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Abstract

This paper examines the effect of women's effective land ownership on female empowerment and household food security in the context of Peruvian family farming. Using an instrumental variable approach, we explore whether self-declared informal ownership of plots provides women with increased bargaining power, empowering them to participate more actively in productive decision-making that leads to improved crop diversity and food security. While our results do not find significant effects of informal land ownership on women's empowerment, we do find that owning land significantly decreases the daily time dedicated to agricultural work, possibly freeing up time for the woman to engage in other activities. Results also show that female land ownership significantly increases the level of crop diversity and improves the household's probability of being food secure by 20 percentage points. This suggests that equal access to land, even without formal title, plays an important role in improving household welfare among smallholder family farmers.

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1. Introduction

Women's contribution to agricultural production is vital in all developing countries. In total, their work accounts for almost half of the agricultural labor force in developing countries; and around 43% in Latin America, as well as 51% of the region's food production (IICA, IDB & Microsoft, 2020). Similar to other countries in the region, female labor in Peru represents 27% of all paid workers employed in agriculture according to the latest agricultural census (INEI, 2012). However, this underrepresents the important role that women play in the country's agricultural sector, as it does not account for unpaid family workers, of which women account for 75% in the sector, compared to only 20% of men (Ballara & Parada, 2009). In terms of their role as producers, women represent 31% of all independent agricultural farmers in the country[1], though only 49% of female land-owning farmers possess more than 1 hectare, compared to 70% of their male peers (INEI, 2012). This limited access to land is one of the most important constraints faced by women in agriculture (World Bank, 2001; FAO, 2011; Quisumbing et al., 2014).

The consequences of gender inequality in access to land can be evaluated from an intra-household bargaining model perspective (McElroy & Horney, 1981; Manser & Brown, 1980). It is generally assumed that the ability to influence the allocation of household resources to accommodate the preferences of individual household members relies on each individual's bargaining power within the household (Behrman, 1997). Therefore, differences in preferences and bargaining power should lead to differences in the household's collective decisions by reaching different cooperative equilibria. Most importantly, the improvement in an individual's bargaining power should translate into an improvement of their utility at the cooperative equilibrium.

There are many factors determining a woman's bargaining power within the family. These factors are related to the woman's individual characteristics, but also to household characteristics, community resources, social norms and perceptions, traditional support systems, and support from other non-communal institutions. Ownership of productive land is perhaps the most important individual endowment providing bargaining power to women in the rural context (Agarwal, 1997). According to the intra-household bargaining models, improved access to land should have a direct effect on women's ability to influence household decisions through an improvement in their bargaining power. The main reason is that it provides women with control over wealth-generating property. However, it could also affect women through other channels such as self-perception of empowerment.

Previous empirical studies have confirmed this relationship between empowerment and female land ownership. Campus (2016), as well as Mishra and Sam (2016) both use observational data from Nepal to establish that land ownership is associated with an increase in empowerment, as measured by female levels of decision-making power.[2] In an evaluation of the Special Land Titling and Cadaster Program (PETT) in Peru that provided joint property titles to men and women, Wiig (2013) estimate a positive relationship between receiving joint land titles and female empowerment, as measured by women's participation in household decision-making. Similarly, Montenegro-Guerra et al. (2019) study the effects of land inheritance on women's empowerment (measured as female influence on decision-making compared to men in different dimensions) in the context of Peru, and while they find no evidence of effects of female land inheritance on empowerment, they encounter negative effects of men inheriting land, and a positive effect of an increase in land owned by either a man or a woman on female empowerment.

Furthermore, increased empowerment within the household has been shown to affect how household resources are allocated and what the household produces. Evidence strongly suggests that women tend to assign higher value to their children's nutrition (Hallman, 2003; Skoufias, 2005), so that higher levels of female empowerment should lead to higher

[1] Note that this does not take into account the possible joint ownership of farms between partners.

[2] For example, Mishra and Sam find that women who owned land were 38% more likely to have the final say in decisions about their own healthcare.

investments in nutrition. For instance, Allendorf (2007) finds that land-owning women are more likely to have the final say in household decisions and are also less likely to have severely underweight children. Sraboni et al. (2014) show results suggesting that empowerment is related to higher levels of caloric availability, dietary diversity and body mass index (BMI) of adult household members. This may occur because a household's budget allocated to food increases when the female share of property ownership increases (Doss, 2015; Duflo & Udry, 2004). Higher levels of female empowerment may also induce changes in and increases of household output. According to Wouterse (2019), female empowerment is related to an increase in agricultural productivity, as measured by equipment productivity. This is particularly true for households with both a male and a female adult (hence, not single women households). Therefore, there is much to be gained by improving female participation in productive decisions, control over assets and income, and confidence, as an increase of 1% in empowerment could lead to an increase in output of around 0.93%. Furthermore, higher levels of female empowerment have been shown to be related to a larger diversification of agriculture production (De Pinto et al, 2020). More diversified crop production is usually linked to better nutrition and food security when oriented towards household consumption (Islam et al, 2018; Ciain, 2018).

The existing empirical literature thus supports the hypothesis that land ownership improves women's empowerment, which can lead to changes in resource allocation that prioritize household nutrition as well as increased crop diversity, thereby contributing to improved food security. Nevertheless, the evidence is still limited, and most studies fail to establish a causal relationship. The main challenge for answering this question arises from the bidirectional relationship between empowerment and land ownership: Not only can owning land empower women, but empowered women could also be more capable of acquiring land.

Our study aims to contribute to the literature by overcoming this potential issue of endogeneity and evaluating the causal impact of land ownership on women's empowerment. For our analysis, we rely on rich cross-sectional agricultural household survey data collected for the impact evaluation of the Rural Land Cadaster, Titling and Registration Project (PTRT-3) in Peru at baseline (i.e., prior to the beginning of project activities). We focus on the sample of approximately 1,048 farmer households where both the household head and his or her partner were present, and at least one plot owned by the household had not received formal title at the time of the survey.[3] Land ownership without formal documentation was self-declared by the household head, and is considered a reliable measure of effective ownership in terms of resource allocation and investment decisions.[4] In order to address potential concerns of endogeneity, we employ an instrumental variable approach that uses land inheritance as a source of exogenous variation in land ownership, to estimate the effect of women's effective land ownership on empowerment, as well as measures of food security and crop diversity.

Our results do not find that effective land ownership has a significant effect on women's empowerment as measured by a four-dimensional empowerment index that applies the methodology for the *Abbreviated Women's Empowerment in Agriculture Index* (A-WEAI) first developed by Alkire et al. (2013). However, we do find that effects on food security and crop diversity are strong and robust to various specifications, indicating that female land ownership increases the household's likelihood of being food secure by 20 percentage points. This result is consistent with our conceptual model and with evidence from the literature, which suggest a positive relationship between land owned by women and their input on productive household decisions, meaning that a woman possessing her own plot(s) can cultivate crops dedicated to the dietary needs of the household in accordance with her individual preferences, thereby improving the overall welfare of the family.

[3] In total, less than 10% of the households in our sample had property titles for at least one plot at the time of the survey, and only 1% of the women in the sample owned a titled plot.

[4] As formal land ownership does not necessarily translate into effective control over the land, it creates some potential limitations on the positive effect that female land ownership may have on their bargaining power. For example, Das et al. (2013) find that, in the context of a program that transfers resources to women in Bangladesh, the investments made in new assets are disproportionally owned by men. They also show that the program reduces women's input in decisions about their income, purchases and household budgeting.

To our knowledge, this is the first study to find causal relationship between female land ownership, food security and crop diversity, using a quasi-experimental approach to overcome potential issues of endogeneity. As such, the study provides an important insight into the relevance of effective land ownership for household production diversification and food security, in the context of rural households in the Andean and Amazon regions of Peru.

The remainder of the paper is organized as follows: Section 2 describes the data used, and discusses how measures of land ownership, female empowerment and food security are constructed. Section 3 presents the empirical approach and discusses potential empirical issues and how these are addressed. Results off the analysis are presented and analyzed in Section 4. Finally, Section 5 contains concluding notes and implications for future research.

