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Women's Empowerment in Agriculture

What Role for Food Security in Bangladesh?

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ABSTRACT

Women's low status and persistent gender gaps in health and education in South Asia contribute to chronic child malnutrition (Smith et al. 2003) and food insecurity (von Grebmer et al. 2009), even as other determinants of food security, such as per capita incomes, have improved. This is particularly relevant for Bangladesh, where chronic food insecurity continues to be an important issue despite steady advances in food production. To be able to leverage agriculture as an engine of inclusive growth, there is a need to develop indicators for measuring women's empowerment, examine its relationship to various food-security outcomes, and monitor the impact of interventions to empower women.

Using nationally representative survey data from Bangladesh, we examine the relationship between women's empowerment in agriculture and two measures of household food security: per adult equivalent calorie availability and dietary diversity. We use the Women's Empowerment in Agriculture Index to assess the extent of women's empowerment in agriculture and instrumental variables techniques to correct for the potential endogeneity of empowerment. We find that the overall women's empowerment score, the number of groups in which women actively participate, women's control of assets, and a narrowing gap in empowerment between men and women within households are positively associated with calorie availability and dietary diversity.

Keywords: women's empowerment, gender parity, agriculture, food security, South Asia, Bangladesh

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1. INTRODUCTION

While Bangladesh has experienced steady advances in food production thanks to the adoption of agricultural technologies, it has yet to overcome chronic food insecurity. In South Asia, the low status of women and gender gaps in health and education contribute to chronic child malnutrition (Smith et al. 2003) and food insecurity (von Grebmer et al. 2009), even as other determinants of food security, such as per capita incomes, have improved. Renewed interest in agriculture as an engine of inclusive growth and specifically in women's empowerment has highlighted the need to develop indicators for measuring women's empowerment, to examine its relationship to various food-security outcomes, and to monitor the impact of interventions to empower women.

This paper demonstrates how the recently developed Women's Empowerment in Agriculture Index (WEAI) (Alkire et al. 2013) can be used to assess the extent of women's empowerment in agriculture, diagnose areas where gaps in empowerment exist, and examine the extent to which improvements in the underlying indicators in these areas can improve food security in rural Bangladesh. The WEAI is a new survey-based index that uses individual-level data collected from primary male and female respondents within the same households and is similar in construction to the Alkire and Foster (2011) group of multidimensional poverty indexes.

Although it was initially developed as a monitoring and evaluation tool for the US government's Feed the Future programs, the WEAI has broader applicability as a diagnostic tool for policymakers, development organizations, and academics seeking to inform efforts to increase women's empowerment. The WEAI was developed and tested between 2011 and 2012 using three country pilot surveys in Bangladesh, Guatemala, and Uganda (Alkire et al. 2013); this paper is the first effort to calculate the index using a nationally representative survey.

Using nationally representative data from the 2012 Bangladesh Integrated Household Survey (BIHS) conducted by IFPRI, this paper examines the relationship between women's empowerment in agriculture in rural Bangladesh and two measures of food security at the household level: per adult equivalent calorie availability and household dietary diversity. We use five measures of women's empowerment: the aggregate women's empowerment score, based on the five domains of empowerment in agriculture (5DE), as well as four individual indicators derived by decomposing the 5DE to identify in which of the five domains disempowerment is most acute and using the specific indicators that comprise those domains. In addition, we examine whether women's empowerment relative to men, reflected by another component of the WEAI, the Gender Parity Index (GPI), affects household food security. Because empowerment itself is endogenous, we use instrumental variables (IV) regression to examine the relationship between various measures of women's empowerment, women's relative empowerment, and measures of household food security.

We find that increases in women's empowerment scores, as measured by 5DE, increase both calorie availability and household dietary diversity. Empowerment gaps for women in rural Bangladesh are found to be greatest in terms of leadership in the community and control and access to resources. Analyzing these two domains further in terms of their component indicators, we find that the number of groups in which women actively participate and women's greater control of assets are positively associated with both food-security outcomes. Results regarding credit decisionmaking are ambiguous, because seeking credit does not necessarily signify empowerment in the Bangladeshi context, given that wealthier households may be able to self-finance and that microfinance groups target poor women as their clients. We also find that narrowing the gap in empowerment between men and women within households is positively associated with calorie availability and household dietary diversity, consistent with the growing literature arguing that reducing intrahousehold gender inequality contributes positively to household welfare.

Our results also indicate that increasing crop diversity improves dietary diversity, an important finding in Bangladesh, where about 77 percent of the total cropped area is under rice cultivation, implying very little crop diversity (Ahmed et al. 2013). Our findings call for increased investment in agricultural research to enhance the productivity of other food crops, such as pulses, vegetables, and fruits, which would induce farmers to increase their production of these crops.

2. BACKGROUND

Agriculture, Women's Empowerment, and Food Security

Agriculture is closely linked to food security, in that it provides a source of food and nutrients and a broad-based source of income as well as directly influencing food prices (Arimond et al. 2010). Women account for 43 percent of the agricultural labor force in developing countries (FAO 2011b), yet considerable gender bias exists in the agricultural sector, in terms of quantities of assets, agricultural inputs, and resources that women control (see Agarwal [1994] on land in South Asia; Deere et al. [2013] on assets; and Peterman, Behrman, and Quisumbing [2010] on nonland inputs) as well as returns to those inputs (Kilic, Palacios-Lopez, and Goldstein 2013).

In Bangladesh, although the number of women in the agricultural labor force is increasing (Asaduzzaman 2010), women still tend to be "invisible" in the sector, owing to the commonly held view that women are not involved in agricultural production, especially outside the house, because of cultural norms that value female seclusion and undervalue female labor (Kabeer 1994; Rahman 2000). However, women in poor households, who are at greater risk of being food-insecure, are more likely to be involved in the agricultural sector, particularly as wage laborers, because women's earnings are important to their families' subsistence. Zaman (1995) provides evidence that the gender division of labor in agriculture is not as strictly demarcated as assumed, with women being involved in agricultural work both inside and outside the household. Rahman (2010) shows that female agricultural labor contributes significantly to productivity as well as technical efficiency, but finds, similar to Zaman (1995), that gender bias exists in the agricultural labor market. Remunerative employment of labor remains skewed in favor of men, since female labor is engaged only when the male labor supply is exhausted. Women's ability to generate income in the agricultural sector is also severely constrained by their lack of access to productive assets.

The rationale for examining gender inequality in agriculture is rooted in a body of empirical evidence that demonstrates the ways in which women are essential to improvements in household agricultural productivity, food security, and nutrition security. Considerable evidence exists that households do not act in a unitary manner when making decisions or allocating resources (Alderman et al. 1995; Haddad, Hoddinott, and Alderman 1997). This means that men and women within households do not *always* have the same preferences nor pool their resources. The nonpooling of agricultural resources within the household creates a gender gap in the control of agricultural inputs, which has important implications for productivity. Several empirical studies have found that redistributing inputs between men and women in the household has the potential to increase productivity (Udry et al. 1995; Peterman, Behrman, and Quisumbing 2010; Kilic, Palacios-Lopez, and Goldstein 2013). A growing body of empirical evidence suggests that increasing women's control over resources has positive effects on a number of important development outcomes. For *Côte d'Ivoire*, Hoddinott and Haddad (1995) and Duflo and Udry (2004) find that increasing women's share of cash income significantly increases the share of household budget allocated for food. Doss (2006) shows that in Ghana, women's share of assets, particularly farmland, significantly increases budget shares allocated for food.

Considerable evidence also suggests that mothers' greater control over resources improves child outcomes, in particular nutrition and education (Hallman 2003; Quisumbing 2003; Quisumbing and Maluccio 2003; Skoufias 2005). Although much of the above-mentioned evidence has emerged from observational studies, a systematic review of programs targeting transfers to women (Yoong, Rabinovich, and Diepeveen 2012) has found that these programs improve children's well-being, especially in the form of investments in children's health and education.

The linkages between women's empowerment and food security have been more difficult to quantify, owing to the difficulty of measuring empowerment. Kabeer (1999) defines empowerment as expanding people's ability to make strategic life choices, particularly in contexts in which this ability had been denied to them. In Kabeer's definition, the ability to exercise choice encompasses three dimensions: resources, agency, and achievements (well-being outcomes). The WEAI focuses on the "agency" aspect, as it is far less studied than resources such as income, or achievements such as educational levels.

Moreover, while nationally representative surveys such as some demographic and health surveys (DHS) include a range of questions about decisionmaking within the household, these are typically confined to the domestic sphere and do not encompass decisions in the productive and economic spheres, nor do the surveys have identical questions for men and women (Alkire et al. 2013). The WEAI also covers new ground in that it captures control over resources, or agency, within the agricultural sector, something which existing indexes have not done.

