diego-Rosell (2015) assessed the index by evaluating how much the respondent understands the survey questions relative to researcher intension in Haiti to assess the cognitive validity of WEAI. The authors found that in general, the questionnaire employed in the WEAI is well understood but they recommended avoiding the usage of jargon and formal language to elicit a valid response. In addition, respondents had difficulty using scales to quantify their response when they were asked about levels of satisfaction with their available leisure time.

Additionally, Doss *et al.* in 2017 evaluated the WEAI in regard to measuring ownership, control and use of assets. They also used a qualitative approach to evaluate the questionnaire. Their study found that there is a prominent respondent selection problem since the questions related to ownership and control of assets is asked only to the head of the household (woman or man) leaving out information among non-respondents.

A most recent paper done by O'Hara and Clement (2018) had a critical view of the index. Their qualitative finding from a small data collected in Nepal (152 households), compared to the data collected from the WEAI in the same region, suggest that in the development sector, the WEAI is limited to assessing a visible form of agency because the concept of critical consciousness (power within) is absent. They also argued that the WEAI index focuses exclusively on visible forms of agency related to decision-making, instead of resources or achievements.

Finally, the most complete study dedicated to the assessment of the A-WEAI evaluates the internal validity of the content of the index in Ethiopia. Min-Barron *et al.* 2017 mentioned that the study performed a mixed method approach to evaluate the internal content validity of the A-WEAI[1]. The mixed method approach consisted of three stages: one of those included a data collection, a panel of experts evaluating the index, and the construction of a "content validity" index. The study used principal component analysis and the Cronbach's alpha to test content validity in the quantitative portion of the method. The approach uses a mixed methods approach that helps present a more in-depth rage of information and knowledge on the content of the index. But one criticism of the content validity studies is that in stage three, the feedback of the panel of experts can be biased.

[1] The issue of the journal that mentions the article "Content Validity of the Abbreviated Women's Empowerment in Agriculture Index (A-WEAI) in Ethiopia: A Mixed Methods Approach" is only a collection of abstracts submitted to the Experimental Biology Meeting (see https://www.fasebj.org/loi/fasebj and click 2017). The full abstract is available at: https://www.fasebj.org/doi/10.1096/fasebj.31.1_supplement.786.36. Access to the paper has not being granted by the authors.

In addition, this type of study does not necessarily identify content that might have been omitted from the measurement. Last of all, this type of study does not eliminate the need for additional testing, which is critical for the development of the index and the authors encourage future researchers to conduct studies on the validity, accuracy, and reliability of the index (Rubio *et al.* 2003).

A review of methodologies to evaluate the multidimensional indices

The introduction of the capability approach, inspired by Sen, has initiated the development of index-based methodologies to measure abstract concepts like well- being or poverty (Sen 1985, 2000). Some examples of these multidimensional indices are: Physical Quality Index (PQLI) proposed by Morris (1979), The Human Development Index (HDI) proposed by the UNDP, UNICEF's MODA (Multidimensional Poverty of Children) Poverty Index, and most recently the WEAI index.

With the creation of these indices many researchers have used qualitative, quantitative, or mixed methods to evaluate them. The qualitative methodology, known as the constructivist approach, evaluates the properties of the indices using methods like cognitive testing and validity testing. Cognitive testing is paired with a survey (quantitative tool) to systematically identify and analyze sources of response error in surveys, like questions not being phrased properly to identify certain indictors. The information obtained from this testing is used to improve the quality and accuracy of the survey tool (Johnson 2015). For the case of the WEAI, authors like Johnson, Malapit and O'Hara have evaluated the index utilizing this qualitative approach advising some changes in the questionnaire of the WEAI and A-WEAI survey (Malapit *et al.*2016; O'Hara *et al.*2018).

The quantitative methodologies, or positivism approach, evaluates the statistical properties of multidimensional indices. Krishnakumar in 2008 reviewed several quantitative methodologies and came to the conclusion that the most appropriate methodologies for the multidimensional indices (latent variables, and weighted indicators) are: Principal Component (PC), Factor Analysis (FA), Multiple Indicators Multiple Causes (MIMIC), and Structural Equation Model (SEM).

The PC methodology is used in empirical applications and is very common in the measurement of quality of life and well-being. The PC is a reduction technique with the objective of obtaining fewer variables/dimensions. Eigenvalues and eigenvectors are calculated and sorted in decreasing order of importance. The first eigenvectors are selected as those containing the most information. The other eigenvectors are eliminated and thus the reduction of the data happens. The PC method does not have an underlying exploratory model or latent variables, as opposed to the FA,

MIMIC or SEM. Since there is no assumption of a model, the PC is pure manipulation of the data using variance/covariance matrices and eigenvalues and eigenvectors.

The FA method is a tool that can be used to explore data for patterns, confirm hypotheses, or reduce many variables to a more manageable number. It is used to cluster variables into homogeneous sets, create new variables, or select variables that represent the eliminated ones. This method, as opposed to PC, has an underlying model. In FA, the original variables are expressed as linear combinations of factors (new variables). Also, in FA the method seeks to account for the covariance or correlations among the variables, in contrast to PC which emphasis is on explaining the total variance. Some of the assumptions of FA include that the measurement error has constant variance and is, on average, zero. The factors (the created new variables) have no association with the measurement error. There is no association between the errors. Given a factor, observed variables are independent of one another (Manly 2005). The FA method is considered a method of latent variables and it is the simplest of all.

The MIMIC model has an underlying model that is divided in a structural and measurement model. The MIMIC adds to the FA the exogenous causes of the latent variables. According to this model, the observed variables result from the latent factors and these factors themselves are caused by other exogenous variables denoted here as *x.* Furthermore, MIMIC introduces "causes" of latent factors. Thus, in this model we have a "measurement equation" and a "causal" relationship set of equations. Since there is a "causal" relationship established, there is an underlying theoretical model and its objective is not reduction of the data as is the case of the PC and FA. In addition, those observed variables that are indicators of the latent variable are likely to be correlated in theory. For the WEAI case, the correlation of all indicators is the foundation and largest assumption of the index.

The most complex set of models are the Structural Equation Models. The SEMs' framework encompasses all aspects of MIMIC model and goes further by adding interdependencies and exogenous influences in both the structural model and the measurement model. For the WEAI index there is no assumption of interrelationships between the exogenous variables (they are treated as independent to each other), thus this higher degree of complexity is unnecessary and not justifiable.

The last group of methods to assess indices is the Mixed Method Approach (MMA). The MMA uses qualitative and quantitative procedures to assess instruments such as indices (Creswell *et al.* 2003). This method has become popular because it is a more comprehensive method that reduces the weakness of the quantitative or qualitative approach. In the mixed methods approach, qualitative data are acquired through focus groups. The focus group's data is then transformed into categories or themes. Then, the data is quantified into numeric values, scores, or rankings. Both qualitative and

quantitative data are simultaneously collected, analyzed and interpreted. Even though the mixed method can be seen as a more robust method, assessing the validity of an instrument can be complex because mixed research involves combining complementary strengths and no overlapping weaknesses of quantitative and qualitative research methods yielding a problem of integration (Newman 2013).

When it comes to the evaluation of a tool such as indices or instruments, the concept of content validity becomes relevant. In the traditionally psychometric testing literature, validity can be measured in three forms: content, criterion, and construct. Content validity refers to how accurately an assessment or measurement tool taps into various aspects of the specific construct in question (Rubio 2003). A validity content study determines the degree of consensus among experts about the instrument in question using a multimethod process. Criterion validity finds significant relationship between a measure and a criterion, and usually a correlation is used to assess the statistical relationship (Rubio 2003). Construct validity refers to "the extent to which the test may be said to measure a theoretical construct or trait". Possible tools to use in the construct validity are Principal Component Analysis, Factor Validation of Structural Equation Models, MIMIC models and SEM models.

All the former studies that have evaluated the WEAI index have used a qualitative approach. In addition, there have been some advances into the evaluation of the content validity but in this chapter we will focus on the construct validity aspect of the index. Thus, the study presents a construct validity approximation (the index measures what the theoretical empowerment construct is) method to test the validity of the WEAI and A-WEAI. The Constructive validity approximation demonstrates the statistically significant relationship between the indicators of empowerment and the latent variable of empowerment (in case there is one). This study complements the content validity evaluation done by Min-Barron *et al.* in 2017 and will supplement the other qualitative studies that have assessed the WEAI and A-WEAI.

The Women's Empowerment in Agricultural Index (WEAI)

In 2012, the Women's Empowerment in Agriculture Index WEAI was released (IFPRI 2012). The WEAI is an index created by the International Food Policy Research Institute (IFPRI), the US Government's Feed the Future initiative of the United States Agency for International Development (USAID), and the Oxford Poverty and Human Development Initiative (OPHI) of Oxford University. This index serves to monitor, evaluate, and diagnose the empowerment of women in the agricultural sector.

This index is composed of different indicators that address factors affecting empowerment in agriculture. The index and its components measure empowerment using survey- based data, with questions that measure the expansion of individual agency rather than only asking about asset ownership or education levels. The WEAI is a measure of empowerment that attempts to measure the actual power an individual has (intrinsic valuation[2]) by utilizing questions about the use of income and assets, or bargaining power, as well as how much the individual values this power (extrinsic valuation[3]). Thus, the index also asks questions to extract subjective measurements of empowerment such as the individual self-assessment (for example: how satisfied are you with your free time?) as well as objective questions (such as: what activities did you do during the last 24 hours?).

The Women's Empowerment in Agriculture Index (WEAI) is an index created to monitor, evaluate, and diagnose the empowerment of women in the agricultural sector. The WEAI is an index that is based on a multidimensional concept of empowerment, and it is constructed using two weighted sub-indices: The Five Domain Empowerment Index (5DE) and the Gender Parity Index (GPI). Both 5DE and GPI range zero to one, where higher values indicate a greater level of empowerment. The 5DE contributes to 90 percent of the WEAI index score, and the GPI makes up the remaining 10 percent (IFPRI 2012). The percentage choice is somewhat arbitrary but presents the emphasis on 5DE while still recognizing the importance of gender equity as an aspect of empowerment (IFPRI 2012).

$$WEAI = 0.9 * (5DE) + 0.1 * (GPI) \quad (1)$$

The Five Domain Empowerment Index (5DE) is based on the Alkire-Foster methodology (Alkire-Foster 2007), and it constructs an empowerment score for each woman. The score is a summation of the woman's level of achievement (adequate or inadequate) in ten indicators, and the

[2] This evaluation implies a self- assessment of one person's condition.

[3] This evaluation refers to an assessment of a person's condition which source is outside the person involved.

higher the score the greater the woman's level of empowerment. The ten indicators are grouped into five different domains in the WEAI: production, resources, income, leadership, and time (Table 1), and weighted by arbitrary importance.

Table 1 5DE and its domains, indicators, and weights

Domain	Indicators	Weight
Production	Input in productive decisions	1/10
	Relative autonomy in production	1/10
Resources	Ownership of land and assets	1/15
	Decisions on the purchase, sale, or transfer of assets	1/15
	Access to decisions about credit	1/15
Income	Control over use of income	1/5
Leadership	Group membership	1/10
	Speaking in public	1/10
Time	Workload	1/10
	Leisure	1/10

Source: IFPRI (2012)

The first domain is production; there are two indicators that measure if the woman has sole or joint decision making over agricultural practices, as well as autonomy in agricultural production decisions. The second domain, access to and control of productive resources, is divided into three indicators. This domain refers to ownership, access to, and decision-making power over productive resources such as land, livestock, agricultural equipment, consumer products, and credit. The income domain, which is a single indicator, measures sole or joint control over income and expenditures generated from food crops, cash crops, livestock production, nonfarm activities, wage and salary work, and fish culture. This dimension assesses the economic empowerment and the ability to increase economic resources. The fourth domain is leadership, which measures membership in economic or social groups, and woman's comfort level for public speaking. The domain assesses the role of participation on collective actions like wage negotiation and presents some indication of the respondent's empowerment on exerting voice and engaging in collective action. The last domain, time, measures the allocation of time to productive and domestic tasks and satisfaction with available time for leisure activities. This indicator is derived from a detailed 24-hour time allocation module, and respondents are asked to recall the time spent on primary and secondary activities during the previous 24 hours.

According to the authors of the WEAI, two equivalent notations can be used to describe the construction of the 5DE. The "positive" notation that concentrates on the adequacies of women/men in each indicator and focuses on the empowerment of each women/men that are empowered. The other notation looks at the disempowerment of women/men, and level of inadequacy (Alkire et al. 2013). The notation that is presented in the paper will focus on the second notation.

5DE

The formula to calculate the 5DE is[4]:

$$5DE = H_e + H_n * (A_a) \quad (2)$$

$H_e = \%\ of\ women\ who\ are\ empowered$

$H_n = \%\ of\ women\ who\ are\ NOT\ empowered$

$A_a = \%\ of\ dimensions\ in\ which\ disempowered\ women\ have\ adequate\ achivement$

$A_n = average\ inadequacy\ score/intensity\ of\ inadequacy$ where:

$$A_a = (1 - A_n) \quad (3)$$

The construction of the 5DE combines two pieces of information: the first component (H_n) is the proportion of individuals whose share of weighted inadequacies is more than k, where k is the share of (weighted) inadequacies a woman must have to be considered disempowered.

$$H_n = \frac{q}{n} \quad (4)$$

$q = number\ of\ individuals\ who\ are\ disempowered$

$n = total\ population$

The second component is the intensity of their inadequacies, or disempowerment. It is the average inadequacy score of disempowered individuals and can be expressed as follows:

$$A_n = \frac{\sum_{i=1}^{n} c_i\,(k)}{q} \quad (5)$$

Where $c_i(k) = censored\ inadequacy\ score\ of\ individual\ i$

The censored inadequacy score is computed for each person, according to their achievements across all indicators. First, it is calculated by the summation of the weighted inadequacies c_i, and the score lies in a range from 0 to 1. The score increases as the number of inadequacies of the person

[4] These formulas were designed when the WEAI was created.

increases and reaches its maximum of 1. The lower the number the less inadequacies are presented in all the indicators.

$$ci \quad = w_1 \ I_1 + w_2 I_2 + w_3 \ I_3 + \cdots + w_d I_d \tag{6}$$

$w_i = weight\ attached\ to\ indicator\ i\ with\ \sum_{d=1}^{D} w_d = 1 \qquad D=10$

$$I_i = \begin{cases} 1 = \ person\ inadequate\ achivement\ in\ indicator\ i \\ 0 = \ otherwise \end{cases}$$

Additionally, a second cut-off is used to identify the disempowered. This cut-off is the share of inadequacies a person must have to be considered disempowered and is denoted by $c_i(k)$. It is important to mention that c_i and c_i(k) are different. The first one, c_i, refers to the inadequacy count. The second one refers to the censoring of inadequacy score. If the level of inadequacy (c_i) is less or equal to the threshold (k) then the score is replaced[5] by a 0. Formally,

$$c_i(k) = \begin{cases} c_i, & if\ c_i > k \\ 0, & if\ c_i \leq k \end{cases} \tag{7}$$

Thus, for those whose c_i is less than or equal to the disempowerment cut-off, even if is not 0, their score is replaced by 0 and $c_i(k)$ is called censor because the inadequacies of individuals who are empowered are not included.

The 5DE index is constructed using the $c_i(k)$ so the disempowerment can be analyzed. In short, the 5DE index reports the percentage of domains in which those women who are not yet empowered already enjoy adequate achievements (A_a). A woman needs to have adequate achievement in 80 percent or more of the weighted indicators. If she has 80 percent or more this will be interpreted as "empowered".

The GPI Index

The GPI index, the second weighted component of the index, is based on the Foster Greer Thorbeck Poverty Gap (Alkire *et al.* 2007). It measures relatively inequality measure between the primary adult male and the female in each household. The formula used to calculate the index is:

$$GPI = 1 - (H_w * (R_p)) \tag{8}$$

$H_w = \%\ of\ women\ without\ gender\ parity$

$R_p = average\ empowerment\ gap\ between\ women\ versus\ \ men\ in\ their\ household$

[5] For those whose inadequacy score is less than or equal to the disempowerment cut-off, even if it is not 0, their score is replaced by 0.

The sub-index consists of two relevant pieces of information. First, it indicates the proportion of parity-inadequate households (H_w).

$$H_w = \frac{h}{m} \tag{9}$$

$h = number\ of\ houses\ clasified\ as\ lacking\ gender\ parity$

$m = total\ of\ dual - adult\ \ household\ in\ the\ population$

The second component of the sub index GPI is the average empowerment gap between the censored inadequacy scores of the women and men living in the households that lack gender parity (R_p).

$$R_p = \frac{1}{h}\sum_{j=1}^{h} \frac{c_j'(k)^m - c_j'(k)^w}{1 - c_j'(k)^m} \tag{10}$$

$c_j'(k)^m$=*censored inadequacy scores for men living in the household j*

$c_j'(k)^w$=*censored inadequacy scores for women living in the household j*

Male inadequacy scores are calculated in the same way as female's inadequacy scores. Note the new censored score notation $c_j'(k)$. For this new censored score, the scores of those whose inadequacy score is less than or equal to the disempowerment cut-off of *k* is replaced by the value of *k*

$$c_i'(k) = \begin{cases} c_i, & if\ c_i > k \\ k, & if\ c_i \leq k \end{cases} \tag{11}$$

When constructing this GPI index, only data from households that have both female and male decision makers are used. Second, the index reflects the percentage of women who enjoy gender parity[6]. For a woman who does not experience gender parity, the GPI index indicates the percentage difference experienced between her and the male head of the house with respect to the 5DE score.

Abbreviated-Women's Empowerment in Agricultural Index (A- WEAI)

After the first round of the Feed the Future (FTF) baseline surveys in 13 countries (Ethiopia, Ghana, Kenya, Liberia, Mali, Malawi, Mozambique, Tanzania, Rwanda, Senegal, Uganda, Zambia, and Bangladesh), a new version of the index was proposed. The main criticism of the WEAI was the length of the questionnaire, which substantially affects enumeration costs. As a result, the Abbreviated WEAI (A-WEAI) was developed to shorten the time to implement the interviews

[6] Gender parity measures the percentage of women who are as empowered as the men in their households.

(Malapit 2015). The A-WEAI has the same five dimensions but the ten indicators were reduced to six indicators. With the reduction, some of the weights had to change but each indicator still measures if each individual reached a certain threshold (has adequate achievement) with respect to each indicator. This new version was piloted in Uganda and Bangladesh and formally launched in 2015.

The main changes of the index occurred in the indicators, not in the dimension of the index. All the original five dimensions are still present and the calculation of the 5DE score and the GPI remains the same as described in equation (1). The main domains that have changed in the A-WEAI are production, leadership and time. In the original version, the production dimension had two indicators; input in production decision, and, autonomy (see **Error! Reference source not found.**). In the A- WEAI the autonomy indicator was removed because the questions were problematic, thus there is only one indicator left with one fifth of the weight. For the leadership dimension, the indicator speaking in public was eliminated because it is a highly sensitive topic in many cultures.

With respect to the time domain, WEAI included two indicators, time allocation and time satisfaction. The second indicator is no longer present in the A-WEAI, so workload is the only indicator for this domain. With the new questionnaire, respondents now must narrate their days and they themselves will allocate time periods to the different activities that have occurred in a 24-hour period. In addition, the new version does not collect time allocated into secondary activities to save data collection time. A study done by IFPRI researchers found no significant difference on whether a respondent was empowered or disempowered by collecting only primary activities (Malapit 2015). Therefore, a person who was classified as time poor (had very limited time to do activities for him or herself) was classified as such regardless of whether secondary activities were counted.

For the domain called “resources”, two indicators were used, ownership of assets and access to and decision making about credit. The third indicator that was included in the original WEAI asking about decision over productive resources was excluded because those respondents who can make decisions over productive assets are also more likely to own assets. A modification on a question about credit was included. The question distinguishes between households that had access to credit but chose not to borrow, and households who wanted to borrow, but were unable to do so.

A comparative table between the WEAI and the A-WEAI that displays the five dimension and the different indicators for each version is in **Error! Reference source not found.**.

Table 2 Comparison of Original Women's Empowerment in Agricultural Index (WEAI) and Abbreviated Women Empowerment in Agricultural Index, its weights

ORIGINAL WEAI			A-WEAI	
Domains	**Indicators**		**Indicators**	
Production	Input in productive decisions	1/10	Input in productive decisions	1/5
	Autonomy production	1/10		
Resources	Ownership of assets	1/15	Ownership of assets	2/15
	Purchase, sale, or transfer of assets	1/15		
	Access to and decision on credit	1/15	Access to and decision on credit	1/15
Income	Control over use of income	1/5	Control over use of income	1/5
Leadership	Group membership	1/10	Group membership	1/5
	Speaking in Public	1/10		
Time	Workload	1/10	Workload	1/5
	Leisure	1/10		

Instructional Guide on the Abbreviated Women's Empowerment in Agricultural Index (A-WEAI). October 2015

Data

The study will use the individual scores of disempowerment calculated from a population-based survey (PBS) performed in Bangladesh in 2012 and 2015. The Bangladesh Integrated Household Survey (BIHS), is the most comprehensive, nationally represented household survey conducted to date, and has served as the basis for assessing performance of the FTF rural program in Bangladesh. The BIHS's questionnaire includes modules that provide data on plot-level agricultural production and practices data, dietary intake of individual household members, anthropometric measurements of all household members, and data to measure women's empowerment in agriculture. The first wave of the survey was conducted from November 2011 to March 2012 in the south and southwestern regions of the country, close to the Indian border, in the Barguna, Jessore, Khulna, Madaripur, and Patuakhali districts (Ahmed 2013). During the first wave, the survey was used to calculate the WEAI for about 75 percent of the total sample of 6500 households that were in rural areas, totaling 4400 households (IFPRI, 2012). Since WEAI was designed to measure empowerment

in agriculture, the study presented here analyzes 1438 rural observations with complete individual scores of the WEAI. The second wave of the survey took place from January to June 2015 and the same primary adult female decision makers that were surveyed in 2012 were surveyed in 2015.

To assess the index, we will first test if there are differences between the average scores of women's empowerment between the two version of WEAI. The reason why this is important is to verify the assumption that women's empowerment is measured in a different manner under the two indices. In other words, first it needs to be established that in fact the two calculations of the average inadequacy count (ci) scores (equation 6) are different under the different indices for the same population at different times. If they are not different, then the two versions of the index are similar in calculating women's empowerment and the assessment of the new index would be purposeless. To test these differences, a paired t-test was performed on a sample of 1431 primary adult female decision makers inadequacy count (ci_i) scores to determine whether there was a statistically significant mean difference between the scores obtained under WEAI in 2012 compared to the scores obtained under the A-WEAI in 2015.

The results from the t-test found that the average of disempowerment is statistically different between the years 2012 and 2015 under the A-WEAI calculation (

Table 4). Principal adult female decision makers had a higher level of inadequacy under A-WEAI (34% +/- 17%) as opposed to primary adult female decision makers' scores under WEAI (21% +/-18%); a statistically significant decrease of 13 percentage points (95% confidence interval, -0.11 to -0.13), t(1834)=-20.28. These results motivate this study to find out the reasons for those differences between WEAI and A-WEAI. Mean and standard deviation scores for the ci_i (k) for two years under the WEAI and the A-WEAI are displayed in the next Table 3.

Table 3 Mean comparison of original WEAI and A-WEAI inadequacy scores (ci_i)

Variable	**Mean**	**SE**
Ci from WEAI 2012	0.22	.004
Ci from AWEAI 2015	0.34	0.004
Difference	.126	.006
Total Sample	1431	t=20.23

Following the t-test between the average scores of the individual Ci from the versions of the index, the study assesses how well both version of the WEAI measures the latent variable of women's empowerment. To accomplish this second objective, it is important to identify variables in the data that determine women's empowerment and use these variables to relate them with the indicators of WEAI. According to existing literature, this study identifies and uses eight variables that are assumed to determine women's empowerment (Alkire *et al.* 2013; Allendorf 2007; Trommlerová *et al.* 2015; Goldman and Little 2015; Anderson and Eswaran 2009; Orso 2016). These variables are divided into five categories: demographics, physical capital, human capital, health, and income. The study assumes these variables affect women's empowerment, as these are indicators of the "resources" needed to affect change in one's life and in the community according to Kabeer's theoretical approach (1999).

The demographic variables used are: age, marital status, and size of the household. In more detail, married is a binary variable: married versus otherwise.The choices that are into the otherwise group are: single, divorced, separated, cohabiting, widow, and single. The study also assumes that women's empowerment has a component of empowerment within the community; certain groups of individuals are expected to be more influential than others. Then, physical capital, human capital,

wealth, living conditions, and ownership of assets are likely to be relevant (Trommlerová 2015). To capture these aspects of women's empowerment, the study includes the physical capital (size of the plot(s) a household owns), human capital (literacy), and living conditions (access to water, access to electricity). Literacy is divided into a binary variable: can read and write versus otherwise. The option under otherwise are: can only read, can only write, can not read or write. Lastly, Trommlerová 2015 stated that health affects empowerment, thus to capture this relationship the study includes the variable household hunger scale (HHS) to measure that particular determinant of women's empowerment. HHS has three categories where a household can be classified as: "little to no hunger in the household", "moderate hunger in the household", and "severe hunger in the household". This scale was created based on the answers obtained to the question: "In the past 4 weeks was there ever no food to eat of any kind in your house because of a lack of resources to get food?".

Table 4 provides the summary descriptives of the data used in 2012 and 2015 in the study. Keeping in mind that there are ten indicators in the WEAI, and that these have been edited, we present only six indicators' statistics for 2012. According to the statistics in 2012 an average woman in the sample was married, was approximatly 46 years old and about 48 percent of women could read and write. The household size of female head of household was around 12 people counting herself, the size of the plot(s) or water bodies own/operated by their households in average were 147 decimal units (6300 sq.feet)[7] but with a standard deviation of about the same number of decimals. About 77 percent of the households had access to a source of drinkable water, and 48 percent of them had access to electricity. The average household in 2012 was considered under little to moderate hunger. The statistics for 2015 show a small increase in literacy, household size, access to electricity with respect to 2012. A reduction on the hunger household scale was registered for 2015.

[7] A unit of area in India and Bangladesh approximately equal to 1/100 acre (40.46 m²) or 435.6 sq feet. The survey used decimals instead of acres.