2. Data description

Our study uses agricultural household survey data collected for the baseline of the impact evaluation of the Rural Land Cadaster, Titling and Registration Project (PTRT-3) in Peru. The Program, executed by the Ministry of Agriculture and Irrigation (MINAGRI) with financial support from the Inter-American Development Bank (IDB), aims to contribute to increasing tenure security, as well as agricultural productivity and income, by providing registered property titles to 214,000 individual farmers, 331 native communities, and 168 campesino communities located in the Andean and Amazon regions of Peru.[5]

The baseline survey was carried out in October and November of 2019. For farmers with individual parcels, the survey was conducted among 2,385 farmers in six departments of the Andean and Amazonas regions (Apurímac, Cajamarca, Cusco, Puno, and San Martín).[6] The questionnaire applied to the selected agricultural households in the sample collected detailed information on agricultural production and land characteristics, and was composed of the following 11 modules: Household roster and sociodemographic characteristics, household economic activities, information on plots (including ownership), agricultural production (temporary and permanent crops), livestock, forestry production, remittances, credits and savings, asset ownership and dwelling characteristics, organization and association memberships, as well as food security and dimensions of female empowerment.

Of the total sample of 2,385 farmer households, we use a subsample of 1,048 households for the purposes of this study. First, we limited our sample to households that responded to the food security and women empowerment sections of the questionnaire, which excluded 337 observations. These sections were answered by a female member of the household that could be either the household head or their partner, so observations were excluded for male-led households with no female partner who could have answered the section.[7] Second, the sample was limited to households where the head was cohabitating with his or her partner, thus considering only households with at least one male and one female member present and excluding an additional 456 observations. In this manner we aim to exclude households with female heads of household who are single or widowed, given that the woman is the principal decision maker for the household by default under these circumstances, and therefore not comparable to households where the female respondent is part of a couple and subject to the aforementioned intrahousehold bargaining dynamics.[8] Third, we excluded 544 households with no land destined for crops, thus excluding households that only own livestock. The excluded households are significantly larger in terms of land, and differ completely in terms of land use, making them difficult to compare. This group is also unable to answer some of the decision-making questions we rely on for measuring female empowerment, nor is it possible to evaluate crop diversity for this subsample.

[5] The program aims to title in approximately 274 rural districts under 10 regional governments: Amazonas, Apurímac, Cajamarca, Cusco, Huánuco, Junín, Loreto, San Martín, Ucayali, and Puno (IDB, 2014).

[6] The survey was also conducted among 33 campesino communities (for 431 households) and 172 native communities (1,699 households).

[7] Only 0.1% of excluded cases were due to the household member refusing to respond to the survey section. Therefore, we do not expect this to cause a significant potential for self-selection bias.

[8] Evidence shows that single women in agriculture may encounter other sources of discrimination (Del Águila, 2016), which for the purposes of our analysis cannot be controlled for or quantitatively observed.

The respondents – typically the household head – provided information about the ownership of each individual plot owned by the household, so that it is possible for us to assign plots to each member of the household. As previously mentioned, we measure effective land ownership as the self-declared ownership of each plot held by a household member for which no official land title has been conferred. Respondents were also asked about the origin of this ownership, and for legal documents pertaining to plot tenure. The questionnaire did not include any option for joint ownership of the same plot, so that we consider that the self-declared owner is the primary owner of said plot.

Lastly, it is worth highlighting that the underlying quasi-experimental design of the impact evaluation ensures that sampled households exhibit similar socioeconomic and productive characteristics to allow for attribution of impact to the titling program, and that the sample is statistically representative of the Andean and Amazon regions. For our purposes, the availability of the various socioeconomic and productive variables will allow us to control for potential differences in such characteristics across households to better identify the effect of effective landownership on empowerment, food security and crop diversity.

2.1. Descriptive Statistics

Table 1 reports the distribution of plot ownership across households, distinguishing between the number and proportion of households in which the man, the woman, or both own plots. Unsurprisingly, men own all plots in the majority of households (77.6%). Only 22.4% of women in our sample own plots: In only 9.8% of cases the totality of plots is owned by a woman, and in 12.6% of households both the woman and the man own plots.

Table 1. Plot ownership

	Number of households	Percentage
Woman owns all plots	103	9.8
Man owns all plots	813	77.6
Both man and woman own plots	132	12.6
Total	**1,048**	**100.0**

Table 2 presents the source of plot ownership for female and male landholders, at a plot level. Land was acquired through three different methods: purchase, inheritance, or occupation. In total, women in our sample own 345 plots, while men own 1,813 plots. Notably, the primary mode of acquisition varies by gender: While 47% of plots owned by men were purchased, only 22% of women's plots were acquired this way. In contrast, women attained effective ownership of their plots through inheritance in 72% of cases, while only 47% of men owned plots were inherited. It is important to note that this table refers only to land owning individuals. In total, 75% of women in the sample that owned land inherited at least one of their plots.

Table 2: Source of plot ownership by gender

Source of plot ownership	***Women***		***Men***	
	Total owned	*%*	*Total owned*	*%*
Inheritance	248	71.88	852	46.99
Purchase	77	22.32	858	47.32
Occupation	20	5.80	103	5.68
Total	**345**		**1,813**	

Table 3 presents summary statistics for the sample, distinguishing between households where the woman owns at least one plot and households where she does not. Looking at the whole sample, we find that it is comprised of rural, mostly small agricultural households. On average, households have 3.5 members, 1 child below the age of 16, and almost two thirds of their members are of working age. The women in our sample are around 47 years old on average,

Table 3. Summary Statistics			
	Land ownership in household		
Variables	*Woman does not own any plots*	*Woman owns at least one plot*	*All*
Household composition			
Household size	3.51 (1.46)	3.42 (1.48)	3.49 (1.46)
Number of children (under age 16)	0.99 (1.21)	0.93 (1.19)	0.98 (1.2)
Share of hh members of working age (16-64 years)	0.63 (0.3)	0.62 (0.32)	0.62 (0.3)
Household members characteristics			
Dummy = 1 if household head is a woman	0.01 (0.09)	0.23 (0.42)	0.06 (0.23)
Dummy = 1 if household head is married	0.50 (0.5)	0.60 (0.49)	0.52 (0.5)
Dummy = 1 if household head has an indigenous native tongue	0.36 (0.48)	0.66 (0.47)	0.43 (0.49)
Woman's age	47.25 (14.85)	47.07 (14.62)	47.21 (14.8)
Man's age	51.35 (14.68)	50.95 (14.93)	51.26 (14.73)
Woman's years of education	5.84 (3.72)	6.09 (3.76)	5.89 (3.73)
Man's years of education	7.19 (3.54)	7.55 (3.88)	7.27 (3.62)
Household wealth			
Productive assets index	0.12 (0.24)	0.21 (0.35)	0.14 (0.27)
Non-productive assets index	0.28 (0.16)	0.26 (0.18)	0.28 (0.17)
House quality index	0.22 (0.26)	0.16 (0.24)	0.20 (0.25)
Access to services index	0.46 (0.25)	0.46 (0.27)	0.46 (0.26)
Land characteristics			
Total land size (in hectares)	5.05 (10.39)	3.64 (14.6)	4.74 (11.45)
Number of plots	2.17 (1.56)	2.60 (1.51)	2.26 (1.56)
Land fragmentation index	0.28 (0.29)	0.41 (0.28)	0.31 (0.29)
Share of irrigated land	0.11 (0.29)	0.14 (0.31)	0.12 (0.29)
Share with at least one existing land conflict	0.04 (0.19)	0.05 (0.21)	0.04 (0.2)
Average year in which household obtained plots	2002 (12.79)	2001 (12.27)	2002 (12.67)
Share of households that invested in a plot	0.05 (0.22)	0.07 (0.25)	0.06 (0.23)
Share of households with perennial trees	0.37 (0.48)	0.25 (0.43)	0.34 (0.48)
Number of observations	**818**	**230**	**1,048**

while men are 51 years old. Around 43% of the sample reports primarily speaking an indigenous language (mainly Quechua or Aymara). In terms of education, both men and women on average attained levels lower than those necessary to finish secondary school. On average, men have acquired almost 1.5 more years of education than women.

One of the main concerns of our study is that women owning plots might differ from landless women in many ways, making both groups hard to compare. As can be seen, household characteristics appear to be largely similar across the groups. However, perhaps not surprisingly, we do find that it is more common for landowning women to be household heads and to speak an indigenous native tongue. In terms of household wealth, we rely on several indices measuring ownership of productive and non-productive assets, as well as access to basic services and dwelling quality.[9] Households with landowning women are richer in terms of the productive asset index, but poorer in terms of house quality. There are almost no differences between households in terms of the productive assets index and access to services, with a mean of 0.28 and 0.46 for all households, respectively.