Measuring Women's Empowerment Using the WEAI

The WEAI is an aggregate index, reported at the country or regional level, which is based on individual-level data on men and women within the same households. The two sub-indexes of the WEAI are (1) the five domains of women's empowerment (5DE) and (2) gender parity (the GPI).[1]

The 5DE sub-index shows how empowered women are, capturing the roles and extent of women's engagement in the agricultural sector in five domains: (1) decisions over agricultural production, (2) access to and decisionmaking power over productive resources, (3) control over use of income, (4) leadership in the community, and (5) time use. It assesses the degree to which women are empowered in these domains, and for those who are not empowered, the percentage of domains in which they are empowered.[2]

The GPI reflects the percentage of women who are as equally empowered as the men in their households. For those households that have not achieved gender parity, the GPI shows the empowerment gap that needs to be closed for women to reach the same level of empowerment as men. Using a survey method that goes beyond the traditional practice of interviewing only a household "head" (often a male) to interview both a principal male and principal female, the GPI permits the comparison of the agricultural empowerment of men and women living in the same household.

Both measures taken together make up the WEAI. The aggregate index therefore shows the degree to which women are empowered in their households and communities and the degree of inequality between women and men in their households. Details regarding the construction and validation of the index can be found in Alkire et al. (2013). In this paper, we use individual measures of 5DE and its component indicators to investigate the relationship between women's empowerment in agriculture and food security; additionally, we examine the relationship between inequality in empowerment and food security in dual-adult households.

[1] This description draws from Alkire et al. (2013).

[2] "Empowerment" within a domain means that the person has adequate achievements or has "achieved adequacy" for that domain.

3. DATA, EMPIRICAL SPECIFICATIONS, AND VARIABLES

Data

The BIHS, designed and supervised by researchers at IFPRI, was conducted from December 2011 to March 2012. The BIHS sample is nationally representative of rural Bangladesh and representative of rural areas of each of the seven administrative divisions of the country. To estimate the total sample size of 5,500 households in 275 primary sampling units (PSUs), BIHS followed a stratified sampling design in two stages—selection of PSUs and selection of households within each PSU—using the sampling frame developed from the community series of the 2001 population census. In the first stage, a total sample of 275 PSUs were allocated among the seven strata (seven divisions) with probability proportional to the number of households in each stratum. Sampling weights were adjusted using the sampling frame of the 2011 population census.

The WEAI relies on information collected from both primary male and female adults in the household, and thus our estimation samples depend on valid responses from these household members. For the analysis using women's 5DE alone, we use data from the self-identified primary female adult. We dropped 1,072 observations because the primary female respondent was either unavailable on the day of the interview or did not respond to all the WEAI survey questions. We dropped 227 observations because a female other than the primary female was interviewed, and 9 additional cases because of possible data entry errors in the demographic data. Our final estimation sample consists of 4,195 households. In examining women's relative empowerment within the household, we restrict the analyses to households where both the primary male and female decisionmakers were interviewed, reducing our sample size to 3,944 households.

The BIHS questionnaires include several modules that provide an integrated data platform to answer a variety of research questions, as well as separate questionnaires for self-identified primary male and female decisionmakers in sampled households. Our study relied primarily on information concerning household demographics, educational attainment, occupation and employment, food and nonfood consumption and expenditures, household-level agricultural production and livestock holding, household assets, housing and amenities, community infrastructure and facilities, and a detailed module on the WEAI.

Empirical Specification

To examine the relationship between women's empowerment in agriculture and household food security, we estimate the following equation:

$$f = \beta_0 + \beta_1\, empowerment + \beta_2 h + \beta_3 c + \varepsilon, \quad (1)$$

where f is a vector of food-security outcomes, β_1 are coefficients to be estimated, h is a vector of household-level characteristics, c is a vector of community or village characteristics, and ε is an error term. We use two measures of women's empowerment in alternative specifications. In the first main specification, estimated for the full estimation sample, our measure of empowerment is the 5DE score; in the second main specification, estimated for a subsample of households in which we have both men's and women's empowerment scores, our measure of empowerment consists of the GPI, a measure of women's relative empowerment within the household. Because it is likely that women's empowerment within the household might be affected by the same factors affecting the availability of food and dietary diversity, we apply standard IV techniques to correct for potential endogeneity bias, using the ivreg2 procedure in Stata12 (Baum, Schaffer, and Stillman 2010; StataCorp 2011).

Outcome Variables

Per adult equivalent calorie availability: Food consumption data, covering around 300 food items, were collected at the household level. The data capture quantities consumed from market purchases, home production, and other sources outside the house, for example, relatives, government or nongovernment aid, or food received in exchange for labor. Agricultural seasonality is of concern when working with food consumption data, since lack of labor market activities during the lean season might affect household income, food expenditure, and consequently food consumption. The survey period, however, does not coincide with any of the two lean seasons prevalent in Bangladesh, thus allaying concerns about seasonality. The seven-day data were converted to daily calorie equivalents, and the resulting calorie values were divided by the number of adult equivalents in a household in order to obtain daily per adult equivalent calorie availability values (Ahmed and Shams 1994).

Household dietary diversity: Several studies have demonstrated a strong association between dietary diversity and household food security (Hoddinott and Yohannes 2002; Hatloy et al. 2000). Household dietary diversity is defined as the count of food groups consumed using the seven-day recall household food consumption data. Food was grouped into 12 categories: cereals; white tubers and roots; vegetables; fruits; meat; eggs; fish and other seafood; legumes and nuts; milk and milk products; oils and fats; sweets; and spices, condiments, and beverages (FAO 2011a).

Key Independent Variables

Women's Empowerment in Agriculture Index: To measure women's empowerment in agriculture, we use the WEAI, computed using individual-level data collected from primary male and female respondents within the same households. This section focuses on the 5DE component of the WEAI; the GPI is discussed in Section 4.

Table 3.1 presents the five domains, which comprise 10 indicators. Each domain is weighted equally, as are each of the indicators within a domain. The 5DE sub-index is a measure of empowerment that shows the number of domains in which women are empowered. A woman is defined as empowered in 5DE if she has adequate achievements in four of the five domains or is empowered in some combination of the weighted indicators that reflect 80 percent total adequacy. The five domains of empowerment are defined as follows:

Production: This domain concerns decisions over agricultural production and refers to sole or joint decisionmaking over food and cash-crop farming, livestock, and fisheries as well as autonomy in agricultural production.

Resources: This domain concerns ownership, access to, and decisionmaking power over productive resources such as land, livestock, agricultural equipment, consumer durables, and credit.

Income: This domain concerns sole or joint control over the use of income and expenditures.

Leadership: This domain concerns leadership in the community, here measured by membership in economic or social groups and comfort at speaking in public.

Time: This domain concerns the allocation of time to productive and domestic tasks and satisfaction with the available time for leisure activities.

Table 3.1 The five domains of empowerment in the WEAI

Domain	Indicator	Definition of Indicator	Weight
Production	Input in productive decisions	Sole or joint decisionmaking over food and cash-crop farming, livestock, and fisheries	1/10
	Autonomy in production	Autonomy in agricultural production (that is, what inputs to buy, what crops to grow, what livestock to raise, and so on); reflects the extent to which the respondent's motivation for decisionmaking reflects his or her values rather than a desire to please others or avoid harm	1/10
Resources	Ownership of assets	Sole or joint ownership of major household assets	1/15
	Purchase, sale, or transfer of assets	Whether respondent participates in decision to buy, sell, or transfer his or her owned assets	1/15
	Access to and decisions on credit	Access to and participation in decisionmaking concerning credit	1/15
Income	Control over use of income	Sole or joint control over income and expenditures	1/5
Leadership	Group member	Whether respondent is an active member in at least one economic or social group (for example, agricultural marketing, credit, water users' groups)	1/10
	Speaking in public	Whether the respondent is comfortable speaking in public concerning various issues such as intervening in a family dispute, ensuring proper payment of wages for public work programs, and so on	1/10
Time	Workload	Allocation of time to productive and domestic tasks	1/10
	Leisure	Satisfaction with the available time for leisure activities	1/10

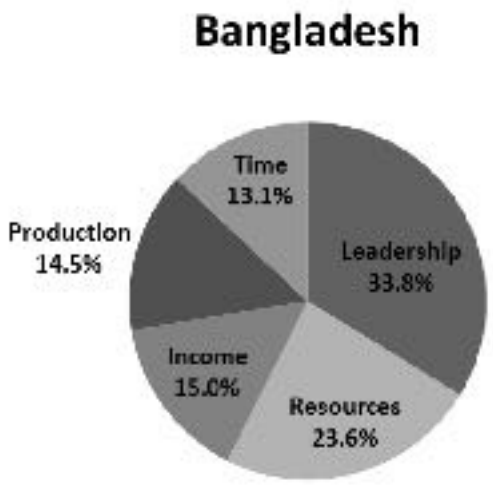
Source: Alkire et al. (2013).