Table 4 Summary Statistics of variables included in the Multile Indicators Multiple Causes model

		2012		2015	
Variable	**Description**	**Mean**	**SD**	**Mean**	**SD**
Variables that are part of the Strutural model					
Age	Years	46	12.8	46	12.9
Literacy	1=can read and write; 0=otherwise	.48	.5	.51	.5
Marital status	1=married; 0=otherwise	.9	.25	.9	..22
Household size	Individual	11	6	15	9
Size of plot(s)	Decimal (90.46m^2)	147	161.6	151.4	173.4
Access to water	0=no access; 1=access	0.77	0.41	0.93	0.27
Access to electricity	0=no access; 1=access	0.48	0.5	.59	0.49
Household hunger scale	0-1=little to moderate hunger 2-3=moderate 4-6=severe hunger	0.08	0.4	0.07	0.3
Disempowerment meausrement					
Inadequacy count	inadequate >20	.21	.18	.34	.17
Variables that are part of the Measurement model					
Input in productive desicions		.22	.41	.15	.35
Ownership of assests		.62	.45	.60	.48
Access to and decision on credit		.37	.48	.41	.49
Control over the use of income		.18	.38	.10	.31
Group membership		.99	.06	.68	.46
Workload		.11	.31	.10	.30
N=Total Sample Size				**1431**	

As indicated by the descriptives and in accordance with World Health Organization, the governemnt of Bangladesh have designed policies in terms of sanitation and quality of life that have

been tranlated into more access to water and electricity. This translted into increasing the acces to these two public services from 78 percent to 93 percent to the surveyed households in terms of water, and from 48 percent to 59 percent in terms of electricity.

With respect to the indicators, the most significant change from 2012 to 2015 happened in “group membership” indicator. The average mean of the indicator “group membership” for the primary adult female decision maker was 0.99 in 2012 and in 2015 the average mean changed to 0.68 as shown in table 4. It is relevant to mention that the questionnaire changed for this indicator in the years, thus a change of this magnitud is justifiable. Based on the results presented in

Table 4 for “group membership” indicator, it seems that in average women have been found inadequate in this indicator for both 2012 and 2015, being this indicator the highest average inadequacy score from the others.

All other indicators increased the average adequacy of empowerment except for work burden indicator that remains almost unchangable with approximatly 0.1 percent of the females being adequate for both years. The overall average inadequacy score decreased from 0.21 to 0.34 which is higher than the threshold set by the authors of the index (see

Table 4).

Methods

The Multiple Indicators and Multiple Cause model (MIMIC) approach is widely used in economic studies (Kuklys 2005; Raiser. *et al*. 2000; Chaudhuri *et al.* 2016; Borges *et al.* 2016; Zereyesus *et al.* 2017; Dell'anno R. 2018). Many authors have identified this approach as one of the most important latent variable models in the testing of statistical properties of multidimensional indices (Krishnakumar 2008), and it is a step further in the testing of measurement instruments (Rubio 2003).

The study presented here proposes the MIMIC approach to evaluate the WEAI and the A-WEAI based on the existence of multiple and interrelated functioning factors, and the exogenous "causes" that determine the women's empowerment. The MIMIC approach is constructed under a system of equations that specify relationship between: 1) unobservable latent variables (women's empowerment), 2) a set of observable endogenous indicators (the ten indicators/six indicators), and 3) a set of observable exogenous variables (what are believed to be the causes of women's empowerment).

In addition, the MIMIC model has several advantages. One of the most important features of the MIMIC model is that a latent variable can be predicted by at least one observed variable (Woods 2009). It can also be estimated using ordinal or continuous data, data with different numbers of groups, and with multiple independent continuous or categorical variables (Woods 2009). This last property is important for the evaluation of the WEAI and A-WEAI because the indicators that are measured in the WEAI and A-WEAI are binary variables, and the exogenous variables are a mix of continuous, binary and categorical variables.

The MIMIC model explains the relationship between observable variables and an unobservable variable by minimizing the distance between the sample covariance matrix and the covariance matrix predicted by the model (Bollen 1989). All MIMIC models consist of two parts: the structural equation modeling and the measurement modeling. The observable variables are also divided into two groups: a) what causes the latent variable, and b) the indicators of the latent variable.

The latent variable in this study is women's empowerment. As a latent variable the study assumes that women's empowerment is an abstract concept, that can not be directly observed and,

and that this concept has multiple factors that influence its outcome for a person and community. For those variables that are part of the structural equation (variables 'causing' the empowerment), the study used eight variables that are assumed to determine women's empowerment. The variables for the structural model are: age, marital status, literacy, size of the household, size of the household's plot/pond, household access to electricity, household access to water, household hunger scale. These eight variables were chosen based on the literature and the availability of reliable data (Alkire et al. 2013; Allendorf 2012; Trommlerová et al. 2015; Goldman and Little 2015; Anderson and Eswaran 2009; Orso 2016). The study also relies on Kabeer's 1999 theory that states that some of these variables affect women's empowerment, as these are indicators to the "resources" needed to affect change in one's life and in the community.

The structural equation model, the part of the model that holds information on the variables that cause the latent variable, can be represented by the following equation (Joreskog et al. 1975):

$$y^* = \alpha' x + \epsilon \tag{12}$$

Where $y^*$is the latent variable (women's empowerment) x is a vector of explanatory variables of dimensions [1x k] (k=8 for the study). α'= ($\alpha_1, \alpha_2, \alpha_3, \dots, \alpha_k$) is [1xk] vector of coefficients that explain the "causal" relationship between the latent variable and its causes. As it is stated in equation (12), the latent variable y^* is linearly determined and subject to a disturbance ϵ.

The measurement model, the second part of the MIMIC model, represents the relationship between the latent variable and its indicators. For this part of the model, the latent variable determines linearly a set of observable endogenous variables. For this study, the assumption is that women's empowerment can be expressed in ten/six indicators that are observable, i.e. "input in productive decisions", "ownership of assets", "access to decision on credit", "control over the use of income", "group membership", "workload". The specification of the measurement model is:

$$Y = \beta y^* + u \tag{13}$$

There Y= ($y_1, y_2, \dots, y_m$)′ is a [1xm] vector of observables indicators Y. $Y_1 = \beta_1 y^* + u_1, \dots, Y_m = \beta_m y^* + u_m$, and for the study m=10 or m=6[8]. The term β represents a vector (mx1) of regression coefficients/parameters to be estimated that can be interpreted as the magnitude of the expected change of the respective indicator for a unit change in the latent variable (this interpretation is correct if the indicator is a continuous variable and the model is standardized). This vector of coefficients can be represented as β=($\beta_1, \beta_2, \dots, \beta_m$)′. Like the structural equation model presented in equation (12), the indicators are directly measurable. The disturbance terms (u) from

[8] For the WEAI the number of observed indicators that reflect the women's empowerment latent variable is 10. For the A-WEAI, this number changes to 6 indicators.

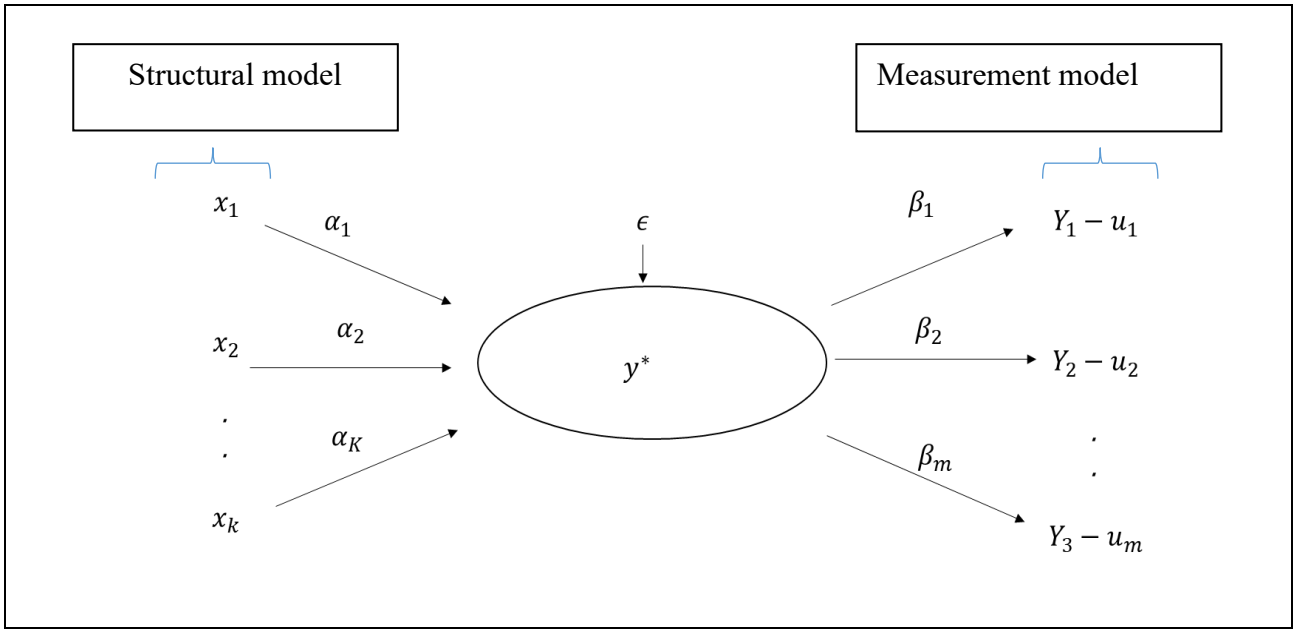
equation (13) are assumed to be all mutually independent and have an expected value of zero. It is also assumed that $E(\epsilon) = 0$, $E(\epsilon^2)=\sigma^2$, $E(uu')=\Theta^2$. Lastly, the error term for the equation (13) is an uncorrelated error term that is represented by a vector (mx1) where the vector of disturbances for the measurement model is $u = (u_1, u_2, \dots, u_m)'$.

Combining (12) and (13), it is possible to connect all observable variables through the latent y^*, thus the reduced form in terms of observable exogenous and endogenous variables is

$$Y = \beta(\alpha' x + \epsilon) + u \quad (14)$$

The strategy proposed here is to select ten/six different indicators (the ten/six indicators used in the *ci* of the WEAI/A-WEAI) to be the closest to reflect the unobserved variable (women's empowerment). In addition, the set of observable exogenous variables that have a theoretical relationship with the latent variable were chosen in accordance to support theory (Amin *et al.* 1995; Alkire *et al*. 2013; Anderson *et.al* 2009; Golman *et al.* 2015; Gupta *et al.* 2006; Allendorf 2007; Jejeephoy *et al.* 2000).

Figure 1 MIMIC Model path diagram



Derived from the Path Diagram example in Bollen, 1989.

As the path diagram shows. The latent variable is graphed in the oval and it is called y^*. Since the latent variable is not observable, the parameters of the model must be estimated using the links between the observed variables' variances and the covariance. Thus, the MIMIC model takes a vector of exogenous variables, $[x_{1,..,}x_k]$, that are selected based on theoretical assumption that stablished a "causal" relationship with the latent variable. Also, the MIMIC model utilizes a set of

dependent variables that are seen as reflectors or indicators of the unobserved latent variable. These is is vector $[Y_{1,..}Y_m]$.

To understand how to calculate the estimated coefficients, we will use the OLS model to compare to the MIMIC model. In OLS, the regression coefficients are derived from the minimization of the sum of the squared error terms (difference between the predicted and observed variables). Different than OLS regressions, what is being minimized in the MIMIC model is the difference between the sample covariance and the covariances predicted by the model (Bollen 1989). The main hypothesis of the MIMIC model is that the covariance matrix of the observed model is a function of estimated parameters. If the model that we assumed is correct, and if the parameters are known, then the population covariance would be exactly reproduced. The MIMIC model's covariance matrix is calculated and can be expressed as Σ. Σ(θ) describes the relationship between the observed variables and the unobserved latent variable through the estimated parameters.

$$\Sigma = \Sigma(\theta) \tag{15}$$

The matrix of variances and covariances is a function of all parameters in equations (12) and (13), as well as the error terms of the two parts of the model. In equation (15) *theta* is a vector that contains such parameters. To illustrate the content of the covariance matrix, assume $y^* = \alpha x + \epsilon$. Here the y^*, x, ϵ are random variables (dependent, independent and error term, respectively). This model in terms of equation (12) is:

$$\begin{bmatrix} VAR(y^*) & \\ COV(x,y^*) & VAR(x) \end{bmatrix} = \begin{bmatrix} \alpha^2 VAR(x) + VAR(\epsilon) & \\ \alpha VAR(x) & VAR\ (x) \end{bmatrix} \tag{16}$$

In here VAR(.)[9] and COV (.) refer to the population variance or covariance of the elements in parenthesis. In (16) the left-hand side is Σ and the right-hand side is Σ(θ).

Now, let's consider different indicators Y_1 and Y_2 that reflect a latent variable (in our case, the ten/six indicators of the WEAI) as an example. The relationship between the latent variable and the indicators is given by: Y_1=$y^* + u_1$ and Y_2=$y^* + u_2$ (in general terms see equation 13). Where Y_1, $u_{1,}u_2$ are random disturbances terms, and E(u_1) = $E(u_2)$ =0. Then the variance covariance matrix is:

$$\begin{bmatrix} VAR(Y_1) & \\ COV(Y_1,Y_2) & VAR(Y_2) \end{bmatrix} = \begin{bmatrix} \varphi\ + VAR(u_1) & \\ \varphi & \varphi + VAR\ (u_2) \end{bmatrix} \tag{17}$$

[9] The Variance and Covariance can be expressed in terms of expected values as: VAR (x)= $E[x^2] - E[x]^2, and\ COV\ (x)\ =\ E[XY] - E[X]E[Y]$.

In equation (17), φ is the variance of the latent factor y^*. For our model, this is the type of covariance matrix it needs to be calculated except that more indicators and more latent factors are allowed. Also, the unbiased sample estimator of covariances is:

$$COV(X,Y) = \frac{\sum_{i=1}^{N}(X_i - \bar{X})\,(Y_i - \bar{Y})}{N-1} \tag{18}$$

Finally, a mix between the covariance matrix that comes from a regression equation (14) and the covariance matrix that comes from (15) gives the resulting structural equation modeling that this study is using. The assumption for the variance-covariance matrix in equation (16) is that the error terms u_m and ϵ are uncorrelated with the latent variable and with each other. Also, error term has an expected value of zero. The resulting structural equation system:

$$\begin{bmatrix} VAR(y^*) & & \\ COV(Y_1, y^*) & VAR(Y_1) & \\ COV(Y_2, y^*) & COV(Y_1, Y_2) & VAR(Y_{2)} \end{bmatrix} \tag{19}$$

$$= \begin{bmatrix} \alpha^2\varphi + VAR(\epsilon) & & \\ \alpha\varphi & \varphi + VAR(u_1) & \\ \alpha\varphi & \varphi & \varphi + VAR\,(u_2) \end{bmatrix}$$

All α and β parameters are interpreted as if they were parameters in a regression equation. All parameters indicate the change in the expected value of the observable variable after a unit increase holding all other variables in the model constant. If these coefficients are standardized, then the meaning of the coefficient indicate a change measured in standard deviation units.

For this paper, the vector of variables that will be used in the calculation of the different parameters is the eight variables that are based on the women's empowerment theory that are supposed to affect the latent variable women's empowerment. Also, in the measurement model, we will use a vector of Y variables (dependent variables) that are the indicators used to calculate the *ci* of the WEAI and A-WEAI. These indicators are binary variable that will be used to get the variance-covariance matrix.

Results

This paper evaluates and compares the WEAI and the revised version of it, the A- WEAI. Since there is a concern that derived new indices can fail in its purpose if the original versions are not an accurate measurement of women's empowerment in agriculture, it is relevant to assess the original

version of the Women's Empowerment Index in Agriculture (WEAI) and the A-WEAI to assure the index is a reliable tool.

In order to accomplish this objective, this study estimated three different MIMIC models utilizing both the 2011-2012 data, and the 2014-2015 data that were collected from the Bangladesh Integrated Household Survey (BIHS). The first two MIMIC models use the baseline database (2011-2012) and evaluate the original WEAI and A-WEAI. The third MIMIC model evaluates the A-WEAI with the 2015 database. To avoid under identification problems, the MIMIC model fixes one indicator to one, and the estimated coefficients of the other indicators are calculated in relationship to the fixed indicator. Thus, to assess all indicators under the two versions of the index, twenty-two different specifications of the MIMIC model were calculated\fixing one indicator at a time. For the MIMIC model of WEAI 2012, we had 10 specifications. For the A-WEAI 2012 we had 6 specification for the six indicators, and for the A-WEAI 2015 there were 6 specifications for the six indicators for a total of 22 estimations.

The results presented in the following tables are unstandardized coefficients. This study did not standardize the variables, since the units to measure the indicators (ten for the WEAI/six for the A-WEAI) are the same, 1= empowered, 0=disempowered, for all the indicators. If two explanatory variables in an equation have the same units then a comparison of the unstandardized coefficients is enough for the interpretation of the coefficients (Bollen 1989). In the models of this study, all *beta* coefficients of equation (14) are measured on the same units, thus comparing β_1 and β_m without any transformation is possible for their interpretation. The indicator control over the use of income (see Table 5 and Table 6) was fixed to 1 for identification purposes so the model is not over identified[10]. Control over the use of income was not modified in A-WEAI, consequently the metric/units, and the questionnaire that is related to this indicator, are the same for both samples. Tables with the resulting coefficients for the models where all other ten/six indicators were fixed to one are presented in the Appendix B - , and Appendix C - .

Model one and two: Assessing WEAI and A-WEAI with baseline database 2011-2012 fixing control over the use of income

Table 5 contains the results of the MIMIC model that assesses the indicators of the WEAI as variables that reflect the latent variable women's empowerment. The MIMIC model has two parts,

[10] Additionally, in the Stata software the standardized option for Generalized Structural Equation Modeling is not available.

the structural model and measurement model. In Table 5, the first eight variables are the structural model, and the second set of variables are the measurement model. The first specification is the WEAI 2012, and it gives insight on how the original indicators are correlated to the latent variable women's empowerment. In addition, Table 5 shows the second specification A-WEAI 2012 that contains results assuming only six indicators that "reflect" women's empowerment. When comparing coefficients for the WEAI 2012 and A-WEAI 2012 the study assesses how much the index might have improved if the only change made was the omission of four indicators, as opposed to all three changes that A-WEAI faced[11].

The variables as shown in Table 5 are divided into sets labeled "Structural Model" and "Measurement Model". In the structural model of WEAI 2012 and A-WEAI 2012, eight exogenous variables are assumed to cause the latent variable women's empowerment.

[11] In the A-WEAI section, the reader learned about the three major changes that occurred to the WEAI after the IFPRI revision. 1) omission of four indicators;2) changes in the weights of those indicators; 3) changes in the questionnaire.

Table 5 Regression results of the MIMIC model of the WEAI and A-WEAI with data set 2011-2012 fixing control over the use of income

	(a) Specification 1 WEAI 2012		(b) Specification 2 A-WEAI 2012	
	Coefficient	**Std. Error**	**Coefficient**	**Std. Error**
Structural Model				
Age	.0055**	.002	0.0004	2.4E-03
Literacy	.1036	.069	.088	.063
Marital Status	-.292*	.159	-.245*	.144
Household Size	.002	.005	.001	.007
Size of plot	7.8E-04***	2.2E-04	.001***	3.5E-04
Electricity	.045	0.68	.094	.100
Water	.256***	.087	.351***	.129
Household hunger scale	.075	.088	.122	.131
Measurement Model				
Input in productive decisions	1.07***	.111	1.06***	.111
Ownership of assets	1.52***	.297	1.84***	.358
Access to and decisions on credit	1.58***	.314	1.905***	.382
Control over the use of income	1	-	1	-
Group member	-1.94***	.916	-1.58***	.615
Workload	.836***	.166	-.954***	.182
Speak in public	.231	.039	-	-
Leisure time	-.10***	.040	-	-
Autonomy in production	-.207***	.052	-	-
Autonomy in purchase, sale or transfer of assets	-.603***	.0907	-	-

*,**, *** denotes significance of standardized coefficients at the five percent and one percent levels, respectively.

The estimated coefficients of the structural model for WEAI 2012 reflect that four variables are statistically significant (see Table 5), meaning they are statistically correlated with the latent variable. The coefficients of age and size of the plot variables are positive which indicates that older women and bigger size of plots are positively correlated to women's empowerment if other variables are held constant. In addition, access to water as opposed to not having access to water is positively

correlated with women's empowerment holding other variables constant. There is no evidence that changing ten indicators to six indicators in the MIMIC model affects the size of the exogenous coefficients, but there is evidence that coefficients for "water" increased in size if the indicators reflecting the latent variable are reduced to six. When the regressions were estimated fixing one indicator at a time, all coefficients from the structural model had the same sign, showing a consistent positive or negative relationship between the exogenous variable and the latent for each specification.

The results from the measurement model concluded that there is statistical evidence that all indicators, but one, utilized in the calculation of the WEAI are significant at the 1 percent level, implying that the latent variable is correlated to these indicators. This result can justify the inclusion of nine indicators in the WEAI to measure women's empowerment. On the other hand, the indicator speaking in public was found not to have a statistically significant relationship with the latent variable (see Table 5).

In specification 2, A-WEAI 2012, variables like: size of plot, and access to water were found statistically significant and positive in relation to control over the use of assets. From the results of the measurement model, only six indicators were included to "reflect" the latent variable women's empowerment and all of them were statistically significant. Also, workload has changed the sign from 2012 to 2015. This changed can only be justified if we consider that this indicator has been calculating with a different weight. Under WEAI there were two indicators and under A-WEAI there is only one. From satisfaction of leisure and workload to only workload.

The coefficients of A-WEAI 2012 are very similar in signs to the coefficients where the ten indicators are present, and all of them are found statistically significant. All indicators have the same positive signs except for workload that changes from a positive sign to a negative sign even though the same data from 2012 was utilized to obtain this coefficient. Several of the models presented in the Appendix B - have similar results as the ones discussed above where the sign of the coefficient changes across indicators or years. According to the authors of the WEAI index, all dimensions and indicators contribute to the empowerment of women. They all serve as a complement of each other rather than substitutes. What this assumption means to our models is that all coefficients from the measurement model should be positive regardless of which indicator is being fixed. Special attention should be paid to workload that is subject to changes when the indicators are reduced to six.

Model three: Assessing A- WEAI with 2015 data MIMIC model fixing control over the use of income

With the revised version of the index, the measurement model is reduced to six variables, and changes in the questionnaire took place. The results of the MIMIC model that assess A-WEAI 2015 show a decrease in the number of variables that are found statistically significant in the measurement model.

In Table 6, the Structural Model under Specification 3 found age, household size, and size of the plot statistically significant at one, five and ten percent levels respectively. Age and size of plot variables have the expected theoretical positive signs and then this finding adds to the evidence other studies found that physical capital and demographics play a significant role in the empowerment of women in Bangladesh (Alkire et al. 2013; Anderson 2009; Amin et al. 1998). Also, these results are consistent results with those from WEAI 2012 (Specification 1) presented in Table 5 where age and size of the plot among other two variables were statistically significant.

Table 6 Regression results of the A-WEAI Structural and Measurement model (MIMIC) with data set 2011 and 2015

	Specification 2 A-WEAI 2012		Specification 3 A-WEAI 2015	
	Coefficient	**Std. Error**	**Coefficient**	**Std. Error**
Structural Model				
Age	4.7E-03	2.4E-03	1.6e-02***	.005
Literacy	.088	.063	.181	.137
Marital Status	-.245*	.144	-.92	.275
Household Size	.001	.007	.016**	6.4e-03
Size of plot	.001***	3.5E-04	5.7e-04*	3.1e-04
Electricity	.094	.100	8.3e-03	.136
Water	.351***	.129	-.156	.263
Household hunger scale	.122	.131	.229	.168
Measurement Model				
Input in productive Decisions	1.06***	.111	.827***	.123
Ownership of assets	1.84***	.358	.052	.044
Access to and decisions on credit	1.905***	.382	.107*	0.058
Control over the use of income	1	-	1	-
Group member	-1.58***	.615	.063*	.038
Workload	-.954***	.182	-.219	.156

, * denotes significance of standardized coefficients at the five percent and one percent levels, respectively.

Results under the specification of A-WEAI 2015 (Specification 3) found the estimated coefficients, for most of the variables in the measurement model, to be positive and significant at the five percent and one percent level (see Table 6). These estimated coefficients indicate that women's empowerment has a statistically significant relationship with some of the indicators proposed under A-WEAI (input in production decisions, access to and decision on credit, control over the use of income, group membership). There were two indicators that were not found statistically significant under Specification 3 but were significant under Specification 1 and 2. They are ownership of assets and workload (these results with respect to the fixed indicator control over the use of assets).

Table 7 shows the signs of the estimated coefficients for the three MIMIC models. The signs of the coefficients show if the indicators of the index are complements (positive sign) or substitutes (negative sign) in explaining the latent variable women's empowerment. If they are positive, the adequacy score of the indicator would increase the level of empowerment. The positive sign for input in production decisions, access to and decision on credit, control over the use of income, and group membership indicators means that increases in the latent women's empowerment would increase the probability of a women to be found adequate in those indicators with respect to the indicator control over the use of assets. These results also mean that those indicators mentioned above, that are statistically significant, serve as complements in reflecting women's empowerment rather than substitutes. Being complement indicators is one of the theoretical pillars of the index thus the results obtained for those indicators are consistent with the main assumptions of the index.

Table 7 Classification between complements or substitutes of the indicators' estimated coefficients obtained from MIMIC models of WEAI 2012, A-WEAI 2012 and A-WEAI 2015 based on their sign.

Indicator	Sign for WEAI 2012	Sign A-WEAI 2012	Sign A-WEAI 2015
Input in productive decisions	Complement***	Complement ***	Complement ***
Ownership of assets	Complement ***	Complement ***	Complement
Access to and decision on credit	Complement ***	Complement ***	Complement *
Control over the use of income	1	1	1
Group membership	Substitute***	Substitute ***	Complement*
Workload	Complement ***	Substitute ***	Substitute

, * denotes significance of standardized coefficients at the five percent and one percent levels, respectively.