In terms of the characteristics of land effectively owned by the household, the sample appears to be composed of predominantly small farms, with a majority of their plots located in mountainous regions, and it is unsurprising that low levels of investment translate into a low rate of access to irrigation, and that there appears to be little difference in these variables, independent of who owns the plot. Note that households in which the woman owns at least one plot are on average smaller in terms of productive land area (3.64 hectares) than those where all land is owned by her male counterpart (5.05 hectares). This dynamic can be observed independently of how the land is used (temporary crops, permanent crops, pasture, and other uses). As a relevant determinants of land productivity, only 12% of all plots on a farm are irrigated. In terms of how land is divided, farms where the woman owns at least one plot have an average of 2.6 plots, while farms where only the man owns land have an average of 2.17 plots. This also translates into a larger land fragmentation[10] for households where women own some land.

In order to understand how well self-declared plot ownership actually translates into effective land ownership, we considered the number of existing land conflicts and find that it is not common for households to experience land conflicts over their plots, as reported by only 4% of the sample. The average plot in the sample was acquired in 2002, around 17 years ago. Although only 6% of the sample had made investments in at least one plot, 34% of the households had at least one plot with perennial trees. These results suggest that, even with no land title, farmers in our sample effectively own the land they claim to own.

2.2. Empowerment, Time Use, and Food Security

To measure the relationship of land ownership and female empowerment, we construct our dependent variables using questions extracted from the empowerment module. This module was answered by either the household head's partner, when the household head was male, or the household head herself, when the household head was female. Respondents were surveyed separately from other family members to avoid biasing their responses. The module included questions that allow for the construction of a reduced version of the *Abbreviated Women's Empowerment in Agriculture Index* (A-WEAI), a multidimensional measure for women's empowerment first developed by Alkire et al. (2013). This index was specifically crafted for the agricultural context, as it includes questions on agricultural use and agricultural production decision making.

There are two main differences between our index and the original index that should be noted here. First, the A-WEAI is constructed as a linear combination of the *5 Dimensions of Empowerment Index* (5DE) and the *Gender Parity Index* (GPI), where the GPI is calculated

[9] Refer to Appendix A for a more detailed explanation of how these indices were constructed.

[10] Land fragmentation (LF) is measured by the Simpson's diversity index, where the index ranges between zero and one and its value increases with the increasing distribution of land area over individual plots owned by household. The index is constructed as $LF = 1 - \sum_{i=1}^{N} a_i^2 / \left(\sum_{i=1}^{N} a_i\right)^2$, where a_i is the area of plot i and N the total number of plots (see Blarel et al. 1992; Tanet al., 2008; and others).

as the differences between the man and the woman's 5DE within the household. Given that in our questionnaire, men did not respond the empowerment module, we are not able to calculate the GPI. Secondly, the 5DE includes five dimensions of disempowerment, each composed by one or two indicators (Alkire, 2012). Our questionnaire did not include questions on the leadership dimension, so that we constructed the remaining four dimensions: Production, Resources, Income and Time. Thus, our index can be thought of as an index of four dimensions of empowerment (4DE)[11], and care will be taken in interpreting results with this limitation in mind.

We constructed the four dimensions as established by Alkire (2021). First, the *Production Dimension* relies on female input in productive decisions as its indicator. This dimension considers the sole or joint decision-making on crop production for household consumption, crop production for sale in the market, and livestock (and sub-products) production. A woman is considered empowered in the production dimension if she has some input in at least one of these decisions, or if she feels she could have a say. Second, the *Resources Dimension* is measured as access to and decision about credit. Women with the ability to influence these decisions are considered empowered. Households with no access to credit are disempowered in this dimension. Third, the *Income Dimension* is measured as control over use of income. This refers to the income generated by the same activities considered for the production domain, and a woman is considered empowered if she can make a decision on where to spend the income generated by at least one of these activities. Fourth, the *Time Dimension* refers to the workload of economic activities and household chores. A woman is considered disempowered in the time dimension if she uses more than 10.5 hours a day on work (including domestic work).[12] For each dimension, we construct dummy variables that take the value of one if the woman is disempowered in said dimension. Then, we use these four dummies to measure multidimensional disempowerment. For the 4DE index, a woman is then considered disempowered if she is disempowered in at least three of the four dimensions.

Summary statistics for these the 4DE index and its individual dimensions are presented in Table 4. As shown, disempowerment in the resource dimension is very prevalent in our sample, mainly because of households' general lack of access to credit (only 8% of households in our sample reported having applied for and received a loan). This fact could potentially be related to the complete unavailability of property titles of the households in our study. On the other hand, it is important to mention that empowerment in the production and income dimensions are mainly driven by decisions concerning plots destined for household consumption (around 67%). Only around 25% of women had any say on plots which were used for livestock production or production to be sold, and about the income derived from said activities. Table 4 also shows that women who own plots are less disempowered in the multidimensional index and in most of the independent dimensions. The only exception is the time dimension, where women with no plots tend to be more empowered.

To further examine empowerment in the time dimension, Table 4 also presents women's average time spent daily on agricultural work, domestic work, work outside the household and leisure. On average, women spend almost 6 hours on domestic work, 4 hours on agricultural work, and only 1 hour on work outside the household and leisure, respectively. We observe that women who own land dedicate slightly more time to agricultural work than those without land. This implies that women with no plot of their own still contribute to the household by

[11] It is important to note that, given the difference, our results should not be compared to other studies using the full version of the A-WEAI. However, as each independent dimension was constructed following the A-WEAI methodology, comparisons at the level of each of the available four dimensions are possible.

[12] We acknowledge that leisure time is not the only way in which female empowerment may be improved. As one can intuit, not all uses of time and work activities have the same relationship with female bargaining power. There is some evidence of the importance of time used in work outside the household on inputs in decision-making (Rahman and Rao, 2004). Anderson and Aswaran (2009) provide evidence suggesting that women gain more bargaining power from earned income than from unearned income. In this context, work performed outside the household, which generates personal income, can be more important for autonomy than work that generates on-farm income for the household. Therefore, it is important to differentiate between work within and outside the household given its diverging effect on empowerment. Thus, we will further explore the effects in the time dimension of the empowerment index by examining the relationship between land ownership and women's time use across several activities.

working on someone else's plot. Time used for domestic work, leisure and work outside the household is also similar between the two groups, though notably leisure time is 15% larger among landowning women.

Table 4. Summary Statistics for Women's Empowerment, Time Use and Food Security

	Woman land ownership in household		
Variables	*Woman owns land*	*Woman does not own land*	*All*
Women's Empowerment			
Dummy = 1 if Woman is Disempowered (4DE)	0.25 (0.43)	0.17 (0.37)	0.23 (0.42)
Dummy = 1 if Disempowered in Productive Dimension	0.27 (0.44)	0.19 (0.39)	0.25 (0.43)
Dummy = 1 if Disempowered in Resources Dimension	0.96 (0.19)	0.93 (0.25)	0.95 (0.21)
Dummy = 1 if Disempowered in Income Dimension	0.24 (0.43)	0.17 (0.37)	0.22 (0.42)
Dummy = 1 if Disempowered in Time Dimension	0.65 (0.48)	0.72 (0.45)	0.67 (0.47)
Time use (in hours per day)			
Time used in agricultural work	4.19 (3.53)	4.43 (3.4)	4.24 (3.5)
Time used in domestic work	5.78 (3.38)	5.54 (3.13)	5.73 (3.32)
Time used for leisure	1.50 (2.06)	1.30 (1.94)	1.46 (2.04)
Time used in work outside the household	1.01 (2.26)	1.13 (2.29)	1.04 (2.26)
Food security			
Dummy = 1 if household is food secure	0.58 (0.49)	0.61 (0.49)	0.59 (0.49)
Crop diversification index	0.16 (0.23)	0.20 (0.24)	0.17 (0.23)
Note: Average value by group. Standard deviation in parenthesis.			