A key innovation of the index is that it identifies the domains in which women are disempowered as well as the relative degree of disempowerment. Figure 3.1 shows that the *leadership* and *resources* domains contribute most to women's disempowerment in rural Bangladesh, while Figure 3.2 shows the contribution of each domain indicator. We use this information to identify the key domains, and indicators within each key domain, on which to focus our analysis. *Group membership* emerges as the indicator that contributes most to disempowerment in the leadership domain and *access to and decisions on credit* as the most critical indicator for the resources domain. The credit indicator, however, may be problematic, since it is not clear whether nonborrowers are truly credit constrained (they may not avail of credit because they have sufficient liquidity). In light of this issue, we also analyze the two other indicators for the resources domain, namely, *asset ownership* and *rights over assets*. Based on this information, we use the following alternative measures of empowerment:

Aggregate empowerment score of primary female respondent is the 5DE empowerment score of the female respondent in the household, which is the weighted average of her achievements in the 10 indicators that comprise the five domains of empowerment in agriculture. This measure is increasing in empowerment, and ranges from 0 to 1.

(*Leadership domain, group membership indicator*) *Number of groups in which woman is an active member* is the total number of groups in which the female respondent reports being an active member.

Figure 3.1 Contribution of each of the five domains to the disempowerment of women



Source: Sraboni, Quisumbing, and Ahmed (2013).

(Resources domain, access to and decisions on credit indicator) Average number of decisions, concerning credit, taken by female is the number of credit decisions that the female respondent has made solely or jointly, averaged over the lending sources used. For each of the five possible lending sources (nongovernmental organization [NGO], informal, formal, friends and family, and rotating savings and credit association), the survey asks who made the decision to borrow and who made the decision on how to use the money or item borrowed.

(*Resources domain, asset ownership indicator*) *Number of assets woman has sole or joint ownership of* is the total number of asset types for which the female respondent reports sole or joint ownership.

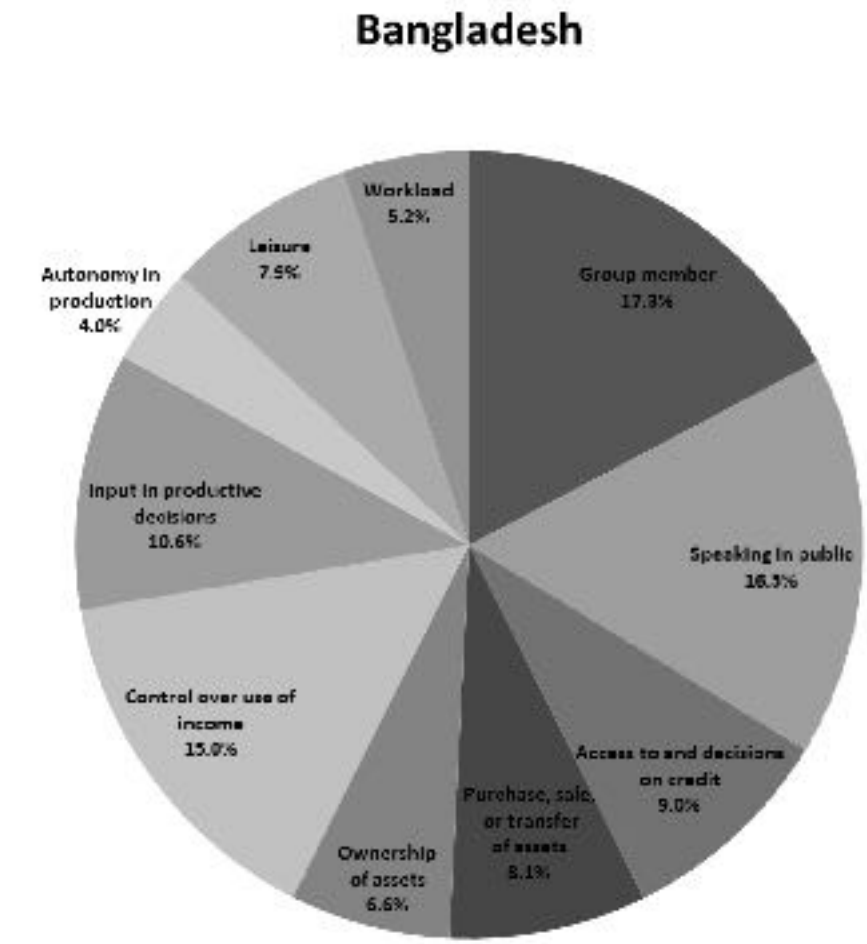
(*Resources domain, rights over assets indicator*) *Number of sole or joint decisions, concerning purchase, sale, or transfer of assets, taken by woman* is the total number of decisions made solely or jointly by the female respondent, summed over all asset types. For each asset type, the survey asks who can decide whether to sell, give away, mortgage or rent, or purchase the asset.

Instruments

We use the difference in ages between the primary male and female decisionmakers, and number of types of informal credit sources in the village, as instruments for all the empowerment indicators. The survey collected information on whether the following types of informal credit sources are present in the community: moneylender within or outside village, shopkeepers who offer credit, agricultural input dealers who sell on credit, and large farmers or traders who buy crops at a fixed forward price. We do not include formal credit sources, because obtaining credit from these sources typically requires collateral (which could be correlated with household wealth and could directly affect the outcomes being considered), or NGOs, because obtaining credit from NGOs is membership-based. The existence of a large number of informal credit sources could be indicative of both greater social capital within the community, which could influence a woman's decision to actively participate in a group, and the size of the informal credit market. The availability of a large pool of funds could thus facilitate decisionmaking concerning credit, and accumulation of assets by the borrowers. The differences in ages can reflect differences in human capital between the primary female and her spouse, and therefore reflect relative bargaining strengths (Quisumbing and Hallman 2005).[3]

[3] For households where information on the woman's spouse was not available (in female-headed households where the male

Figure 3.2 Contribution of each of the 10 domain indicators to disempowerment of women



Source: Sraboni, Quisumbing, and Ahmed (2013).

We also instrument empowerment scores as well as group membership using information on the number of community activities the woman participated in during the previous year; a woman who is more active in the community is more likely to be an active participant in groups. The survey collected information on whether the woman was involved in the following community activities during the last year: (1) contribution of money or time to building/maintenance of small wells and irrigation facilities, (2) contribution of money or time to building/maintenance of communal roads, (3) contribution of money or time to building/maintenance of local mosques/churches/temples, (4) contribution of money or time to development projects, (5) contribution of money to other families having one or more sick members, (6) helping out other families with agricultural labor, and (7) helping out other families with childcare. The difference in recall period implies that the decision to participate in the mentioned activities was already given (exogenous) prior to the current decision to join (or maintain membership in) a group.

An additional variable, whether the homestead land has been inherited by the woman, is used to instrument for both ownership of and rights over assets. Inherited assets have been previously used as a bargaining measure in the literature (Quisumbing 1994; Quisumbing and Maluccio 2003). While inherited land is arguably endogenous, inherited homestead land is much less likely to be correlated with the error term.

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spouse is a migrant or the female is widowed or separated), we considered the age difference to be zero.

Other Independent Variables

Other independent variables include age, age squared, years of schooling of the household head,[4] household size, and proportion of males and females in various age groups (with males aged 60 and above as the excluded category). The occupation of the household head is accounted for using dummy variables for two types of primary occupation: farming and trading. We also include the price of rice as a control variable, since rice is the staple food in Bangladesh, accounting for a fifth of all spending of an average rural household, 35 percent of food expenditure, and 71 percent of total calorie intake (Ahmed et al. 2013). The number of dairy cows owned by a household is expected to affect the food-security outcomes through the pathway of production and consumption of milk and milk products, as well as household wealth. Three other variables are used as indicators of the socioeconomic status of the household: the amount, in decimals,[5] of cultivable land owned by the household; a dummy for whether the household has access to electricity; and a dummy for whether it owns at least one tube well.

We also include diversity in food crop production (that is, the total number of food crops produced by the household) as a regressor; if households consume some of the food that they produce, then more diverse agricultural production is expected to increase dietary diversity at the household level. A change in the total number of food crops produced may also alter the calorie availability of producer households through explicit or implicit change in household income. A household's crop production decisions may be affected by the same factors that influence its calorie availability and dietary diversity, which could lead to endogeneity bias in our analysis. We use the following instruments at the farm level to identify food crop production diversity: (1) whether or not the soil type is clay-loam, (2) whether or not the soil type is sandy-loam, and (3) the percentage of cropped land that is irrigated. Finally, division dummies are included to control for location-specific effects. Summary statistics of all the variables used are presented in Table 3.2.

