Do Commercialization and Mechanization of a "Women's Crop" Disempower Women Farmers? Evidence from Zambia and Malawi

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Selected Paper prepared for presentation for the 2016 Agricultural & Applied Economics Association, Boston, MA, July 31-August 2

Abstract.

It is widely believed that commercialization and mechanization of food crops lead to disempowering women as men take over control from women. We argue that women are not necessarily discontent in the face of the agrarian transformation. By collecting sex-disaggregated panel data and applying a 'women's crop tool', we analyze and rethink the implication of agricultural commercialization for intra-household gender relation among smallholder farmers through research on groundnut producers in southern Africa, where groundnut is largely regarded as a 'women's crop'. In addition to examining the effect of commercialization in Zambia and Malawi, small-scale post-harvest mechanization was provided experimentally to selected farmers in Zambia. The panel regression results show that commercialization did not lead to disempowering women in either country, which is consistent with the qualitative discussions with farmers held before the baseline surveys. Furthermore, by combining PSM and DID methods, it was found that machine shelling did not disempower women farmers either. The finding provides insights into how gender relation among smallholders is affected at the initial stage of commercialization and mechanization of 'women's crops'.

Key Words: gender, women, commercialization, mechanization, groundnut, Zambia, Malawi

JEL Codes: J16, O13, Q12

Acknowledgement

The article synergizes the outcome of different research activities implemented by International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and funded by USAID Feed the Future through the I-FINITE Project, Irish Aid through the Malawi Seed Industry Development Project, and the McKnight Foundation through its Collaborative Crop Research Program in which ICRISAT closely collaborates with Compatible Technology International. The women's crop tool was developed by ICRISAT Eastern and Southern Africa, which was funded by the CGIAR (Consultative Group on International Agricultural Research) Research Program on Policies, Institutions and Markets led by International Food Policy Research Institute. The CGIAR Research Program on Grain Legumes contributed administrative support. The shellers were manufactured by C to C Engineering in Malawi. The authors thank Mr. Whytson Sakala and Ms. Rosie Hoare of Eastern Province Farmers Cooperative for giving access to its groundnut producer groups in Zambia. We also thank the enumerators for collecting data, the lead farmers in each site for mobilizing fellow farmers, and the women and men farmers who pleasantly agreed to join the discussions and answer our questions.

1. Introduction

The majority of farm households in Malawi and Eastern Zambia produce groundnut for both consumption and sales. Production has been growing significantly for the past several decades in Malawi, and the crop has become the second income earner for smallholder farmers (Tsusaka et al., 2016a). A similar trend is observed in neighboring Eastern Zambia where seed production for improved varieties is increasing. In southern Africa, groundnut is regarded as a 'women's crop' primarily because much of the labor is provided by women, especially during the labor intensive post-harvest handling such as harvesting, stripping, and shelling (Tsusaka et al., 2016b), resulting in women perceiving greater control over groundnut production than men, where control extends to decision making at various steps in production (Orr et al., 2016a). This is in line with Doss (2001)'s argument that 'women's crops' are defined not only by who controls the output but also by who makes the management decisions.

It is widely argued that mechanization and commercialization of 'women's crops' leads to disempowering women (Forsythe et al., 2016; Mudege et al., 2015). Traditional gender roles in agrarian communities view women as the care takers of food and men as the providers of cash crops. However, when food crops become commercialized, often driven by market demand, these gender roles may conflict. Typically, men then assert their role to gain control of the income generated from food crops, relegating women to merely suppliers of labor. The paradigmatic case is irrigated rice in The Gambia, where the commercialization of irrigated rice subverted women's rights to land, increased male control over their labor power, and turned women farmers into hired workers (Carney, 1998, 1992, 1988; Carney and Watts, 1991, 1990; Dey, 1982, 1981; von Braun and Webb, 1989). Another aspect is that commercialization, when scaled up, accompanies mechanization which induces men to take control. The adverse impact of mechanization and commercialization on women in The Gambia resulted in a minor cottage industry. Subsequently, researchers seem to have lost interest in this topic, although later work on global value chains supports these earlier conclusions (Dolan, 2001). In short, what we know about mechanization and commercialization leads to the dispiriting conclusion that it disempowers women in some way.

Our study attempts to rethink this framing of gender, mechanization, and commercialization as a zero-sum game, based on fieldwork with women and men groundnut

farmers in Zambia and Malawi. Based on the baseline study conducted in Eastern Zambia in 2014 (Orr et al., 2014), we argue that while some of their attitudes match this narrative, others do not. While defending their power to name groundnut as a women's crop, women were also willing to cooperate with men toward commercialization. In particular, women seemed prepared to trade some degree of autonomy or control in exchange for greater male participation in shelling groundnut, the role typically regarded as drudgery. By relieving this post-harvest bottleneck, women saw male participation in shelling as an opportunity to scale up groundnut production, which would benefit the whole household through income generation. This suggests that women did not see the commercialization of groundnut as a zero sum game but were willing to bargain and negotiate, welcoming greater male participation while striving to retain operational and financial control. We hypothesize that commercialization and mechanization do not necessarily disempower women.

To measure autonomy or control, we applied the women's crop tool (Orr et al., 2016b) by which we elicited women's and men's levels of control over decision-making in various steps (namely, land allocation, land preparation, plating, weeding, hiring labor, harvesting, selling, and use of income) in production of four major crops in the region: maize, groundnut, cotton, and sunflower in Zambia, and maize, groundnut, soybean, and tobacco in Malawi. To construct composite indicators, the weights were collected as the relative importance given to these key decisions. The weighted scores are aggregated to produce a weighted gender control indicator (WGCI).

In Eastern Zambia and Central Malawi, panel data were collected to capture variables for commercialization and gender control, among other things. In addition, for Zambia, machine shellers were provided to the treatment group between the baseline and follow-up surveys.