Finally, to examine how changes in female empowerment caused by landownership may affect crop diversity and food security of the household, we construct two additional indices. The first index measures the household's level of food security and was constructed following the FAO index based on the Latin American and Caribbean Food Security Scale (ELCSA), which includes questions regarding a household's accessibility to food. The questions do not only focus on objective information, but also include subjective assessments of the concerns faced by the household regarding food acquisition. The index takes the value of 1 if the household is food secure; and 0 otherwise. More information about the construction of this index can be found in Appendix B. The second index measures the diversity of the household's crop production, using the Simpson's Diversity Index.[13] Crop diversity can range between values of zero and one, and increases with a growing distribution of the crops' production values relative to the total number of crops produced by the household. The last two rows of Table 5 report summary statistics for these two indicators. Results indicate that 60% of the sample appears to be food secure, while experiencing a relatively low level of crop diversity. At the same time, it appears that households where the woman owns at least one plot tend have a more diversified production and are slightly less likely to experience food insecurity.

[13] For crop diversification (CD), the index is constructed as $CD = 1 - \sum_{i=1}^{N} a_i^2 / \left(\sum_{i=1}^{N} a_i\right)^2$, where a_i is the value of the product i and N the number of products (see Simpson, 1949; Hirschman, 1964; Ciain, 2018).

3. Empirical approach

3.1. Basic empirical model

As discussed in Section 2, our theoretical framework assumes that women's effective land ownership positively affects their empowerment, thereby improving productive resource allocation in terms of crop diversity, and food security. To estimate the relationship between land ownership, empowerment, crop diversity and food security, we propose two empirical models. These models represent a reduced form approach for the mechanisms described in Section 1. The first model, denoted Model 1, can be described by the following linear regression model:

$$y_{ij} = \alpha + \beta_1 x_i + \boldsymbol{\gamma W_i} + \boldsymbol{\delta_j} + \varepsilon_{ij} \ , \qquad (1)$$

where y_i is a generic variable used to denote each of the dependent variables measuring women's empowerment, time use, crop diversity and food security for household i, in province j. For this empirical model, we estimate the effect of the woman owning at least one plot (x_i) on the various indicators of empowerment, time use, crop diversity and food security. Thus, variable x_i takes the value of 1 if the woman in the household owns at least one plot and 0 otherwise. This also implies that the variable "only man owns land" represents the omitted category. Therefore, the estimated coefficient β_1 measures the difference in terms of empowerment, crop diversity and food security between households where the woman owns land to households where the woman does not.

As discussed in Section 1, although this study focuses on the importance of land ownership as a determinant of empowerment, our model acknowledges that there are many variables influencing female empowerment. These can be cultural in nature, determined by social norms within the community and region, as well as household- and individual-level characteristics. Therefore, vector $\boldsymbol{W_i}$ controls for several covariates, as presented in Table 3. The selected control variables are consistent with relevant explanatory covariates for the empowerment of rural women in other studies, such as Sell and Minot (2018), and include household size, number of children in the household, share of household members of working age, access to dwelling, wealth index, ethnicity, age, and education of the woman and man. We control for some production variables, namely number of plots in the household and money spent on external labor, as they can affect the number of plots owned by women or men, and reductions in agricultural work. However, we do not control for other productive variables presented in Table 3, as we do not want our model to be overidentified: As discussed, the theoretical framework implies that land ownership affects productive decisions. For model 1, we also include total size of land owned by the household, in order to control for the possible effect of women's land ownership through an increment of total land. Dummies to control for potential differences at a province level, denoted by parameter $\boldsymbol{\delta_j}$, are included to take into account differing cultural and social local norms in our estimation.[14] The error term is denoted as ε_{ij} and α represents the intercept. Standard errors are clustered at a province level.

Beyond the simple relationship between female land ownership and empowerment, our second empirical model, denoted Model 2, aims to explore the relationship between the size of land owned by women, and their level of empowerment, crop diversity and food security. For this model, we assume that female empowerment is affected linearly by each hectare owned. In this case, x_i represents the number of hectares owned by the woman in the household.[15] As in the previous model, x_i takes the value of 0 for households where the woman does not own any land. Parameter β_1 measures the changes in the dependent variable related to each additional hectare owned. As in Model 1, vector $\boldsymbol{W_i}$ controls for the same covariates at the household level. Province dummies and clustered robust standard errors remain the same. However, instead of controlling for total hectares owned by the household, we control for the size of land owned by the man.

[14] Provinces represent the second-level administrative subdivision in Peru, which are grouped into the different regions. They are geographically small enough to imply a certain level of intercorrelation, but not so small that there is a lack in variation.

[15] Results were not sensitive to including higher order terms of this independent variable.

3.2. Instrumental variable approach

A potential limitation of the cross-sectional data is the inability to control for the level of empowerment women had prior to acquiring land. It can be argued that empowered women are more likely to be able to purchase land than disempowered women, as they might be wealthier a priori. This dynamic could imply potential reverse causality in the context of our hypothesis. One could also make the argument that both channels may operate simultaneously: Acquiring land empowers women, and empowered women acquire more land. This also affects the proposed links between land ownership and food security: Richer women might more easily be able to simultaneously guarantee food security and acquire more land. It could also be that wealth acts as a third factor, influencing both land ownership and empowerment. To help us address this potential source of endogeneity, it is necessary to identify a source of exogenous variation in women's land ownership.

One possibly exogenous source of variation in women's land ownership is land inheritance. In fact, Campus (2016) argues that inheritance is an exogenous determinant of land ownership in most country contexts. Following this example from the literature, our identification strategy relies on the assumption that inheritance is determined exogenously, independent of a woman's level of empowerment prior to inheritance. This assumption fails if parents are more likely to give land as inheritance to their daughters according to observed female empowerment levels. This would be the case, for example, if parents try to compensate their more disempowered daughters by disproportionally giving them more land. However, the reality in the case of Peru is that all daughters and sons are entitled by law to the same percentage of inherited land. According to Peruvian law, when a person is deceased, two thirds of their inheritance are necessarily transferred to their immediate surviving family.[16] Also, both the Peruvian Constitution (Art. 6) and the Peruvian Civil Code (Art. 818) establish that all children have equal inheritance rights, regardless of gender, age, consanguinity, among others. The national legal statute represents an external factor that appears to determine land inheritance independently of observed female empowerment and household food security.

As discussed in the previous section, a significant share of women in our sample acquired at least some of their land through inheritance (75%). We take advantage of this fact and propose that plot inheritance can be instrumented for effective plot ownership. Instrumental variables can be used to obtain a consistent estimator when they are correlated with the instrumentalized variable, but uncorrelated with the error term. Thus, they need to satisfy two conditions (Greene, 2002): First, the condition of *instrumental exogeneity* requires that the covariance between the instrument and the error term be equal to zero. The second condition of *instrumental relevance* implies that the covariance between the instrument and the instrumented variable should be different from zero. Intuitively, this strategy allows us to focus on the portion of variation in land ownership that is uncorrelated with the error term.

With regards to instrumental relevance, inheritance of land is conceptually strongly correlated with land ownership. In order to further assess relevance, we consider the first stage F-statistic, which provides a measure of how well the instrument can explain variations in the variable of interest (effective land ownership). As a rule of thumb, an F-statistic value of less than 10 suggests that the instrument is weak and that the 2SLS estimation will be biased (Stock and Watson, 2011). As shown in Appendix C, first stage estimations of our two models indicate an F-statistic value of 158 and 80, respectively, suggesting that inheritance is indeed a strong instrument for effective land ownership. Furthermore, estimated coefficients for the instrumental variable are strongly statistically significant in both models.

Several potential threats to instrumental exogeneity exist. For instance, one could argue that women who inherit land are richer than women who do not. However, the reason why these women might be richer is because they own more land. Inheriting land per se does not make women richer through any other channel. Also, as observed in Table 3, it does not seem to be

[16] The other third is of free disposal for the deceased person, but he/she must have a written statement on who will be the heir. In case this information is absent (which is usually the case), it is also has to be transferred to the surviving family.

the case that these are wealthier women. Another possible threat to exogeneity is that it is possible for the instrument to act as a proxy for having deceased parents. If so, having parents or parents-in-law living in the same household could reasonably be correlated with higher levels of empowerment in the time dimension, as they can provide help working at home or on the field. It could also be the case that, if parents are too old, having them at home could imply an expense for the household, forcing resource allocation decisions and threatening food security. However, for our sample only 2% of households have a parent or parent-in-law residing with them, and no significant differences are observed for women who own at least own plot, so that the effect of a living parent on household outcomes do not appear relevant in this context.