This study does not calculate marginal effects of the coefficients; thus, the magnitude of a coefficient does not provide information on the actual percentage change of the indicator. The magnitude of the coefficients must be interpreted as probabilities. Thus, the results presented in Table 5 and Table 6 imply that holding all variables constant, the probability of increasing the correlation with women's empowerment and the indicators is higher under the A-WEAI 2012 than under the other two models, since for the most part, the magnitude of the estimated coefficients for A-WEAI 2012 are higher than the other coefficients.

According to Table 6, the indicators that are a cause of concerned are ownership of assets and workload. The coefficient for ownership of assets and workload were statistically significant in A-WEAI 2012 but they are not when control of the use of assets is fixed. Also, from Specification 3 in Table 6, group membership coefficient changed signs from 2012 to 2015. In 2012 the coefficient was -1.58 and in 2015 it was 0.063 (see Table 6). Under the latest result, the switch in signs makes group membership to be an indicator that not only reflects the latent variable but serves as a complement indicator to the others in reflecting women's empowerment. Thus, the modification to this indicator in the A-WEAI made it to be more theoretically sound.

Other results that are consistent with different specifications calculated in this study found that group membership, leisure time, autonomy in production and purchase, sale or transfer of assets have negative coefficients (see Appendix B -). We expect from the theoretical framework that all

indicators should be positive and statistically significant, because they reflect the latent variable. The negative coefficients found in these indicators coincided with the indicators modified in the A-WEAI. The authors of A-WEAI omitted or modified these same indicators/dimensions, thus the results obtained in WEAI 2012 (Specification 1) increase the credibility that the MIMIC specification used in this study can serve as a method to assess the index, since the results highlighted are similar indicators that the creators of the index had pointed out needed review.

Goodness-of fit diagnostic tests

Table 8 shows the values of goodness of fit for the three models. The test conducted included Akaike's (AIC) and Schwarz's Bayesian information criteria (BIC). These two test criteria are the only tests of goodness of fit that can be applied to the MIMIC models. The MIMIC models that we considered have variables in the measurement model that are binary, therefore a Generalized Structural Equation Model (GSEM) was used instead of the Structural Equation Model (Acock 2013). The only difference that GSEM has over SEM is that GSEM models are based on the log-likelihood function in Stata, and the only information criteria that are available to test goodness of fit under this software are the two mentioned above. In general, "smaller is better" (StataCorp 2019) and given two models, the one with the smaller AIC fits the data better than the one with the larger AIC. As with the AIC, a smaller BIC indicates a better-fitting model.

This means that A-WEAI 2015 and A-WEAI 2012 have better goodness of fit than the WEAI model. The MIMIC models that used A-WEAI explained a higher percentage of the variable in the latent variable empowerment compared to the other models where WEAI was used.

Table 8 Values of fit statistics for the MIMIC models

Diagnostic Test	Description	Specification 1 WEAI 2012	Specification 2 A-WEAI 2012	Specification 3 A-WEAI 2015
AIC	Akaike's' Information Criteria	13137	6725	10642
BIC	Schwarz's Bayesian information criteria	13284	6831	10747

Statistics indicate successful MIMIC models have been obtained. Thus, the evaluation of women's empowerment can be assessed, and the results come from relatively reliable model specifications. The unobserved latent variable women's empowerment can be modelled with a "cause" and "effect" indicators, but causality of all exogenous variables in the structural part of the MIMC model is an imposition to the model supported by the findings from the literature.

Conclusion

The purpose of this paper was to assess the WEAI and the A-WEAI using their indicators to verify that the indices reflect women's empowerment in agriculture through five main domains. The method utilized in this study evaluated the relationships between specific indicators that are part of the index, and the latent variable of women's empowerment (via the 5DE component of the index) using a Multiple Indicator Multiple Causes approach (MIMIC). The data came from the Bangladesh Integrated Household survey conducted in 2011 and then in 2015. Statistics indicators of goodness of fit indicated successful MIMIC models have been obtained in terms on how well they described the out of sample prediction error. Thus, the evaluation of women's empowerment can be assessed: and the unobserved latent variable of women's empowerment can be modelled with "cause" and "effect" indicators. Consequently, the study concludes that for the most part the indicators that are part of the WEAI and A-WEAI are correlated with the latent variable of women's empowerment. Also, according to the MIMIC model specification proposed in this study (Specification 3), the estimated coefficients, for most indicators included in the A-WEAI, were found to be theoretically consistent and statistically relevant.

The result under Specification 1 that assessed WEAI had ambiguous results in four indicators: group membership, leisure time, autonomy in production, purchase, sale or transfer of assets. The signs of the coefficients for these variables, according to the model, were not consistent with the literature since the variables were negative. These results described above coincide with what the authors of the WEAI found as problematic indicators and as a result the authors removed and/or modified them in the new version of the index.

In the A-WEAI version, the index became an abbreviation of the original one. This study also tested the A-WEAI using 2015 data indicating that the coefficients from the A-WEAI are smaller in magnitude than those calculated under WEAI. What these results imply is that holding all other variables constant, the probability of increasing the correlation between women's empowerment and the indicators is higher under the WEAI than under A-WEAI. It is more likely to find a woman empowered under the WEAI than under A-WEAI.

Another conclusion from this study is that there are two indicators that should be revised. Ownership of assets and workload have changed from being statistically significant to not statistically significant. Most likely, the modifications made in the A-WEAI related to the weight assigned to this ownership of assets indicator and workload may have caused this situation. Under A-

WEAI, the indicators' weights for Ownership of assets and workload were 2/15 and 1/5 respectively, which are different weights than those initial assigned of 1/5 and 1/10 respectively (see Table 2).

An improvement that the study found from the modification of the WEAI is in relation to group membership indicator. Group membership's coefficient changed signs from 2012 to 2015, in 2012 the coefficient was -1.58 and in 2015 it was 0.063 (see Table 6). According to Table 4 (summary of the data), the percentage of women that were empowered in the indicator group membership in 2012 was particularly low. This result might be due to the presence of the indicator speaking in public that later was excluded from the A-WEAI because it proved to be highly sensitive (Malapit et al. 2015). As a result, more than 95 percent of respondents did not miss the criteria to be considered empowered in this dimension in 2015. In short, under A-WEAI and after the modification that happened to this indicator, now the indicator is consistent with the theoretical framework the index relies on (positive sign) and does reflect a relationship between being part of a group and women's empowerment (statistically significant).

Overall, for the case of Bangladesh, it seems that labor and physical capital influence positively women's empowerment. These results agree with previous studies done by Allendorf in Nepal (2007), Goldman et al. in Tanzania (2015), and Mishra and Sam in Nepal (2016), where there is evidence linking access to land and physical capital with women's empowerment. In addition, the results of the MIMIC model under A-WEAI 2015 revealed that not only physical capital, but also age, is associated with women's empowerment in Bangladesh. On the other hand, the results highlighted the positive correlation between household size and women's empowerment in agriculture.

The main indicator that requires attention is workload since it appears to be not significant and negative in sign in the specification where the A-WEAI is being assessed. As a result of this finding, the following questions arise: are there adverse consequences between women's empowerment and workload that make the relationship between these two variables ambiguous? Is it the case that by empowering women there is a high tradeoff in workload? How are women allocating their time as empowerment levels increase? The answer to some of these questions could contribute to the women's empowerment in agricultural literature because they would help develop an empirical framework that highlights linkages and trade-offs between time consumption, time allocation and women's empowerment.

For the consideration of future research, other aspect of empowerment in relationship with the agricultural sector that can be contemplating to be added to the domains are mobility, technology

and communication. These dimensions: mobility, technology, and communication, are closely related to the agricultural sector and direct mechanisms that can affect women's empowerment. From the mobility dimension we can argue that a person would be able to increase different resources if they can freely move. Not only she can expand her economic opportunities, but also her social and human capital to increase achievements and be more empowered. From a combination of technology, communication and mobility, it is important to understand that mobility is not necessary the physical aspect of it but also the virtual mobility that comes with the access to technology that to a certain extend has to do with communication. The access to technology and the effectiveness of the adoption of technology, as well as the use of the information obtained from the communication should be part of the assessment of women's empowerment in agriculture.

Chapter 2 - Women's empowerment and time allocation under a revised classical theoretical approach

Introduction

Being able to manage time is a component of women's empowerment (Alkire et al. 2013). According to the empowerment definition by Sen (2000), an individual's empowerment comes from a multidimensional interaction of autonomy and agency exercised over multiple resources and one of them is time. The notion of empowerment that is associated with time is based on the tradeoff between work and leisure. Having autonomy over allocation of time is reflected in allocation to leisure which is interpreted as a proxy for empowerment leading to a causality dilemma that can generate potential endogeneity issues when trying to conduct empirical analysis. The perception that leisure is a desirable good is rooted in the classical framework proposed by Becker in 1965. The Beckerian model describes utility as a function of two variables: consumption of goods and leisure. If empowerment, autonomy of time allocation, and the classical utility maximization theory are combined, the theoretical result is that empowered individuals (if rational) would maximize their utility by allocating their time to lower workload and increased leisure.

Two similar ideas hold under the theoretical consumer framework and under the women's empowerment theory. From consumer theory, less leisure would decrease utility, and from the empowerment theory, less autonomy over time would decrease leisure (Becker 1965; Alkire 2013). The classical theory holds under certain assumptions, but empirical results show that, at least in the agriculture sector with respect to the women's empowerment theory, agricultural practices and interventions that increase women's empowerment lead to higher workloads. On one hand, agricultural empowerment policies tend to improve the empowerment of women giving them more decision power, autonomy, and better access to different resources (agricultural outputs, financial resources, productive resources, etc.). On the other hand, better access to resources increases the workload of farmers because they allocate more time to productive activities and reduce the amount of time allocated to activities that are related to nutrition, taking care of family members, or leisure (Seymour et. al 2019).

Although workload for women and men are high in the rural areas due to the lack of basic resources (water, electricity, etc.), household family dynamics and the power relations between men and women often increase the workload for women (Richarson 2017). Women in rural areas spend a

considerable amount of time taking care of children, preparing food, and collecting water and fuel for their households (Malhotra and Schuler 2005; Mosedale 2005). The fact that there are social norms, the scarcity of economic resources, and the lack of substitutes to take care of home responsibilities, limits the flexibility of choice for women.

Women have heavy workloads at the household, farm and community levels, imposed perhaps by structural variables like age, caste, or religion and these loads could increase depending on their husband's situation, seasonality, economic need, stage of life, or climate change. For instance, wives of migrant husbands that are away during a particular agricultural season have reported to have high workloads in Nepal, Burkina Faso, and Bangladesh (Meinzen-Dick et.al 2019). In terms of climate change, climatic shocks tend to increase the time required to fetch water or collect wood or fuel, and these are, in many cultures, the responsibility of women. In relation to social norms, in many cultures young women have greater labor responsibilities compared to older women, who have more free time and depend on their daughters-in-law or daughters to perform household chores, because the local culture dictates that young women have to take care of their in-laws (Sachs, 2019; Ahmand 2016).

With all activities that women are expected to perform, by choice or by norm, and the time restriction of having 24 hours in a day, there is little time to allocate to productive activities without taking time from activities that traditionally are considered leisure or non-obligatory. That is, we might observe activities related to production agriculture, income generating activities, educational activities, and even leadership activities that seem to be competing with activities of leisure, resting or nutrition that are essential for the wellbeing of individuals. Therefore, it might be seen that incentives to increase the participation of women in different productive activities, or activities of leadership that reflect or contribute to women's empowerment, affect their time allocation leading to a perception that empowerment counts against them in terms of managing their time. But, if women have decided in an autonomous manner to allocate more time to productive activities (income generating activities, leadership activities, etc.) over leisure, that is evidence that they are exerting agency which permits to be more empowered.

There have been studies indicating that despite the undesirable consequences of increasing the workloads of women in rural areas, some women perceive more workload as a positive outcome. It is even their desire to engage in income generating activities. For instance, a multi-cross culture study done in Asia observed that in different countries like Thailand and Indonesia, women are perfectly satisfied with the little leisure they have during the peak agricultural season (Akter 2017). Many times, women were found to be very proud when they worked extensive hours because they

felt they contributed to farming and the income of their families (Akter 2017). It seems, that some women have adapted their preferences and have chosen work over leisure, and so reported higher satisfaction rates, whereas their actual hours of leisure per day might be lower (Alkire 2013). Women in certain countries see the increased workload and the resultant lack of leisure as a way of increasing their income, which contributes to increase their resources.

If women have chosen to allocate time in productive activities (produce resources) over leisure activities, and if these decisions have not been imposed to them; this is a way to exercise agency. But, if a person that has little empowerment, lacks the ability to allocate time into more satisfying or remunerative activities, this person might face an empowerment trap.

According to the empowerment definition proposed by Amartya Sen, and combined with Naila Kabeer's definition (see Figure 2), there are three critical components of empowerment: resources (material, human, and social), agency (ability to define and act on one's individual or shared goals), and achievement (well-being outcomes).

Figure 2 Components of empowerment identified by Kabeer (1999)

Source: Author based on Kabeer 1999

As Figure 2 shows, resources facilitates the exercise of agency, a concept from Sen's (1999), which leads to achievements. Achievements, in turn, can contribute to increased resources. If a woman is left without much resources, and her empowerment conditions do not allow her to allocate time in productive activities, she is potentially trapped in this disempowerment condition. Figure 2 can also have the opposite interpretation where instead of agency we have absence of it or

disempowerment. If this is the case, disempowerment is a self-reinforcing mechanism which causes the disempowerment to persist. Therefore, if we revisit the empirical evidence in Akter (2017), where women have taken the decision of decreased their leisure in an autonomous manner to allocate more time to work, they are more empowered than those that had more leisure but did not have the option (no agency) to allocate their time as they had wished. Also, women that were empowered enough to be able to allocate time to resource generating activities, according to Kabeer's theory, can increase their empowerment over other groups of women.

It is worth to analyze if women in different empowerment conditions allocate time in similar ways and determine the main drivers of their time allocation decisions. If those drivers are structural variables (age, caste, religion, etc.) and if they influence more the highly disempowered women than the empowered ones, then highly disempowered women are facing an empowerment trap. Thus, it is worthwhile to test if empowerment traps exist, and we could hypothesize that highly disempowered women are subject to structural conditions that are difficult to change with external interventions.

In addition, assuming that empowerment has a role in time allocation, and assuming that the more agency a person experiences, the more *non-obligatory activities* the person would perform, it is taking us away from the Beckerian model. If less leisure increases the women's utility function, then the classical utility function assumption (which variables are consumption of goods and leisure) no longer holds. In order to make the theory agree with the evidence, a different theoretical approach is needed.

To reconcile consumer theory and women's empowerment theory, it is necessary to rethink some of the assumptions of the classic consumer model. The theoretical model proposed here will test the hypothesis that empowerment does shift the allocation of time. Additionally, looking at different levels of empowerment, this study can test if there are variables correlated to the allocation of time to certain activities. It can also test if there are potential self-reinforce mechanisms that make a person stay in certain level of empowerment. Testing this hypothesis would allow us to give explanation to some of the empirical outcomes that seem to be counter intuitive.

Economic theory of time allocation

Economic theory poorly addressed labor and time allocation issues prior to the 1960's (Sanchis 2016). In 1965, Becker proposed incorporating non-working time (leisure) into the utility function to explain the supply of working hours and the tradeoff between consumption of goods.

Nevertheless, the lack of empirical evidence points to the need for a more general theory that can explain other economic and social aspects of an individual's use of time (like women's empowerment) and the relationship with agency.

The seminal paper written by Becker (1965) laid the foundation for models on the consumption-leisure trade-off by specifying a production function linking time and market goods to produce "basic" commodities. These commodities are the direct components of the utility function while time and market goods are derived from the demand for these "basic" commodities. Since time is a component in the production of the basic commodity, an additional time constraint is added to the utility maximization problem. Becker emphasized that there are different types of time use, just as there are many types of goods, allowing for differentiation by activity. The combination of time allocation and consumption of goods yields a basket of commodities fundamental to the functioning of a household in domestic, caregiving, revenue generating and leisure activities.

Becker's model assumes that the household consumes and obtains utility from goods purchased ($y_{1,..,}y_n$). It also assumes that the consumer is rational, and her objective is to maximize her utility function.

$$Max_{y_1,\ldots,y_n}\ U = U(y_1, \ldots, y_n) \tag{20}$$

Household will be assumed to combine time and inputs to produced more basic commodities written as $Z_i = f(x_i, T_i)$ where x_i is a bundle of inputs at prices p_i, and T_i is a bundle of time quantities. In this formulation households are producers and consumers. They combine time and inputs via production function $f_i$to produce commodities Z_i. They would choose the best combination by maximizing the following utility function

$$Max_{x_i,\ldots,T_i}\ \mathrm{U}= U(\mathfrak{f}_1(x_1, T_1), \ldots, \mathfrak{f}_i(x_i, T_i)) \tag{21}$$

The household is endowed with a fixed resource constraint of time, and it is allocated between leisure (L) and hours of work for pay (h) in the production of each household commodity, as indicated by (22),

$$T_i = L_i + h_i \tag{22}$$

Becker introduces the wage rate $\bar{w}_i$ and assumes that the household trades time for money, thus there is only one constraint that the household faces. The household receives cash income (I) from members working for a wage ($\bar{w}$), and this income is allocated to purchasing Z_i.

$$I = \bar{w}*h = P_1Z_1+\ldots+P_iZ_i \tag{23}$$

Re-arranging equation (22) to obtain $h_i = T_i - L_i$, and then substituting this expression into equation (23) we obtain Beckerian full income constraint (S).

$$S = \bar{w} * T_i = \bar{w} * L_i + P_1 Z_1 + \ldots + P_i Z_i \quad (24)$$

Full income is received from the sale of part of the time endowment at the wage rate ($\bar{w}$) and this income is spent on leisure and purchases of commodities at prices P_i. From this constraint, we can derive demand for leisure, as a normal good that would increase utility.

Assuming an interior solution for consumption, the household derives the mix of inputs, L_i and $Z_i$that maximizes utility subject to the equation (24). These first-order conditions for the household's decision problem are, with a Lagrange multiplier (λ) describing the marginal utility of full income:

$$\frac{\partial \mathcal{L}}{\partial T_i} = \frac{\partial U_i}{\partial T_i} - \lambda \bar{w} = 0 \quad (25)$$

$$\frac{\partial \mathcal{L}}{\partial X_i} = \frac{\partial U_i}{\partial X_i} - \lambda P_i = 0 \quad (26)$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = \bar{w} * T_i - \bar{w} * L_i - P_i * Z_i = 0 \quad (27)$$

Equations (25) − (27) can be solved jointly to obtain the marginal rate of substitution (MRS), between consumption, labor (and leisure by the identity). The general form of the household's demand for commodities, and the labor supply function:

$$MRS = \frac{U_T}{U_x} = \frac{\bar{w}}{P_i} \quad (28)$$

$$x_i = x_i\ (w_1, \ldots, w_i, p_1, \ldots, p_i) \quad (29)$$

$$T_i = T_i\ (w_1, \ldots, w_i, p_1, \ldots, p_i) \quad (30)$$

From (28), the MRS is equal to the ratio of prices of labor and goods and the demands for labor and goods are determined by the wage rate, which is the price of time at an interior solution, and the price of commodities (P_i). According to this Beckerian model more leisure and consumption of goods would produce more utility, at least until the marginal cost of leisure equals the marginal cost of work.

Let us introduce the notion of empowerment into the economic theory of allocation of time. Which is a theoretical approach that is novel in the consumers theory and the empowerment theory. There are two possible ways of introducing this concept to the utility function. The first assumes $U = U(a_i, \varepsilon)$ where time allocation and empowerment were variables of choice. This approach would not be considered in this paper. The second framework consist on estimating the utility function using empowerment in an indirect way through allocation of time, $U = U(a_i(\varepsilon))$.

The new theoretical framework that we proposed then assume that empowerment has a role when a person decides how to allocate time because the way a person distributes her time reflects her

ability to enact strategic choices, which is exercising agency. Second, rather than focusing on consumption goods and the derived demand for labor and leisure, let us assume that time allocation decisions and the activities performed are the only arguments of concern (31). The idea of maximizing the utility of time use is not novel. Evans (1972) proposed a microeconomic model based on a utility maximization approach where the primary source of satisfaction is the time allocated to an activity performed (T_i).

To better understand this idea, the utility function could be said to be estimated on time spent at the cinema instead of the number of visits to the cinema or, more generally, the time spent in consuming a commodity. This concept contrasts the classical consumption model where utility comes from the consumption of discrete goods not from time spent doing activities. Third, let us assume that women's empowerment is a variable that affects utility via time allocation. That is, let us modify the Beckerian utility function and have allocation of time in activities as a function of empowerment. Fourth, let there be a woman who is a utility maximizing agent whose utility function depends on the time she spends in certain activities a_i, which also depends on her level of empowerment (ε), subject to a time and budget constraint.

$$U = U(a_i(\varepsilon)) \quad i = 1, .., n \quad \varepsilon \in [0,1] \tag{31}$$

From (31) we have a woman that allocates time among i different activities in a pattern that is correlated with empowerment. For example, a weakly empowered woman with limited agency might allocate time to unremunerated chores or "drudgery" necessary for the household while a highly empowered woman may engage in public service or charity. Fifth, rather than comparing time allocation across all potential usages of time, allow for aggregation of time into three different sets of activities, *unpaid obligatory activities* a_u, *paid obligatory activities* a_w, and a_n, *non-obligatory activities* (Evans 1972; Yamamoto et. al. 1999).

Unpaid obligatory activities are those activities that women must perform, and they do not have the freedom or agency to reject allocation of time to these activities. The reason they have to perform these activities is because of a natural need (sleeping, eating, personal care), or because they do not have the choice to choose to perform, or not to perform the activity. For example, the time a woman spends caring for members of the family could be considered an *unpaid obligatory activity* if she spends time doing it because she is expected to do so. Time allocated to a_u is considered to generate less utility compared to other activities.

The second set of activities *paid obligatory activities*, a_w, are activities that women must perform and in exchange for their time they receive financial compensation. Examples in this

category include caregiving, field labor, non-agricultural jobs as an income generating activity to pay expenses or purchase inputs for her family. The *non-obligatory activities*, a_n, are freely chosen by the individual. Most importantly, these activities are an expression of free will in the presence of other choices with implicit or explicit opportunity costs. Therefore, activities classified in the a_n set include caring for members of the household if she has decided to allocate time to this activity having other choices available to her. For example, highly educated women who decide not to enter the workforce are empowered and exercise agency when raising children despite the financial opportunity cost and social expectations.

In this classification system, the same activity, caregiving, may belong to a_u, a_w, $or\ a_n$ depending upon agency/autonomy, and whether a person is required to conduct the activity, choses to do so for financial compensation, or forgoes income to do so out of personal choice and agency. It is important to make a distinction on how leisure is entering into the utility function in this model. For example, time to rest, like taking a nap, is classified as a *non-obligatory activity*, because there is a sense of agency in being able to take a rest and to allocate time to this activity. On the other hand, the time a person is naturally required to sleep, which is obligatory, would be classified as an *unpaid obligatory activity*.

In summary, the sixth assumption establishes that leisure has been divided between leisure as an *obligatory activity* (sleeping) and leisure as a *non-obligatory activity* (napping, meditating). Seventh, in terms of preferences *non-obligatory activities* are strictly preferred over *paid obligatory activities* and *unpaid obligatory activities* thus, $a_n \succ a_w \succ a_u$. Eighth, it is not possible that the same person, for the same period of time classifies one activity into different groups. One activity can only be classified by an individual into one of these groups: $a_u, a_w, or\ a_n$[12]. Nine, the model will consider the interior solutions with level of empowerment between 0 and 1 and will exclude corner solutions. Thus, this model does not account for the extreme cases where a person is 100 percent empowered, enjoying a royalty condition of empowerment (ε=1), or 0 percent empowered, bearing slavery (ε =0).

More formally,

$$U= U(a_u(\varepsilon), a_w(\varepsilon), a_n(\varepsilon)) \qquad \varepsilon \in [0,1] \tag{32}$$

[12] The case in which a woman wants to stay home to cook every day for the simple pleasure of enjoying cooking would be considered a *non-obligatory activity*. If the woman must cook because she does not have the agency to decide differently, and it is expected from her to do so, then it is an *unpaid obligatory activity*. Lastly, the woman that allocates time to cook to get an economic remuneration because even though she might prefer to do something else, she has to earn some means to survive, then that activity would be classified into *paid obligatory activity*.