Table 3.2 Summary statistics

Variable	Obs.	Mean	Standard deviation	Min.	Max.
Dependent variables					
Per adult equivalent calorie availability	4,195	3,138	804.51	1,185.94	9,529.97
Household dietary diversity	4,195	9.55	1.59	4	12
Empowerment variables					
Empowerment score of woman	4,195	0.65	0.24	0.07	1
Number of groups woman is an active member of	4,195	0.32	0.49	0	3
Average number of decisions over credit	4,195	0.95	0.98	0	2
Number of assets woman has self/joint ownership of	4,195	1.90	1.51	0	10
Number of self/joint decisions over purchase, sale, or transfer of assets made by woman	4,195	11.15	9.49	0	48
Gender parity gap	3,944	0.39	0.49	0	1
Other controls					
Age (in years) of household head	4,195	44.74	13.49	20	95
Age squared of household head	4,195	2,183.54	1,318.87	400	9,025
Years of education of household head	4,195	3.20	3.96	0	16
Household head is farmer (=1, 0 otherwise)	4,195	0.25	0.43	0	1
Household head is trader (=1, 0 otherwise)	4,195	0.12	0.32	0	1
Household size	4,195	4.30	1.53	2	17

[4] The *household head* is the self-identified primary decisionmaker (in most cases, male) in the sample household.
[5] 100 decimals = 1 acre.

Table 3.2 Continued

Variable	Obs.	Mean	Standard deviation	Min.	Max.
Proportion of males 0–4 years old	4,195	0.05	0.10	0.00	0.60
Proportion of males 5–10 years old	4,195	0.07	0.12	0.00	0.60
Proportion of males 11–18 years old	4,195	0.07	0.12	0.00	0.67
Proportion of males 19–59 years old	4,195	0.25	0.13	0.00	0.75
Proportion of females 0–4 years old	4,195	0.05	0.10	0.00	0.60
Proportion of females 5–10 years old	4,195	0.07	0.12	0.00	0.50
Proportion of females 11–18 years old	4,195	0.07	0.12	0.00	0.60
Proportion of females 19–59 years old	4,195	0.28	0.12	0.00	0.75
Proportion of females 60 years and older	4,195	0.04	0.10	0.00	0.67
Number of food crops produced by household	4,195	1.08	1.36	0	11
Number of dairy cows owned	4,195	0.62	1.12	0	9
Price of rice (in taka)	4,195	30.19	3.61	20	55
Ln (owned cultivable land+1)	4,195	0.68	1.52	0.00	6.98
Access to electricity (=1, 0 otherwise)	4,195	0.47	0.50	0	1
Owns hand tube well (=1, 0 otherwise)	4,195	0.25	0.43	0	1
Division dummy 1	4,195	0.06	0.23	0	1
Division dummy 2	4,195	0.13	0.34	0	1
Division dummy 3	4,195	0.29	0.46	0	1
Division dummy 4	4,195	0.13	0.34	0	1
Division dummy 5	4,195	0.18	0.38	0	1
Division dummy 6	4,195	0.15	0.36	0	1
Instruments					
Age difference (male–female)	4,195	8.07	4.76	-15	40
Types of informal credit sources in village	4,195	2.34	1.50	0	5
Whether female has participated in any community activity during last year (=1, 0 otherwise)	4,195	0.47	0.50	0	1
Number of community activities woman has participated in during last year	4,195	0.85	1.17	0	7
Whether homestead land has been inherited by woman (=1, 0 otherwise)	4,195	0.03	0.18	0	1
Clay-loam soil (=1, 0 otherwise)	4,195	0.24	0.43	0	1
Sandy-loam soil (=1, 0 otherwise)	4,195	0.16	0.36	0	1
Percent of land irrigated by household	4,195	39.66	42.32	0	100

Source: IFPRI Bangladesh Integrated Household Survey, 2011–2012.

Notes: Obs. = observed; Min. = minimum; Ma. = maximum.

Per adult equivalent calorie availability is obtained by converting seven-day food consumption data collected at the household level to daily calorie equivalents, and then dividing resulting calorie values were divided by the number of adult equivalents in a household (Ahmed and Shams 1994). *Household dietary diversity* is the count of food groups consumed using the seven-day recall household food consumption data. Food was grouped into 12 categories: cereals; white tubers and roots; vegetables; fruits; meat; eggs; fish and other seafood; legumes and nuts; milk and milk products; oils and fats; sweets; and spices, condiments, and beverages (FAO 2011a). *Empowerment score of the woman* is the 5DE empowerment score of the female respondent in the household, which is the weighted average of her achievements in the 10 indicators that comprise the five domains of empowerment in agriculture. This measure is increasing in empowerment, and ranges from 0 to 1. *Gender parity gap* is defined as the difference in the male and female empowerment scores for households where the female score is less than the male score. The gender parity gap is zero if the woman is empowered or her empowerment score is greater than or equal to that of the male in her household.

4. RESULTS

Women's Empowerment and Food Security

Tables 4.1–4.5 present the ordinary least squares (OLS) and IV regression results for the determinants of household food security. IV diagnostics are presented at the end of each table. The Anderson-Rubin test results imply that the endogenous variables are relevant. The overidentification and under-identification test results confirm that the instruments are valid and the models identified. The Kleibergen-Paap F-statistics show that the null hypothesis for weak instruments is rejected at the 5 percent (Tables 4.1, 4.4, and 4.5) and 10 percent level thresholds (Table 4.2). However, the F-statistic in Table 4.3 fails to exceed the critical value of 4.79, which is associated with a bias relative to OLS of less than 30 percent (Stock and Yogo 2005). This suggests that the instruments used for women's decisions on credit may be weak.

Columns 1 and 3 of Table 4.1 present the OLS coefficient estimates of the determinants of per adult equivalent calorie availability and household dietary diversity, respectively. These estimates show that the female empowerment score is highly significant and positively correlated with both per adult equivalent calorie availability and dietary diversity at the household level. In columns 2 and 4, after instrumenting for both potentially endogenous variables (empowerment and food crop production), the estimates show a similar pattern, with the IV estimates being larger than the OLS estimates. These results, together with the good performance of the instruments in general, suggest that household diet diversity and calorie availability increase if the primary female decisionmaker is more empowered; the larger IV coefficients suggest that neglecting endogeneity of empowerment may underestimate the impact of increasing women's empowerment on these food-security outcomes.

Table 4.1 Women's empowerment scores and household food-security outcomes

	Per adult equivalent calorie availability		Household dietary diversity	
	OLS	2SLS	OLS	2SLS
Variable	(1)	(2)	(3)	(4)
Empowerment score of woman	283.655***	1,133.135***	0.504***	2.074***
	(54.124)	(197.971)	(0.107)	(0.376)
Age (in years) of household head	21.125***	15.059**	-0.016	-0.029**
	(6.900)	(7.375)	(0.013)	(0.014)
Age squared of household head	-0.176**	-0.115	0.000	0.000**
	(0.075)	(0.081)	(0.000)	(0.000)
Years of education of household head	11.943***	13.057***	0.074***	0.075***
	(3.588)	(3.673)	(0.006)	(0.007)
Household head is farmer (=1, 0 otherwise)	129.948***	138.533***	0.215***	0.171**
	(33.079)	(42.577)	(0.062)	(0.077)
Household head is trader (=1, 0 otherwise)	26.398	1.468	0.498***	0.462***
	(35.909)	(37.666)	(0.073)	(0.076)
Household size	-105.370***	-99.942***	0.078***	0.084***
	(10.349)	(10.821)	(0.018)	(0.020)
Proportion of males 0–4 years old	-758.544***	-803.255***	0.593	0.547
	(232.427)	(241.790)	(0.420)	(0.434)
Proportion of males 5–10 years old	-903.854***	-990.638***	0.459	0.322
	(217.761)	(226.289)	(0.374)	(0.388)
Proportion of males 11–18 years old	-990.073***	-1,069.477***	0.171	0.031
	(213.427)	(221.066)	(0.373)	(0.384)
Proportion of males 19–59 years old	-1,313.033***	-1,307.468***	0.559**	0.565*
	(179.218)	(183.990)	(0.283)	(0.293)

Table 4.1 Continued

	Per adult equivalent calorie availability		Household dietary diversity	
	OLS	2SLS	OLS	2SLS
Variable	**(1)**	**(2)**	**(3)**	**(4)**
Proportion of females 0–4 years old	-885.690***	-869.089***	0.629	0.701
	(228.888)	(237.256)	(0.420)	(0.433)
Proportion of females 5–10 years old	-465.520**	-574.674**	0.579	0.387
	(223.544)	(231.496)	(0.384)	(0.397)
Proportion of females 11–18 years old	-354.555	-489.436**	0.770**	0.514
	(230.958)	(238.271)	(0.386)	(0.402)
Proportion of females 19–59 years old	-615.654**	-713.747***	1.036**	0.865*
	(258.171)	(265.924)	(0.448)	(0.465)
Proportion of females 60 years and older	-68.111	-123.622	0.391	0.313
	(286.197)	(294.660)	(0.465)	(0.482)
Number of food crops produced by household	50.706***	32.405	0.073***	0.100*
	(11.048)	(26.417)	(0.019)	(0.051)
Number of dairy cows owned	62.499***	51.176***	0.123***	0.089***
	(12.868)	(14.094)	(0.023)	(0.025)
Price of rice (in taka)	-3.262	0.686	0.029***	0.036***
	(3.956)	(4.129)	(0.008)	(0.008)
Ln (owned cultivable land+1)	37.528***	38.595***	0.045***	0.048***
	(9.652)	(9.872)	(0.016)	(0.016)
Owns hand tube well (=1, 0 otherwise)	130.895***	61.002*	0.284***	0.142**
	(30.354)	(33.583)	(0.056)	(0.063)
Access to electricity (=1, 0 otherwise)	7.089	-21.754	0.416***	0.362***
	(25.487)	(27.115)	(0.050)	(0.053)
Division-level fixed effects	Yes	Yes	Yes	Yes
Constant	3,820.881***	3,382.509***	7.111***	6.312***
	(240.298)	(263.754)	(0.455)	(0.506)
Observations	4,195	4,195	4,195	4,195
F	23.777	23.013	34.287	32.838
Adjusted R^2	0.191	0.140	0.179	0.130
Hansen J p, Ho: instruments valid		0.642		0.181
Under ID test p, Ho: under identified		0.000		0.000
Weak ID test stat (Kleibergen-Paaprk Wald F)		49.480		49.480
Anderson-Rubin, Ho: endogvars irrelevant				
A-R Wald test, p-value		0.000		0.000
A-R Wald chi^2 test, p-value		0.000		0.000

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011–2012.