The objective of this paper is to assess the extent to which commercialization and mechanization affect women's perceived control in farming by use of propensity score matching and panel data models. Following this introduction, Section 2 describes the methodology in depth, Section 3 discusses the descriptive statistics, Section 4 presents the regression results, and Section 5 concludes the paper.

2. Methodology

2.1. Surveys

A semi-structured questionnaire was converted into ODK (Open Data Kit) to electronically capture data through personal interviews with smallholder farmers. By the nature of this study, households with both male and female adults were purposively selected. Among such households, randomly sampling was conducted in each site. The spouses from each household were interviewed separately to ensure that the collected sex-disaggregated data would not be biased by the partner. In the case of polygamy, the main wife identified by the husband was interviewed. In principle, female enumerators interviewed women respondents, whilst male enumerators spoke to men respondents, except for a few cases of exception.

Zambia

Recently, increasing demand has resulted in new investment in seed production, processing, and grain trading. The Eastern Province Farmers' Cooperative (EPFC) is a farmers' organization that buys and sells groundnut seed and grain. EPFC distributed machine shellers to selected groundnut producer groups as a pilot case.[1] Gender-disaggregated focus group discussions revealed that men were keen to operate these shellers and to assume a greater role in decision-making for groundnuts, including use of income from sales. The baseline survey was conducted with randomly selected 400 women and men from 200 households in two villages in Eastern Province just before harvest in 2014.[2]

Since it is extremely difficult to exclude particular farmers from intervention with a club good, the intervention was provided at village level. That is, after the baseline, manually operated shelling machines were provided to the treatment village (Mkhazika), while the control village (Kapenya) was kept shelling by hand. The provision of shellers was accompanied by training on use of the equipment, where women and men were equally invited and did participate. The follow-up survey was conducted in 2015 with largely the same households, enabling us to construct panel data for two consecutive years.

Malawi

In recent years, groundnut area has been increasing by replacing tobacco area due to the relatively favorable prices and the improvement in seed systems (Tsusaka et al., 2016a). Central

[1] The machine shellers used by EPFC farmer groups were is manufactured by C-to-C Engineering in Malawi. The equipment is operated by three people and can shell four 50 kg bags in one hour or thirty-four 50 kg bags in a working day of eight hours, averaging 533 kg per person. In one eight-hour day a woman can shell 25 kg by hand. Thus, in unit time, the machine sheller does the work of 20 women.

[2] The number of observations used in the analysis is less than the number mentioned here because of the difficulty in merging the data from husbands and wives.

Malawi is the center of the so-called groundnut belt which cuts across Chinyanja Triangle. The baseline survey was conducted with randomly selected 240 women and men from 120 households in Lilongwe, Kasungu, and Mchingi districts near the end of 2014.[3] The follow-up survey was conducted in early 2016 with largely the same households, enabling us to construct panel data for two consecutive years.

2.2. Women's Crop Tool

The women's crop tool was recently developed

2.2.1. Gender Control Indicator

In Figure 1, the crops (C1-C4) in each quadrant are the crops for which women's control is compared. The decisions (D1-D6) are the key decisions for crop production and sale for which the degree of women's control is measured. The weights (W1-W6) are the relative importance that women give to these key decisions (D1-D6). Finally, the scores (S1-S6) measure the degree of control that women perceive they have over these key decisions.

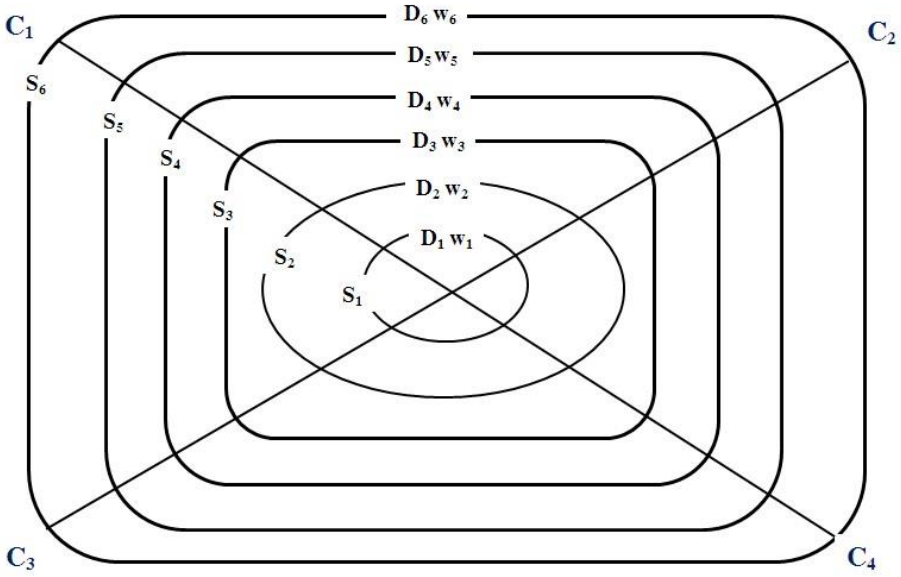

Figure 1 A tool to identify 'women's crops'

Source: Orr et al., (2016b)

In our study, the gender-disaggregated perceived levels of control in farming processes were elicited for eight different decision-making categories: land allocation, land preparation, hired

[3] Ditto.

labour, use of inputs, weeding, harvesting, selling, and use of income. The concept of indexing gender empowerment stems directly from WEAI (IFPRI, 2012) and WEI (Paris et al., 2010). To identify and incorporate which category is relatively important, weighting factors were collected on the scale of 0 to 5. In practice, the tool was adapted into the electronic questionnaire and administered to women and men respondents separately. The weighted gender control indicator (WGCI) can be defined for each crop as follows:

$$WGCI_g = \frac{\sum_{j=1}^{k} w_{jg} C_{jg}}{\sum_{j=1}^{k} w_{jg}}$$

where *w* is the weighting factor, C is the perceived level of control expressed in percentage, the subscript *j* is a category, *k* is the number of categories (i.e., 8 in our case), and *g* refers to either male (husband) or female (main wife).