The model assumes that each person is endowed with 24 hours each day ($\bar{T}$) and all time in daily activities sums to ($\bar{T}$). With $\bar{T}$ number of minutes, there are three choices where to allocate time and this constraint can be written as:

$$\bar{T} = a_u(\varepsilon) + a_w(\varepsilon) + a_n(\varepsilon) \quad \varepsilon \in [0,1] \quad , \bar{T}=24\text{h} \tag{33}$$

The model also assumes a budget constraint that has three components: explicit financial income and two opportunity costs components that produce "full income". First, $\tilde{r}_u$ represents an opportunity cost and the willingness to accept a wage that induces a woman to step out *unpaid obligatory activities.* For example, for a disempowered woman, the social cost and the opportunity cost are high to change *obligatory activities* to *non-obligatory activities*. Second, there is the wage rate r_w that is obtained by performing *paid obligatory activities* and r_w. In the base model it is assumed that r_w is not a function of empowerment[13]. There is also, $\tilde{r}_n$ which is the willingness to pay to reduce the hours of *paid obligatory activities* over *non-obligatory activities*. This willingness to pay, or forgo income, comes at relatively high levels of empowerment. Thus, the willingness to pay $\tilde{r}_n$ can only be afforded as women obtain more agency, and are not constrained by rigid social norms, or subject to high budget constraints. Finally, the model is static and does not incorporate savings. The budget constraint is written:

$$I = \tilde{r}_u a_u(\varepsilon) + r_w\, a_w(\varepsilon) + \tilde{r}_n a_n(\varepsilon) \tag{34}$$

Now maximizing the utility function subject to the new time constraint and budget constraint,

$$Max_{a_u, a_w a_n, \lambda_1, \lambda_2}\ \mathcal{L} = U(a_u(\varepsilon), a_w(\varepsilon), a_n(\varepsilon)) + \lambda_1(\bar{T} - a_u(\varepsilon) - a_w(\varepsilon) - a_n(\varepsilon)) + \lambda_2\ (I - \tilde{r}_u a_u(\varepsilon) - r_w a_w(\varepsilon) - \tilde{r}_n a_n(\varepsilon)) \tag{35}$$

$$\frac{\partial \mathcal{L}}{\partial a_u} = \frac{\partial U_i}{\partial a_u} - \lambda_1 - \lambda_2 \tilde{r}_u = 0 \tag{36}$$

$$\frac{\partial \mathcal{L}}{\partial a_w} = \frac{\partial U_i}{\partial a_w} - \lambda_1 - \lambda_2 r_w = 0 \tag{37}$$

$$\frac{\partial \mathcal{L}}{\partial a_n} = \frac{\partial U_i}{\partial a_n} - \lambda_1 - \lambda_2 \tilde{r}_n = 0 \tag{38}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_1} = \bar{T} - a_u(\varepsilon) - a_w(\varepsilon) - a_n(\varepsilon) = 0 \tag{39}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_2} = I - \tilde{r}_u a_u(\varepsilon) - r_w\, a_w(\varepsilon) - \tilde{r}_n a_n(\varepsilon) = 0 \tag{40}$$

Solving equation (35) and using FOC (36) to (40) we obtained,

[13] For future research, it is worth to test the following Ho= $\frac{\partial r_w}{\partial \varepsilon} > 0$

$$U_{au} = \frac{\partial U_i}{\partial a_u} = \lambda_1 + \lambda_2 \tilde{r}_u \tag{41}$$

$$U_{aw} = \frac{\partial U_i}{\partial a_w} = \lambda_1 + \lambda_2 r_w \tag{42}$$

Where $\lambda_1 \; and \; \lambda_2$ can be identified as Lagrange multipliers related to the marginal utility of time and money respectively. In equilibrium, we can solve the maximization problem to find the marginal rate of substitution between groups of activities. If we define the marginal rate of substitution between the *j*th and the *i*th activities as the time in the *i*th activity which would just compensate the consumer for the loss of marginal unit of time in the *j*th activity, then we can solve the problem and find the maximum.

$$MRS = -\frac{\partial a_w}{\partial a_u} = \frac{U_{au}}{U_{aw}} \tag{43}$$

Thus, from (36) divided by (37) we obtained (intermediate steps Appendix D - from (64) to (69)),

$$MRS = \frac{\lambda_1 + \lambda_2 \tilde{r}_u}{\lambda_1 + \lambda_2 r_w} \tag{44}$$

$$MRS = \frac{U_{au}}{U_{aw}} = \frac{\lambda_1}{\lambda_1} + \frac{\tilde{r}_u}{r_w} \tag{45}$$

In this case, the MRS in equilibrium, is not equal to the ratio of rates of $\tilde{r}_u / r_w$, unless the marginal utility of time is zero ($\lambda_1 = 0$). As is stated in (46), (47) and (48), MRSs are shifted λ_1 units.

From the other FOCs we similarly obtained the MRS between *paid obligatory activities* to the *non-obligatory activities* (48) and we obtained the following expressions (intermediate steps in Appendix D - Equations ((70)-(73)):

$$\frac{\tilde{r}_u}{r_w} = \frac{U_{au} - \lambda_1}{U_{aw} - \lambda_1} \tag{46}$$

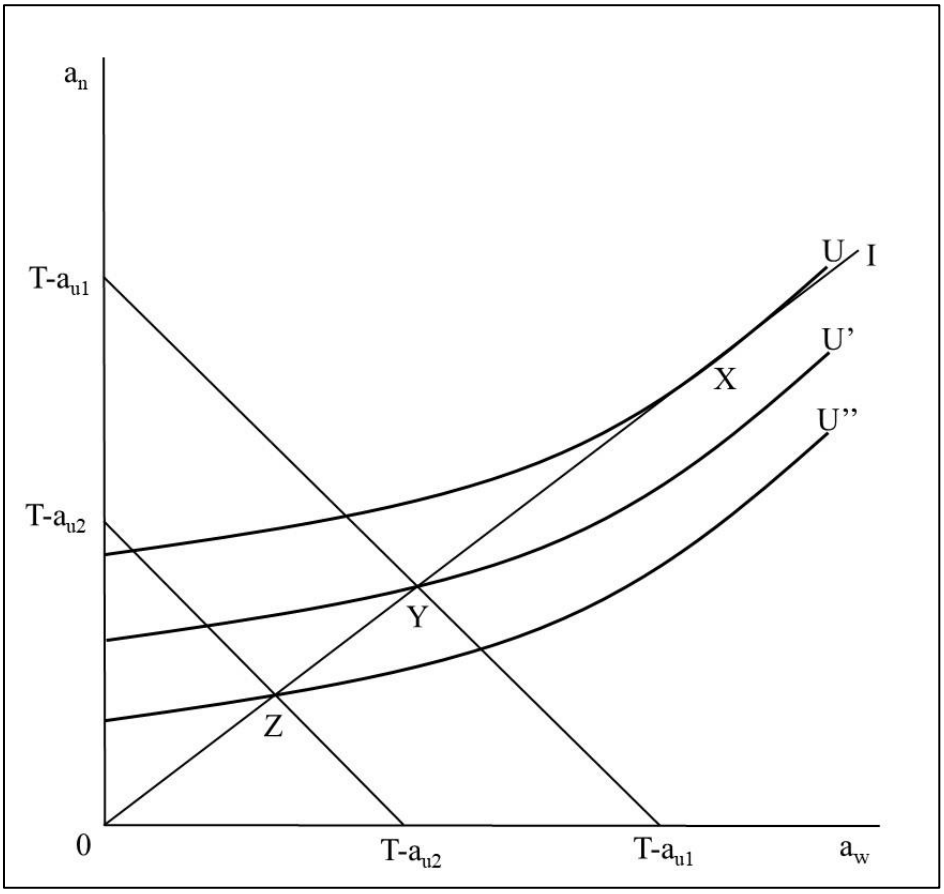
$$\frac{\tilde{r}_u}{\tilde{r}_n} = \frac{U_{au} - \lambda_1}{U_{an} - \lambda_1} \tag{47}$$

$$\frac{r_w}{\tilde{r}_n} = \frac{U_{aw} - \lambda_1}{U_{an} - \lambda_1} \tag{48}$$

A remark from these results is that in equilibrium, the ratio of the prices is not equal to the rate of substitution. The shadow price of time, λ_1 , comes into consideration and restricts the maximization. The time constraint that we proposed in (33) is more restrictive than the classical time constraint depicted in (22). Under the new model, individuals have less time to allocate in an

autonomous way compare to the Beckerian model because now we consider some *obligatory activities* that the Beckerian model omits. Therefore, the indifference curves that a consumer can reach under the Beckerian model are higher than under the model where allocation of time and empowerment are being considered. A graphical representation of the effects of more restrictive time constraints is presented in Figure 3

Figure 3 Utility maximization problem under income and time constraints



Source: Evans (1972)

In this figure, the consumer can allocate time between three sets of labor activities (a_w, a_n, and a_u). The amount of time spent in a_n is represented on the vertical axis, a_w on the horizontal axis and two levels of a_u along the diagonal between the two axes where $a_{u2>}a_{u1}$. The budget constraint is shown by the upward sloping line 0I. If the budget constraint were the only constraint, the consumer's equilibrium allocation would be on point *X* where the indifference curve U is tangent to the budget constraint 0I. With the additional time constraint, the consumer's equilibrium allocation of time would be point *Y*. A third scenario is where the highest indifference curve that the consumer can

reach is U''. If, for example, a woman allocates a large percentage of her time to a_u, leaving less time available to allocate to other activities, her tangency would be at point *Z.* Also, notice that the MRS is no longer the slope of the budget constraint (ratio of prices). The more restrictions we have in the problem of maximization of utility for time allocation (less autonomy), the lower indifference curves the consumer would attain in the equilibrium. Additionally, the MRS between group of activities is no longer the pure ratio of the wages, but includes the willingness to pay or willingness to accept, as shown in equations (46)-(48).

The maximization problem that is faced by the consumer does not only include the budget constraint and time constraint but also what we call *the minimum unpaid obligatory activities allocation of time constraint*. This minimum restriction establishes the minimum time spent in activities classified as *unpaid obligatory activities* ($a_u{}^{min}$). At first, one can think that *the minimum amount of unpaid obligatory activity* is, in general, constant across individuals. This statement is true only if basic biological *unpaid obligatory activities*, such as sleeping and eating, are considered. Overall, there is a minimum amount of time allocated to biological obligatory activities so people can stay healthy and productive regardless of their social, economic, political, on religious situations. But, if the $a_u{}^{min}$ set of activities also includes minimum religious practices (investing certain amount of daily time in ritual or practices), minimum social practices (serving elders), or minimum social conditions (belonging to a caste system), then this constraint will be different across individuals and it can become binding for those with higher obligations of their time. The more *minimum unpaid obligatory activities* a person is subject to, the less time is free to allocate to other activities. For example, women under a caste system have very high $a_u{}^{min}$ compared to women under a system where they have autonomy over the allocation of their time. Including this *minimum unpaid obligatory activity allocation of time constraint* takes into consideration the heterogeneities of culture and social norms that is absent in many models. Diagnosis of the reasons for allocating time to a_u allows for understanding whether empowerment traps exist that are difficult to overcome through project interventions. We write this third constraint as:

$$a_u(\varepsilon) \geq a_u(\varepsilon)^{min} \tag{49}$$

With constraint (49), the maximization problem is stated in equation (50). If $\mathrm{a_u}, \mathrm{a}_w, \mathrm{a_n} > 0$, the equilibrium condition for the number of hours spent in all three of the group activities is found when this problem is solved:

$$Max_{a_u,a_w,a_n,\lambda_1,\lambda_2,\lambda_3}\ \mathcal{L} = U(a_u(\varepsilon), a_w(\varepsilon), a_n(\varepsilon)) + \lambda_1(\bar{T} - a_u(\varepsilon) - a_w(\varepsilon) - a_n(\varepsilon)) + \lambda_2\ (I - \tilde{r}_u a_u(\varepsilon) - r_w\, a_w(\varepsilon) - \tilde{r}_n a_n(\varepsilon)) + \lambda_3(a_u(\varepsilon) - a_u(\varepsilon)^{min}) \tag{50}$$

FOC

$$\frac{\partial \mathcal{L}}{\partial a_u} = \frac{\partial U_i}{\partial a_u} - \lambda_1 - \lambda_2 \tilde{r}_u + \lambda_3 = 0 \quad (51)$$

$$\frac{\partial \mathcal{L}}{\partial a_w} = \frac{\partial U_i}{\partial a_w} - \lambda_1 - \lambda_2 r_w = 0 \quad (52)$$

$$\frac{\partial \mathcal{L}}{\partial a_n} = \frac{\partial U_i}{\partial a_n} - \lambda_1 - \lambda_2 \tilde{r}_n = 0 \quad (53)$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_1} = T - a_u(\varepsilon) - a_w(\varepsilon), -a_n(\varepsilon) = 0 \quad (54)$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_2} = I - \tilde{r}_u a_u(\varepsilon) - r_w\, a_w(\varepsilon) - \tilde{r}_n a_n(\varepsilon) = 0 \quad (55)$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_3} = a_u(\varepsilon) - a_u^{min}(\varepsilon) = 0 \quad (56)$$

The Lagrangian multipliers $\lambda_1, \lambda_2, and\ \lambda_3$ represent the marginal utility of changing/relaxing the available time, income/cost, and minimum obligatory time respectively. From the condition on (49), the constraint that is an inequality needs the Kuhn-Tucker condition. We required then that $\lambda_3 = 0$, or $a_u(\varepsilon) - a_u(\varepsilon)^{min} = 0$. If $\lambda_3 = 0$, all that is allocated to the *unpaid obligatory activities* is the minimum amount of time required to live (in this case the person is completely autonomous of her time). But if women have a *minimum unpaid obligatory* activity set different than biological set of activities (no extreme cases), then $\lambda_3 \neq 0$. Therefore, we remain with the case written in (56). which is $\lambda_3 \neq 0$.

From the FOC, the marginal utility for the three set of activities $\frac{\partial U}{\partial a_i}$ or (U_{ai}) indicates that the marginal utility of allocating time in a certain group of activities depends on the willingness to pay, willingness to accept, or wage rate, a constraint imposed by time allocation plus a constraint on empowerment.

The marginal utility of the three set of activities are:

$$U_{a_u} = \lambda_1 + \lambda_2 \tilde{r}_u - \lambda_3 \quad (57)$$

$$U_{a_w} = \lambda_1 + \lambda_2\, r_w \quad (58)$$

$$U_{a_n} = \lambda_1 + \lambda_2 \tilde{r}_n \quad (59)$$

The marginal rate of substitution between *unpaid obligatory activities* and *non-obligatory activities* comes from (57) divided by (59) is as follows,

$$\frac{U_{a_u} - \lambda_1}{U_{a_n} - \lambda_1} = \frac{\lambda_2 \tilde{r}_u - \lambda_3}{\lambda_2 \tilde{r}_n} \tag{60}$$

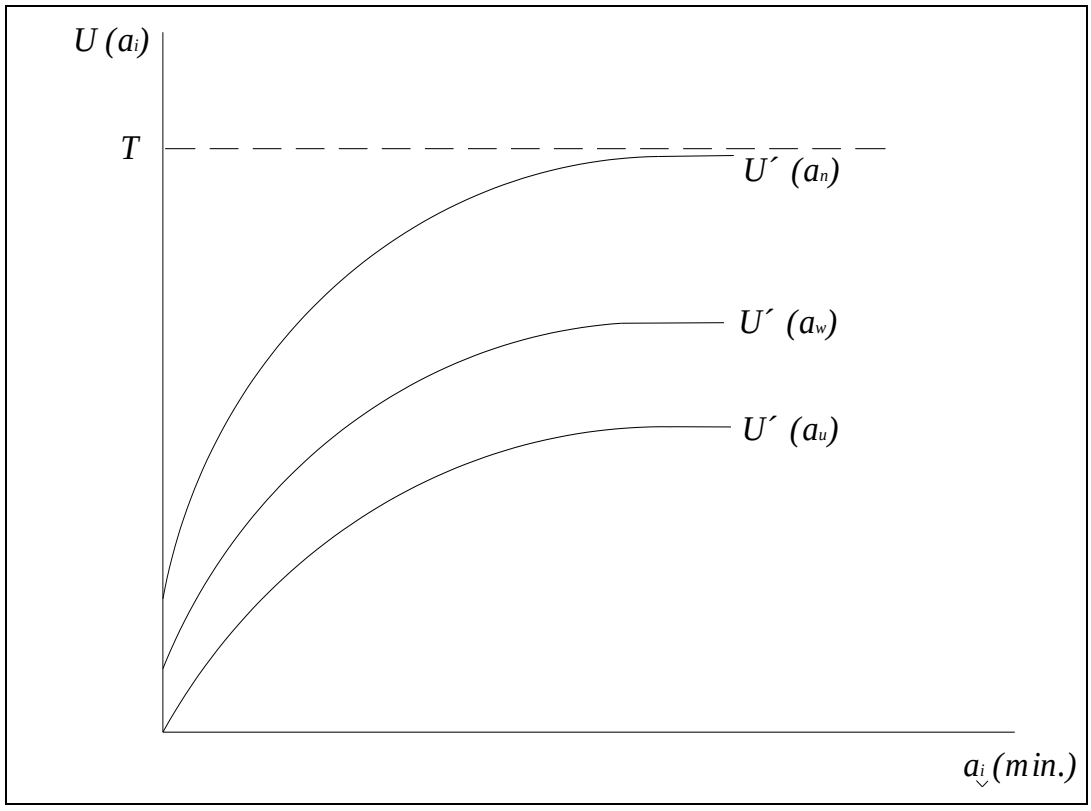
Now, for the three results of the marginal utility of the allocation of time, we see that U_{au} (the marginal utility of allocation of time in *unpaid obligatory activities)* is the lower among the three due to the fact that there is a third factor (λ_3) that is subtracted from this marginal utility. Part of the reason (λ_3) is affecting only U_{a_u} is the heterogenous effects of empowerment. Let us take into consideration different levels of empowerment to understand how they affect the allocation of time, and the utility maximization problem. Considering the extreme case where a person is a slave and their level of empowerment is 0 ($\varepsilon = 0$), then the person would only perform *unpaid obligatory activities,* having no time to allocate into any other set of activities. On the other extreme, if a person is completely empowered ($\varepsilon = 1$), most of her activities would be *non-obligatory activities* except for those that are minimum *unpaid obligatory activities* like biological necessities (sleeping or eating). Also, consider a person that has an intermediate level of empowerment, $0 < \varepsilon < 1$, then the set of activities chosen by her would be a combination of *unpaid obligatory activities*, *paid obligatory activities*, and some *non-obligatory activities*. According to the theory proposed here, a person with high levels of empowerment would spend more time on *non-obligatory activities* compare to the other two set of activities since it is preferred over the alternatives. Also, suppose that α, β denote certain levels of empowerment and that α and β are constants from 0 to 1, where 0 is when a person is totally disempowered and 1 means total empowered. Let us assume that $\alpha < \beta$. Therefore, the amount of time allocated in the different groups of activities, according to the levels of empowerment are written as follows:

$$if \begin{cases} 0 < \varepsilon < \alpha \ then \ a_u > a_w > a_n & Low\ empowerment \\ \alpha < \varepsilon < \beta \ then \ a_w > a_u, \quad a_u > a_n & Medium\ empowerment \\ \beta < \varepsilon < 1 \ then \ a_n > a_w > a_u & High\ empowerment \end{cases} \tag{61}$$

If a person *must* spend more time in an activity than what the person *desires* or wishes to, she will be better off by reducing the time she spends in those obligatory activities. According to this motivation, a person is better off by changing the allocation of time and this is possible with more agency/empowerment (ε). To illustrate the heterogeneous effects, Figure 4 shows different levels of marginal utility of time allocation at different levels of empowerment depending on where the time is being allocated (a_i). Allow the utility function to be a monotonic transformation of time allocation then the maximum marginal utility that a person can get is limited by the 24 hours that a day has. In

Figure 4, all three marginal utilities asymptotically approach a maximum for all three sets of activities. Note that for the marginal utility of time allocated to *non-obligatory activities* U_{a_n}, its slope is steep which means that the little time spent in *non-obligatory activities* gives the person high marginal utility. The flat marginal utility of allocating time in *unpaid obligatory activities* can be interpreted as the first minutes spent in those *unpaid obligatory activities;* they provide a lower marginal utility level to the person compared to the marginal utility of the very first minutes of time allocated to *non-obligatory activities* or *paid obligatory activities*. The implications of the marginal utility under different empowerment levels can be seen in the analytical expressions (57)-(59), where λ_1 represents how much the consumer is willing to pay to have time increased in a certain set of activities. Since we have declared preference ordering in assumption seven, ($a_u \prec a_w \prec a_n$), then the marginal utilities of time allocation differ based on a common amount of time employed. Note that Becker's marginal utility is one as opposed to these three because under Becker there is only a trade of between leisure and inputs and he does not account for heterogeneities of empowerment.

Figure 4 Diminishing marginal returns of utility (U') in the presence of heterogeneity of empowerment



Empirical challenges

The results from the last problem (50), that are depicted in (57), (58), and (59) allow us to find demand equations for time allocation across alternative activities and the impact of empowerment on that time allocation. In practice, to calculate these demand functions for the three groups of activities along with MRSs and marginal utilities, it is necessary to obtain the willingness to accept $\tilde{r}_u$, marginal opportunity cost/salaries r_w, and willingness to pay $\tilde{r}_n$. It is anticipated to be challenging to obtain this information because:1) the qualitative variables such $\tilde{r}_u$, $\tilde{r}_n$, required questions to the consumers that are not available in the current questionnaires that gather empowerment information, 2) the quantitative variable $\tilde{r}_w$, that has to do with women's salaries is hard to calculate because in many contexts wages for women are almost nonexistence and they are implicitly determined since the formal labor market is thin.

Another empirical challenge that we anticipate from the data available is the effects of the changes in empowerment over time. In order to estimate the impact of empowerment activities, panel data and an intervention that is designed to empower women is required. Since this study is limited to cross-sectional data, this study is limited to understanding correlates of empowerment and provides a basis for further investigation. Nonetheless, we will test the hypothesis dividing the cross-sectional data in different levels of disempowerment (high, medium, low). Thus, the empirical section of the paper will try to test two hypothesis that are assumptions of the theoretical model 1) time allocation is correlated with women's empowerment, 2) women's empowerment shifts time allocation from the *unpaid obligatory activities* to the *non-obligatory activities* as level of empowerment increases.

Data and their characteristics

The data for this study comes from the second wave of the Bangladesh Integrated Household Survey (BIHS 2014-2015). The BIHS 2014-2015 provides information on 6500 households and it is nationally representative. This survey took place from January to June 2015. The dataset collected information on the household and individual characteristics, food security, women's empowerment, maternal and child nutrition. The survey contains information on the primary male and female respondents of the house. The nutrition and health modules collected information from all members of the household.

This study also uses the disempowerment score calculated using the Abbreviated Women Empowerment in Agricultural index (A-WEAI) to measure women's empowerment. A-WEAI is a revised version of the Women's Empowerment in Agricultural index (WEAI) that was created in 2012 and has been applied in different cultural contexts to measure women's empowerment in rural development settings. This unique index is based on the concept of agency defined by Sen (1999) and uses household surveys to obtain information on the primary male and female respondents in a household. The A-WEIA index calculates an "empowerment score" that reflects the achievements women have in six indicators that are part of five equality weighted domains (Production, Resources, Income, Leadership, and Time). Within the A-WEAI, the survey had a specific module that includes a time use section, and respondents reported the amount of time allocated to 21 different activities using a 24-hour recall period in 15-minute intervals. We will use this data to create the dependent variables of our models. Thus, observations that did not have reported time allocated to these activities, exceeded the 1440 minutes, or had a trivial inconsistency[14] were omitted.

This study analyzes 1354 females primary respondents with complete information on all variables needed for the calculation of the models. The sample is restricted to women in the reproductive age of 15-49, and to those with complete information in the time allocation module of the A-WEAI index, as well as in all the questions that are needed to calculate the disempowerment scores of the index. The sample also was restricted to members of families that were not split[15] in the second period of the surveyed wave.

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[14] The outliers of time allocated into activities like eat of sleep that took more than 15 hours are not considered, as they are assumed to be possible data errors.

[15] Examples of houses that have split are a son of the household head from the first round that got married and moved to another house. Their identification number comes as decimal number as opposed to integer.

As Table 9 suggests, women have in average disempowerment scores of 0.32 which means on average they are disempowered. When recalculating the disempowerment score and exclude the workload component, *ci** (this procedure took place to treat potential endogeneity of the empirical model that would be explained later) the average score increased to 0.36, which still show women are disempowered. The average disempowerment scores that women in the sample face from workload is low, since in average is 0.12. This last result is explained by the fact that women in general do not engaged in formal labor thus the threshold for this indicator that measures workload over 10.5 hours is rarely met. Additionally, the average primary respondent of the sample is 39 years old, Muslim and has two children. The average food consumption score is 10 which is considered poor according to World Food Programmed (WFP 2008). Most women in the sample do not have autonomy to leave their communities and the number of cellphones in average in their households is one. In terms of their household's assets, the amount of land owned consist of lots which in average is 140 decimals[16] that is 6090 square feet. The monthly average salary of women is relatively low income, 445 taka which is US$57. The sample has 32 percent of people coming from the region of Dhaka, follow by the region Raishahi and Ragpur. Women in the sample brought to the marriage an average value of US$140 (11800 Taka) in assets. The assets they brought are mainly jewelry and household appliances. Have of the women in the sample have autonomy over their own toiletry's expenditure, most of them use birth control and have not been physically abused. The difference in education between the head of the household and wife is less than a year of education, and there is minimal difference between the mean of education in the village and the woman head of the household, this last variable is measured in years.

[16] The area of plots has been calculated using decimals. Decimals is a unit of area in India and Bangladesh approximately equal to 1/100 acre (40.46 m^2).

Table 9 Mean and standard deviation from independent variables

	Description	Mean	SD	Min	Max	Obs
Empowerment variables						
Disempowerment score (*ci*)[17]	Continous	0.32	0.17	0	1	1354
Disempowerment score star (*ci**)[18]	Continous	0.36	0.29	0	0.8	1354
Workload indicator	Binary (1=indequate)	0.12	0.33	0	1	1354
Women's demographics and household composition						
Age	Count	39.6	0.1	19	73	1354
Muslim	Binary (1=Yes)	0.8	0.3	0	1	1354
Hindu	Binary (1=Yes)	0.1	0.3	0	1	1354
Christian	Binary (1=Yes)	0.003	0	0	1	1354
Number of children	Counts	2	1.2	0	7	1354
Women's health and nutritional characteristics						
Pregnant	Binary (1=Yes)	0.02	0.1	0	1	1354
Breastfeeding	Binary (1=Yes)	0.1	0.3	0	1	1354
Food consumption score[19]	Continous	10.4	4.8	0	21	1354
Woman's status						
Autonomy to leave community	Binary(1=Yes)	0.06	0.23	0	1	1354
Communication Technology						
Number of cellphones per household	Count	1	.78	0	6	1354
Wealth and Finance						
Land owned by hh	Continous (Decimals)	140	122	0	249	1354
Value of animals	Continous (Taka)	7.2	3.2	0	12.5	1354
Woman's monthly salary	Continous (Taka)	445.8	1384	0	17550	1354
Woman has taken a credit	Binary(1=Yes)	0.48	0.49	0	1	1354
Division						
Barisal[20]	Binary(1=Yes)	.08	.27	0	1	1354
Chittagong	Binary(1=Yes)	.1	.3	0	1	1354
Dhaka	Binary(1=Yes)	.32	.46	0	1	1354
Khulna	Binary(1=Yes)	.11	.32	0	1	1354
Rajshahi	Binary(1=Yes)	.15	.36	0	1	1354
Rangpur	Binary(1=Yes)	.12	.32	0	1	1354
Instruments						
Value of the assest brought to marriage	Continous (Taka)	11800	23129	0	300000	1354
Decision on expenses in toiletries	Binary(1=Yes)	0.55	0.5	0	1	1354
Physically Abused	Binary(1=Yes)	0.09	0.29	0	1	1354
Uses birthcontrol	Binary(1=Yes)	0.8	0.39	0	1	1354
Husband and wife education difference	Continous (equivalent to years)	.12	3.45	-9	12	1354

[17] *ci*, Inadequacy count of disempowerment score is a component (90%) of the calculation of the A-WEAI score. It is calculated with the 6 indicators that are part of the A-WEAI.
[18] *ci**, Inadequacy count of disempowerment score *star* is calculated with the 5 indicators that are part of the A-WEAI. Workload is not included in this disempowerment score.
[19] Calculation from the author. The food consumption score is a proxy indicator of household caloric availability (World Food Programme (WFP) 1996). To calculate the FCS from these results, the consumption amount is summed and multiplied by the standardized food group weight. The food groups and corresponding weights: of (1) starchy x2, (2) vegetables x 1, (3) legumes and nuts x 3, (4) dairy products x 4, (5) flesh foods x 4, (6) eggs x 4, (7) fruits x 1, (8) sugar x 0.5, (9) oil x 0.5.
[20] The study comprehends seven division in Bangladesh: Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur, Sylhet.