Another potential threat to exogeneity is that family wealth may drive both empowerment and land inheritance, meaning that women from wealthier families may be more likely to inherit land, as well as more likely to be empowered due to wealth. However, it appears that our sample does not differ significantly in characteristics that may be affected by this driving factor between women who have inherited their land and those who have obtained land through other means, as results presented in Appendix D indicate. Overall, women and their households exhibit similar socioeconomic characteristics independently of how land was acquired, including in terms of the household's productive assets, though they are slightly less endowed in non-productive assets. It is worth noting that women who inherit their land tend to have smaller plots, which suggests the relevance of examining the differential effect of owning additional land size under Model 2.

Overall, however, this suggests that it is unlikely that a third factor, such as wealth, would determine both land ownership and empowerment, nor that the instrumental variable serves as a proxy for having a deceased parent. Therefore, we consider inheritance to be a valid instrument for effective land ownership, and that the estimated effect on empowerment, crop diversity and food security has external validity for households that are similar to those where the woman inherited her plots.

Assuming that the conditions of exogeneity and relevance are fulfilled, the instrumental variable regression can be estimated with the two stage least squares (2SLS) regression for the two models described above. As its name suggests, this methodology requires estimating two stages, as follows:

$$1.\quad x_{ij} = \sigma + \pi z_i + \boldsymbol{\tau W_i} + \boldsymbol{\rho_j} + \mu_{ij}, \quad (2)$$

$$2.\quad y_{ij} = \alpha + \beta \hat{x}_i + \boldsymbol{\gamma W_i} + \boldsymbol{\delta_j} + \varepsilon_{ij}, \quad (3)$$

In the first stage, the endogenous regressor of interest, x_i, is regressed on the instrumental variable, z_i. Variable x_i in Model 1 refers to the binary variable for female land ownership. In Model 2, x_i refers to hectares owned by the woman. Variable z_i is our instrument, a dummy variable for "woman inherited land". All other covariates included in vector $\boldsymbol{W_i}$ are the same as in equation (1), while parameter σ represents the intercept, μ_{ij} the error term, $\boldsymbol{\rho_j}$ the cluster effects at province level, and π and $\boldsymbol{\tau}$ are coefficients to be estimated. In the second stage, the estimated values of effective land ownership, $\hat{x}_i$, as predicted by land inheritance, will then be regressed on our set of dependent variables of interest, including women's empowerment, time use and food security. Both stages of 2SLS are estimated using ordinary least squares.[17]

4. Results

We present estimation results for the instrumental variable specification in Tables 5-7. Results for the simple OLS estimation are included in Appendix E. Table 5 displays the results of 2SLS estimation for indicators of female empowerment, for Models 1 and 2. The results presented in the first column correspond to full multidimensional disempowerment (4DE), while the remaining columns correspond to each of the four included dimensions of disempowerment.

[17] In the case of dichotomous dependent variables, we still estimate 2SLS using OLS, as it would be a mistake to impute predicted values into a logit estimation, or any maximum likelihood estimation (Chesher, 2010). This means that the second stage should be interpreted as a linear probability model (LPM).

Table 5. Second Stage Estimation Results for Women's Disempowerment

	Woman is Disempowered (4DE)	Disempowered in Production Dimension	Disempowered in Resources Dimension	Disempowered in Income Dimension	Disempowered in Time Dimension
MODEL 1:					
Dummy = 1 if woman owns land	-0.006	-0.010	-0.003	0.012	0.012
	(0.030)	(0.032)	(0.021)	(0.032)	(0.036)
Adjusted R^2	*0.176*	*0.171*	*0.040*	*0.170*	*0.127*
F-Statistic	*5,995*	*2,007*	*48,414*	*3,198*	*6,917*
Prob > F	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
MODEL 2:					
Size of land owned by woman (in hectares)	-0.003	-0.006	-0.003	0.012	0.010
	(0.025)	(0.026)	(0.016)	(0.027)	(0.029)
Adjusted R^2	*0.178*	*0.173*	*0.042*	*0.154*	*0.127*
F-Statistic	*4,875*	*1,497*	*29,439*	*1,654*	*11,540*
Prob > F	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Observations	**1,048**				

Note: All models include households and individual-level covariates, as well as province fixed effects.
Robust standard errors clustered at the province level reported in parentheses.
Difference unequal to zero if p-value significant at the 99 (***), 95 (**), or 90 (*) confidence level.

Although results in column 1 show indicate that effective land ownership results in a lower probability of being disempowered, this effect is statistically insignificant for both Model 1 and Model 2, suggesting that there is no significant effect of effective land ownership on female empowerment. Results suggest the same for the Production and Resources Dimension, meaning that coefficient magnitudes are consistent with expected effect directions, though similarly statistically insignificant. For the Income and Time Dimension, effects are also statistically insignificant, though effect magnitude goes against expected directions, suggesting that effectively land would increase disempowerment in these dimensions.

Table 6. Second Stage Estimation Results for Women's Time Use

	Hours a Day used in Agricultural Work	Hours a Day used in Domestic Work	Hours a Day used in Other Work Activities	Hours a Day used for Leisure
MODEL 1:				
Dummy = 1 if woman owns land	**-0.840*****	0.311	0.288	0.062
	(0.217)	(0.235)	(0.178)	(0.192)
Adjusted R^2	*0.400*	*0.405*	*0.083*	*0.296*
F-Statistic	*6,417*	*6,188*	*3,310*	*23,348*
Prob > F	*0.000*	*0.000*	*0.000*	*0.000*
MODEL 2:				
Size of land owned by woman (in hectares)	**-0.690*****	0.260	0.231	0.046
	(0.238)	(0.186)	(0.162)	(0.169)
Adjusted R^2	*-0.154*	*0.336*	*-0.060*	*0.292*
F-Statistic	*1,347*	*18,694*	*55*	*10,927*
Prob > F	*0.000*	*0.000*	*0.000*	*0.000*
Observations	**1,048**			

Note: All models include households and individual-level covariates, as well as province fixed effects.
Robust standard errors clustered at the province level reported in parentheses.
Difference unequal to zero if p-value significant at the 99 (***), 95 (**), or 90 (*) confidence level.

Table 6 presents second stage estimation results to further explore potential effects in the time dimension of empowerment, shedding light on how effective land ownership may affect a woman's time dedicated to various tasks throughout the day. These results provide some insight into why women may experience increased time disempowerment due to land ownership: Women who own land, as instrumented by land inheritance, dedicate more time to domestic work and work outside the farm, more so than is compensated by more time dedicated to leisure. These effect sizes, however, are not statistically significant. Interestingly, if a woman owns land, she dedicates 50 minutes less per day to agricultural work activities, an effect which is statistically significant. In terms of land size, each additional hectare owned by a woman significantly decreases time dedicated to agricultural work by approximately 41 minutes.

Lastly, Table 7 presents results for food security and crop diversity. For Model 1, we find that when women own land, the probability of being food secure significantly increases by 20 percentage points for the average household. Additionally, results for Model 2 show that each additional hectare effectively owned by a woman increases the probability of the household being food secure by 16 percentage points. In this context, changes in the cooperative equilibrium obtained through intrahousehold bargaining appears to be affected by female land ownership in favor of prioritizing household food consumption.

Table 7. Second Stage Estimation Results for Household Food Security and Crop Diversity

	Household is Food Secure	Household Crop Diversity
MODEL 1:		
Dummy = 1 if woman owns land	**0.196***** (0.064)	**0.060**** (0.028)
Adjusted R^2	*0.269*	*0.187*
F-Statistic	*22,170*	*232,840*
Prob > F	*0.000*	*0.000*
MODEL 2:		
Size of land owned by woman (in hectares)	**0.164**** (0.079)	0.037 (0.023)
Adjusted R^2	*-1.155*	*-0.096*
F-Statistic	*3,252*	*175,664*
Prob > F	*0.000*	*0.000*
Observations	**1,048**	**746**

Note: All models include households and individual-level covariates, as well as province fixed effects. Robust standard errors clustered at the province level reported in parentheses. Difference unequal to zero if p-value significant at the 99 (***), 95 (**), or 90 (*) confidence level.

These results are further supported by the effect of female land ownership on the farm's crop diversification. Results suggests that crop diversity increases by 0.06 points if the woman owns land, suggesting that households of landowning women are likely to have a more diversified crop production that may benefit household food security. Relative land size does not appear to play a significant factor in this context.