Notes: OLS = ordinary least squares; 2SLS = two-stage least squares.

Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Per adult equivalent calorie availability* is obtained by converting seven-day food consumption data collected at the household level to daily calorie equivalents, and then dividing resulting calorie values were divided by the number of adult equivalents in a household (Ahmed and Shams 1994). *Household dietary diversity* is the count of food groups consumed using the seven-day recall household food consumption data. Food was grouped into 12 categories: cereals; white tubers and roots; vegetables; fruits; meat; eggs; fish and other seafood; legumes and nuts; milk and milk products; oils and fats; sweets; and spices, condiments, and beverages (FAO 2011a). *Empowerment score of the woman* is the 5DE empowerment score of the female respondent in the household, which is the weighted average of her achievements in the 10 indicators that comprise the five domains of empowerment in agriculture. This measure is increasing in empowerment, and ranges from 0 to 1.

Moving on to the individual indicators, in Table 4.2 we find that women's group membership is positively and significantly correlated with both per adult equivalent calorie availability and dietary diversity. This implies that increasing the number of groups in which women actively participate has a positive impact on household food-security outcomes. In Table 4.3, the OLS coefficient estimates (columns 1 and 3) for women's decisionmaking concerning credit are insignificant, but IV estimates emerge as positive and significant, suggesting that women's decisionmaking concerning credit is significant and positively correlated with the food-security outcomes (columns 2 and 4). Since the weak-identification test results suggest that the instruments used for this particular model are weak, we take these results with caution. An underlying problem with using decisions on credit as an indicator of empowerment in this context is that wealthier people may not need to avail of credit (because they can self-finance) and that many microfinance activities are targeted to poorer women in Bangladesh.

Table 4.2 Women's group membership and household food-security outcomes

	Per adult equivalent calorie availability		Household dietary diversity	
	OLS	2SLS	OLS	2SLS
Variable	(1)	(2)	(3)	(4)
Number of groups woman is an active member of	42.061	1,075.849***	0.124**	1.970***
	(26.111)	(224.583)	(0.050)	(0.421)
Age (in years) of household head	22.702***	10.795	-0.014	-0.037**
	(6.875)	(8.362)	(0.013)	(0.016)
Age squared of household head	-0.192**	-0.055	0.000	0.000**
	(0.075)	(0.091)	(0.000)	(0.000)
Years of education of household head	11.813***	17.390***	0.074***	0.083***
	(3.607)	(4.393)	(0.006)	(0.008)
Household head is farmer (=1, 0 otherwise)	133.802***	268.762***	0.228***	0.411***
	(33.238)	(60.763)	(0.062)	(0.110)
Household head is trader (=1, 0 otherwise)	32.306	-21.804	0.506***	0.419***
	(36.208)	(48.862)	(0.073)	(0.091)
Household size	-107.334***	-113.165***	0.074***	0.060***
	(10.435)	(12.820)	(0.018)	(0.022)
Proportion of males 0–4 years old	-754.139***	-994.482***	0.590	0.196
	(232.482)	(275.634)	(0.420)	(0.495)
Proportion of males 5–10 years old	-884.360***	-1,105.770***	0.483	0.111
	(217.738)	(257.112)	(0.375)	(0.446)
Proportion of males 11–18 years old	-975.276***	-1,260.042***	0.184	-0.319
	(213.447)	(252.523)	(0.374)	(0.441)
Proportion of males 19–59 years old	-1,318.719***	-1,415.040***	0.544*	0.368
	(179.175)	(201.151)	(0.283)	(0.330)
Proportion of females 0–4 years old	-895.775***	-986.462***	0.607	0.485
	(229.129)	(270.023)	(0.420)	(0.484)
Proportion of females 5–10 years old	-439.143**	-682.098***	0.614	0.190
	(223.162)	(259.014)	(0.383)	(0.449)
Proportion of females 11–18 years old	-326.156	-738.897***	0.801**	0.057
	(231.384)	(273.480)	(0.386)	(0.473)
Proportion of females 19–59 years old	-588.815**	-728.778**	1.077**	0.837
	(258.257)	(292.920)	(0.448)	(0.513)
Proportion of females 60 years and older	-56.537	-215.056	0.404	0.145
	(286.336)	(324.585)	(0.465)	(0.537)
Number of food crops produced by household	54.931***	39.311	0.081***	0.111*
	(11.122)	(30.553)	(0.019)	(0.057)

Table 4.2 Continued

	Per adult equivalent calorie availability		Household dietary diversity	
	OLS	2SLS	OLS	2SLS
Variable	**(1)**	**(2)**	**(3)**	**(4)**
Number of dairy cows owned	67.246***	84.110***	0.132***	0.149***
	(12.871)	(17.132)	(0.023)	(0.030)
Price of rice (in taka)	-4.167	6.217	0.027***	0.046***
	(3.970)	(5.178)	(0.008)	(0.010)
Ln (owned cultivable land+1)	38.024***	59.500***	0.047***	0.087***
	(9.671)	(12.012)	(0.016)	(0.021)
Owns hand tube well (=1, 0 otherwise)	149.651***	30.234	0.312***	0.086
	(30.249)	(42.483)	(0.056)	(0.078)
Access to electricity (=1, 0 otherwise)	15.288	-19.932	0.428***	0.366***
	(25.607)	(31.863)	(0.050)	(0.060)
Division-level fixed effects	Yes	Yes	Yes	Yes
Constant	3,967.969***	3,990.729***	7.374***	7.425***
	(240.211)	(282.739)	(0.455)	(0.526)
N	4,195	4,195	4,195	4,195
F	22.935	18.350	33.353	25.647
Adjusted R^2	0.186	-0.154	0.176	-0.126
Hansen J p, Ho: instruments valid		0.358		0.963
Under ID test p, Ho: under identified		0.000		0.000
Weak ID test stat (Kleibergen-Paaprk Wald F)		10.650		10.650
Anderson-Rubin, Ho: endogvars irrelevant				
A-R Wald test, p-value		0.000		0.000
A-R Wald chi^2 test, p-value		0.000		0.000

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011–2012.

Notes: OLS = ordinary least squares; 2SLS = two-stage least squares.

Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Per adult equivalent calorie availability* is obtained by converting seven-day food consumption data collected at the household level to daily calorie equivalents, and then dividing resulting calorie values were divided by the number of adult equivalents in a household (Ahmed and Shams 1994). *Household dietary diversity* is the count of food groups consumed using the seven-day recall household food consumption data. Food was grouped into 12 categories: cereals; white tubers and roots; vegetables; fruits; meat; eggs; fish and other seafood; legumes and nuts; milk and milk products; oils and fats; sweets; and spices, condiments, and beverages (FAO 2011a).