As husbands and wives are separately interviewed and asked to provide their perception of level of control, answers from husbands and wives do not need to add up to 100 since they both have a tendency to stake claims (Orr et al., 2016a). For instance, when the wife perceives 40% of control over a certain process, the husband is not expected to perceive 60% of control over the same process, and vice versa.

2.2.2. Gender Workload Indicator

Data on the perceived share of workload for both men and women were also collected across all the crops. This consisted of the perceived share of workload in land preparation, planting, fertilizer application, weeding, harvesting, shelling (or threshing), transport to storage, sorting (or grading), and transport to market if any. Person-hour data taken from on-station trials conducted at Chitedze Research Station collected during the 2013 crop season were used as weighting factors. The weighted gender workload indicator (WGWI) can be defined for each crop as follows:

$$WGWI_g = \frac{\sum_{j=1}^{k} w_{jg} S_{jg}}{\sum_{j=1}^{k} w_{jg}}$$

where *w* is the person-hour factor, *S* is the perceived share of workload expressed in percentage, the subscript *j* refers to a stage in farming processes, *k* is the number of stages involved, and *g* refers to either husband or main wife.

In this paper, both control over decision making and contribution to labor are defined and discussed in the world of perception as we believe perception is what matters most after all, rather than how third parties think it is.

2.2.3. Descriptive Statistics

Descriptive statistics are shown to illustrate the baseline status of the sampled households, as a basis for assessing the impacts of commercialization and mechanization. The various gender indicators and their interrelation are described using bivariate statistical tests such as paired t-test (Hsu and Lachenbruch, 1996).

2.2.4. Econometric Estimation

In this paper, our main interest is in examining the impacts of commercialization and mechanization on women's control over groundnut. Therefore, the dependent variable is the WGCI for women and groundnut. The impacts on men's control and the inter-crop dynamics shall be documented in a separate report.

Commercialization Effect

In both Zambia and Malawi, we test the hypothesis that commercialization of a women's crop does not necessarily disempower women. The endogeneity bias associated with levels of commercialization is addressed by panel regression models (Wooldridge, 2002) which control for any unobservable household specific characteristics that did not alter within a year. The Hausman test (Holy, 1982) is run to determine between the fixed effect and random effect models. Additionally, ordinary least squares (OLS) with standard error corrected for clustering on households (Cameron and Miller, 2015) is also used to show the effects of control variables that were constant within the one year.

Mechanization Effect

In Zambia, we also test the hypothesis that mechanization of a women's crop does not necessarily disempower women. Since the sheller intervention was implemented at village level, we first employ propensity score matching (Rosenbaum and Rubin, 1983) to balance between the treatment and control groups by accounting for potential selection bias arising from observable household characteristics. Then, we utilize the difference-in-difference estimator (Lechner, 2010) to examine the sheller effect on the WGCI.

3. Farmer Profile

To set the stage for impact assessment, it is worthy to outline the status of the studied farmers using the baseline information. Tables 1 and 2 summarize the key characteristics of the sampled households in Zambia and Malawi, respectively. Groundnut and maize are produced by most of the farmers in this region, and the average area allocated to each of the crops does not vary largely across sites, though quantity of groundnut production differs to a larger extent. Average groundnut sales are in the rage of 120 to 320 kg.

The main cash crops in Zambia and Malawi are cotton and tobacco respectively, to which producers allocate less than two acres on average. However, not all the farmers produce these crops. Sunflower in Zambia and Soybean in Malawi are garden crops produced in smaller area for oil consumption or sales.

Table 1 Baseline Agricultural and Demographic Profile of Sampled Households in Zambia Baseline (2013)

Variable	Mkhazika (N=94)		Kapenya (N=88)	
	Mean	Std.Dev.	Mean	Std.Dev.
Groundnut				
Production (kg)/grower	870	2066	404	518
Sales (kg)/grower	316	493	284	411
Area (acres)/grower	1.5	1.0	1.6	0.8
Number of growers	81		85	
Maize				
Production (kg)/grower	1419	1046	1486	1342
Sales (kg) /grower	416	1050	489	1107
Area (acres)/grower	2.5	1.4	2.4	1.5
Number of growers	92		87	
Cotton				
Production (kg)/grower	752	458	566	374
Sales (kg)/grower	611	540	553	383
Area (acres)/grower	1.6	0.9	1.9	1.1
Number of growers	61		54	
Sunflower				
Production (kg)/grower	578	317	642	732
Sales (kg)/grower	25	71	245	829
Area (acres)/grower	0.9	0.9	0.9	0.4
Number of growers	8		13	
Sum of Age (yrs)[1)]	67.7	21.9	73.8	29.9
Gap in Age (yrs)[2)]	5.0	5.3	6.2	4.9
Sum of Education (yrs)[1)]	12.3	3.9	11.5	4.6
Gap in Education (yrs)[2)]	1.0	2.9	2.3	2.4
Household Size (headcount)	5.6	2.4	5.7	2.5
Household Adult female ratio[3)]	0.50	0.06	0.51	0.09

1) Sum: husband's value plus wife's value
2) Gap: husband's value minus wife's value
3) Number of adult female members/total adults in the household.