Although our analysis fails to find a significant effect of land ownership on women's empowerment, positive effects on crop diversity and food security are aligned with the predictions of our theory of change, where female land ownership is expected to positively affect food security through changes in household productive decisions and the allocation of its resources. While we cannot establish a direct link between these results and changes in empowerment, the results are nevertheless indicative of a shift in the household's cooperative

equilibrium in response to differences in female land ownership. Additionally, our results do show that owning land leads to less hours dedicated to agricultural work, which may allow the woman to dedicate time to other activities within and outside the farm.

5. Conclusions

Theoretical and empirical work in economics provides evidence on the importance of women's access to land to guarantee equal opportunities within the household and to improve overall household welfare. Based on an intra-household bargaining model, female land ownership should lead to increased levels of empowerment by increasing their bargaining power, resulting in increased participation in production decisions, which may then translate into higher levels of crop diversification that may benefit the household's dietary needs and thereby improve food security. To our knowledge, this analysis constitutes the first study to simultaneously attempt to link women's land ownership to measures of female empowerment, crop diversity and food security, and to use a quasi-experimental approach to overcome potential issues of endogeneity in this setting. As such, the study provides an important insight into the relevance of female land ownership for gender equality and household wellbeing, in the context of informal landowning rural households in Peru.

While our results are not conclusive with regards to the effects of effective land ownership on women's empowerment in agriculture as measured by the 4DE index, our results on food security are strong and robust, indicating that female land ownership increases crop diversification, and the household's probability of being food secure by 20 percentage points. This result is consistent with our conceptual model and with evidence from the literature, which indicates that increases in crop diversification lead to increases in food security by enhancing the variety of food consumed within the household. The positive relationship between land owned by women and her input on productive household decisions suggests that this is a potential channel through which crop diversification and food security may be achieved. It is also possible that a woman possessing her own plot(s) allows her to cultivate crops dedicated to the dietary needs of the household in accordance with her individual preferences.

Although we do not find evidence of significant effects of land ownership on women's empowerment, positive effects on crop diversity and food security still provide evidence that land ownership has an effect on female empowerment. It could be the case that changes in empowerment are relatively small and fail to be identified by our empirical strategy. For instance, empowerment effects important for crop diversification, such as decision making about plots, may only be relevant in the productive dimension of empowerment, but these marginal changes could be difficult to identify by the WEAI index in our context. As seen in Table 4, only a quarter of our sample is disempowered in the productive dimension, so that marginal changes due to land ownership may not be sufficiently large in magnitude to be detected.

A second and very tempting explanation could be that there is a different channel through which land ownership may affect crop diversification and food security. We do not believe this to be the case, as crop diversity is directly related to intrahousehold decision-making and resource allocation. One could argue that households where women own plots have more land to cultivate crops on, which would allow for a more diversified crop portfolio. However, households with female landowners in our sample are smaller in size, which would seem to make it more instead of less difficult to diversify crop in a more limited land area.

We also find evidence of land ownership reducing women's on-farm agricultural workload. Although our analysis was unable to find positive impacts on other time use variables, women still need to reallocate the time they were using for agricultural work to other activities. It is possible that it was similarly distributed across the different activities, but the effect was so small that observed changes were not statistically detectable. This redistribution of personal time use could imply a beneficial reallocation of time towards activities that enable the woman to increase her bargaining power over time, perhaps making more household related decision, or increasing their personal income in a way that is beneficial to their family's food security and overall welfare.

A potential limitation of our study is the possible endogeneity of the instrumental variable. We checked several sources of endogeneity for our instrument, yet some mechanisms may have gone undetected due to data limitations. For instance, we found that only a small share of households had parents living with them, independently of whether the woman had inherited a plot or not. By doing so, we confirm that the instrument does not proxy for not having a parent be present in the household, which could arguably influence empowerment, time use, crop diversity and food security. However, there may be other reasons why having a deceased parent could affect these results, as parents may be an important source of financial and emotional support even if they do not live in the same household. We also did not find evidence suggesting that inheritance was correlated with being wealthier, though our analysis of this relationship is of course limited to the available observable data that we have for the household itself, and not for wealth and ownership of parents living in other households.

Taken together, our analysis suggests that giving women ownership of farmland is beneficial not only in terms of improving gender equality, but also due to the important positive effects this has on household food security. Therefore, land titling and registration programs should prioritize assigning title jointly to both spouses or partners and ensure that the woman receives legal recognition of tenure for her plots where applicable. Another possible scenario in which policy makers could make an impact is in modifying inheritance laws to favor women, or at least allow women to have equal rights to land inheritance. This is not the case for Peru, but there are several countries, both inside and outside the Latin American and Caribbean region, where inheritance laws are still restrictive and favor male heirs.

An important contribution of our study is the examination of self-declared informal land ownership as a proxy for effective land ownership. This stands in contrast to formally documented and legally recognized ownership of plots that the owner, and female owners in particular, may not have effective decision-making power over. Nevertheless, it is worth noting that direct impacts of effective land ownership on empowerment may be weak precisely due to the lack of legal title: Formal tenure could have stronger effects on women's empowerment, as titles provide women with a better instrument for bargaining, and provide property owners with collateral to access credit, and to sell the land, if necessary, to obtain additional resources. As has been noted extensively in the literature, lack of formal land tenure may also inhibit productive and investment decisions given the uncertainty surrounding long-term security land tenure. Thus, this highlights the important for future research into the causal effect of women's formal land ownership to allow researchers and policymakers alike to better understand the effects of land ownership and tenure on intra-household gender dynamics and general effects on household resource allocation and welfare.

Appendices

Appendix A: Construction of Wealth Indices

Household wealth is proxied by creating four separate indices, ranging from productive and non-productive assts to access to infrastructure and dwelling quality. To create these indices, we use principal component analysis (PCA), as first introduced by Filmer and Pritchett (2001). This method creates a linear index based on the first principal component of the set variables, which captures the largest amount of information common to all variables (ibid). In this approach, the index not only allows aggregating several binary asset ownership characteristics into a single variable, but also assigns adequate weights to individual assets / locations / dwelling characteristics included in the index. Assigning such weights is important considering that the contribution of different assets to overall wealth is likely not the same across all assets, and that the ownership of one asset might be correlated with the ownership of other assets in the index, meaning that certain assets might have more informational content about wealth than others (Moser & Felton, 2007).

Four indices measuring household wealth are created: (1) a productive assets index that includes various agricultural assets such as a plow, sprayer, mill, etc.; (2) a non-productive assets index, consisting of household appliances and other devices such as color TV, radio, cell phone, fridge, stove, motorbike, etc.; (3) a dwelling quality index, capturing the quality of materials used for the household's main dwelling's walls, roofs, and floors; and (4) an access to services index, which captures the household's access to running water, sanitation, electricity, and gas for cooking. Each index represents a weighted sum of its composing variables, and takes a value ranging between zero and one, with the value being larger the more endowed the household is with each type of asset or service. Note that for the purposes of the main specification, each index is divided into its quintiles to be included as control variables, with the first quintile being the omitted variable in each case.

Appendix B: Construction of the Food Security Indicator

The food security indicator was constructed following the FAO index based on the Latin American and Caribbean Food Security Scale (ELCSA), which includes questions regarding a household's accessibility to food. Food security is defined by FAO (2006) as "the situation that exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food to satisfy their nutritional needs to develop an active and healthy life". It considers four dimensions: food availability, access, use, and stability.

The original indicator proposed by FAO classifies households into four categories: Food security, mild food insecurity, moderate food insecurity and severe food insecurity, as shown in Table B1. For the purposes of our study, we consider a dummy for food security (either the household is food secure or not), as there was not enough variability within the different levels of food insecurity present in our data. To classify households in terms of food security, we use the questions detailed in Table B2. When all eight questions get a negative response, then the household is classified as food secure.

Table B1: FAO categories of food insecurity.