Table 4.3 Women's decisions on credit and household food-security outcomes

	Per adult equivalent calorie availability		Household dietary diversity	
	OLS	2SLS	OLS	2SLS
Variable	**(1)**	**(2)**	**(3)**	**(4)**
Average number of decisions over credit	-2.090 (12.455)	761.715*** (239.890)	-0.021 (0.025)	0.700* (0.366)
Age (in years) of household head	23.274*** (6.890)	-4.578 (12.861)	-0.012 (0.013)	-0.041** (0.019)
Age squared of household head	-0.198*** (0.075)	0.103 (0.139)	0.000 (0.000)	0.000** (0.000)
Years of education of household head	11.563*** (3.598)	21.814*** (6.119)	0.073*** (0.006)	0.082*** (0.009)
Household head is farmer (=1, 0 otherwise)	128.207*** (33.317)	302.020*** (88.001)	0.208*** (0.062)	0.277** (0.132)
Household head is trader (=1, 0 otherwise)	34.632 (36.198)	-34.892 (57.918)	0.514*** (0.073)	0.465*** (0.088)
Household size	-107.126*** (10.410)	-86.672*** (16.386)	0.074*** (0.018)	0.087*** (0.023)
Proportion of males 0–4 years old	-743.008*** (232.396)	-1,319.234*** (369.748)	0.634 (0.422)	0.148 (0.544)
Proportion of males 5–10 years old	-874.354*** (217.739)	-1,291.468*** (321.904)	0.521 (0.376)	0.164 (0.465)
Proportion of males 11–18 years old	-962.289*** (213.560)	-1,488.979*** (329.195)	0.232 (0.375)	-0.255 (0.484)
Proportion of males 19–59 years old	-1,314.386*** (179.205)	-1,455.650*** (232.740)	0.560** (0.283)	0.419 (0.322)
Proportion of females 0–4 years old	-891.350*** (228.881)	-1,253.972*** (339.368)	0.627 (0.421)	0.351 (0.507)
Proportion of females 5–10 years old	-428.188* (223.421)	-840.191** (329.532)	0.655* (0.385)	0.280 (0.475)
Proportion of females 11–18 years old	-307.893 (231.138)	-828.317** (342.500)	0.865** (0.387)	0.362 (0.496)
Proportion of females 19–59 years old	-582.599** (258.376)	-797.320** (350.583)	1.099** (0.449)	0.914* (0.507)
Proportion of females 60 years and older	-49.395 (286.749)	-358.569 (387.323)	0.431 (0.467)	0.179 (0.541)
Number of food crops produced by household	55.348*** (11.140)	-2.455 (46.227)	0.082*** (0.019)	0.125* (0.069)
Number of dairy cows owned	66.572*** (12.882)	93.092*** (21.897)	0.130*** (0.023)	0.133*** (0.032)
Price of rice (in taka)	-4.622 (3.976)	5.849 (6.221)	0.026*** (0.008)	0.037*** (0.010)
Ln (owned cultivable land+1)	37.143*** (9.678)	37.400*** (12.745)	0.045*** (0.016)	0.047*** (0.018)
Owns hand tube well (=1, 0 otherwise)	154.852*** (30.062)	59.978 (49.316)	0.329*** (0.056)	0.218*** (0.072)
Access to electricity (=1, 0 otherwise)	16.870 (25.644)	-37.876 (40.524)	0.434*** (0.050)	0.382*** (0.062)
Division-level fixed effects	Yes	Yes	Yes	Yes

Table 4.3 Continued

	Per adult equivalent calorie availability		Household dietary diversity	
	OLS	2SLS	OLS	2SLS
Variable	**(1)**	**(2)**	**(3)**	**(4)**
Constant	3,967.278*** (240.411)	3,857.604*** (331.101)	7.374*** (0.455)	7.287*** (0.505)
Observations	4,195	4,195	4,195	4,195
F	22.916	13.755	32.872	26.740
Adjusted R^2	0.185	-0.578	0.174	-0.016
Hansen J p, Ho: instruments valid		0.661		0.354
Under ID test p, Ho: under identified		0.000		0.000
Weak ID test stat (Kleibergen-Paaprk Wald F)		4.141		4.141
Anderson-Rubin, Ho: endogvars irrelevant				
A-R Wald test, p-value		0.000		0.000
A-R Wald chi^2 test, p-value		0.000		0.000

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011–-2012.

Notes: OLS = ordinary least squares; 2SLS = two-stage least squares.

Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Per adult equivalent calorie availability* is obtained by converting seven-day food consumption data collected at the household level to daily calorie equivalents, and then dividing resulting calorie values were divided by the number of adult equivalents in a household (Ahmed and Shams 1994). *Household dietary diversity* is the count of food groups consumed using the seven-day recall household food consumption data. Food was grouped into 12 categories: cereals; white tubers and roots; vegetables; fruits; meat; eggs; fish and other seafood; legumes and nuts; milk and milk products; oils and fats; sweets; and spices, condiments, and beverages (FAO 2011a).

The OLS and IV coefficient estimates of women's ownership of assets (presented in Table 4.4) and rights over assets (Table 4.5) are significantly positive, implying that female ownership of and control over major household assets has a role to play in improving household food security. Previous work in Bangladesh has demonstrated that greater resource control by women is associated with improved child health (Hallman 2003); evaluations of the long-term impact of agricultural interventions have similarly showed that interventions targeted to women's groups have increased women's assets and improved the nutritional status of women and girls (Kumar and Quisumbing 2010).

Table 4.4 Women's ownership of assets and household food-security outcomes

	Per adult equivalent calorie availability		Household dietary diversity	
	OLS	2SLS	OLS	2SLS
Variable	**(1)**	**(2)**	**(3)**	**(4)**
Number of assets woman has self/joint ownership of	42.385***	183.860***	0.113***	0.204***
	(9.312)	(41.132)	(0.017)	(0.074)
Age (in years) of household head	21.170***	14.232*	-0.018	-0.025*
	(6.901)	(7.461)	(0.013)	(0.013)
Age squared of household head	-0.177**	-0.106	0.000	0.000*
	(0.075)	(0.082)	(0.000)	(0.000)
Years of education of household head	10.152***	5.277	0.070***	0.065***
	(3.554)	(3.830)	(0.006)	(0.007)
Household head is farmer (=1, 0 otherwise)	129.496***	126.502***	0.215***	0.123
	(33.095)	(42.598)	(0.061)	(0.075)
Household head is trader (=1, 0 otherwise)	26.869	2.586	0.492***	0.492***
	(35.869)	(38.108)	(0.072)	(0.074)
Household size	-104.627***	-96.874***	0.081***	0.080***
	(10.260)	(10.873)	(0.018)	(0.020)
Proportion of males 0–4 years old	-740.155***	-721.910***	0.630	0.696
	(232.064)	(240.855)	(0.420)	(0.424)
Proportion of males 5–10 years old	-896.206***	-963.131***	0.455	0.446
	(217.832)	(227.365)	(0.375)	(0.382)
Proportion of males 11–18 years old	-992.371***	-1,087.361***	0.142	0.090
	(213.922)	(223.845)	(0.373)	(0.381)
Proportion of males 19–59 years old	-1,314.900***	-1,315.745***	0.555**	0.548*
	(178.796)	(183.180)	(0.283)	(0.287)
Proportion of females 0–4 years old	-903.165***	-935.337***	0.589	0.630
	(228.560)	(237.774)	(0.420)	(0.425)
Proportion of females 5–10 years old	-446.741**	-504.038**	0.597	0.574
	(223.750)	(232.166)	(0.384)	(0.391)
Proportion of females 11–18 years old	-357.497	-519.020**	0.723*	0.608
	(231.755)	(242.655)	(0.386)	(0.401)
Proportion of females 19–59 years old	-614.915**	-719.800***	1.009**	0.958**
	(258.895)	(271.148)	(0.449)	(0.461)
Proportion of females 60 years and older	-96.354	-247.898	0.300	0.240
	(286.370)	(298.324)	(0.466)	(0.482)
Number of food crops produced by household	50.267***	39.639	0.068***	0.152***
	(11.123)	(27.446)	(0.019)	(0.050)
Number of dairy cows owned	61.405***	42.614***	0.117***	0.084***
	(12.957)	(14.971)	(0.023)	(0.025)
Price of rice (in taka)	-4.148	-2.614	0.027***	0.029***
	(3.961)	(4.105)	(0.008)	(0.008)
Ln (owned cultivable land+1)	36.679***	35.225***	0.044***	0.044***
	(9.683)	(10.046)	(0.016)	(0.016)
Owns hand tube well (=1, 0 otherwise)	141.849***	98.032***	0.293***	0.244***
	(29.971)	(32.503)	(0.055)	(0.057)
Access to electricity (=1, 0 otherwise)	9.215	-15.836	0.413***	0.397***
	(25.558)	(27.685)	(0.050)	(0.052)
Division-level fixed effects	Yes	Yes	Yes	Yes

Table 4.4 Continued

	Per adult equivalent calorie availability		Household dietary diversity	
	OLS	2SLS	OLS	2SLS
Variable	**(1)**	**(2)**	**(3)**	**(4)**
Constant	3,956.755*** (239.188)	3,923.646*** (246.925)	7.344*** (0.453)	7.338*** (0.457)
Observations	4,195	4,195	4,195	4,195
F	23.610	22.367	35.345	32.677
Adjusted R^2	0.190	0.131	0.185	0.173
Hansen J p, Ho: instruments valid		0.691		0.697
Under ID test p, Ho: under identified		0.000		0.000
Weak ID test stat (Kleibergen-Paaprk Wald F)		32.501		32.501
Anderson-Rubin, Ho: endogvars irrelevant				
A-R Wald test, p-value		0.000		0.000
A-R Wald chi^2 test, p-value		0.000		0.000

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011–12.