Table 2 Baseline Agricultural and Demographic Profile of Sampled Households in Malawi Baseline (2014)

Variable	Lilongwe (N=33)		Kasungu (N=33)		Mchinji (N=43)	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Groundnut						
Production (kg)/grower	594	2087	257	309	458	491
Sales (kg)/grower	125	168	139	217	321	443
Area (acres)/grower	1.1	0.8	1.1	0.7	1.5	0.6
Number of growers	28		31		36	
Maize						
Production (kg)/grower	1641	1522	1610	1297	1762	1082
Sales (kg)/grower	186	646	243	609	317	669
Area (acres)/grower	2.1	0.9	2.2	1.1	1.9	0.8
Number of growers	32		33		39	
Tobacco						
Production (kg) /grower	364	317	1484	3111	463	559
Sales (kg)/grower	364	317	1484	3111	463	559
Area (acres)/grower	1.0	0.6	1.1	0.7	0.9	0.7
Number of growers	15		19		24	
Soybean						
Production (kg)/grower	245	527	179	163	146	145
Sales (kg)/grower	211	514	125	152	115	125
Area (acres)/grower	0.5	0.3	0.4	0.2	0.5	0.3
Number of growers	10		9		15	
Sum of Age (yrs)[1)]	92.8	23.5	88.1	15.3	87.7	17.8
Gap in Age (yrs)[2)]	8.4	17.4	6.3	21.5	6.9	13.6
Sum of Education (yrs)[1)]	11.5	3.7	10.7	4.5	11.1	4.3
Gap in Education (yrs)[2)]	1.5	4.6	1.1	4.5	1.4	5.3
Household Size (headcount)	6.7	3.5	7.2	2.9	6.5	2.5
Household Adult female ratio[3)]	0.5	0.2	0.5	0.1	0.5	0.1

1) Sum: husband's value plus wife's value
2) Gap: husband's value minus wife's value
3) Number of adult female members/total adults in the household

3.2. Gender Indicators

Before constructing the crop-level weighted indicators, Figures 1 and 2 present the raw indicators by decision category. Figure 1 compares women's perception of control over groundnut, maize, cotton, and sunflower in Zambia. Women's perceived level of control is higher for groundnut than for the other three crops, consistently across the decision categories.

Albeit less than 50, women also perceive to have a considerable share in control over maize relative to cotton and sunflower. Nonetheless, on the whole, the crop level difference seems small. By decision category, however, women perceive higher control over weeding, harvesting, and use of income than over the other categories, which is consistent across the crops.

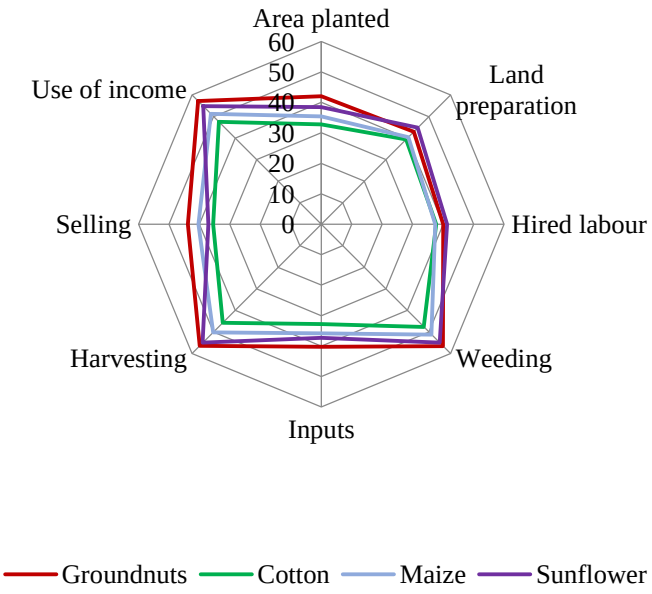

Figure 1 Women's perceptions of control over groundnut, maize, cotton, sunflower in Zambia

Figure 2 compares women's perception of control over groundnut, maize, tobacco, and soybean in Malawi. Similar to Zambia, women's perceived level of control is higher for groundnut than for the other three crops. Albeit less than 50, women also perceive to have a considerable share in control over maize compared to tobacco and soybean. By decision-category, however, women perceive much less control over use of hired labor and marketing than over the other decision categories, in the case of groundnut and maize. Comparing the two income earning crops, women's control over income from tobacco is minimal whereas they enjoy a decent control over income from groundnut. At large, sharper gender contrast across crops is observed in Malawi than in Zambia.

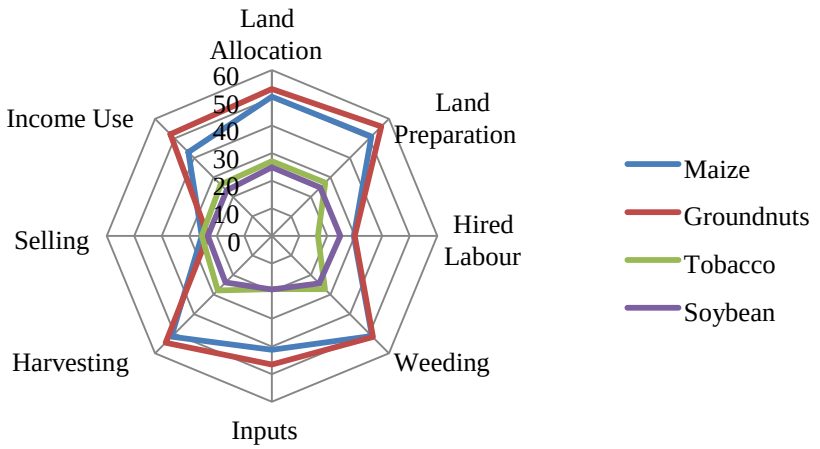

Figure 2 Women's perceptions of control over groundnut, maize, tobacco, and soybean in Malawi

Figures 3-6 contrast women's control as perceived by men and women over the 'men's crop', i.e., cotton in Zambia and tobacco in Malawi, and the 'women's crop', i.e., groundnut in both countries.[4] For groundnut, women perceive they have more control than men perceive women have, in both counties. This clearly suggests a gender gap in perception of women's control over groundnut. The 'men's crop' exhibits a contrast between the two countries. For cotton in Zambia, women perceive limited control while men perceive women have control. For tobacco in Malawi, on the other hand, men perceive women have almost no control over the crop, while women perceive they have slight control. In any case, both women and men perceive that tobacco is dominantly controlled by men.

[4] Sunflower in Zambia and soybean in Malawi are also 'women's crops', but not many households produce these crops in the studied area, and the scale of cultivation is small.