Category	Food security	Mild food insecurity	Moderate food insecurity	Severe food insecurity
Value	0	1-3	4-6	7-8

Table B2: Questions included in the Food Security Index

During the last month, due to lack of food or other resources, have you ever…
1. Have you ever worried about running out of food in your household?
2. Have you ever run out of food in your household at any time?
3. Have you or some adult in your household ever stopped having a healthy diet (composed by meat, fish, vegetables, fruits, and cereals)?
4. Have you or any adult in your household ever had to eat a diet based on a small variety of foods (you always have the same food every day)?
5. Have you or any adult in your household ever skipped a meal (breakfast, lunch and/or dinner)?
6. Have you or any adult in your household ever eaten less than they should?
7. Have you or any adult in your household ever felt hungry but abstained to eat?
8. Have you or any adult in your household ever eaten only once during the day or stopped eating for a whole day?

Appendix C: Regression Results for the First Stage of the 2SLS Estimations

Table C1. Regression results for first stage of 2SLS estimation

	Model 1	*Model 2*
	Dummy = 1 if woman owns land	**Size of land owned by woman (in hectares)**
2SLS First Stage		
Dummy = 1 if woman inherited land	**0.899***** (0.0218)	**0.896***** (0.021)
Adjusted R^2	*0.690*	*0.690*
F-Statistic	*158*	*80*
Prob > F	*0.000*	*0.000*
Observations	**1,048**	

Note: All models include households and individual-level covariates, as well as province fixed effects. Difference unequal to zero if p-value significant at the 99 (***), 95 (**), or 90 (*) confidence level. Robust standard errors clustered at province level reported in parentheses.

Appendix D: Summary characteristics by women's type of plot obtainment

Table D1: Differences between households with women who inherited and did not inherit their land

	Woman purchased or occupied land	Woman inherited land	Difference
Household composition			
Household size	3.54 (1.54)	3.38 (1.46)	-0.17
Share of household members of working age (16-64 years)	0.66 (0.31)	0.61 (0.32)	-0.06
Household members characteristics			
Dummy = 1 if household head has an indigenous native tongue	0.40 (0.49)	0.75 (0.44)	**0.34*** **
Dummy = 1 if household head is married	0.49 (0.5)	0.64 (0.48)	0.14
Woman's age	45.67 (13.44)	47.53 (15)	1.87
Man's age	50.14 (12.82)	51.22 (15.59)	1.08
Woman's years of education	6.07 (3.59)	6.09 (3.83)	0.02
Man's years of education	7.82 (3.71)	7.46 (3.93)	-0.36
Land characteristics			
Dummy = 1 if man does not own land	0.47 (0.5)	0.42 (0.49)	-0.06
Total land size (in hectares)	7.43 (24.15)	2.39 (9.35)	**-5.04***
Number of plots	2.23 (1.18)	2.73 (1.59)	**0.50***
Household wealth			
Productive assets index	0.16 (0.32)	0.23 (0.36)	0.07
Non-productive assets index	0.32 (0.2)	0.24 (0.16)	**-0.09****
House quality index	0.22 (0.27)	0.13 (0.23)	**-0.08***
Access to services index	0.50 (0.32)	0.45 (0.25)	-0.05
Number of observations	**57**	**173**	

Note: Average value by group. Standard deviation in parenthesis. Difference unequal to zero if p-value significant at the 99 (***), 95 (**), or 90 (*) confidence level.

Appendix E: Results for OLS Specification

Table E1. OLS Estimation Results for Women's Disempowerment

	Woman is Disempowered (4DE)	Disempowered in Production Dimension	Disempowered in Resources Dimension	Disempowered in Income Dimension	Disempowered in Time Dimension
MODEL 1:					
Dummy = 1 if woman owns land	-0.022 (0.036)	-0.022 (0.034)	-0.026 (0.020)	-0.016 (0.036)	0.025 (0.041)
Adjusted R^2 / Pseudo R^2	*0.177*	*0.171*	*0.042*	*0.170*	*0.127*
F-Statistic / χ^2	*25*	*15*	*103*	*25*	*30*
Prob > F, Prob > χ^2	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
MODEL 2:					
Size of land owned by woman (in hectares)	**-0.004** (0.001)	**-0.004** (0.001)	**-0.005** (0.001)	**-0.003** (0.001)	**0.007** (0.002)
Adjusted R^2 / Pseudo R^2	*0.178*	*0.173*	*0.043*	*0.172*	*0.127*
F-Statistic / χ^2	*15*	*23*	*12,665*	*15*	*89*
Prob > F, Prob > χ^2	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Observations	**1,048**				

Note: Estimation uses Ordinary Least Squares (OLS) when the dependent variable is continuous, and Logit when the dependent variable is dichotomous. All results from logit regressions are presented as marginal effects at means.
All models include households and individual-level covariates, as well as province fixed effects.
Difference unequal to zero if p-value significant at the 99 (***), 95 (**), or 90 (*) confidence level.
Adjusted R^2 and F-Statistic reported for OLS estimations, Pseudo R^2 and / χ^2 reported for logit estimations.
Robust standard errors clustered at province level reported in parentheses (S.E. are only robust in case of logit regressions).

Table E2. OLS Estimation Results for Women's Time Use

	Hours a Day used in Agricultural Work	Hours a Day used in Domestic Work	Hours a Day used in Other Work Activities	Hours a Day used for Leisure
MODEL 1:				
Dummy = 1 if woman owns land	**-0.656** (0.227)	0.342 (0.218)	0.229 (0.146)	0.207 (0.158)
Adjusted R^2 / Pseudo R^2	*0.401*	*0.405*	*0.083*	*0.297*
F-Statistic / χ^2	*141*	*74*	*102*	*38*
Prob > F, Prob > χ^2	*0.000*	*0.000*	*0.000*	*0.000*
MODEL 2:				
Size of land owned by woman (in hectares)	**0.030** (0.013)	**0.019** (0.011)	-0.006 (0.006)	0.010 (0.006)
Adjusted R^2 / Pseudo R^2	*0.395*	*0.404*	*0.082*	*0.296*
F-Statistic / χ^2	*114*	*25*	*73*	*30*
Prob > F, Prob > χ^2	*0.000*	*0.000*	*0.000*	*0.000*
Observations	**1,048**			

Note: Estimation uses Ordinary Least Squares (OLS) when the dependent variable is continuous, and Logit when the dependent variable is dichotomous. All results from logit regressions are presented as marginal effects at means.
All models include households and individual-level covariates, as well as province fixed effects.
Difference unequal to zero if p-value significant at the 99 (***), 95 (**), or 90 (*) confidence level.
Adjusted R^2 and F-Statistic reported for OLS estimations, Pseudo R^2 and / χ^2 reported for logit estimations.
Robust standard errors clustered at province level reported in parentheses (S.E. are only robust in case of logit regressions).

Table E3. OLS Estimation Results for Household Food Security and Crop Diversity

	Household is Food Secure	Household Crop Diversity
MODEL 1:		
Dummy = 1 if woman owns land	0.103 (0.064)	**0.048*** (0.023)
Adjusted R^2 / Pseudo R^2	*0.274*	*0.188*
F-Statistic / χ^2	*84*	*1,949*
Prob > F, Prob > χ^2	*0.000*	*0.000*
MODEL 2:		
Size of land owned by woman (in hectares)	0.001 (0.001)	-0.002 (0.001)
Adjusted R^2 / Pseudo R^2	*0.268*	*0.181*
F-Statistic / χ^2	*6*	*315*
Prob > F, Prob > χ^2	*0.000*	*0.000*
Observations	**1,048**	**746**

Note: Estimation uses Ordinary Least Squares (OLS) when the dependent variable is continuous, and Logit when the dependent variable is dichotomous. All results from logit regressions are presented as marginal effects at means.
All models include households and individual-level covariates, as well as province fixed effects.
Difference unequal to zero if p-value significant at the 99 (***), 95 (**), or 90 (*) confidence level.
Adjusted R^2 and F-Statistic reported for OLS estimations, Pseudo R^2 and / χ^2 reported for logit estimations.
Robust standard errors clustered at province level reported in parentheses (S.E. are only robust in case of logit regressions).