Notes: OLS = ordinary least squares; 2SLS = two-stage least squares.
Robust standard errors are in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1. Per adult equivalent calorie availability is obtained by converting seven-day food consumption data collected at the household level to daily calorie equivalents, and then dividing resulting calorie values were divided by the number of adult equivalents in a household (Ahmed and Shams 1994). Household dietary diversity is the count of food groups consumed using the seven-day recall household food consumption data. Food was grouped into 12 categories: cereals; white tubers and roots; vegetables; fruits; meat; eggs; fish and other seafood; legumes and nuts; milk and milk products; oils and fats; sweets; and spices, condiments, and beverages (FAO 2011a).

Table 4.5 Women's rights over assets and household food-security outcomes

	Per adult equivalent calorie availability		Household dietary diversity	
	OLS	2SLS	OLS	2SLS
Variable	**(1)**	**(2)**	**(3)**	**(4)**
Number of self/joint decisions over purchase, sale, or transfer of assets made by woman	8.001*** (1.456)	27.591*** (6.448)	0.019*** (0.003)	0.024* (0.012)
Age (in years) of household head	20.339*** (6.865)	13.802* (7.274)	-0.019 (0.013)	-0.023* (0.013)
Age squared of household head	-0.169** (0.075)	-0.105 (0.079)	0.000 (0.000)	0.000* (0.000)
Years of education of household head	10.309*** (3.558)	7.364** (3.684)	0.070*** (0.006)	0.069*** (0.006)
Household head is farmer (=1, 0 otherwise)	121.946*** (33.066)	121.179*** (42.666)	0.196*** (0.061)	0.108 (0.075)
Household head is trader (=1, 0 otherwise)	26.865 (35.907)	5.565 (38.143)	0.494*** (0.072)	0.505*** (0.074)
Household size	-103.149*** (10.320)	-92.442*** (11.263)	0.084*** (0.018)	0.080*** (0.020)
Proportion of males 0–4 years old	-768.640*** (231.546)	-837.073*** (238.983)	0.561 (0.419)	0.598 (0.423)
Proportion of males 5–10 years old	-917.676*** (217.052)	-1,027.041*** (225.593)	0.410 (0.373)	0.417 (0.382)

Table 4.5 Continued

Variable	Per adult equivalent calorie availability		Household dietary diversity	
	OLS (1)	2SLS (2)	OLS (3)	2SLS (4)
Proportion of males 11–18 years old	-1,017.029*** (213.380)	-1,149.217*** (224.017)	0.091 (0.371)	0.069 (0.383)
Proportion of males 19–59 years old	-1,305.459*** (178.450)	-1,281.491*** (180.657)	0.578** (0.282)	0.577** (0.283)
Proportion of females 0–4 years old	-911.948*** (228.039)	-970.849*** (235.213)	0.571 (0.419)	0.618 (0.423)
Proportion of females 5–10 years old	-471.300** (222.956)	-576.499** (229.806)	0.544 (0.382)	0.532 (0.391)
Proportion of females 11–18 years old	-358.701 (230.479)	-477.672** (236.930)	0.733* (0.385)	0.694* (0.394)
Proportion of females 19–59 years old	-617.510** (258.173)	-704.371*** (266.710)	1.012** (0.446)	1.007** (0.454)
Proportion of females 60 years and older	-88.098 (285.742)	-187.335 (293.712)	0.333 (0.464)	0.346 (0.473)
Number of food crops produced by household	47.892*** (11.138)	14.034 (31.362)	0.064*** (0.019)	0.145** (0.058)
Number of dairy cows owned	59.631*** (12.993)	46.044*** (14.629)	0.114*** (0.023)	0.091*** (0.024)
Price of rice (in taka)	-3.966 (3.962)	-2.564 (4.078)	0.028*** (0.008)	0.029*** (0.008)
Ln (owned cultivable land+1)	34.428*** (9.668)	27.510*** (10.180)	0.038** (0.016)	0.038** (0.016)
ns hand tube well (=1, 0 otherwise)	148.932*** (29.815)	138.605*** (30.544)	0.313*** (0.055)	0.291*** (0.056)
Access to electricity (=1, 0 otherwise)	7.976 (25.576)	-13.434 (27.336)	0.412*** (0.050)	0.407*** (0.052)
Division-level fixed effects	Yes	Yes	Yes	Yes
Constant	3,966.494*** (239.276)	3,962.527*** (244.146)	7.370*** (0.453)	7.384*** (0.454)
Observations	4,195	4,195	4,195	4,195
F	24.050	22.874	36.003	33.352
Adjusted R^2	0.192	0.149	0.185	0.181
Hansen J p, Ho: instruments valid		0.312		0.215
Under ID test p, Ho: under identified		0.000		0.000
Weak ID test stat (Kleibergen-Paaprk Wald F)		25.753		25.753
Anderson-Rubin, Ho: endogvars irrelevant				
A-R Wald test, p-value		0.000		0.000
A-R Wald chi^2 test, p-value		0.000		0.000

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011–2012.

Notes: OLS = ordinary least squares; 2SLS = two-stage least squares.

Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Per adult equivalent calorie availability is obtained by converting seven-day food consumption data collected at the household level to daily calorie equivalents, and then dividing resulting calorie values were divided by the number of adult equivalents in a household (Ahmed and Shams 1994). Household dietary diversity is the count of food groups consumed using the seven-day recall household food consumption data. Food was grouped into 12 categories: cereals; white tubers and roots; vegetables; fruits; meat; eggs; fish and other seafood; legumes and nuts; milk and milk products; oils and fats; sweets; and spices, condiments, and beverages (FAO 2011a).

In the IV models, the effect of the number of food crops produced by the household on calorie availability at the household level is insignificant, but a strong and significant positive association between crop diversity and dietary diversity is evident; the more food crops households produce, the higher their dietary diversity. The number of dairy cows owned has a significant positive impact on both household food energy availability and household dietary diversity in all models. Rice price is not significantly associated with household-level food energy availability but is strongly and positively associated with household-level dietary diversity. The latter finding is similar to that of Rashid, Smith, and Rahman (2011), who argue that households may respond to an increase in rice price by partially shifting consumption away from rice to other food items, which results in an increase in dietary diversity. Owned cultivable land is strongly associated with both household food energy availability and household dietary diversity in all models. A change in cultivable landownership modifies household-level calorie availability and dietary diversity through its wealth or income effect. However, the other two income-related variables—ownership of a hand tube well and access to electricity—appear to be important in significantly influencing household-level food energy availability and dietary diversity only in certain models.

Consistent with the existing literature on human capital and household food security, the education of the household head has a positive and significant relationship with both calorie availability and dietary diversity. The impact of the age of the household head on calorie availability is significant and increasing at a decreasing rate in most of the regressions, but households with older heads appear to have less diverse diets. Having a household head whose primary occupation is farming significantly increases both calorie availability and dietary diversity in all the regression models. The positive relationship between farming as the main occupation and both calorie availability and dietary diversity is consistent with our other result that diversity in agricultural production increases dietary diversity at the household level. Having a household head who is primarily involved in trade improves only dietary diversity, not calorie availability.

As expected, household size has a significant negative impact on calorie availability in all the regressions, suggesting that per adult calorie availability decreases in larger households. However, household size has a positive and significant correlation with diet diversity. Since a household member may have access to food from a variety of sources (home production, purchased outside the house, received in exchange for labor, and so on), a larger household size may simply be a reflection of the greater variety in food consumption patterns as a result of having more people living in the household. Coefficients on demographic categories indicate that household demographic composition significantly affects calorie availability across different specifications of the empowerment variable, but only a few demographic categories significantly affect dietary diversity. In the (preferred) IV specification, households with a larger proportion of males and females between 19 and 59 years of age have more diverse diets; these coefficients are weakly significant in the specifications using the overall empowerment score and decisions on credit, and highly significant in the specifications using asset-based empowerment indicators.

Gender Parity and Household Food Security

While our study has mainly focused on examining the relationship between the level of women's empowerment in the household and household food-security outcomes, it is also interesting to examine whether women's *relative* empowerment within the household is associated with household food security. Considerable evidence exists in support of the need to address intrahousehold gender inequality in attaining development objectives (Alderman et al. 1995; Haddad, Hoddinott, and Alderman 1997; Quisumbing 2003). As mentioned above, the WEAI survey collects information from both the principal male and principal female in the household, allowing us to compare the agricultural empowerment of men and women living in the same household. The GPI is a composite index that reflects the percentage of women who have gender parity as well as the empowerment gap between men and women in households not having gender parity. Because we are interested in examining how differences between the

empowerment levels of men and women affect household food-security outcomes, we use the gender parity/empowerment gap component of the GPI as our key control variable here. Since we need both male and female scores to compute the gender parity gap, we use the smaller estimation sample of 3,944 households where both the primary male and female decisionmakers have been interviewed. We describe how the gender parity gap is calculated and instrumented below.

Gender parity gap: According to Alkire et al. (2013), a household enjoys parity if the woman is empowered or her empowerment score is greater than or equal to that of the male in her household. Thus, the gender parity gap is zero if the household enjoys gender parity. Otherwise, the gap equals the difference in the male and female aggregate empowerment scores.