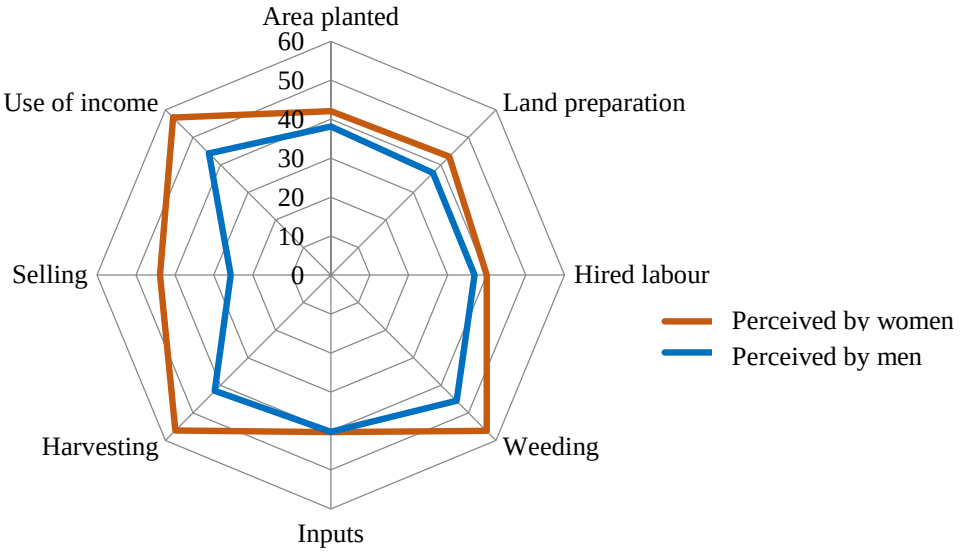

Figure 3 Contrasting perceptions between men and women of women's control over groundnut production in Zambia

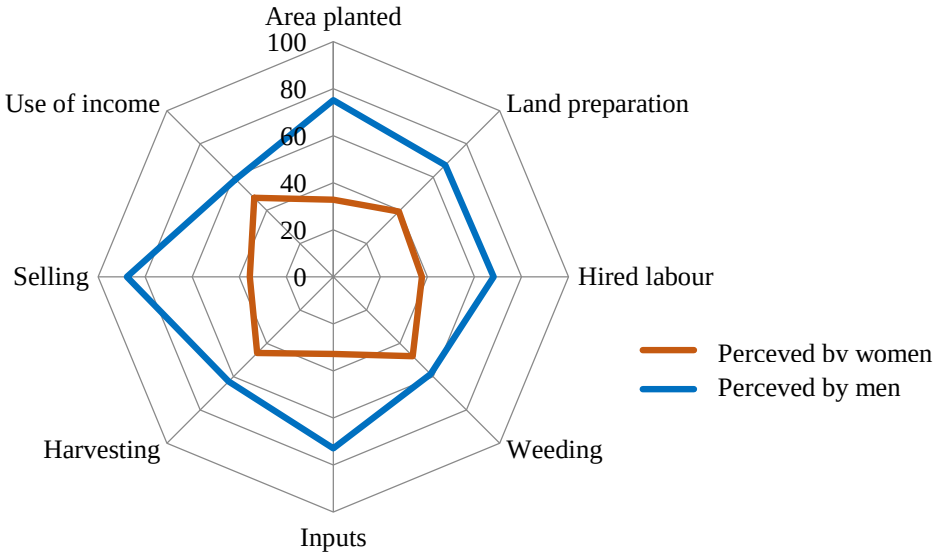

Figure 4 Contrasting perceptions between men and women of women's control over cotton production in Zambia

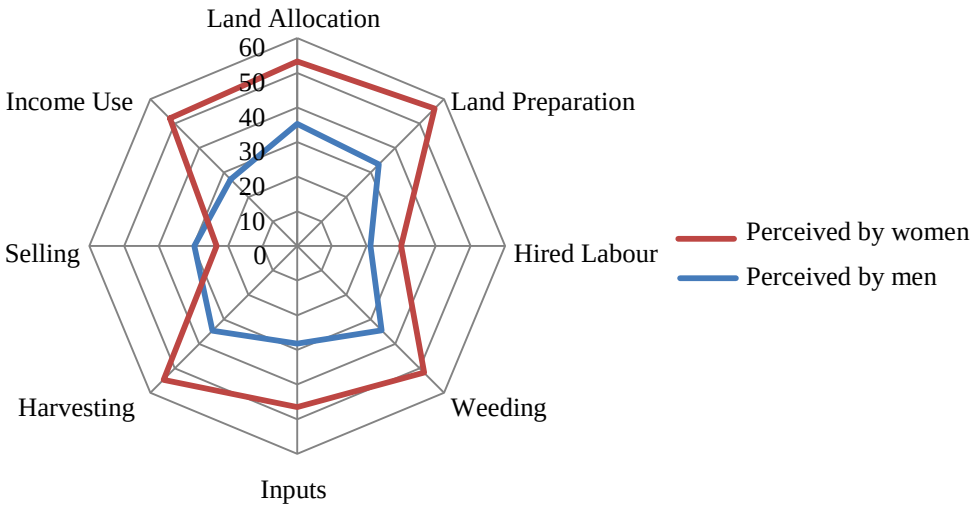

Figure 5 Contrasting perceptions between men and women of women's control over groundnut production in Malawi