	Description	Mean	SD	Min	Max	Obs
Dependent variables[21]						
Unpaid obligatory activities	Continous (minutes)	1051	150	540	1440	1354
Paid obligatory activities	Continous (minutes)	113	132	0	900	1354
Nonobligatory activites	Continous (minutes)	275	145	0	795	1354
Non-leisure activities	Continous (minutes)	537	153	30	1005	1354
Leisure	Continous (minutes)	902	153	435	1410	1354

For the variables that are dependent variables in the model, we have different specifications that differ on how time is allocated in different activities. In average, women spend 17.5 hours in *unpaid obligatory activities* with some women reported that those activities are the only activities they perform in a day[22] (example of these activities are cooking, domestic chores, care of children, eating and drinking). For the *paid activities* the average amount of time women spend on these activities is 113 minutes, and in *non-obligatory activities* is 275 minutes (examples of non-obligatory activities are social interactions, performing hobbies, exercise). With these averages, there is a disproportionate allocation of time to unpaid obligatory activities in comparison with the other groups. If the activities are regrouped into non-leisure and leisure, the average amount of time that women in the sample allocate to leisure is 902 minutes and 537 minutes to non-leisure activities. According to this classification (see appendix E), in average women are allocating more minutes to "leisure" than to non-leisure activities. Going into more detail, on average, women in this sample spend in domestic work (3.4 hours), cooking (2.2 hours), and social activities (1.5 hours).

Data was also classified in three categories of empowerment: high, medium, and low. We could have divided the sample into the A-WEAI thresholds but by doing so the three groups were highly unbalanced in terms of observations. Therefore, we arbitrary divided the data into low disempowered women whose disempowerment scores are in between 0-0.2, the medium disempowered women whose disempowerment scores are in between 0.21-0.34, and the high disempowered women who have disempowerment scores between 0.4 to 1.

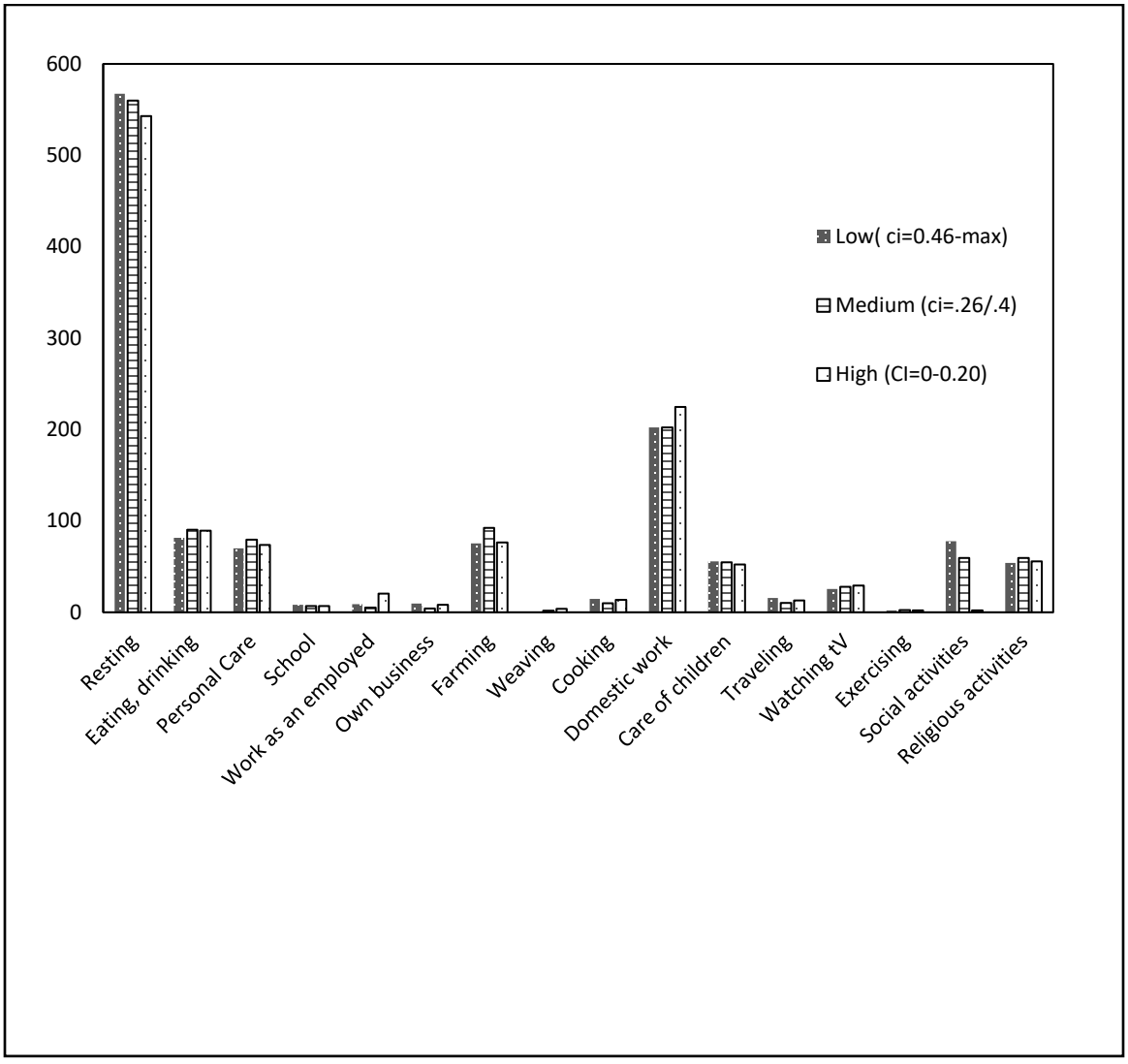
In Figure 5, the data is classified by levels of disempowerment and the minutes allocated to different daily activities. Women of all levels of empowerment allocate in average the same number of minutes to cooking. We found that as disempowerment increases, the hours allocated to resting decrease as well as social activities. Women highly disempowered allocate more time to domestic

[21] The dependent variable is a summation of minutes spend in different activities that has been classified using the judgment of the authors. These group of activities do not considered sleeping hours into the summation of any of the groups.

[22] This is possible since sleeping time was not considered in any of the groups.

work. Thus, substantial differences exist across the groups of women in terms of time allocation. Although woman's disempowerment seems to influence women's time allocation, this, however, is an empirical issue that will be addressed in the following section.

Figure 5 Minutes allocated to daily activities classified by levels of disempowerment



Empirical Estimation

To assess the relationship between time allocation and women's empowerment, the paper considers the two models: the "Becker" model, comprised of two regression equations on time allocated to labor and leisure, and the "Sen" model of three regression equations on unpaid obligatory, paid obligatory and nonobligatory time. Since we are interested in finding the drivers of allocation of time for women under Becker and Sen's, we have the following model:

(62)

$$a_{ij} = b_o + \beta_1\, women's\ disempowerment_i + \beta_2 \boldsymbol{X_i} + \beta_3 \boldsymbol{HH_i} + \beta_4 \boldsymbol{WS_i} + \beta_5 \boldsymbol{T_i} + \beta_6 \boldsymbol{F_i} + \beta_7 \mathbf{R_i} + \beta_8 \boldsymbol{WS_i} + \boldsymbol{u_{ij}}$$

$$i = 1,\ldots \text{n};\ j = 1, \ldots M$$

Where a_i is a vector that represents the share of woman's *i* time spent in activity *j* in the last 24 hours, and $the\ \beta$ coefficients are parameters to be estimated. Women's disempowerment is an individual variable that is calculated in three different manners all using the individual inadequacy score of women that is calculated with the indicators used by the A-WEAI index[23]. $\boldsymbol{X_i}$ is a vector of woman's *i*th characteristics, $\boldsymbol{HH_i}$is a vector of woman's *i*th health and nutrition characteristics, $\boldsymbol{WS_i}$ is a vector of women's status characteristics of the *ith* woman, $\boldsymbol{T_i}$ is a vector of communication technology of the ith woman's household, $\boldsymbol{F_i}$ is a vector of financial resources that woman's *ith* household has available, $\mathbf{R_i}$ is a vector of divisions indicating where the i*th* woman is from, and $\boldsymbol{u_{ij}}$ is the error term of woman's i time allocated to activity *j*. In the study n is 1354 individuals, and M=2 for the so called Beckerian classical model, and M=3 for the Sen model.

For the estimation of the model presented above, we used three disempowerment measurement in alternatives specifications. In the first main specification, our measure of disempowerment (*ci**) is the inadequacy count recalculated taking out the workload indicator; in the second main specification, our measure of disempowerment consists of the inadequacy count with the six indicators of the A-WEAI index (*ci*). Last disempowerment measure we used in an alternative specification shown in the appendix used the measure of workload disempowerment computed by taking the binary indicator workload that measure inadequacy or adequacy according to a threshold of 10.5 hours of work. Because it is very likely that disempowerment affects allocation of time

[23] The Abbreviated Women's Empowerment Index in Agriculture serves to monitor, evaluate, and diagnose the empowerment of women in the agricultural sector using survey-based data. The index is compound by two parts the Five Domain Empowerment Index (5DE), and the Gender Parity Index that represents 10%. The 5DE constructs an empowerment score for each women, the score is a summation of the woman's level of achievement (adequate or inadequate) in ten indicators, and the higher the score the grater the woman's level of empowerment, IFPRI (2012).

through workload, we applied the standard instrumental variable approach to correct for potential endogeneity. Some of the instrumental variables have been used in other studies like Sraboni et al. 2014. We used different instrumental variables like the difference in age and education between the primary male and female decisionmakers, and difference in education between average of village education and female decisionmakers. The survey collected information on the last year of completed education of each member of the family; this was a categorical variable (e.g. completed class I, BA/BSC pass fail, etc.), then the variable was transformed into a numerical with years of schooling as units or its equivalent. This numerical variable was used to calculate the difference in education between the male and the female decisionmakers of the household, and the difference between the median education of the village and the female decisionmaker. We also instrument empowerment scores by using whether woman had inherited land and also value of assets brought to marriage for both ownership of and rights over assets. Inherited assets constituted a measure of bargaining power that affects empowerment. Additional variables used to instrument disempowerment are using birth control and autonomy over the expenses of own toiletries. For instance, the variable "exercises decision on toiletries expenses can be thought as being a variable correlated with empowerment. If a woman can decide over her own toiletries most likely she would be autonomous in allocating her time.

Several additional regressors were used in the models including X_i or women's characteristics including the respondent's age, religion, region, whether the respondent is pregnant, or lactating. For HH_i, household and health characteristics, the study controls for the number of children since the structure of the household has implications on the allocation of time to reproductive work. The WS_i set includes variables describing women status such as binary variables measuring whether physical abuse and autonomy to leave the village. These two variables provide insight on how physical status can affect allocation of time. T_i captures communication and technology as variables that influence allocation of time. Since the only information in this regard has to do with number of cellphones in the household, we acknowledge the limitations of this variable. For once, the access to the household to a cellphone does not warrant the usage of it, the access to signal, access to information, or specific usage of the cellphone. More on this topic should be investigated since communication technology influences the way people allocate their time and potentially reduces asymmetric access to information. F_i, wealth and financial resources available, is measured in the study through a dummy variable that controls for whether the family owns or has access to land, the logarithmic value of the animals owned by the household, and women's monthly

salary. We used seven dummy variables, R_i, that account for seven divisions in the Bangladesh. We tested for division differences and found significant fixed effect differences.

To model Becker's classical model, where leisure is included in the utility function and the other set of activities are counted as non-leisure, we estimated two models with dependent variable a_{ji} (62). In the first equation the a_{ji} is the set of *leisure activities* and has a_{ji} information on time allocated to *non-leisure activities*. *Leisure* in this specification is the sum of resting time, along with eating and drinking time, personal care time, cooking time, watching TV time, exercising time, social activities time, religious practices time, shopping. The *non-leisure* activities are work as an employee time, owned business time, farming time, weaving time, care for others time, school time, and traveling time (Komatsu et al. 2018)[24].

The second model, which we refer to Sen model, will have three specifications. The three dependent variables a_{ji} from (62) are *unpaid obligatory activities*, *paid obligatory activities,* and *non-obligatory activity*. In the *unpaid obligatory activities*, the model includes eating and drinking time, personal care time, shopping time, school time, cooking time, domestic time, care for others time, shopping and traveling time. In the *paid obligatory activities,* it is included weaving time, work as an employee time, owned a business time, and farming time. For the *non-obligatory activities,* we included resting time, watching tv time, exercising time, social activities time, and religious practices.

All three groups are the sum of the minutes reporter by the respondents when were asked "Please record a log of the (24) activities in the last complete 24 hours" Also, to test if the set of activities assigned to the three group of activities are not at random, we assigned a randomized set of activities to each of the three groups and calculate coefficients for the Sen model using (62).The results indicated that with a randomized set of activities most of the coefficients are not statistically significant including the disempowerment variables for at least one of the three groups of activities. The signs of the beta coefficients for most of the variables are also counterintuitive. Randomizing the allocation of the activities between *unpaid obligatory activities*, *paid obligatory activities*, and *non-obligatory activities,* and considering the counterintuitive and insignificant results described above, we can say that the activities that are allocated to each of the groups is theoretically sounded.

Since there are only 24 hours available to all women per day, and that the sum time allocated to all activities from all sets of activities have to add-up to 1440 minutes, the system of equations is

[24] For the Bangladesh data, activities that included home gardening, fishing, off-farm postharvest activities are classified as domestic work. In addition, livestock rearing is classified as non-agricultural work (Komatsu et al. 2018).

singular[25]. Thus, we dropped time allocated to sleep so the covariance matrix of errors is not singular and the *beta* coefficients can be estimated. Also, time allocated to sleep is a biological necessity and there is no more of a choice from individuals to allocate time to it as opposed to other categories where there is individual choice involved on them.

Lastly, if the proposed time allocation and empowerment theory holds (Sen's model), this classification should reflect that women's empowerment is positively correlated with *non-obligatory activities* and negatively correlated with *unpaid obligatory activities*. Also, we will compare the performance of Becker's classical model and Sen's model in terms of prediction.

We will calculate the OLS models and 2SLS models for Becker and Sen, and will consider different levels of empowerment. For this exercise, we divided the data into three levels of empowerment according to the recalculated inadequacy count star score (ci^*). The three levels of inadequacy count are: high ci^* ($0.4 \leq ci^* \leq 0.8$), medium ci^* ($0.21 \leq ci^* \leq 0.34$), and low ci^* ($0 \leq ci^* \leq .201$). We used Stata 14 and utilized ivreg2 procedure to calculate the 2SLS models. There are also instrument test that were perform to the instruments described above.

[25] The rank of a product of matrices is equal to the rank of any matrix in the product.

Results

Becker Model

The following table presents the ordinary least squares (OLS) and two-stage least square (2SLS) regression results for determinants of time allocation under Becker's model. The table contains two specification where *ci* and *ci** are being used as variables of disempowerment. For the Beckerian model, leisure time is time spent in activities that are not related to labor activities, thus activities like cooking or taking care of family members are considered leisure activities according to the classical Beckerian model. According to the results present in Table 10, disempowerment coefficients under 2SLS are not statistically significant and the signs of these coefficients are not consistent with the theory. The opposite occurs for the results of the OLS model that are consistent and supportive of the theory that says the more disempowered a person is, less time would be allocated to leisure activities and more to non-leisure activities. Given the weak significance of the 2SLS and combined with the endogeneity test from 2SLS that showed for one model no endogeneity, we treated the results of the 2SLS with caveat, and focus on the generalities for the two specifications (OLS and 2SLS). Other demographic variables that were found significant are age and pregnancy, and these coefficients show that younger women allocate less time to leisure activities. Also, the results indicated that being pregnant compared to not being pregnant increases the allocation of time in leisure activities. For the OLS specification, columns (1), (3), (5), (7), the number of children variable is significant and negative correlated with allocation of time to leisure. Wealth and finance resources variables are statistically correlated to how women allocate time. The more monthly salary they earned and higher value of animals the household owns, less time would be allocated to leisure and more to non-leisure activities, which is a result we expect to obtain from the Beckerian model. We found regional fixed effects that are statistically different, results indicate that coming from the Chittagong region compare to Sylhet region has a higher correlation to increase time allocated to leisure.

Instrumental variables tests are performed for the 2SLS regressions show that endogeneity variables are relevant according to the Anderson-Rubin test and the endogenous problem is present in *ci** specification. The test for endogeneity for the *ci* specification shows that there is no endogeneity. If this is the case, the results for OLS using *ci* are preferred for Becker model. The under-identification test results confirm that under the *ci**, the model is not under identified and therefore the instruments are "relevant", meaning correlated with the endogenous variable. By rejecting the

null hypothesis, it can be said that this model (2SLS using *ci**) is identified and therefore instruments might be valid. The Kleibergen-Paap *F*-statistics show that the null hypothesis for weak instruments is rejected at the 5% threshold (see Table 22).

Table 10 Estimated coefficients for OLS and 2SLS Becker model

	Leisure				Non-Leisure			
	CI		CI*		CI		CI*	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Disempowerment	-129.760***	40.452	13.373	321.368	148.528***	28.775	-10.783	-315.742
	(21.546)	(219.845)	(19.447)	(171.076)	(22.412)	(225.892)	(20.287)	(177.057)
Age	3.471***	3.265***	3.289***	2.729***	-3.480***	-3.335***	-3.281***	-2.726***
	(0.408)	(0.492)	(0.414)	(0.544)	(0.424)	(0.505)	(0.432)	(0.563)
Muslim	66.259	49.743	53.229	43.101	-58.982	-47.362	-44.216	-34.188
	(62.285)	(66.697)	(63.083)	(68.455)	(64.789)	(68.532)	(65.807)	(70.848)
Hindu	27.043	6.146	10.770	2.888	-20.694	-5.991	-2.183	5.622
	(63.033)	(69.397)	(63.819)	(69.160)	(65.567)	(71.306)	(66.575)	(71.578)
Number of children	-8.332*	-6.842	-7.176*	-6.723	8.318*	7.270	7.002*	6.553
	(3.370)	(3.921)	(3.410)	(3.696)	(3.506)	(4.028)	(3.557)	(3.826)
Pregnant	71.915**	74.201**	73.630**	72.998**	-77.380**	-78.988**	-79.352**	-78.726**
	(24.374)	(24.917)	(24.697)	(26.713)	(25.354)	(25.603)	(25.763)	(27.647)
Breastfeeding	-8.486	-7.114	-7.476	-8.294	5.402	4.436	4.233	5.043
	(13.880)	(14.200)	(14.064)	(15.218)	(14.438)	(14.591)	(14.671)	(15.750)
Food consumption score	0.295	0.489	0.462	0.887	-0.396	-0.533	-0.580	-1.001
	(0.853)	(0.901)	(0.864)	(0.964)	(0.887)	(0.926)	(0.902)	(0.997)
Number of cellphones	5.352	3.406	3.533	-4.203	-2.125	-0.756	-0.156	7.504
	(4.990)	(5.649)	(5.074)	(6.950)	(5.190)	(5.805)	(5.293)	(7.193)
Land owned	-0.194	-0.391	-0.353	-0.554	0.193	0.331	0.372	0.570
	(0.294)	(0.391)	(0.297)	(0.340)	(0.306)	(0.402)	(0.310)	(0.352)
Value of animals	-5.347***	-5.187***	-5.212***	-4.899***	5.420***	5.307***	5.269***	4.959***
	(1.304)	(1.340)	(1.322)	(1.440)	(1.357)	(1.377)	(1.379)	(1.490)
Monthly salary	-0.011***	-0.010***	-0.010***	-0.006	0.012***	0.012***	0.011***	0.008*
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)
Physically abused	12.108	11.653	11.680	9.829	-14.280	-13.960	-13.818	-11.985
	(12.804)	(13.011)	(12.975)	(14.070)	(13.318)	(13.369)	(13.535)	(14.562)
Autonomy to leave community	-39.300*	-32.052	-32.967*	-14.371	38.921*	33.822	31.946	13.533
	(16.301)	(18.990)	(16.534)	(20.612)	(16.956)	(19.512)	(17.247)	(21.332)
Barisal (division 1)	-1.346	2.513	1.899	8.883	0.147	-2.569	-3.465	-10.380
	(17.921)	(18.857)	(18.159)	(20.013)	(18.642)	(19.376)	(18.943)	(20.713)
Chittagong (division 2)	49.278**	59.619**	57.864**	74.048***	-50.605**	-57.880*	-60.195**	-76.219***
	(17.760)	(22.398)	(17.977)	(21.392)	(18.474)	(23.014)	(18.753)	(22.140)
Dhaka (division 3)	-6.819	0.470	-0.612	14.370	13.876	8.747	6.991	-7.843
	(14.361)	(17.330)	(14.553)	(17.775)	(14.938)	(17.806)	(15.181)	(18.396)
Khulna (division 4)	20.653	20.345	20.284	17.203	-21.262	-21.045	-20.884	-17.834
	(16.690)	(16.948)	(16.914)	(18.372)	(17.361)	(17.414)	(17.644)	(19.014)
Rajshahi (division 5)	-18.593	-19.277	-19.260	-22.619	21.090	21.571	21.804	25.130
	(16.042)	(16.310)	(16.257)	(17.680)	(16.687)	(16.758)	(16.959)	(18.298)
Rangpur (division 6)	-18.436	-17.600	-17.433	-9.008	20.436	19.848	19.411	11.069
	(16.933)	(17.224)	(17.167)	(19.139)	(17.614)	(17.697)	(17.908)	(19.808)
Constant	334.524***	295.652***	301.064***	212.945*	621.020***	648.368***	658.024***	745.274***
	(67.996)	(85.209)	(68.947)	(88.995)	(70.730)	(87.553)	(71.924)	(92.106)
Adjusted R2	0.1387	0.1117	0.129	-	0.149	0.131	0.121	-0.028
F	11.90	11.90	9.843	8.438	11.672	9.278	9.189	8.002

Standard errors in parentheses
* p < 0.05, ** p < 0.01, *** p < 0.001

Sen model

The Sen model relies on the idea that the allocation of time depends on the level of woman's empowerment, or time allocation autonomy, when choosing her distribution of time. In the Sen model developed in this paper, there are some activities that are considered *obligatory* and some *non-obligatory*. We studied the relationship between exogenous variables such as demographic characteristics, household characteristics, woman's health and nutritious variables, woman's status, wealth and financial situation. Columns (4), (8), and (12) that are found in Table 11, present the 2SLS coefficients of determinants of allocation of time between *unpaid obligatory activities, paid obligatory activities,* and *non-obligatory activities* and the *ci** disempowerment variable instrumented to treat endogeneity. These estimates show that disempowerment is highly significant and correlated with allocation of time. For instance, the results show that the more disempowered a woman is more time would be allocated to *unpaid obligatory activities*, and less to *paid obligatory activities*. In columns (2), (6), and (10) after instrumenting women disempowerment, the estimates are not statistically significant but, similar than the estimates in columns (4), (8) and (12), these coefficients are larger than the OLS estimates. These results, combined with the test of the instruments, suggests that neglecting endogeneity of disempowerment and time allocation may underestimate the impact of increasing disempowerment on time allocation.

Continuing with the regressors in Table 11 we find that age and number of children are correlated with time spent on *obligatory* and *non-obligatory activities*. More specifically, the coefficients for the variable age show that younger women allocate less time to *non-obligatory* and more to *obligatory activities*. Also, the number of children that a woman has increases the time allocated to *unpaid activities* and decreases the allocation of time in *non-obligatory activities*. These variables can be considered as proxies of structural variables that are not easy to modify through project interventions unless these interventions are focused upon reproductive issues.

In terms of women's health, pregnant women are more likely to increase their allocation of time to *non-obligatory activities* over *obligatory activities*. Also, breastfeeding increases the time in *unpaid obligatory activities* and decreases the time allocated to *paid obligatory activities*. Once again, these variables can be considered structural variables and interventions through these variables are not as flexibles as the non-structural.

The set of coefficients that control for the wealth and financial situation of women, such as the value of animals and monthly salary, are statistically significant and show that with more economic bargaining, women are more likely to decrease the time they allocate to *unpaid economic*

activities, and increased the time allocated in *paid obligatory activities*. Regarding *non-obligatory activities*, the more monthly salary women earn, the less time allocated to *non-obligatory activities*.

Also, women from Chittagong division have less time allocated to *unpaid obligatory activities* and more to *non-obligatory activities* compare to women living on Sylhet region. These finding reflect that regions variable is also considered a structural variable which needs to be carefully considered when designing empowerment interventions.

Considering the relationship of exogenous variables to time allocated to the three groups of activities, the results indicated that for *unpaid obligatory activities*, young women and those with more children, allocate more time to *unpaid obligatory activities*. Also, lactating women allocate more time to *unpaid activities*. The variables that are negatively correlated with the time spent in *unpaid obligatory activities* include being older and the monthly salary variable.

Regarding *paid obligatory activities,* the findings show that more disempowered women spend less time in *paid obligatory activities*. Also, the more financial resources in the household, more value of animals, and less cellphones increase the time women allocate to *paid obligatory activities*. These results suggest that time allocated to paid obligatory activities is highly correlated to the structural variables such as age and women's maternity conditions.