We instrument the gender parity gap using the same set of instruments for 5DE and its component indicators as in the previous analysis. Since the gender parity gap is constructed using the empowerment scores, and measures relative empowerment, it is reasonable to assume that these instruments are relevant in this case as well. The IV diagnostics at the end of Table 4.6 suggest that the instruments are valid and the models are identified. The null hypothesis for weak instruments is rejected at the 5 percent level. For the rest of the controls, we used the same set of variables as in our previous analyses.

Results: Table 4.6 presents the regression results for the GPI gap and food-security outcomes. The OLS and IV coefficient estimates of the GPI gap are significant and negative, implying that a reduction in the gap is associated with an increase in per adult equivalent calorie availability and household dietary diversity. This means that reducing the gender gap in empowerment or improving women's relative empowerment is associated with greater food security at the household level, consistent with the existing literature on female bargaining power within the household and household welfare outcomes.

Table 4.6 Gender parity and household food-security outcomes

	Per adult equivalent calorie availability		Household dietary diversity	
	OLS	2SLS	OLS	2SLS
Variable	**(1)**	**(2)**	**(3)**	**(4)**
Gender parity (=0 if woman enjoys gender parity, 'gap' if not)	-182.724***	-1,344.239***	-0.405***	-3.391***
	(60.559)	(357.337)	(0.121)	(0.673)
Age (in years) of household head	24.627***	17.005**	-0.015	-0.036**
	(7.093)	(7.796)	(0.013)	(0.015)
Age squared of household head	-0.211***	-0.135	0.000	0.000**
	(0.078)	(0.085)	(0.000)	(0.000)
Years of education of household head	12.610***	15.017***	0.074***	0.080***
	(3.729)	(3.919)	(0.007)	(0.007)
Household head is farmer (=1, 0 otherwise)	127.739***	117.792***	0.227***	0.145*
	(33.752)	(43.980)	(0.063)	(0.082)
Household head is trader (=1, 0 otherwise)	42.501	13.171	0.540***	0.475***
	(37.145)	(40.094)	(0.075)	(0.082)
Household size	-108.391***	-98.910***	0.067***	0.087***
	(10.954)	(11.875)	(0.019)	(0.023)
Proportion of males 0–4 years old	-812.849***	-875.952***	0.806*	0.684
	(248.194)	(266.230)	(0.439)	(0.483)
Proportion of males 5–10 years old	-950.953***	-1,044.579***	0.615	0.403
	(231.912)	(247.617)	(0.392)	(0.436)
Proportion of males 11–18 years old	-1,047.595***	-1,141.976***	0.288	0.055
	(229.872)	(245.578)	(0.395)	(0.431)
Proportion of males 19–59 years old	-1,368.008***	-1,356.017***	0.706**	0.737**
	(192.281)	(199.922)	(0.300)	(0.328)

Table 4.6 Continued

	Per adult equivalent calorie availability		Household dietary diversity	
	OLS	2SLS	OLS	2SLS
Variable	**(1)**	**(2)**	**(3)**	**(4)**
Proportion of females 0–4 years old	-925.249***	-905.673***	0.796*	0.893*
	(243.019)	(256.473)	(0.439)	(0.477)
Proportion of females 5–10 years old	-503.177**	-639.336**	0.697*	0.362
	(238.794)	(256.912)	(0.404)	(0.448)
Proportion of females 11–18 years old	-358.777	-516.252*	0.971**	0.564
	(246.791)	(263.821)	(0.407)	(0.452)
Proportion of females 19–59 years old	-714.127**	-808.360***	1.108**	0.877*
	(278.568)	(295.440)	(0.478)	(0.528)
Proportion of females 60 years and older	-174.592	-216.269	0.446	0.368
	(311.735)	(327.986)	(0.500)	(0.553)
Number of food crops produced by household	50.923***	62.651**	0.083***	0.171***
	(11.278)	(26.721)	(0.019)	(0.052)
Number of dairy cows owned	63.768***	50.528***	0.130***	0.084***
	(12.992)	(14.378)	(0.023)	(0.026)
Price of rice (in taka)	-3.740	0.541	0.024***	0.036***
	(4.088)	(4.528)	(0.008)	(0.009)
Ln (owned cultivable land+1)	38.959***	44.889***	0.045***	0.061***
	(10.231)	(10.765)	(0.016)	(0.018)
Owns hand tube well (=1, 0 otherwise)	140.379***	74.648**	0.291***	0.109
	(31.208)	(35.454)	(0.057)	(0.070)
Access to electricity (=1, 0 otherwise)	5.828	-23.004	0.396***	0.322***
	(26.492)	(28.819)	(0.051)	(0.058)
Division-level fixed effects	Yes	Yes	Yes	Yes
Division-level fixed effects	Yes	Yes	Yes	Yes
Constant	4,027.818***	4,300.734***	7.451***	8.163***
	(252.729)	(281.812)	(0.477)	(0.552)
Observations	3,944	3,944	3,944	3,944
F	22.162	20.760	32.267	27.140
Adjusted R^2	0.189	0.114	0.175	0.029
Hansen J p, Ho: instruments valid		0.478		0.757
Under ID test p, Ho: under identified		0.000		0.000
Weak ID test stat (Kleibergen-Paaprk Wald F)		24.012		24.012
Anderson-Rubin, Ho: endogvars irrelevant				
A-R Wald test, p-value		0.000		0.000
A-R Wald chi^2 test, p-value		0.000		0.000

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011–12.

Notes: Notes: OLS = ordinary least squares; 2SLS = two-stage least squares.

Robust standard errors are in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1. *Per adult equivalent calorie availability* is obtained by converting seven-day food consumption data collected at the household level to daily calorie equivalents, and then dividing resulting calorie values were divided by the number of adult equivalents in a household (Ahmed and Shams 1994). *Household dietary diversity* is the count of food groups consumed using the seven-day recall household food consumption data. Food was grouped into 12 categories: cereals; white tubers and roots; vegetables; fruits; meat; eggs; fish and other seafood; legumes and nuts; milk and milk products; oils and fats; sweets; and spices, condiments, and beverages (FAO 2011a). *Gender parity gap* is defined as the difference in the male and female empowerment scores for households where the female score is less than the male score. The gender parity gap is zero if the woman is empowered or her empowerment score is greater than or equal to that of the male in her household.

5. CONCLUSIONS AND PUBLIC IMPLICATIONS

This paper has demonstrated that the recently developed WEAI can be used not only to assess the extent of women's empowerment in agriculture but also to identify areas where the gaps in empowerment are more severe. Because the WEAI is decomposable into its component sub-indexes and domains (Alkire et al. 2013), it has the potential to help researchers identify areas for policy intervention. In Bangladesh, out of the five domains over which empowerment is measured, the domains of leadership in the community and control over resources emerged as the areas of greatest disempowerment for women. Moreover, because the WEAI is decomposable into its component indicators, we can examine more closely how each component indicator affects the well-being outcomes that we are trying to influence—in this case, calorie availability and dietary diversity.

The WEAI is based on a very rich household- and individual-level dataset, enabling us to analyze component indicators in greater detail. In particular, these component indicators can be used to identify concrete areas for policy interventions to enhance the contribution of women's empowerment to food-security outcomes—specifically, increasing the number of groups in which women actively participate and increasing women's control of assets. While it is well known that NGOs have been active in increasing their membership base among poor rural women, women with more bargaining power within their households (owing to greater schooling or assets brought to marriage) are more likely to participate in NGOs (Quisumbing 2009). Group-based efforts have often been unable to reach the ultra-poor because many group-based activities, such as those in microfinance, require a minimum level of resources for participation, such as funds for the compulsory savings requirements. Long-seated systems of property rights that favor men in terms of inheritance, and the difficulty that women face in accumulating assets that they can control, need to be addressed so that women can build up their control of assets. This suggests that reforms of inheritance and property rights law more broadly, and specific interventions to increase women's control of assets, should be important parts of the policy agenda to reduce gender inequality.

These interventions could include targeted asset transfers to poor women (similar to those implemented by the Bangladesh Rural Advancement Committee through its Targeting the Ultra Poor Program) as well as efforts to improve women's access to financial instruments (both savings and credit) so they can accumulate assets. The finding that not only absolute empowerment but also the relative empowerment of women within households positively affects household food security provides additional support for policies to narrow the gender gap in Bangladesh.

Our results also highlight the importance of investing in the agricultural sector as a whole to increase production diversity. The BIHS results show that about 77 percent of the total cropped area in Bangladesh is under rice cultivation, implying very little crop diversity. While there have been significant advances in agricultural research, these have focused mainly on rice. Our findings call for increased investment in agricultural research to enhance the productivity of other food crops, such as pulses, vegetables, and fruits. The positive impacts of tube-well ownership and access to electricity also suggest that investments in complementary infrastructure will be important to increase household-level food energy availability and dietary diversity. Lastly, continued investments in schooling, particularly of women and girls, will be important not only to increase food security but also to narrow the gender gap in human capital.

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