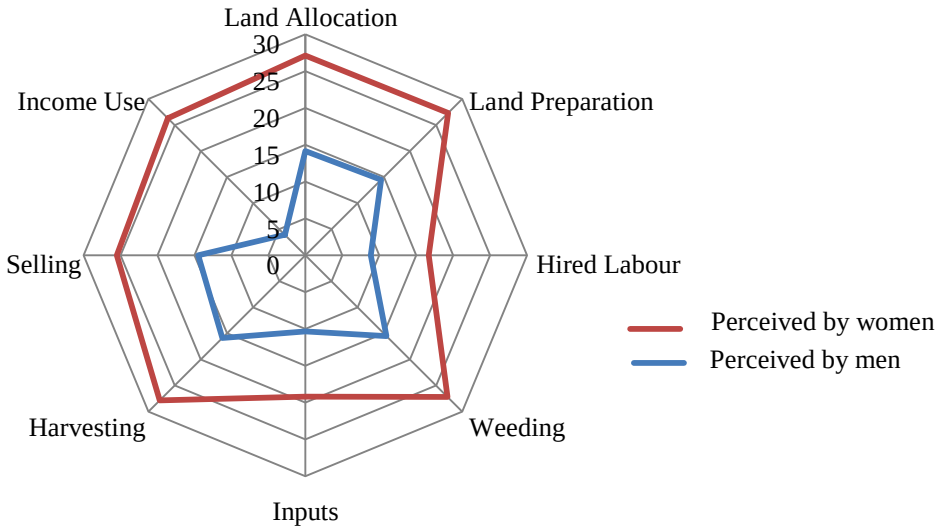

Figure 6 Contrasting perceptions between men and women of women's control over tobacco production in Malawi

By incorporating the weighting factors, which had also been collected from the respondents, the WGCI was constructed for different crops by gender by site (Tables 3 and 4). Men's perceived control in the farming activities for all the crops was higher than that of women, which is basically consistent with literature, e.g., Ogunlela and Mukhtar (2009), Kabeer (2009), and Quisumbing (1996). In each country, groundnut and maize exhibit similar values, while the gender gap is greater in Zambia. As expected, the gender gap is pronounced for the men's crops.

Table 3 WGCI by Crop by Site, Zambia Baseline, 2013

		Mkhazika			Kapenya			t-test (p-value)
		N	Mean	Std. Dev	N	Mean	Std. Dev	
Groundnut	Husband	81	63.7	10.8	85	61.0	11.6	0.112
	Main wife		44.6	11.9		48.4	14.7	0.055
Maize	Husband	92	66.1	12.0	87	64.9	11.1	0.456
	Main wife		42.8	10.9		41.7	11.9	0.529
Cotton	Husband	61	67.8	14.5	54	66.6	11.3	0.575
	Main wife		40.3	9.2		37.7	11.3	0.136
Sunflower	Husband	8	57.5	11.8	13	61.9	14.0	0.099
	Main wife		44.3	11.7		41.9	11.9	0.342

Source: Survey Data 2013

Table 4 WGCI by Crop by Site, Malawi Baseline, 2014

		Lilongwe			Kasungu			Mchinji			ANOVA (p-value)
		N	Mean	Std. Dev	N	Mean	Std. Dev	N	Mean	Std. Dev	
Groundnut	Husband	29	55.2	17.3	32	54.3	11.6	39	56.7	12.7	0.756
	Main wife		50.7	21.2		49.8	16.1		42.5	11.5	0.080
Maize	Husband	33	60.5	15.7	33	57.0	9.7	43	57.7	13.1	0.520
	Main wife		49.6	25.3		54.3	18.9		48.4	16.0	0.438
Tobacco	Husband	26	62.6	19.0	17	59.8	11.0	20	62.6	12.2	0.809
	Main wife		40.0	22.5		36.2	15.1		35.4	13.2	0.667
Soybean	Husband	13	62.9	18.5	15	51.4	12.4	19	59.5	14.0	0.117
	Main wife		50.4	25.7		53.0	17.3		47.2	12.6	0.650

Source: Survey Data 2014

In addition to control over decision-making, women's and men's perceived share of workload or contribution to labor was also collected, and the WGSW was constructed for different crops by gender by site (Tables 5 and 6). Similar to the result for the WGCI, men tend

to perceive a higher level of participation than women, which confirms the finding by Enete, A., Nweke, F., and Tollens, E. (2002) and is also in line with Orr et al. (2016a)'s result that labor participation and control over decisions are closely linked. Blackden et al. (2006) also mention time constraints women face due particularly to burdens associated with household tasks and child care. Nonetheless, the male dominance for WGWI is not as eminent as for WGCI, since at least for groundnut in Zambia and soybean in Malawi, women's labor participation is notably higher than men's. This suggests that women do not maintain adequate authority that they may deserve.

Table 5 WGWI by Crop by District, Zambia, 2013

		Mkhazika			Kapenya			t-test (p-value)
		N	Mean	Std. Dev	N	Mean	Std. Dev	
Groundnut	Husband	81	61.0	19.0	85	61.8	10.2	0.758
	Main wife		71.2	46.2		69.0	17.8	0.678
Maize	Husband	92	58.0	12.6	87	61.8	11.5	0.033
	Main wife		53.7	10.3		52.5	13.3	0.497
Cotton	Husband	61	76.9	119.8	54	69.2	23.5	0.596
	Main wife		49.2	97.4		52.7	23.2	0.769
Sunflower	Husband	8	62.2	85.2	13	50.1	30.6	0.417
	Main wife		58.3	19.6		52.4	25.4	0.184

Source: Survey Data 2013

Table 6 WGWI by Crop by District, Malawi, 2014

		Lilongwe			Kasungu			Mchinji			ANOVA (p-value)
		N	Mean	Std. Dev	N	Mean	Std. Dev	N	Mean	Std. Dev	
Groundnut	Husband	28	47.4	14.1	31	51.6	12.1	36	54.5	12.0	0.087
	Main wife		52.7	22.1		51.5	18.7		48.2	13.1	0.563
Maize	Husband	32	61.4	15.2	33	54.3	10.3	39	57.4	12.3	0.076
	Main wife		41.3	13.2		39.9	11.3		38.6	10.9	0.598
Tobacco	Husband	15	57.1	17.0	19	58.6	13.4	24	59.0	11.0	0.896
	Main wife		38.4	16.5		36.6	14.1		37.8	10.5	0.915
Soybean	Husband	10	45.0	7.5	9	39.0	8.7	15	40.8	9.4	0.206
	Main wife		45.3	23.3		51.2	16.1		48.2	16.1	0.691

Source: Survey Data 2014

Tables 7 and 8 statistically confirm the gender gap in perception of women's control in farming. In general, women perceive themselves having more control than men think women have, with the exception of tobacco in Malawi for which both genders agree on women's level of control as 37%.