Non-obligatory activities are found not to be statically significant correlated with disempowerment under the 2SLS model, but age and being pregnant were found to be positively correlated to time allocated to *non-obligatory activities.* Also, the wealth and financial variables were negatively correlated to allocation of time in *non-obligatory activities*.

For those regressions that instrument the disempowerment variable, the Anderson-Rubin test of irrelevant endogeneity variables fail to reject this hypothesis the IV regression of *non-obligatory activities* and it did not suffer from endogeneity. For the other regressions involving paid obligatory activities and unpaid obligatory activities, the Anderson-Ruby test and the endogeneity test results imply that the endogenous variable women's disempowerment (*ci)* is relevant and in fact endogenous. The under-identification test results confirm that the instruments are valid, and the model is not under-identified. The Kleibergen-Paap *F*-test shows that the null hypothesis for weak instruments is rejected but does not exceeds the critical values. Thus, these results translate into a weak relationship between the endogenous variable and the instruments as a set if IVs. These test results are presented in CHAPTER 1 - Chapter 1 -Appendix F -

Table 11 Estimated coefficients for OLS and 2SLS Sen model

	Unpaid obligatory activities				Paid obligatory activities				Non-obligatory activity			
	CI		CI*		CI		CI*		CI		CI*	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Disempowerment	91.86***	481.89	57.33**	521.17**	64.24**	-565.00*	-41.14*	-676.75***	-156.10***	141.66	-16.19	155.58
	(22.32)	(246.80)	(19.95)	(193.71)	(19.67)	(262.94)	(17.55)	(202.48)	(21.02)	(226.72)	(19.10)	(161.12)
Age	-2.87***	-3.34***	-2.87***	-3.71***	-0.40	0.36	-0.25	0.91	3.27***	2.91***	3.11***	2.80***
	(0.42)	(0.55)	(0.42)	(0.61)	(0.37)	(0.58)	(0.37)	(0.64)	(0.40)	(0.50)	(0.41)	(0.51)
Muslim	71.36	33.52	78.39	63.14	-120.62*	-59.56	-113.03*	-92.13	49.26	20.37	34.64	29.00
	(64.53)	(74.87)	(64.71)	(76.38)	(56.85)	(79.18)	(56.93)	(79.84)	(60.76)	(68.27)	(61.96)	(63.53)
Hindu	67.40	19.51	77.21	65.34	-87.31	-10.05	-78.37	-62.10	19.91	-16.65	1.16	-3.24
	(65.31)	(77.91)	(65.46)	(77.16)	(57.53)	(82.42)	(57.59)	(80.66)	(61.49)	(71.07)	(62.68)	(64.18)
Numb of children	11.61***	15.03***	10.89**	11.58**	-3.97	-9.48*	-4.60	-5.53	-7.64*	-5.04	-6.30	-6.05
	(3.49)	(4.40)	(3.50)	(4.12)	(3.08)	(4.66)	(3.08)	(4.31)	(3.29)	(4.02)	(3.35)	(3.43)
Pregnant	-60.07*	-54.84*	-61.42*	-62.38*	-3.88	-12.33	-4.66	-3.36	63.96**	67.95**	66.09**	65.73**
	(25.25)	(27.97)	(25.33)	(29.80)	(22.25)	(29.56)	(22.29)	(31.15)	(23.78)	(25.49)	(24.26)	(24.79)
Breastfeeding	39.43**	42.58**	38.54**	37.31*	-21.07	-26.14	-21.48	-19.79	-18.36	-15.96	-17.06	-17.52
	(14.38)	(15.94)	(14.43)	(16.98)	(12.67)	(16.85)	(12.69)	(17.75)	(13.54)	(14.53)	(13.81)	(14.12)
Fcs	0.25	0.69	0.22	0.86	0.32	-0.39	0.19	-0.68	-0.57	-0.23	-0.42	-0.18
	(0.88)	(1.01)	(0.89)	(1.08)	(0.78)	(1.07)	(0.78)	(1.12)	(0.83)	(0.92)	(0.85)	(0.90)
Autonomy to move	20.04	36.65	19.59	47.59*	15.80	-10.99	10.59	-27.79	-35.84*	-23.16	-30.17	-19.80
	(16.89)	(21.32)	(16.96)	(23.08)	(14.88)	(22.57)	(14.92)	(24.13)	(15.90)	(19.46)	(16.24)	(19.20)
Physically abused	-14.52	-15.56	-14.61	-17.40	6.40	8.09	6.82	10.64	8.11	7.32	7.79	6.76
	(13.27)	(14.61)	(13.31)	(15.70)	(11.69)	(15.43)	(11.71)	(16.41)	(12.49)	(13.31)	(12.74)	(13.06)
Number of cellular	6.78	2.32	6.39	-5.26	-12.70**	-5.51	-10.94*	5.03	5.93	2.52	4.55	0.23
	(5.17)	(6.34)	(5.20)	(7.80)	(4.55)	(6.71)	(4.58)	(8.15)	(4.87)	(5.79)	(4.98)	(6.49)
Owned land	-0.11	-0.56	-0.04	-0.35	0.30	1.02*	0.40	0.81*	-0.18	-0.53	-0.35	-0.47
	(0.30)	(0.44)	(0.30)	(0.38)	(0.27)	(0.47)	(0.27)	(0.40)	(0.29)	(0.40)	(0.29)	(0.32)
Value of animals	2.40	2.77	2.38	2.85	4.20***	3.61*	4.10***	3.46*	-6.61***	-6.33***	-6.48***	-6.30***
	(1.35)	(1.50)	(1.36)	(1.61)	(1.19)	(1.59)	(1.19)	(1.68)	(1.27)	(1.37)	(1.30)	(1.34)
Monthly salary	-0.01***	-0.01**	-0.01***	-0.01	0.02***	0.02***	0.02***	0.01**	-0.01***	-0.01*	-0.01***	-0.01*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	1043.85***	954.78***	1048.43***	915.72***	172.32**	316.02**	198.76**	380.61***	223.83***	155.83	192.81**	143.67
	(70.45)	(95.66)	(70.72)	(99.74)	(62.06)	(101.37)	(62.22)	(104.25)	(66.33)	(87.40)	(67.72)	(82.96)
Adjusted R2	0.12	0.08	0.11	0.24	0.12	0.55	0.12	0.75	0.17	0.04	0.13	0.08
F	9.09	6.90	8.61	6.19	9.24	5.15	8.95	4.92	13.21	9.10	10.08	9.51

Heterogeneity of Empowerment Effects

In order to evaluate heterogeneities that appear in the subgroups of empowerment, we divided the data into three subsets to study the differences across levels of empowerment. The A-WEAI uses specific thresholds to classify a person as empowered or disempowered. The empowered women have an inadequacy count $0 \leq ci \leq 0.2$, the disempowered women have an inadequacy count score between $0.2 < ci \leq 1$. After dividing the data based on the thresholds from A-WEAI, we obtained very unbalanced groups. The category of empowered women has only 208 observations. Thus, we arbitrarily adjusted our categories to create three groups that are more balanced. The three levels of inadequacy count are: high ci^* ($0.4 \leq ci^* \leq 0.8$), medium ci^* ($0.21 \leq ci^* \leq 0.34$), and low ci^* ($0 \leq ci^* \leq .201$).

Table 12 presents the estimated coefficients for the 2SLS models under Sen specifications for the three levels of disempowerment using ci^* as a variable of disempowerment. The results are not statistically significant for the low and medium levels of empowerment. Only for the highly disempowered women, there are statistically and theoretically consistent estimates for how disempowerment relates to employment of time in *unpaid* and *paid activities*. For the other two levels of disempowerment, even though the coefficients are not significant they have the signs that the Sen model predicts if levels of disempowerment increases. The theory states that the higher the level of disempowerment the more hours woman spends on *obligatory activities* and less in *non-obligatory activities*.

In terms of other variables influencing the allocation of women's daily time, wealth and financial resources of women are consistent across all level of disempowerment. The results show that increasing the value of animals would increase the time allocated in *paid obligatory activities* and decrease the time employed in *non-obligatory activities* for the low and medium disempowered women. Owned land is an indicator of wealth and results show that this variable positively influences the allocation of time to *paid obligatory activities* as land owned increases for low disempowered women. For medium disempowered women more land owned increases the allocation of time in *non-obligatory activities*. Other variables that have been found significant are pregnancy and breastfeeding variables. For the low disempowered women being pregnant, in comparison to those that are not, reduces the time allocated to *unpaid obligatory activities* and increases the *non-obligatory activities*. Perhaps those that are low disempowered find substitutes that can carry on the domestic responsibilities that they normally have to perform

while they are pregnant. For this group of women, less time in *unpaid obligatory activities* represents a shift in the allocation of time to *non-obligatory activities*. For the high disempowered women, breastfeeding was found statistically significant, thus a lactating woman would shift allocation of time from *paid* to *non-obligatory activities*.

More isolated results were found with respect to variable physically abused. A woman that has been physically abused compared to one that has not would allocate less amount of time to *paid obligatory activities* in the highly disempowered group of women. For the less disempowered group, experiencing physical abused decreases the time allocated to *unpaid obligatory activities.*

For the division variable, the results displayed in Table 26 in the Appendix G show that low and highly disempowered women coming from Chittagong[26] region spend more time in *non-obligatory activities* than those from Sylhet division (the base division). Also, in average, for the highly disempowered women coming from Chittagong, the number of hours allocated to *unpaid obligatory activities* is reduced compare to other divisions. Similar result was obtained in the division of Khulna where highly disempowered women allocate less time to *unpaid obligatory activities* compare to highly disempowered women from Sylhet division.

In general, we observe that for the competing Beckerian and Sen models, results are more significant in the Sen model. The results are not consistent across different disempowerment levels though. The results, when divided the sample into their disempowerment categories, only were statistically significant for the *unpaid obligatory activities* and *paid obligatory activities* in relationship to the disempowerment variable (*ci**).

The models that had the disempowerment score calculated without workload, known as *ci**, have higher adjusted R^2 compare to those models that used as disempowerment variable *ci*, or the indicator of workload. Also, the test of endogeneity and instrumental variables showed that if endogeneity is present, which was the case for most of the specifications, then Sen models that corrected the endogeneity of the *ci** variable with instrumental variables performed better. The instrumental variable regressions are presented inCHAPTER 1 - Chapter 1 -Appendix I -

[26] Chittagong region has the second largest city of Bangladesh, which is Chittagong city a port city. Some intervention has taken place in the Chittagong Hill Tracts. This is a unique cultural section in Bangladesh with mixed of within minorities (Asian Development Bank2011).

Table 12 Estimated coefficients for Sen model by levels of disempowerment using *ci**

	Low disempowerment			Medium disempowerment			High disempowerment		
	Unpaid	**Paid**	**Non-obligatory**	**Unpaid**	**Paid**	**Non-obligatory**	**Unpaid**	**Paid**	**Non-obligatory**
Disempowerment	814.49	-485.79	-256.79	1757.91	465.11	-477.23	1150.86*	-1117.57**	29.07
	(437.27)	(319.47)	(359.70)	(1222.96)	(858.50)	(940.52)	(490.53)	(412.01)	(272.31)
Age	-0.87	-0.06	0.94	0.14	1.06	-0.50	0.09	-0.92	0.77
	(1.06)	(0.77)	(0.87)	(0.80)	(0.84)	(0.92)	(1.10)	(0.92)	(0.61)
Muslim	198.43*	-128.22	-54.23	-45.67	104.51	-150.30	239.24	-364.60	137.44
	(100.42)	(73.37)	(82.61)	(132.27)	(144.42)	(158.22)	(244.70)	(205.53)	(135.84)
Hindu	166.55	-107.82	-36.04	-39.74	129.55	-152.50	268.57	-382.47	126.97
	(104.25)	(76.16)	(85.75)	(135.32)	(153.16)	(167.79)	(248.84)	(209.01)	(138.14)
Number of children	8.26	-1.82	-5.57	-8.31	-6.22	-0.70	1.66	-1.45	-1.19
	(7.54)	(5.51)	(6.20)	(6.20)	(7.42)	(8.13)	(9.34)	(7.84)	(5.18)
Pregnant	-139.67**	30.06	100.34**	-31.43	-29.78	39.00	9.04	-58.56	46.25
	(44.96)	(32.85)	(36.98)	(57.86)	(56.25)	(61.63)	(71.53)	(60.08)	(39.71)
Breastfeeding	8.92	-6.80	-0.45	-18.93	-1.03	-20.96	124.47**	-77.39*	-49.83*
	(30.76)	(22.48)	(25.31)	(24.24)	(24.10)	(26.41)	(44.22)	(37.14)	(24.55)
FCS	0.34	0.07	-0.61	1.86	1.96	-1.90	1.96	-2.12	0.16
	(1.93)	(1.41)	(1.59)	(1.57)	(1.61)	(1.77)	(2.39)	(2.01)	(1.33)
Autonomy to move	40.59	30.29	-63.79*	5.15	33.25	-23.20	30.17	-48.04	10.93
	(31.86)	(23.28)	(26.21)	(30.94)	(41.52)	(45.49)	(52.90)	(44.43)	(29.37)
Abused	-63.04*	32.52	25.46	-11.53	17.97	-15.52	58.99	-70.35*	13.41
	(26.38)	(19.27)	(21.70)	(9.60)	(32.06)	(35.13)	(38.09)	(31.99)	(21.14)
Number of cellular	10.13	-9.89	3.46	0.47	-5.68	-17.42	-0.81	6.98	-2.34
	(13.07)	(9.55)	(10.75)	(0.32)	(10.24)	(11.22)	(15.38)	(12.92)	(8.54)
Owned land	-1.39	2.45*	-1.21	-1.36	-0.44	4.03*	0.31	0.20	-0.54
	(1.65)	(1.21)	(1.36)	(3.27)	(1.53)	(1.67)	(0.53)	(0.45)	(0.30)
Value of animals	-1.39	8.61***	-6.91**	0.01*	6.24*	-9.64**	5.63	0.10	-5.64**
	(3.01)	(2.20)	(2.47)	(0.01)	(3.02)	(3.31)	(3.47)	(2.91)	(1.92)
Monthly salary	-0.01	0.02***	-0.01**	36.79	0.01	-0.01	-0.01	0.03**	-0.02**
	(0.00)	(0.00)	(0.00)	(24.77)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	347.65**	235.59*	346.98**	-408.33	-306.04	729.90	-258.69	1116.25***	71.44
	(131.34)	(95.96)	(108.04)	(338.11)	(456.39)	(499.99)	(388.40)	(326.23)	(215.61)
Adjusted R2	0.10	0.07	0.09	0.02	0.14	0.04	n/a	n/a	0.11
F	2.52	4.54	2.62	1.74	1.04	1.56	1.43	2.38	2.86

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Conclusions

After proposing a theoretical model where the maximization of utility depends on the allocation of time and empowerment, as opposed to the existing literature where there is no consideration of women's empowerment, we were able to test the existence of this relationship in a general model. We evaluated specifications that emulated a Beckerian framework and one focused on the Sen concept. We concluded that in general, after accounting for the endogeneity problem of the models, the Sen models have more consistent estimates and performed better. We tested the models for three subgroups stratified by levels of disempowerment, but found the coefficients were not statistically significant, though signs were consistent with the theory. Future research should try to collect information on how obligated the person feels when choosing to allocate time to daily activities. If women can express their autonomy of choice in allocating time to an activity, researchers could measure how much agency they have in allocating time to daily activities. Thus, the Sen model can be tested with data appropriate for the model. Without knowing how autonomous women are in allocating time to daily activities, it is an arbitrary choice of the researcher to classify the information collected in the surveys between the *unpaid obligatory*, *paid obligatory* and *non-obligatory activities*. If women can express their autonomy for her choice in allocating time to an activity, researchers could measure how much agency they have in allocating time to daily activities. Thus, the Sen model can be tested with data appropriate for the model. Without knowing how autonomous women are in allocating time to daily activities, it is an arbitrary choice of the researcher to classify the information collected in the surveys between the *unpaid obligatory*, *paid obligatory* and *non-obligatory activities*. Also, in terms of data collection, future research should try to obtain information on wage rate or salary so the hypothesis related to the correlation between women's empowerment and wages can be tested.

In terms of how women allocate time to different activities by level of empowerment, we observed that for this sample, as empowerment increases, more time is allocated to resting and social activities. The contrary happens to time allocated to domestic work and eating or drinking. Women who are highly empowered decreased their participation in agricultural practices such as farming. This finding can be related to the structural transformation of the economy that refers to the process of shifting labor and other resources from the agriculture sector (or lower productivity sector) to the non-agriculture sector. If women are rational agents, they would allocate more time to more productive activities off-farm. As the level of empowerment rises the allocation of time to paid work

increases. Other activities that women tend to allocate less time to as empowerment increases is the care of children. These findings to support the hypothesis that women's empowerment affects the way women allocate time.

A series of variables are correlated with low levels of empowerment and time allocation to *unpaid obligatory activities*. Many of these variables are structural variables such as age, or regional variables and may be potential structural traps. For instance, young women that are lactating have a higher probability to decrease the share of time allocated to the *non-obligatory activities*. Most likely, young mothers would be trapped in parenthood performing obligatory activities. This trap would become harder to escape if women experience physical abuse and are highly disempowered because the estimated coefficient shows that they allocate more time to *unpaid obligatory activities*, decreasing time allocated to *paid obligatory activities*, contributing to keeping women in low levels of empowerment. If women were able to increase the share of time in those activities, the probability to generate economic resources could potentially enable women to have more agency and escape the empowerment trap as described by Kabeer.

Lastly, if one of the goals of development interventions is being more efficient, being aware of these potential structural empowerment traps can make interventions more effective. We suggest that these structural conditions be assessed before the development interventions take place in order to maximize their impact in the more vulnerable populations in term of women's empowerment.

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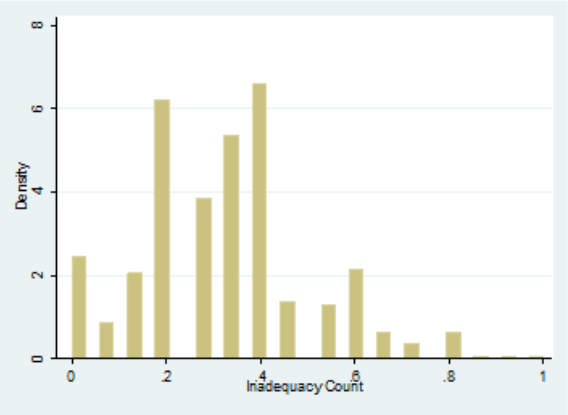
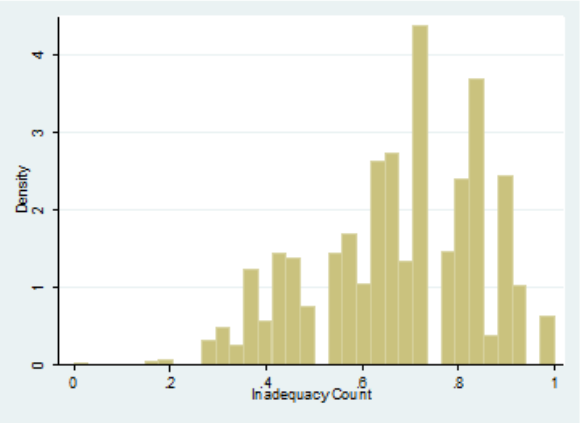
Appendix A - **Tests results for the WEAI and AWEAI data**

Figure 6 Histogram of Inadequacy count calculated with WEAI -2012 and A-WEAI-2015



Ci calculated with the WEAI 2012



Ci calculated with the A-WEAI 2012

Table 13 t-values and p-values of the paired t-test for the variables in 2012 and 2015

Variable	t-value	p-value
Inadequacy Count	20.23	0.00
Age	-9.99	0.00
Literacy	-1.58	0.00
Marital	-2.49	0.006
Household size	-18.38	0.00
Size of plot	-1.18	0.237
Access to water	-13.99	0.00
Access to electricity	-9.09	0.00
Household hunger scale	1.59	0.11
Input in productive desicions	5.418	0.00
Ownership of assests	-13.06	0.00
Access to and decision on credit	- -2.26	0.02
Control over the use of income	5.95	0.00
Group membership	25.64	0.00
Work Burden	61.13	0.00

Appendix B - **MIMIC model estimated coefficient calculated under different fixed indicators for WEAI 2012**

Table 14 Estimated coefficients fixing input in the productive indicators, ownership of assets, access to decision on credit, and control over the usage of income.

	Specification 1 WEAI 2012		**Specification 2 WEAI 2012**		**Specification 3 WEAI 2012**		**Specification 4 WEAI 2012**	
	Coefficient	**Std. Error**	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**
Structural Model								
Age	6.3E-03*	.033	6.9E-03	3.6E-03	8.7E-03**	.011	.0055**	.002
Literacy	.113	.085	.123	.094	.16	.11	.1036	.069
Marital Status	-.365*	.201	-.397*	.215	-.463*	.25	-.292*	.159
Household Size	.0038	.0065	4.1E-03	.007	4.2E-03	0.008	.002	.005
Size of plot	.000096***	.00027	.001	.0003***	.00012***	.00003	.00007***	.00002
Electricity	.061	.084	.066	.091	0.071	3.5E-04	.045	0.68
Water	.3208***	.111	.348	.115***	.40***	.134	.256***	.087
Household hunger scale	.103	.1095	.112	.118	.119	.139	.075	.088
Measurement Model								
Input in Productive decisions	1	-	.923***	.210	.679***	.128	1.07***	.111
Ownership of assets	1.08***	.246	1	-	.964***	.106	1.52***	.297
Access to and decisions on credit	1.14***	.267	1.05***	.103	1	-	1.58***	.314
Control over the use of income	.936***	.099	.865***	.202	.631***	.125	1	-
Group member	-1.77*	1.04	-1.62**	.962	-1.225**	.612	-1.94***	.916
Workload	-.308***	.094	-.283***	.067	.528***	.085	0.836***	.166
Speak in public	-.023	.032	-.021	.029	-.015	.024	.231	.039
Leisure Time	-.089***	.033	-.082***	.067	-.067***	.025	-.10***	.040
Autonomy in Production	-.306***	.079	-.157***	.038	-.13***	.032	-.207***	.052
Decisions on the purchase, sale, transfer assets	-.497***	.084	-.458***	.067	-.38***	.056	-.603***	.0907

, * denotes significance of standardized coefficients at the five percent and one percent levels, respectively.

Table 15 Estimated coefficients fixing group membership, workload, speaking in public indicators using the WEAI 2012 data

	Specification 5 WEAI 2012		Specification 6 WEAI 2012		Specification 7 WEAI 2012	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Structural Model						
Age	-.01	.007	4.6E-03	2.2E-03	-1.4E-04	1.9E-04
Literacy	-.2	.161	.086	.058	-.002	.003
Marital Status	.567	.404	-.244	.134	8.5E-03	.011
Household Size	-.005	.010	2.2E-03	.004	9.05E-05	1.8E-05
Size of plot	.001*	8.1e-03	6.5E-04	1.9E-04	2.2E-04	2.7E-05
Electricity	-.087	.137	.037	.056	-.0014	.0025
Water	-.497	.282	.214	.073	-.0075	.009
Household hunger scale	-.146	.183	.063	.073	-.0024	.0038
Measurement Model						
Input in Productive decisions	-.554**	.265	1.28	.249	-42.8	51.81
Ownership of assets	-.786**	.4	1.8	.281	-46.3	56.8
Access to and decisions on credit	.816**	.406	1.89	.238	-49.01	60.03
Control over the use of income	-.515**	.242	1.19	.238	-40.12	48.56
Group member	1	-	-2.32	1.14	75.14	99.25
Workload	-.430**	.211	1	-	13.14	16.25
Speak in public	.012	.61	-.029	.047	1	-
Leisure Time	0.054*	.032	-.127	.050	3.8	4.8
Autonomy in Production	.106*	.054	-.247	.064	7.32	8.95
Decisions on the purchase., sale, transfer assets	0.31**	.148	-.721	.123	21.25	25.81

, * denotes significance of standardized coefficients at the five percent and one percent levels, respectively.

Table 16 Estimated coefficients using the MIMIC model fixing WEAI 2012 leisure time, autonomy in production, autonomy in decision on the purchase, sale, or transfer of assets

	Specification 8 WEAI 2012		Specification 9 WEAI 2012		Specification 10 WEAI 2012	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Structural Model						
Age	-5.8E04*	3.5E-03	-10.8E-03*	6.1E-04	-.003*	1.6E-03
Literacy	-.011	8.2E-03	.019	.015	-.05	.042
Marital Status	.031	.019	.062*	.36	.182*	.098
Household Size	-2.8E-04	5.6E-04	-6.62E-04	1.1e-03	-.001	3.2E-03
Size of plot	8.3E-04**	3.7E-05	-1.64E-04	5.4E-05	4.7E-04***	1.3E-04
Electricity	-.004	.007	-.010	.014	-.03	.041
Water	.027**	.013	-.055**	.021	-.159***	.052
Household hunger scale	-.008	.009	-.0177	.019	-.051	.054
Measurement Model						
Input in Productive decisions	-10.11***	3.79	-5.849***	1.53	-2.008***	.341
Ownership of assets	-14.9***	5.66	-6.336***	1.56	-2.18***	.32
Access to and decisions on credit	-14.9***	5.66	-6.695***	1.66	-2.3***	.352
Control over the use of income	-9.41***	3.54	-5.481***	1.47	-1.88***	.331
Group member	18.26*	10.76	10.264*	6.11	3.57*	2.06
Workload	-7.86**	3.06	1.795***	.578	.619***	.160
Speak in public	.231	.378	-.136	.188	.046	.064
Leisure Time	1	-	.520**	.222	.179***	.066
Autonomy in Production	1.95**	.84	1	-	.615***	.145
Decisions on the purchase, sale, transfer assets	5.67***	2.11	2.903***	1.47	1	-

, * denotes significance of standardized coefficients at the five percent and one percent levels, respectively.