References

Agarwal, B. (1997). "Bargaining" and gender relations: Within and beyond the household. *Feminist economics*, 3(1), 1-51. doi: 10.1080/135457097338799

Allendorf, K. (2007). Do women's land rights promote empowerment and child health in Nepal?. *World Development*, 35(11), 1975-1988. doi: 10.1016/j.worlddev.2006.12.005

Alkire, S., Meinzen-Dick, R., Peterman, A., Quisumbing, A. R., Seymour, G., & Vaz, A. (2013). The Women's Empowerment in Agriculture Index. *World Development*, 52, 71–91. doi: 10.1016/j.worlddev.2013.06.007

Anderson, S., & Eswaran, M. (2009). What determines female autonomy? Evidence from Bangladesh. *Journal of Development Economics*, 90(2), 179-191. doi: 10.1016/j.jdeveco.2008.10.004

Ballara, M., & Parada, S. (2009). "El empleo de las mujeres rurales. Lo que dicen las cifras." FAO-CEPAL. Retrieved from: https://www.cepal.org/es/publicaciones/1346-empleo-mujeres-rurales-lo-que-dicen-cifras

Behrman, J. R. (1997). Intrahousehold distribution and the family. *Handbook of population and family economics*, 1, 125-187. doi: 10.1016/S1574-003X(97)80021-9

Campus, D. (2016). "Does land titling promote women's empowerment? Evidence from Nepal (No. wp2016_03. rdf)". Università degli Studi di Firenze, Dipartimento di Scienze per l'Economia e l'Impresa. Retrieved from: http://www.disei.unifi.it/upload/sub/pubblicazioni/repec/pdf/wp03_2016.pdf

Chesher, A. (2010). Instrumental variable models for discrete outcomes. *Econometrica*, *78*(2), 575-601. doi: 10.3982/ECTA7315

Das, N., Yasmin, R., Ara, J., Kamruzzaman, M., Davis, P., & Behrman, J. A., et al. (2013). "How do intrahousehold dynamics change when assets are transferred to women? Evidence from BRAC's challenging the frontiers of poverty reduction – Targeting the ultra-poor program in Bangladesh". Washington, DC: International Food Policy Research Institute. Retrieved from: http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/127911

De Pinto, A., Seymour, G., Bryan, E., & Bhandari, P. (2020). Women's empowerment and farmland allocations in Bangladesh: evidence of a possible pathway to crop diversification. *Climatic Change*, 163(2), 1025-1043. doi: 10.1007/s10584-020-02925-w

Doss, C. (2005). The effects of intrahousehold property ownership on expenditure patterns in Ghana. *Journal of African Economies*, 15(1), 149–180. doi: 10.1093/jae/eji025

Duflo, E., & Udry, C. (2004). "Intrahousehold resource allocation in Cote d'Ivoire: Social norms, separate accounts, and consumption choices. No. w10498". Cambridge, MA: National Bureau of Economic Research. Retrieved from: http://www.nber.org/papers/w10498

Ferrant, G., & Thim, A. (2019). Measuring women's economic empowerment: Time use data and gender inequality. *OECD Development Policy Papers, No. 16*. Paris: OECD Publishing. doi: 10.1787/02e538fc-en

Filmer, D., & Pritchett, L. H. (2001). Estimating wealth effects without expenditure data – or tears: An application to educational enrollments in states of India. *Demography*, 38(1), 115-132. doi: 10.1353/dem.2001.0003

Food and Agriculture Organization of the United Nations (FAO, 2011). "The state of food and agriculture. Women in Agriculture. Closing the gender gap for development". Rome: FAO. Retrieved from: http://www.fao.org/3/i2050e/i2050e.pdf

Greene, W. H. (2002). *Econometric Analysis* (5th ed.). Upper Saddle River, NJ: Prentice Hall.

Hallman, K. (2003). Mother-father resources, marriage payments, and girl–boy health in rural Bangladesh. In A. R. Quisumbing (Ed.), *Household decisions, gender, and development: A synthesis of recent research (pp. 115–120).* Baltimore, MD: Johns Hopkins University Press for the International Food Policy Research Institute. Retrieved from: http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/129664

Hirschman, A. O. (1964). The paternity of an index. *American Economic Association*, 54 (5): 761–762. Available at: https://www.jstor.org/stable/i331529

IICA, IDB & Microsoft (2020): "Rural connectivity in Latin America and the Caribbean: a bridge for sustainable development in a time of pandemic". *Inter-American Institute for Cooperation on Agriculture (IICA).* Available at: https://repositorio.iica.int/handle/11324/12896

Instituto Nacional de Estadística e Informática (INEI, 2012). IV Censo Nacional Agropecuario 2012. Retrieved from http://censos.inei.gob.pe/cenagro/tabulados

Inter-American Development Bank (IDB, 2014). Loan proposal for the Rural Land Cadaster, Titling and Registration Project in Peru (Project Nr. PE-L1026). *IDB, Environment and Natural Disasters Sector*. Retrieved from https://www.iadb.org/projects/document/EZSHARE-1470197173-1275?project=3370/OC-PE;PE-L1026

International Labor Organization (ILO, 2017). *"World Employment and Social Outlook: Trends for Women 2017".* Geneva: ILO. Available at: http://www.ilo.org/global/research/global-reports/weso/trends-for-women2017/lang--en/index.htm

Islam, A., von Braun, J., Thorne-Lyman, A.L., & Ahmed, A.U. (2018). Farm diversification and food and nutrition security in Bangladesh: empirical evidence from nationally representative household panel data. *Food Security*, 10:701–720. doi: 10.1007/s12571-018-0806-3

Manser, M., & Brown, M. (1980). Marriage and household decision-making: a bargaining analysis. *International Economic Review*, 21 (1), 31–44. doi: 10.2307/2526238

McElroy, M., & Horney, M.J. (1981). Nash-bargained household decisions: toward a generalization of the theory of demand. *International Economic Review*, 22, 333–349. doi: 10.2307/2526280

Mishra, K., & Sam, A. G. (2016). Does women's land ownership promote their empowerment? Empirical evidence from Nepal. *World Development*, 78, 360-371. doi: 10.1016/j.worlddev.2015.10.003

Monchuk, D., Deininger, K., & Nagarajan, H. (2010). Does land fragmentation reduce efficiency: Micro evidence from India. *2010 Annual Meeting, July 25-27, 2010, Denver, Colorado 61652, Agricultural and Applied Economics Association.* doi: 10.22004/ag.econ.61652

Montenegro Guerra, M. J., Mohapatra, S., & Swallow, B. (2019). What influence do empowered women have? Land and the reality of women's relative power in Peru. Review of Economics of the Household, 17(4), 1225-1255. doi: 10.1007/s11150-019-09461-2

Moser, C., & Felton, A. (2007). *The construction of an asset index measuring asset accumulation in Ecuador*. Chronic Poverty Research Center Working Paper No. 87. doi: 10.2139/ssrn.1646417

Quisumbing, A., Meinzen-Dick, R., Raney, T., Croppenstedt, A., Behrman, J., & Peterman, A. (Eds.). (2014). "Gender in agriculture: Closing the knowledge gap". Rome: Food and Agriculture Organization.

Rahman, L., & Rao, V. (2004). The Determinants of Gender Equity in India: Examining Dyson and Moore's Thesis with New Data. *Population and Development Review*, 30(2), 239–268. doi: 10.1111/j.1728-4457.2004.012_1.x

Simpson, E. H. (1949). Measurement of diversity. *Nature*, 163 (4148), 688. doi: 10.1038/163688a0

Skoufias, E. (2005). PROGRESA and its impacts on the welfare of rural households in Mexico. *Food Consumption and Nutrition Division Discussion Paper No. 139.* Washington, DC: International Food Policy Research Institute. Retrieved from: https://www.ifpri.org/publication/progresa-and-its-impacts-welfare-rural-households-mexico-0

Sraboni, E., Malapit, H., Quisumbing, R., & Ahmed, A. (2014). Women's empowerment in agriculture: What role for food security in Bangladesh. *World Development*, 61, 11–52. doi: 10.1016/j.worlddev.2014.03.025

Stock, J. H. & Watson, M. W. (2011). *Introduction to Econometrics* (3rd ed.). Boston, MA: Addison-Wesley.

Tan, S., Heerink, N., Kruseman, G., & Qu, F. (2008). Do fragmented landholdings have higher production costs? Evidence from rice farmers in Northeastern Jiangxi province, P.R. China. *China Economic Review*, 19, 347-358. doi: 10.1016/j.chieco.2007.07.001

Wiig, H. (2013). Joint titling in rural Peru: Impact on women's participation in household decision-making. *World Development*, 52, 104-119. doi: 10.1016/j.worlddev.2013.06.005

Wouterse, F. (2019). The role of empowerment in agricultural production: evidence from rural households in Niger. *The Journal of Development Studies*, 55(4), 565-580. doi: 10.1080/00220388.2017.1408797