Table 7 Paired t-test on Women's Control: Women's perception vs Men's perception, Zambia, 2013

	N	Women's Control		Mean Difference	P-value
		Women's Perception	Men's Perception		
Groundnut	166	47.7	39.1	8.6	0.000
Maize	179	42.9	35.6	7.3	0.000
Cotton	115	39.4	34.1	5.3	0.000
Sunflower	21	45.0	43.1	1.9	0.004

Source: Survey Data 2013

Table 8 Paired t-test on Women's control: Women's perception vs Men's perception, Malawi, 2014

	N	Women's Control		Mean Difference	P-value
		Women's Perception	Men's Perception		
Groundnut	101	47.5	44.5	3.1	0.099
Maize	109	50.5	41.8	8.6	0.000
Tobacco	60	36.8	36.9	-0.1	0.489
Soybean	47	49.4	42.1	7.3	0.130

Source: Survey Data 2014

4. Estimation Results

This section presents the estimation result through panel regressions with the two year data in each country: 2013 & 2014 in Zambia and 2014 & 2015 in Malawi. 14 cases of attrition occurred due to relocation, unavailability of one of the spouses at the interview, and difficulty in merging the data from the two spouses. The attrition was found to be random with respect to the key covariates.

4.1. Zambia

For Zambia, since the sheller intervention was provided at village level, we begin the estimation process by balancing the treatment and control groups on the basis of the baseline data. The most important covariate to be balanced is quantity of groundnut production, as implied by Table 1. We tried seven algorithms with propensity score matching (Rosenbaum, 2002) and two algorithms with Mahalanobis matching (Rubin, 1980) to establish a counterfactual group.[5] Among these, the nearest one neighbor matching with replacement (Becker & Ichino, 2002; Dehejia, 2005) using the score predicted by logit was found to achieve the best balance. Four households came off common support (Caliendo and Kopeinig, 2008) and were dropped from the sample. To confirm the balance achieved by this algorithm, Table 9 presents the outcome of the balancing test. The mean difference in all the key covariates has become insignificant through matching, in particular the production level. The % bias also reduced remarkably where it was large before matching. Overall, the result confirms the validity of the matching.

Table 9 Sample Balance Test on Baseline, 2013: Before vs. After Matching

Variable	Sample	Mean		% bias	t-test	
		Treated	Control		t-statistic	p-value
Groundnut Production (kg)	Unmatched	802	381	28.2	1.83	0.069
	Matched	554	483	4.8	0.73	0.464
Spouses of Same Religion (yes=1)	Unmatched	0.48	0.52	-9.5	-0.61	0.540
	Matched	0.49	0.43	12.4	0.79	0.431
Husband Has Official Duty (yes=1)[1)]	Unmatched	0.08	0.06	9.2	0.60	0.552
	Matched	0.09	0.08	4.8	0.29	0.774
Wife Has Official Duty (yes=1) [1)]	Unmatched	0.07	0.08	-4.4	-0.29	0.774
	Matched	0.08	0.10	-9.3	-0.56	0.579
Polygamy (yes=1)	Unmatched	0.20	0.08	34.3	2.22	0.027
	Matched	0.18	0.24	-18.0	-0.97	0.332
Sum of Age (year)	Unmatched	73.6	68.0	22.3	1.44	0.150
	Matched	72.4	68.3	16.6	1.09	0.276
Gap in Age (year)[2)]	Unmatched	6.35	5.11	23.7	1.53	0.127
	Matched	6.08	6.48	-7.6	-0.59	0.557
Groundnut Experience (years)	Unmatched	8.93	5.77	33.3	2.15	0.033
	Matched	7.61	6.65	10.1	0.73	0.465
Household Size (headcount)	Unmatched	5.75	5.52	9.0	0.59	0.559
	Matched	5.55	5.85	-12.0	-0.77	0.444
Household Adult	Unmatched	0.51	0.50	18.8	1.22	0.224

[5] The following nine algorithms were tried: nearest one neighbor with logit, nearest one neighbor without replacement with logit, nearest one neighbor with probit, nearest one neighbor without replacement with probit, nearest two neighbors with logit, kernel matching (bandwidth=0.002) with logit, radius matching (caliper=0.06) with logit, Mahalanobis metric matching, and Mahalanobis metric matching with caliper (=10).

Female Ratio	Matched	0.51	0.52	-11.9	-0.64	0.523
Improved Seed Area Ratio, All Crops	Unmatched	0.62	0.64	-9.0	-0.58	0.562
	Matched	0.63	0.66	-10.3	-0.69	0.490
Unmatched: Likelihood Ratio $\chi^2 = 17.79$ (p = 0.087)						
Matched: Likelihood Ratio $\chi^2 = 8.26$ (p = 0.690)						

NB: N = 168 for unmatched and 164 for matched.
1) Official duty with EPFC
2) Husband age minus wife's age

With the matched sample households, the two year panel regression models were estimated, where the DID estimator captured the sheller effect and the coefficient on groundnut sales captured the commercialization effect. The Hausman test returned χ^2 (4) = 14.18 (p = 0.4365), pointing to the random effect specification rather than the fixed effect. Table 10 presents the estimation results. The sheller effect was found to be statistically insignificant, indicating that the small-scale mechanization had not disempowered women. The effect of commercialization was found to be positive and statistically significant, indicating that commercialization had led to empowering women. The quantitative interpretation is that, on average, a one ton increase in groundnut sales is associated with a 4.6-5.0 percentage point increase in women's perceived level of control over groundnut farming. Admittedly, the magnitude of the effect is not very large. Yet, the result implies that, at least, commercialization had not disempowered women. The finding is consistent with the result by Orr et al. (2016a) based on the one-year data from three villages in Eastern Zambia. Replacing sales by production gave the coefficient 0.0033 (p = 0.123 for Random Effect and 0.093 for OLS-RSE), suggesting that increased production had also resulted in empowering women. Among the control variables, sum of age shows a positive and significant effect. In Zambia, older couples are more likely to have separate economic activities (Harrison, 2000).