Appendix C - **MIMIC model calculated under six different fixed indicators for A-WEAI 2012**

Table 17 Estimated coefficients for the MIMIC model A-WEAI 2012 fixing input in productive decision, ownership of assets, and access to and decision of credit

	Specification 1 A-WEAI 2012		**Specification 2 A-WEAI 2012**		**Specification 3 A-WEAI 2012**	
	Coefficient	**Std. Error**	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**
Structural Model						
Age	.005*	.005	.007*	.004	-9.1.4E-03	1.9E-04
Literacy	.093	.078	.122	.105	.168	.003
Marital Status	-.30	.18	-.398*	.238	-.468*	.011
Household Size	.001	.006	.001	.007	8.3E-04	1.8E-05
Size of plot	9.1E-03****	2.7e-03	.001***	3.5E-04	1.4E-03	2.7E-05
Electricity	.072	.078	.094	.100	.099	.0025
Water	.269**	.105	.351***	.129	.411***	.009
Household hunger scale	.093	.101	.122	.131	.126	.0038
Measurement Model						
Input in Productive decisions	1	-	.768	.227	.56***	51.81
Ownership of assets	1.3***	.385	1	-	.965***	56.8
Access to and decisions on credit	1.38***	.43	1.06	.118	1	-
Control over the use of income	.944***	.100	.725	.223	.524	48.56
Group member	-1.34**	.578	-1.03	.477	-.831**	99.25
Workload	-.348***	.117	-.267	.063	.500***	16.25
Speak in public	-	-	-	-	-	-
Leisure Time	-	-	-	-	-	-
Autonomy in Production	-	-	-	-	-	-
Decisions on the purchase., sale, transfer assets	-	-	-	-	-	-

, * denotes significance of standardized coefficients at the five percent and one percent levels, respectively.

Table 18 Estimated coefficients for the MIMIC model A-WEAI 2012 fixing control over the use of input, group membership, and workload

	Specification 4 A-WEAI 2012		Specification 5 A-WEAI 2012		Specification 6 A-WEAI 2012	
	Coefficient	**Std. Error**	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**
Structural Model						
Age	4.7E-03	2.4E-03	-.007	-.007	.002*	.001
Literacy	.088	.063			.048	.035
Marital Status	-.245*	.144	.389	.27	-.134*	.079
Household Size	.001	.007	-.0006	.007	2.4E-04	.002
Size of plot	.001***	3.5E-04	-.0011	5.3E-04	4E-04***	1.1E-04
Electricity	.094	.100	-.082	.102	.049	.033
Water	.351***	.129	-.341	.175	.117***	.043
Household hunger scale	.122	.131	-.105	.134	.036	.044
Measurement Model						
Input in Productive decisions	1.06***	.111	-.067***	.262	1.93***	.345
Ownership of assets	1.84***	.358	-1.16**	.488	3.41***	.532
Access to and decisions on credit	1.905***	.382	-1.2**	.494	3.509***	.585
Control over the use of income	1	-	-.63***	.244	1.806***	.332
Group member	-1.58***	.615	1	-	-2.82**	1.11
Workload	.954***	.182	-.602**	.241	1	-
Speak in public	-	-	-	-	-	-
Leisure Time	-	-	-	-	-	-
Autonomy in Production	-	-	-	-	-	-
Decisions on the purchase., sale, transfer assets	-	-	-	-	-	-

, * denotes significance of standardized coefficients at the five percent and one percent levels, respectively.

Table **19 Estimated coefficients for the MIMIC model A-WEAI 2015 fixing input in productive decision, ownership of assets, and access to and decision of credit**

	Specification 1 A-WEAI 2015		Specification 2 A-WEAI 2015		Specification 3 A-WEAI 2015	
	Coefficient	**Std. Error**	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**
Structural Model						
Age	.013***	.005	8.7E-03	8.3E-04	.011	6.9E-03
Literacy	.15	.078	9.6E-003	.011	.069	.069
Marital Status	-.077	.18	-.004*	.015	-.047	.132
Household Size	.013**	.006	8.5E-04	7.2E-04	5E-04	8E-03
Size of plot	4.7E-03*	2.7e-03	3.1E-05	3.2E-06	5.6E-04	5E-05
Electricity	-.006	.078	-4.3E-04	7.1E-03	.139	.185
Water	-.129	.105	-.008	8.3E-04	-.085	.142
Household hunger scale	.19	.101	.012	.013	.078	.092
Measurement Model						
Input in Productive decisions	1	-	15.66	13.14	7.7*	1.41
Ownership of assets	.063	.053	1	-	.491	.149
Access to and decisions on credit	.129*	.07	2.03	1.76	1	-
Control over the use of income	1.20 ***	.18	18.93	15.81	9.30*	1.733
Group member	.077*	.046	1.2	1.05	.593	.150
Workload	-.265	.186	-4.16	4.84	-2.09	.326
Speak in public	-	-	-	-	-	-
Leisure Time	-	-	-	-	-	-
Autonomy in Production	-	-	-	-	-	-
Decisions on the purchase., sale, transfer of assets	-	-	-	-	-	-

, * denotes significance of standardized coefficients at the five percent and one percent levels, respectively.

Table 20 Estimated coefficients for the MIMIC model A-WEAI 2015 fixing control over the use of input, group membership, and workload

	Specification 4 A-WEAI 2015		Specification 5 A-WEAI 2015		Specification 6 A-WEAI 2015	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Structural Model						
Age	.016***	.005	-.001	-.0007	-.003	.002
Literacy	.181	.136	.011	.011	-.034	.042
Marital Status	-.092	.275	-.005	.017	.02	.061
Household Size	.016**	6.4E-03	.001	6.8E-04	3.5E-03	.002
Size of plot	5.7e-03*	3.1E-04	3.6E-04	3.1E-05	1.2E-04	1E-04
Electricity	-8.2e-03	.136	-.5.2E-04	.0086	.0018	.029
Water	-.156	.263	-.009	.017	.034	.063
Household hunger scale	.229	.168	.014	.013	-.05	.051
Measurement Model						
Input in Productive decisions	.827***	.123	-.067	7.85	-3.76	2.64
Ownership of assets	.052	.044	-1.16	.725	-.24	.279
Access to and decisions on credit	.107*	.058	1.68	1.17	-.488	.451
Control over the use of income	1	-	15.69*	9.51	-4.55	3.23
Group member	.0637*	.038	1	-	-.29	.286
Workload	-.219	.156	-3.44	3.4	1	-
Speak in public	-	-	-	-	-	-
Leisure Time	-	-	-	-	-	-
Autonomy in Production	-	-	-	-	-	-
Decisions on the purchase., sale, transfer assets	-	-	-	-	-	-

, * denotes significance of standardized coefficients at the five percent and one percent levels, respectively.

Appendix D - **Solution of the Utility maximization problem with two constraints.**

$$Max_{a_u, a_w a_n, \lambda_1, \lambda_2}\ \mathcal{L} = U(a_u(\varepsilon), a_w(\varepsilon), a_n(\varepsilon)) + \lambda_1(\bar{T} - a_u(\varepsilon) - a_w(\varepsilon) - a_n(\varepsilon)) + \lambda_2\ (I - \tilde{r}_u a_u(\varepsilon) - r_w\ a_w(\varepsilon) - \tilde{r}_n a_n(\varepsilon)) \quad (63)$$

To find MRS between *unpaid obligatory activities* and *paid obligatory activities* we have that

$$\frac{\frac{\partial U_i}{\partial a_u}}{\frac{\partial U_i}{\partial a_w}} = \frac{U_{au}}{U_{aw}} \quad (64)$$

$$\frac{\partial U_i * \partial a_w}{\partial U_i * \partial a_u} = \frac{U_{au}}{U_{aw}} \quad (65)$$

And at a maximum point

$$-\frac{\partial a_w}{\partial a_u} = \frac{U_{au}}{U_{aw}} = MRS \quad (66)$$

Then taking (41) and divided by (42),

$$\frac{U_{au}}{U_{aw}} = \frac{\frac{\partial U_i}{\partial a_u}}{\frac{\partial U_i}{\partial a_w}} = \frac{\lambda_1 + \lambda_2 \tilde{r}_u}{\lambda_1 + \lambda_2 r_w} \quad (67)$$

$$\frac{U_{au}}{U_{aw}} = \frac{\lambda_1 + \lambda_2 \tilde{r}_u}{\lambda_1 + \lambda_2 r_w} \quad (68)$$

$$\text{MRS } of\ a_u\ to\ a_w = \frac{\lambda_1 + \lambda_2 \tilde{r}_u}{\lambda_1 + \lambda_2 r_w} \quad (69)$$

To find MRS between *paid obligatory activities* and *non-obligatory activitie*s equation (58) and (59) are combined

$$\frac{\frac{\partial U_i}{\partial a_w}}{\frac{\partial U_i}{\partial a_n}} = \frac{U_{aw}}{U_{an}} \quad (70)$$

Then dividing (37) by(38)

$$\frac{U_{aw}}{U_{an}} = \frac{\frac{\partial U_i}{\partial a_w}}{\frac{\partial U_i}{\partial a_n}} = \frac{\lambda_1 + \lambda_2 r_w}{\lambda_1 + \lambda_2 \tilde{r}_n} \quad (71)$$

Since at a maximum point

$$-\frac{\partial a_n}{\partial a_w} = \frac{U_{aw}}{U_{an}} = MRS \quad (72)$$

Using (71) and (72),

$$\frac{U_{aw}}{U_{an}} = \frac{\lambda_1+\lambda_2 r_w}{\lambda_1+\lambda_2 \tilde{r}_n} = \text{MRS of } a_w \text{ and } a_n \quad (73)$$

To find MRS between *unpaid obligatory activities* and *non-obligatory activities*, equation (36)is divided by (38),

$$\frac{\frac{\partial U_i}{\partial a_u}}{\frac{\partial U_i}{\partial a_n}} = \frac{U_{au}}{U_{an}} \quad (74)$$

$$\frac{U_{au}}{U_{an}} = \frac{\frac{\partial U_i}{\partial a_u}}{\frac{\partial U_i}{\partial a_n}} = \frac{\lambda_1 + \lambda_2 \tilde{r}_u}{\lambda_1 + \lambda_2 \tilde{r}_n} \quad (75)$$

Since at a maximum point

$$-\frac{\partial a_u}{\partial a_n} = \frac{U_{an}}{U_{au}} = MRS \quad (76)$$

Using (75) and (76), we obtained

$$\frac{U_{an}}{U_{au}} = \frac{\lambda_1+\lambda_2 \tilde{r}_u}{\lambda_1+\lambda_2 \tilde{r}_n} = \text{MRS of } a_u \text{ and } a_n \quad (77)$$

Maximization problem with three constraints

$$Max_{a_u,a_w,a_n,\lambda_1,\lambda_2,\lambda_3}\ \mathcal{L} = U(a_u(\varepsilon), a_w(\varepsilon), a_n(\varepsilon)) + \lambda_1(\bar{T} - a_u(\varepsilon) - a_w(\varepsilon) - a_n(\varepsilon)) + \lambda_2\ (I - \tilde{r}_u a_u(\varepsilon) - r_w\ a_w(\varepsilon) - \tilde{r}_n a_n(\varepsilon)) + \lambda_3(a_u(\varepsilon) - a_u(\varepsilon)^{min}) \quad (78)$$

To find MRS between *unpaid obligatory activities* and *paid obligatory activities* equation (51) and (52) are combined

$$\frac{U_{au}}{U_{aw}} = \frac{\frac{\partial U_i}{\partial a_u}}{\frac{\partial U_i}{\partial a_w}} = \frac{\lambda_1 + \lambda_2 \tilde{r}_u - \lambda_3}{\lambda_1 + \lambda_2 r_w} \quad (79)$$

At a maximum, then

$$\frac{\lambda_1 + \lambda_2 \tilde{r}_u - \lambda_3}{\lambda_1 + \lambda_2 r_w} = \frac{U_{au}}{U_{aw}} = MRS \quad (80)$$

Re-arranging

$$\frac{\lambda_2 \tilde{r}_u - \lambda_3}{\lambda_2 r_w} = \frac{U_{au} - \lambda_1}{U_{aw} - \lambda_1} \tag{81}$$

To find MRS between *paid obligatory activities* and *non-obligatory activitie*s, we divide (52) by(53),

$$\frac{\frac{\partial U_i}{\partial a_w}}{\frac{\partial U_i}{\partial a_n}} = \frac{U_{aw}}{U_{an}} \tag{82}$$

$$\frac{U_{aw}}{U_{an}} = \frac{\frac{\partial U_i}{\partial a_w}}{\frac{\partial U_i}{\partial a_n}} = \frac{\lambda_1 + \lambda_2 r_w}{\lambda_1 + \lambda_2 \tilde{r}_n} \tag{83}$$

Since at a maximum point

$$-\frac{\partial a_n}{\partial a_w} = \frac{U_{aw}}{U_{an}} = MRS \tag{84}$$

Using (58) and(59), and replacing on (84)

$\frac{U_{aw}}{U_{an}} = \frac{\lambda_1 + \lambda_2 r_w}{\lambda_1 + \lambda_2 \tilde{r}_n}$= MRS of a_w and a_n (85)

To find MRS between *unpaid obligatory activities* and *non-obligatory activities*, equation (51) is divided by(53),

$$\frac{\frac{\partial U_i}{\partial a_u}}{\frac{\partial U_i}{\partial a_n}} = \frac{U_{au}}{U_{an}} \tag{86}$$

$$\frac{U_{au}}{U_{an}} = \frac{\frac{\partial U_i}{\partial a_u}}{\frac{\partial U_i}{\partial a_n}} = \frac{\lambda_1 + \lambda_2 \tilde{r}_u - \lambda_3}{\lambda_1 + \lambda_2 \tilde{r}_n} \tag{87}$$

Since at a maximum point

$$-\frac{\partial a_u}{\partial a_n} = \frac{U_{an}}{U_{au}} = MRS \tag{88}$$

Using (87) and (88), we obtained

$\frac{U_{an}}{U_{au}} = \frac{\lambda_1 + \lambda_2 \tilde{r}_u}{\lambda_1 + \lambda_2 \tilde{r}_n - \lambda_3}$= MRS of a_u and a_n (89)

Appendix E - **Summary statistics of minutes allocated to different activities**

Table 21 Summary of allocation of time by activities

	Description	Mean	SD	Min	Max	Obs
Activities						
Sleeping and resting	Continous (minutes)	556	113	150	990	1354
Eating and drinking	Continous (minutes)	87	41	0	645	1354
Personal care	Continous (minutes)	74	31	0	300	1354
School	Continous (minutes)	7.2	26	0	285	1354
Work as an employee	Continous (minutes)	12.5	74	0	900	1354
Owned business	Continous (minutes)	7.8	48	0	585	1354
Farming	Continous (minutes)	7.7	47	0	585	1354
Shopping	Continous (minutes)	81	101	0	705	1354
Textile	Continous (minutes)	13	49	0	465	1354
Cooking	Continous (minutes)	136	75	0	495	1354
Domestic	Continous (minutes)	209	120	0	795	1354
Care of others	Continous (minutes)	54	68	0	495	1354
Traveling	Continous (minutes)	13	36.5	0	345	1354
Tv	Continous (minutes)	27.7	59	0	465	1354
Exercising	Continous (minutes)	2.2	12.5	0	165	1354
Social	Continous (minutes)	100	103	0	615	1354
Religion practices	Continous (minutes)	56	72	0	570	1354

Appendix F - **Instrumental variables test for Women's Empowerment**

Table 22 p-values and *F*-values for the instrumental variables' tests perform for Becker model

	Leisure				Non-Leisure			
Variable	**CI**		**CI***		**CI**		**CI***	
	OLS	**2SLS**	**OLS**	**2SLS**	**OLS**	**2SLS**	**OLS**	**2SLS**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Under ID test p, Ho: underidentification		0.0601		0.0046		0.0629		0.0046
Weak ID test stat (Kleibergen-Paap rk Wald F)		1.90		2.909		1.895		2.909
Anderson-Rubin, Ho: endogvars irrelevant		0.0000		0.0007		0.0001		0.0001
A-R Wald test, p-value		0.0000		0.0005		0.000		0.0000
Wu-Hausman, Ho: variables are exogenous		0.4298		0.0497		0.5933		0.0497

Table 23 p-values and *F*-values for the instrumental variables' tests perform for Sen model

	Unpaid Obligatory activities				Paid Obligatory activities				Non-obligatory activities			
Variable	CI		CI*		CI		CI*		CI		CI *	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Under ID test p, Ho: underidentification		0.0402		0.0029		0.0402		0.0029		0.0402		0.0029
Weak ID test stat (Kleibergen-Paap rk Wald F)		2.18		3.296		2.176		3.296		2.176		3.296
Anderson-Rubin, Ho: endogvars irrelevant		0.0008		0.0007		0.0000		0.0000		0.7307		0.7307
A-R Wald test, p-value		0.0006		0.0005		0.0000		0.0000		0.7213		0.7213
Wu-Hausman, Ho: variables are exogenous		0.1410		0.0045		0.5933		0.0015		0.16		0.2726

Table 24 p-values and F values for the instrumental variables' tests perform for Sen model by levels of empowerment

	Low disempowerment				Medium Disempowerment				High Disempowerment			
Variable	CI		CI*		CI		CI*		CI		CI *	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Under ID test p, Ho: underidentification		0.1618		0.0602		0.0080		0.0904		0.3437		0.1266
Weak ID test stat (Kleibergen-Paap rk Wald F)		1.479		1.950		2.647		1.746		1.084		1.607
Anderson-Rubin, Ho: endogvars irrelevant		0.0159		0.0159		0.4510		0.0830		0.0020		0.0020
A-R Wald test, p-value		0.0101		0.0101		0.4510		0.0587		0.0011		0.0011
Wu-Hausman, Ho: variables are exogenous		0.4724		0.0784		0.7397		0.4647		0.0068		0.0005

Appendix G - **Division Variable Estimated Coefficients and Standard Errors of the for the Sen model**

Table 25 Estimated coefficients and standard errors for the Sen model

	Unpaid obligatory activities				Paid obligatory activities				Non-obligatory activity			
	CI		CI*		CI		CI*		CI		Ci*	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Barisal	15.90	24.74	15.12	25.63	0.21	-14.05	-2.18	-14.05	-16.11	-9.36	-12.94	-9.05
	(18.57)	(21.17)	(18.63)	(22.34)	(16.36)	(22.38)	(16.39)	(22.38)	(17.48)	(19.30)	(17.84)	(18.58)
Chittagong	-81.48***	-57.79*	-84.05***	-59.68*	21.80	-16.43	15.74	-16.43	59.68**	77.77***	68.32***	77.34***
	(18.40)	(25.14)	(18.44)	(23.93)	(16.21)	(26.65)	(16.22)	(26.65)	(17.33)	(22.98)	(17.66)	(19.90)
Dhaka	-26.78	-10.07	-27.92	-5.36	28.27*	1.32	23.52	1.32	-1.49	11.26	4.40	12.76
	(14.88)	(19.45)	(14.93)	(19.90)	(13.11)	(20.61)	(13.13)	(20.61)	(14.01)	(17.77)	(14.29)	(16.55)
Khulna	-35.91*	-36.62	-36.32*	-40.96*	38.20*	39.34	38.73*	39.34	-2.29	-2.83	-2.41	-4.13
	(17.29)	(19.03)	(17.35)	(20.50)	(15)	(20.10)	(15.26)	(20.10)	(16.28)	(17.33)	(16.61)	(17.05)
Rajshahi	-14.01	-15.57	-14.26	-19.32	27.94	30.46	28.64	30.46	-13.93	-15.13	-14.38	-16.25
	(16.62)	(18.31)	(16.68)	(19.73)	(14.)	(19.35)	(14.67)	(19.35)	(15.65)	(16.68)	(15.97)	(16.41)
Rangpur	-49.46**	-47.54*	-48.34**	-35.65	65.72***	62.62**	64.28***	62.62**	-16.26	-14.80	-15.94	-11.24
	(17.54)	(19.34)	(17.61)	(21.37)	(15.45)	(20.43)	(15.49)	(20.43)	(16.52)	(17.62)	(16.86)	(17.78)

Standard errors in parentheses
* p < 0.05, ** p < 0.01, *** p < 0.001

Table 26 Division variable estimated coefficient and standard errors for 2SLS Sen model with ci* and model by levels of disempowerment

	Low disempowerment			Medium disempowerment			High disempowered		
Division	Unpaid obligatory activities			Paid Obligatory activities			Non-obligatory activities		
Barisal [27]	-26.31	-6.26	38.09	-4.04	12.31	-63.35	-2.15	7.89	-12.41
	(39.13)	(28.59)	(32.19)	(38.51)	(39.58)	(43.36)	(49.01)	(41.16)	(27.21)
Chittagong	-62.79	-20.23	80.98*	-8.06	23.87	-33.57	-104.29*	38.58	64.43*
	(45.68)	(33.38)	(37.58)	(40.87)	(31.89)	(34.94)	(52.29)	(43.92)	(29.03)
Dhaka	-47.25	7.37	48.95	-19.92	47.23	-42.99	-24.22	24.04	8.02
	(31.96)	(23.35)	(26.29)	(28.29)	(40.63)	(44.51)	(40.98)	(34.42)	(22.75)
Khulna	-34.03	36.90	3.40	-7.86	44.11	-69.91*	-100.69*	54.40	41.94
	(37.00)	(27.03)	(30.43)	(32.58)	(30.57)	(33.49)	(45.29)	(38.04)	(25.14)
Rajshahi	-6.93	15.68	-5.32	-12.11	32.07	-33.28	12.32	7.77	-17.13
	(36.76)	(26.86)	(30.24)	(31.31)	(27.81)	(30.47)	(43.97)	(36.93)	(24.41)
Rangpur	-48.72	24.82	25.76	42.23	68.13	-29.82	18.67	10.45	-18.42
	(40.01)	(29.23)	(32.91)	(30.14)	(41.55)	(45.52)	(58.84)	(49.43)	(32.67)

Standard errors in parentheses
* p < 0.05, ** p < 0.01, *** p < 0.001

Appendix H - **Estimated Coefficients and Standard Errors of the division variables for the Sen model**

Table 27 Estimated coefficients and standard error of the SEN models for low disempowered women

	Unpaid obligatory activities				Paid obligatory activities				Non-obligatory activities			
	CI		CI*		CI		CI*		CI		CI*	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Disempowerment	185.807	666.626	122.342	814.49	161.89*	-5.75	-85.44	-485.79	-365.75***	-731.91	-73.25	-256.79
	(95.546)	(678.169)	(64.571)	(437)	(72.9)	(506.78)	(49.43)	(319.47)	(85.74)	(603.92)	(59.02)	(359.70)
Age	0.149	-0.072	0.069	-0.870	-0.789	-0.71	-0.60	-0.06	0.76	0.93	0.69	0.94
	(0.802)	(0.863)	(0.806)	(1.06)	(0.613)	(0.64)	(0.62)	(0.77)	(0.72)	(0.77)	(0.74)	(0.87)
Muslim	171.582	170.378	176.010	198.4*	-112.8	-112.47	-115.25	-128.22	-45.00	-44.08	-48.28	-54.23
	(90.582)	(91.022)	(90.625)	(100.4)	(69.2)	(68.02)	(69.37)	(73.37)	(81.29)	(81.06)	(82.83)	(82.61)
Hindu	126.973	125.954	133.252	166.546	-84.793	-84.44	-88.56	-107.82	-22.91	-22.14	-27.21	-36.04
	(93.025)	(93.472)	(93.097)	(104.2)	(71.06)	(69.85)	(71.26)	(76.16)	(83.48)	(83.24)	(85.09)	(85.75)
Numb of children	11.730	11.716	11.214	8.263	-3.896	-3.89	-3.53	-1.82	-6.66	-6.64	-6.35	-5.57
	(6.655)	(6.686)	(6.662)	(7.538)	(5.084)	(5.00)	(5.10)	(5.51)	(5.97)	(5.95)	(6.09)	(6.20)
Pregnant	-135.731***	-135.770***	-136.31***	-139.6**	27.689	27.70	28.12	30.06	99.13**	99.15**	99.45**	100.34**
	(40.918)	(41.110)	(40.928)	(44.960)	(31.26)	(30.72)	(31.33)	(32.85)	(36.72)	(36.61)	(37.41)	(36.98)
Breastfeeding	23.733	19.824	22.792	8.922	-17.850	-16.49	-14.82	-6.80	-2.62	0.36	-4.12	-0.45
	(26.880)	(27.552)	(26.906)	(30.764)	(20.53)	(20.59)	(20.60)	(22.48)	(24.12)	(24.54)	(24.59)	(25.31)
Fcs	0.376	0.358	0.377	0.341	0.035	0.04	0.05	0.07	-0.61	-0.59	-0.62	-0.61
	(1.761)	(1.770)	(1.762)	(1.933)	(1.346)	(1.32)	(1.35)	(1.41)	(1.58)	(1.58)	(1.61)	(1.59)
Autonomy to move	27.907	25.886	30.477	40.595	36.708	37.41	36.14	30.29	-58.50*	-56.96*	-61.10*	-63.79*
	(28.442)	(28.714)	(28.461)	(31.862)	(21.72)	(21.46)	(21.79)	(23.28)	(25.52)	(25.57)	(26.01)	(26.21)
Physically abused	-65.544**	-70.689**	-63.478**	-63.036*	31.098	32.89	32.78	32.52	29.53	33.45	25.57	25.46
	(24.054)	(25.211)	(24.037)	(26.378)	(18.37)	(18.84)	(18.40)	(19.27)	(21.59)	(22.45)	(21.97)	(21.70)
# of cellular	19.691	16.499	19.304	10.134	-17.4*	-16.29	-15.19	-9.89	2.49	4.92	1.03	3.46
	(10.689)	(11.627)	(10.707)	(13.066)	(8.166)	(8.69)	(8.20)	(9.55)	(9.59)	(10.35)	(9.79)	(10.75)
Owned land	-0.166	-0.483	-0.245	-1.386	1.538	1.65	1.79	2.45*	-1.39	-1.15	-1.51	-1.21
	(1.353)	(1.430)	(1.356)	(1.650)	(1.034)	(1.07)	(1.04)	(1.21)	(1.21)	(1.27)	(1.24)	(1.36)
Value of animals	-0.644	-0.753	-0.721	-1.392	8.10***	8.14***	8.23***	8.61***	-7.08**	-6.99**	-7.09**	-6.91**
	(2.713)	(2.730)	(2.714)	(3.008)	(2.073)	(2.04)	(2.08)	(2.20)	(2.43)	(2.43)	(2.48)	(2.47)
Monthly salary	-0.012**	-0.013**	-0.012**	-0.009	0.02***	0.02***	0.02***	0.02***	-0.01**	-0.01**	-0.01**	-0.01**
	(0.004)	(0.004)	(0.004)	(0.005)	(0.003)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Barisal [28]	-40.085	-13.122	-46.869	-26.305	17.253	7.85	5.64	-6.26	25.21	4.68	43.55	38.09
	(34.058)	(50.873)	(33.696)	(39.135)	(26.01)	(38.02)	(25.79)	(28.59)	(30.56)	(45.30)	(30.80)	(32.19)
Chittagong	-102.070**	-64.442	-108.52***	-62.786	24.540	11.42	6.22	-20.23	69.33*	40.67	93.11**	80.98*
	(33.093)	(62.175)	(32.525)	(45.683)	(25.28)	(46.46)	(24.90)	(33.38)	(29.70)	(55.37)	(29.73)	(37.58)
Dhaka	-60.272*	-39.351	-65.186*	-47.247	27.000	19.71	17.74	7.37	39.69	23.76	53.70*	48.95
	(27.539)	(40.234)	(27.281)	(31.957)	(21.03)	(30.07)	(20.88)	(23.35)	(24.71)	(35.83)	(24.93)	(26.29)
Khulna	-38.780	-28.469	-41.453	-34.028	45.587	41.99	41.20	36.90	-1.69	-9.54	5.37	3.40
	(33.497)	(36.605)	(33.449)	(36.995)	(25.59)	(27.35)	(25.60)	(27.03)	(30.06)	(32.60)	(30.57)	(30.43)
Rajshahi	-13.313	-9.024	-13.762	-6.927	21.925	20.43	19.64	15.68	-6.05	-9.32	-3.51	-5.32
	(33.274)	(33.962)	(33.276)	(36.763)	(25.42)	(25.38)	(25.47)	(26.86)	(29.86)	(30.24)	(30.41)	(30.24)
Rangpur	-66.620	-54.241	-67.996	-48.723	42.520	38.20	35.97	24.82	23.49	14.06	30.87	25.76
	(34.808)	(39.009)	(34.775)	(40.006)	(26.59)	(29.15)	(26.62)	(29.23)	(31.24)	(34.74)	(31.78)	(32.91)
Constant	434.945***	365.250*	444.7***	347.6**	143.98	168.29	179.44*	235.59*	363.98***	417.05**	321.23**	346.98**
	(106.719)	(144.795)	(106.226)	(131.3)	(81.5)	(108.20)	(81.31)	(95.96)	(95.77)	(128.94)	(97.09)	(108.04)
Adjusted R2	0.126	0.07	0.09	0.02	-0.14		0.19		0.14		0.11	
F	3.158	4.54	2.62	1.74	1.04	1.56	5.24		3.66		2.73	

Table 28 Estimated coefficients and standard error of the SEN models for medium disempowered women

	Unpaid obligatory activities				Paid Obligatory activities				Non-obligatory activities			
	CI		CI*		CI		CI*		CI		CI*	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Disempowerment	194.82*	292.79	-137.84	1757.91	-118.38	-2019.24	-294.31***	465.11	-48.63	2845.45	179.67*	-477.23
	(75.81)	(294.02)	(340.03)	(1222.96)	(201.33)	(1275.87)	(77.77)	(858.50)	(228.41)	(1560.70)	(89.46)	(940.52)
Age	-1.19	-1.25	0.52	0.14	0.87	1.14	0.72	1.06	-0.28	-0.69	-0.20	-0.50
	(0.96)	(0.94)	(0.75)	(0.80)	(0.69)	(0.78)	(0.68)	(0.84)	(0.79)	(0.95)	(0.78)	(0.92)
Muslim	2.88	-22.78	55.36	-45.67	72.57	153.17	44.16	104.51	-110.31	-233.03	-98.10	-150.30
	(146.38)	(160.11)	(114.69)	(132.27)	(118.78)	(139.79)	(116.35)	(144.42)	(134.76)	(171.00)	(133.84)	(158.22)
Hindu	15.43	-12.89	66.17	-39.74	90.02	180.42	55.82	129.55	-103.86	-241.49	-88.73	-152.50
	(148.80)	(165.89)	(116.49)	(135.32)	(119.98)	(143.56)	(117.52)	(153.16)	(136.11)	(175.61)	(135.19)	(167.79)
Numb of children	16.07*	16.02*	-7.44	-8.31	-4.09	-9.54	-2.19	-6.22	-3.38	4.91	-4.20	-0.70
	(7.78)	(7.53)	(6.08)	(6.20)	(5.48)	(6.97)	(5.36)	(7.42)	(6.22)	(8.52)	(6.17)	(8.13)
Pregnant	18.03	22.25	-37.19	-31.43	-15.49	-35.19	-4.45	-29.78	22.58	52.57	17.09	39.00
	(72.83)	(71.55)	(56.82)	(57.86)	(45.11)	(50.78)	(44.27)	(56.25)	(51.18)	(62.12)	(50.92)	(61.63)
Breastfeeding	3.45	6.60	-24.64	-18.93	3.33	-0.44	6.47	-1.03	-25.76	-20.03	-27.44	-20.96
	(30.28)	(30.71)	(23.59)	(24.24)	(21.01)	(22.99)	(20.61)	(24.10)	(23.83)	(28.12)	(23.71)	(26.41)
Fcs	-0.19	-0.03	1.22	1.86	1.63	1.44	1.43	1.96	-1.57	-1.30	-1.44	-1.90
	(1.92)	(1.91)	(1.50)	(1.57)	(1.39)	(1.52)	(1.37)	(1.61)	(1.58)	(1.86)	(1.57)	(1.77)
Autonomy to move	-12.12	-12.08	-4.94	5.15	17.45	20.16	7.18	33.25	-6.75	-10.87	-0.65	-23.20
	(38.11)	(36.89)	(29.82)	(30.94)	(27.23)	(29.68)	(26.83)	(41.52)	(30.89)	(36.30)	(30.87)	(45.49)
Physically abused	15.25	14.64	-6.70	-11.53	28.62	13.52	36.90	17.97	-27.80	-4.81	-31.89	-15.52
	(11.45)	(11.22)	(8.97)	(9.60)	(22.29)	(26.22)	(21.88)	(32.06)	(25.28)	(32.07)	(25.17)	(35.13)
Number of cellular	0.02	-0.09	0.52	0.47	-7.86	0.75	-10.11	-5.68	-14.41	-27.52*	-13.58	-17.42
	(0.41)	(0.51)	(0.31)	(0.32)	(8.37)	(10.74)	(8.17)	(10.24)	(9.49)	(13.13)	(9.40)	(11.22)
Owned land	7.38*	6.67	1.98	-1.36	-0.46	-0.10	-0.51	-0.44	4.08*	3.52	4.09*	4.03*
	(3.15)	(3.67)	(2.49)	(3.27)	(1.42)	(1.56)	(1.39)	(1.53)	(1.61)	(1.91)	(1.60)	(1.67)
Value of animals	-0.00	-0.00	0.01	0.01*	5.39*	8.31**	4.55*	6.24*	-8.51***	-12.96***	-8.18**	-9.64**
	(0.01)	(0.01)	(0.01)	(0.01)	(2.21)	(3.08)	(2.15)	(3.02)	(2.50)	(3.77)	(2.47)	(3.31)
Monthly salary	-10.61	-8.80	29.53	36.79	0.01	0.01*	0.01	0.01	-0.00	-0.01	-0.00	-0.01
	(30.68)	(30.16)	(23.96)	(24.77)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Barisal 29	48.41	51.97	-32.02	-4.04	2.06	3.86	-4.62	12.31	-52.66	-55.41	-48.70	-63.35
	(42.95)	(42.84)	(33.84)	(38.51)	(32.25)	(35.11)	(31.67)	(39.58)	(36.59)	(42.94)	(36.43)	(43.36)
Chittagong	36.22	43.40	-36.10	-8.06	26.14	12.67	28.94	23.87	-37.10	-16.59	-37.95	-33.57
	(46.52)	(49.62)	(36.41)	(40.87)	(29.23)	(33.03)	(28.64)	(31.89)	(33.16)	(40.40)	(32.94)	(34.94)
Dhaka	42.75	44.59	-29.46	-19.92	30.87	48.99	18.68	47.23	-24.58	-52.17	-18.29	-42.99
	(34.83)	(34.13)	(27.23)	(28.29)	(23.05)	(27.79)	(22.71)	(40.63)	(26.15)	(34.00)	(26.13)	(44.51)
Khulna	57.73	60.10	-9.41	-7.86	40.66	45.69	37.96	44.11	-65.92*	-73.58*	-64.59*	-69.91*
	(41.08)	(40.36)	(32.05)	(32.58)	(27.71)	(30.33)	(27.18)	(30.57)	(31.44)	(37.10)	(31.26)	(33.49)
Rajshahi	40.39	39.59	-7.79	-12.11	28.79	30.20	26.58	32.07	-29.80	-31.94	-28.54	-33.28
	(39.30)	(38.11)	(30.70)	(31.31)	(25.23)	(27.47)	(24.75)	(27.81)	(28.63)	(33.60)	(28.47)	(30.47)
Rangpur	-33.64	-34.05	40.65	42.23	53.43*	79.54*	41.47	68.13	-12.39	-52.15	-6.75	-29.82
	(37.96)	(36.76)	(29.64)	(30.14)	(26.76)	(33.85)	(26.24)	(41.55)	(30.36)	(41.40)	(30.19)	(45.52)
Constant	494.20**	491.96**	77.32	-408.33	-40.26	430.28	80.07	-306.04	499.30**	-217.12	395.91**	729.90
	(160.20)	(155.19)	(152.43)	(338.11)	(133.73)	(343.48)	(127.95)	(456.39)	(151.71)	(420.16)	(147.19)	(499.99)
Adjusted R2	0.11	0.10	0.11	0.02	0.07	-0.17	0.10	-0.14	0.09	-0.33	0.10	-0.04
F	1.78	1.49	1.83	1.74	1.28	1.12	2.03	1.04	1.76	1.36	1.98	1.56

Table 29 Estimated coefficients and standard error of the SEN models for high disempowered women

	Unpaid obligatory activities				Paid Obligatory activities				Non-obligatory activities			
	CI		CI*		CI		CI*		CI*		CI*	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Disempowerment	37.02	-1343.75	4.44	1150.86*	156.77**	1325.79*	-160.76***	-1117.57**	-172.29***	16.73	134.46***	29.07
	(58.48)	(732.18)	(46.40)	(490.53)	(49.84)	(621.88)	(39.27)	(412.01)	(47.96)	(419.69)	(38.05)	(272.31)
Age	0.21	-0.59	0.19	0.09	-0.92	-0.24	-1.00	-0.92	0.68	0.79	0.76	0.77
	(0.75)	(1.15)	(0.75)	(1.10)	(0.64)	(0.98)	(0.64)	(0.92)	(0.62)	(0.66)	(0.62)	(0.61)
Muslim	189.86	157.90	189.20	239.24	-312.19*	-285.12	-322.83*	-364.60	132.18	136.55	142.04	137.44
	(167.08)	(238.40)	(167.15)	(244.70)	(142.41)	(202.48)	(141.47)	(205.53)	(137.03)	(136.65)	(137.09)	(135.84)
Hindu	161.29	138.35	161.10	268.57	-275.09	-255.67	-292.77*	-382.47	121.38	124.52	136.85	126.97
	(167.62)	(238.88)	(167.74)	(248.84)	(142.87)	(202.89)	(141.97)	(209.01)	(137.47)	(136.93)	(137.57)	(138.14)
Numb of children	4.51	-4.41	4.26	1.66	-2.97	4.58	-3.62	-1.45	-2.24	-1.02	-1.43	-1.19
	(6.36)	(10.20)	(6.36)	(9.34)	(5.42)	(8.67)	(5.38)	(7.84)	(5.22)	(5.85)	(5.21)	(5.18)
Pregnant	-2.60	-37.69	-3.49	9.04	-42.36	-12.65	-48.10	-58.56	41.55	46.35	47.40	46.25
	(48.91)	(72.03)	(48.91)	(71.53)	(41.69)	(61.18)	(41.39)	(60.08)	(40.11)	(41.29)	(40.11)	(39.71)
Breastfeeding	89.67**	69.39	89.26**	124.47**	-40.76	-23.60	-48.00*	-77.39*	-53.26*	-50.48*	-46.60*	-49.83*
	(28.50)	(41.95)	(28.54)	(44.22)	(24.30)	(35.63)	(24.15)	(37.14)	(23.38)	(24.05)	(23.41)	(24.55)
Fcs	0.10	-1.11	0.08	1.96	-0.15	0.88	-0.55	-2.12	-0.04	0.13	0.33	0.16
	(1.55)	(2.29)	(1.55)	(2.39)	(1.32)	(1.95)	(1.31)	(2.01)	(1.27)	(1.31)	(1.27)	(1.33)
Autonomy to move	-9.21	-74.26	-10.79	30.17	-0.72	54.36	-13.85	-48.04	1.78	10.68	14.70	10.93
	(34.32)	(59.67)	(34.26)	(52.90)	(29.25)	(50.68)	(29.00)	(44.43)	(28.15)	(34.20)	(28.10)	(29.37)
Physically abused	26.51	-17.60	25.46	58.99	-32.66	4.69	-42.37*	-70.35*	7.06	13.10	16.49	13.41
	(24.25)	(41.62)	(24.23)	(38.09)	(20.67)	(35.35)	(20.51)	(31.99)	(19.89)	(23.85)	(19.87)	(21.14)
Number of cellular	19.77*	1.15	19.20*	-0.81	-10.41	5.35	-9.72	6.98	-4.15	-1.60	-4.18	-2.34
	(8.79)	(15.90)	(8.80)	(15.38)	(7.49)	(13.51)	(7.45)	(12.92)	(7.21)	(9.12)	(7.22)	(8.54)
Owned land	0.21	0.91	0.23	0.31	0.21	-0.39	0.27	0.20	-0.46	-0.55	-0.53	-0.54
	(0.37)	(0.64)	(0.37)	(0.53)	(0.31)	(0.54)	(0.31)	(0.45)	(0.30)	(0.37)	(0.30)	(0.30)
Value of animals	4.53	0.39	4.42	5.63	1.75	5.25	1.11	0.10	-6.19**	-5.62*	-5.53**	-5.64**
	(2.36)	(4.00)	(2.35)	(3.47)	(2.01)	(3.40)	(1.99)	(2.91)	(1.93)	(2.29)	(1.93)	(1.92)
Monthly salary	-0.01	-0.02	-0.01	-0.01	0.03***	0.03***	0.03***	0.03**	-0.02**	-0.02**	-0.01**	-0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Barisal [30]	15.02	17.06	15.01	-2.15	-9.07	-10.80	-6.43	7.89	-11.72	-12.00	-13.99	-12.41
	(33.21)	(47.28)	(33.23)	(49.01)	(28.31)	(40.16)	(28.12)	(41.16)	(27.24)	(27.10)	(27.25)	(27.21)
Chittagong	-88.91*	-80.28	-88.74*	-104.29*	22.44	15.13	25.60	38.58	65.90*	64.72*	63.00*	64.43*
	(35.55)	(50.80)	(35.57)	(52.29)	(30.30)	(43.15)	(30.10)	(43.92)	(29.16)	(29.12)	(29.17)	(29.03)
Dhaka	-32.78	-46.02	-33.10	-24.22	34.20	45.41	31.45	24.04	6.14	7.95	8.83	8.02
	(27.97)	(40.42)	(27.98)	(40.98)	(23.84)	(34.33)	(23.68)	(34.42)	(22.94)	(23.17)	(22.95)	(22.75)
Khulna	-81.86**	-95.16*	-82.29**	-100.69*	37.98	49.24	39.05	54.40	40.74	42.56	40.25	41.94
	(30.57)	(44.08)	(30.59)	(45.29)	(26.06)	(37.44)	(25.89)	(38.04)	(25.08)	(25.27)	(25.09)	(25.14)
Rajshahi	-6.32	-48.93	-7.39	12.32	31.82	67.90	24.22	7.77	-22.95	-17.12	-15.32	-17.13
	(29.63)	(47.77)	(29.60)	(43.97)	(25.25)	(40.58)	(25.05)	(36.93)	(24.30)	(27.38)	(24.27)	(24.41)
Rangpur	-65.37*	-139.18*	-67.01*	18.67	102.36***	164.85**	81.96**	10.45	-29.80	-19.70	-10.54	-18.42
	(31.70)	(59.57)	(31.75)	(58.84)	(27.02)	(50.59)	(26.87)	(49.43)	(26.00)	(34.14)	(26.04)	(32.67)
Constant	404.86*	1269.28*	425.38*	-258.69	351.25*	-380.61	545.32***	1116.25***	196.64	78.31	8.54	71.44
	(178.77)	(521.67)	(177.23)	(388.40)	(152.38)	(443.08)	(150.00)	(326.23)	(146.62)	(299.02)	(145.36)	(215.61)
Adjusted R2	0.09	-0.91	0.09	-1.01		-0.76	0.17	-0.80	0.12	0.10	0.12	0.11
F	2.60	1.39	2.58	1.43		2.30	5.25	2.38	3.55	2.82	3.53	2.86

Appendix I - **First Stage Estimated Coefficients and Standard Errors of the region variables for the Sen model**

	CI	CI*
Age	0.00139**	0.002***
	(0.000578)	(0.001)
Religion1	0.0997	0.025
	(0.0791)	(0.089)
Religion2	0.122	0.011
	(0.0800)	(0.090)
Number children	-0.00788*	0.000
	(0.00430)	(0.005)
Pregnant1	-0.0162	-0.005
	(0.0310)	(0.035)
Breastfeeding1	-0.0101	0.001
	(0.0177)	(0.020)
Fcs	-0.00121	-0.002
	(0.00108)	(0.001)
Autonomous to move	-0.0422**	-0.055*
	(0.0209)	(0.023)
Number cell	0.00221	0.016*
	(0.0163)	(0.007)
Owned land	0.00769	0.001
	(0.00667)	(0.000)
Ln value animals	0.00155***	-0.001
	(0.000413)	(0.002)
Monthly salary	-0.000834	-0.000**
	(0.00166)	(0.000)
Barisal [31]	-6.11e-06*	0.009
	(3.37e-06)	(0.018)
Chittagong	-0.0178	-0.020
	(0.0232)	(0.026)
Dhaka	-0.0626***	-0.058*
	(0.0225)	(0.025)
Khulna	-0.0409**	-0.050*
	(0.0183)	(0.021)
Rajshahi	0.00665	0.013
	(0.0215)	(0.024)
Rangpur	0.0103	0.016
	(0.0208)	(0.023)
Barisal [32]	-0.00111	-0.025
	(0.0217)	(0.024)
Instruments		
Asset pre-marriage	1.72e-07	0.000
	(2.27e-07)	(0.000)
Birth control	-0.0180	-0.016
	(0.0128)	(0.014)
Inherited lad	-0.0556***	-0.041
	(0.0206)	(0.023)
Diff education	0.00109	0.004*
	(0.00150)	(0.002)
Mean educ village	0.00290	0.006**
	(0.00188)	(0.002)
Toiletries expenses	-0.00513	0.001
	(0.00979)	(0.011)
Constant	0.237***	0.290**
	(0.0867)	(0.097)

Appendix J - **Estimated Coefficients and Standard Errors for Becker and Sen's model with time disempowerment indicator as disempowerment**

Becker Model				
	Leisure		Non-leisure	
	OLS	**2SLS**	**OLS**	**2SLS**
Time_hat	-211.389***	174.806	234.807***	217.214
	(10.187)	(232.335)	(10.394)	(129.778)
Age	3.274***	3.102***	-3.256***	-3.259***
	(0.359)	(0.517)	(0.366)	(0.364)
Muslim	53.131	36.707	-43.974	-44.018
	(54.850)	(69.964)	(55.963)	(55.588)
Hindu	29.892	-10.349	-23.319	-21.756
	(55.499)	(72.826)	(56.625)	(57.407)
No_children	-9.423**	-5.666	9.492**	9.307**
	(2.967)	(4.117)	(3.027)	(3.301)
Pregnant1	70.002**	76.004**	-75.314***	-75.618***
	(21.476)	(26.118)	(21.911)	(21.879)
Breastfeeding1	-18.830	-6.031	16.856	15.908
	(12.241)	(14.885)	(12.490)	(14.230)
Fcs	1.111	0.642	-1.307	-1.251
	(0.752)	(0.945)	(0.767)	(0.865)
Autonomy to move outside of the community	-22.864	-26.331	20.478	21.386
	(14.350)	(19.943)	(14.641)	(16.002)
Physically abused	13.506	11.294	-15.822	-15.676
	(11.282)	(13.637)	(11.511)	(11.483)
Number of cellphones	2.519	1.869	1.073	0.960
	(4.392)	(5.931)	(4.481)	(4.527)
Owned land	-0.176	-0.547	0.178	0.192
	(0.258)	(0.412)	(0.264)	(0.281)
Value of animal	-5.594***	-5.061***	5.689***	5.658***
	(1.149)	(1.405)	(1.172)	(1.186)
Monthly salary	-0.005*	-0.009**	0.006*	0.006
	(0.002)	(0.003)	(0.002)	(0.004)
Abused	0.000	0.000	0.000	-6.042
	(.)	(.)	(.)	(16.086)
Barisal	4.341	5.559	-6.270	-64.095***
	(15.786)	(19.775)	(16.106)	(16.040)
Chittagong	61.508***	67.781**	-64.457***	-4.235
	(15.608)	(23.545)	(15.924)	(14.596)
Dhaka	10.172	6.224	-5.186	-32.774*
	(12.640)	(18.208)	(12.896)	(16.483)
Khulma	31.884*	20.101	-33.728*	10.464
	(14.717)	(17.763)	(15.015)	(15.817)
Rajshahi	-8.192	-19.817	9.555	-15.344
	(14.145)	(17.094)	(14.432)	(25.830)
Rangpur	16.312	-16.939	-18.183	640.274***
	(15.010)	(18.052)	(15.315)	(61.190)
Constant	319.162***	264.969**	639.087***	
	(59.761)	(89.565)	(60.973)	0.363
Adjusted R2		0.024		12.796
R2	0.341		0.364	
F	34.517		38.205	

Sen Model						
	Unpaid obligatory activities		Paid obligatory activities		Non-obligatory activities	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
Time disempowerment	25.86	-287.91	149.28***	377.970**	-151.72***	-60.991
	(13.20)	(196.47)	(9.77)	(144.789)	(10.78)	(137.953)
Age	-0.02	-0.08	-0.29	-0.249	0.33	0.349
	(0.46)	(0.55)	(0.34)	(0.407)	(0.38)	(0.387)
Muslim	154.86*	154.06	-114.01*	-113.426	-31.70	-31.465
	(71.08)	(84.16)	(52.62)	(62.018)	(58.03)	(59.089)
Hindu	118.59	146.47	-92.68	-112.999	-19.34	-27.397
	(71.92)	(86.91)	(53.25)	(64.047)	(58.72)	(61.023)
Numb of children	6.09	2.78	-2.96	-0.553	-3.06	-2.103
	(3.84)	(5.00)	(2.85)	(3.683)	(3.14)	(3.509)
Pregnant	-66.53*	-71.95*	-2.17	1.790	63.38**	64.949**
	(27.83)	(33.12)	(20.60)	(24.410)	(22.72)	(23.257)
Breastfeeding	38.44*	21.54	-13.54	-1.223	-26.87*	-21.984
	(15.86)	(21.54)	(11.74)	(15.876)	(12.95)	(15.126)
Fcs	-0.03	0.96	-0.22	-0.943	0.06	-0.228
	(0.97)	(1.31)	(0.72)	(0.965)	(0.80)	(0.919)
Autonomy to move	5.94	22.13	5.36	-6.438	-13.69	-18.374
	(18.60)	(24.23)	(13.77)	(17.853)	(15.18)	(17.010)
Physically abused	-12.65	-10.06	5.34	3.456	4.99	4.242
	(14.62)	(17.38)	(10.82)	(12.811)	(11.94)	(12.206)
# of cellular	20.87***	18.87**	-11.02**	-9.555	-6.27	-5.687
	(5.69)	(6.85)	(4.21)	(5.050)	(4.65)	(4.812)
Owned land	0.16	0.41	0.25	0.070	-0.41	-0.485
	(0.33)	(0.43)	(0.25)	(0.314)	(0.27)	(0.299)
Value of animals	2.45	1.90	4.40***	4.802***	-6.76***	-6.600***
	(1.49)	(1.80)	(1.10)	(1.323)	(1.22)	(1.261)
Monthly salary	-0.01***	-0.00	0.02***	0.012**	-0.01*	-0.008
	(0.00)	(0.01)	(0.00)	(0.004)	(0.00)	(0.004)
Barisal [33]	0.00	3.16	0.00	-6.151	0.00	0.992
	(.)	(24.35)	(.)	(17.946)	(.)	(17.099)
Chittagong	-0.92	-67.03**	-3.18	10.125	2.17	53.843**
	(20.46)	(24.28)	(15.14)	(17.895)	(16.70)	(17.050)
Dhaka	-73.48***	-26.26	14.83	5.074	55.71***	25.865
	(20.23)	(22.10)	(14.97)	(16.285)	(16.51)	(15.516)
Khulna	-43.23**	-30.11	17.44	17.814	30.77*	10.141
	(16.38)	(24.95)	(12.13)	(18.389)	(13.37)	(17.521)
Rajshahi	-47.13*	3.00	30.22*	8.665	15.06	-10.590
	(19.07)	(23.95)	(14.12)	(17.646)	(15.57)	(16.813)
Rangpur	-13.22	-16.16	20.48	4.409	-5.90	8.964
	(18.33)	(39.10)	(13.57)	(28.817)	(14.96)	(27.457)
Constant	-66.79***	491.22***	41.31**	161.469*	23.60	305.172***
	(19.45)	(92.64)	(14.40)	(68.267)	(15.88)	(65.044)
Adjusted R2		3.31		7.529		4.799
R2	0.07		0.25		0.18	
F	4.76		21.81			