Table 10 Matched Regression Estimation for Zambia, 2013 & 2014

Dependent Variable: $WGCI_f$ (Groundnut)	Random Effect		OLS Robust SE	
	Coeff.	P-Value	Coeff.	P-Value
Sheller Group Dummy	-5.5845	0.040	-5.5846	0.007
Year Dummy (1 if 2014)	2.1805	0.463	2.1805	0.528
DID (Sheller Effect)	2.6932	0.510	2.6932	0.563
Groundnut Sales (kg)	0.0050	0.089	0.0046	0.071
Spouses of Same Religion (yes=1)	3.0658	0.135	3.0658	0.133
Husband Has Official Duty (yes=1)[1)]	-0.7529	0.850	-0.7529	0.851

Wife Has Official Duty (yes=1)[1)]	4.3628	0.279	4.3628	0.205
Polygamy (yes=1)	3.1290	0.501	3.1290	0.414
Sum of Age	0.5357	0.051	0.5357	0.084
[Sum of Age]^2	-0.0023	0.147	-0.0023	0.216
Gap in Age[2)]	-0.1025	0.769	-0.1024	0.779
[Gap in Age]^2	-0.0058	0.771	-0.0058	0.770
Groundnut Experience (years)	-0.0567	0.731	-0.0283	0.737
Household Size	-0.5290	0.231	-0.5209	0.366
Household Adult Female Ratio	2.1386	0.875	2.1386	0.897
Improved Seed Area Ratio, All Crops	-4.5692	0.207	-4.5692	0.187
Constant	26.2982	0.035	26.2982	0.058
N = 291; RE: Wald $\chi^2(16)$ = 26.03 (p= 0.054); OLS-RSE: F(16, 163) = 2.59 (p= 0.001)				

1) Official duty with EPFC
2) Husband age minus wife's age

4.2. Malawi

For Malawi, the Hausman test returned χ^2 (3) = 0.01 (p=9998), strongly pointing to the random effect specification rather than the fixed effect. Table 11 shows the estimation result. The effect of commercialization was found to be positive but statistically insignificant. Again, the result indicates that increased commercialization did not lead to lowering women's control over decision making as to groundnut. Substituting production for sales gave the coefficient 0.0008 (p = 0.227), meaning that increased production had not resulted in disempowering women either.

Table 11 Regression Estimation for Malawi, 2014 & 2015

Dependent Variable: $WGCI_f$ (Groundnut)	Random Effect		OLS Robust SE	
	Coeff.	P-Value	Coeff.	P-Value
Year Dummy (1 if 2015)	-0.6762	0.102	-0.6762	0.115
Groundnut Sales (kg)	0.0006	0.467	0.0006	0.464
Spouses of Same Religion (yes=1)	-0.1371	0.756	-0.1371	0.714
Polygamy (yes=1)	-0.3745	0.529	-0.3745	0.558
Sum of Age	0.0048	0.833	0.0048	0.836
[Sum of Age] ^{2}	0.0000	0.962	0.0000	0.964
Gap in Age	-0.0200	0.798	-0.0200	0.746
[Gap in Age] ^{2}	0.0010	0.768	0.0010	0.662
Groundnut Experience (years)	-0.0250	0.538	-0.0250	0.519
Household Size	0.0492	0.504	0.0492	0.435
Household Adult Female Ratio	1.5027	0.244	1.5027	0.269
Improved Seed Area Ratio, All Crops	-0.2837	0.163	-0.2837	0.162
Kasungu District Dummy	0.7635	0.108	0.7635	0.125
Mchinji District Dummy	-0.6854	0.128	-0.6854	0.138

Constant	3.6737	0.000	3.2043	0.000
N = 217; RE: Wald $\chi^2(14) = 37.86$ ($p = 0.001$); OLS-RSE: $F(12, 108) = 2.96$ ($p = 0.001$)				

4. Discussion

Table 12 juxtaposes the three available results for the gender impact of commercialization and small-scale mechanization of groundnut production in southern Africa. None of these cases exhibits negative effects of such transformation. While the detail differs, all these results are consistently obtained from smallholder households producing the 'women's crop' in recent years in southern Africa. Thus, the similar implications could not be a coincidence.

Table 12 Comparison of three assessment results for effects of commercialization and small-scale mechanization on women's control in southern Africa

Site	Period	Model	N	Commercialization Effect	Mechanization Effect
Three sites in Eastern Zambia (Orr et al., 2016a)	2013	PSM	262	Positive & Insignificant	Positive & Significant
Two sites in Eastern Zambia	2013 & 2014	PSM, DID, Random Effect	291	Positive & Significant	Positive & Insignificant
Three sites in Central Malawi	2014 & 2015	Fixed Effect	218	Positive & Insignificant	N/A

We have noticed that there are two forces as to impacts of commercialization of smallholder agriculture on household gender equity. On one hand, expansion and commercialization of a food crop induce men to increase their involvement with that crop, which may lower women's control. On the other hand, women endorse it as long as part of the generated income is utilized in their favor. What has commonly been believed in is the mechanism driven by the former force. However, which of these forces overwhelms the other is actually an empirical question, since at least the aforementioned findings from southern Africa suggest the prevalence of the latter force. The balance between these forces must be determined by certain parameters such as level of commercialization, scale of mechanization, availability of irrigation, and stage of economic growth (e.g., wage level, off-farm income opportunities, etc.).

In the present case, mechanization looks certain to change the status of groundnut as a women's crop, reducing women's involvement in post-harvest handling, but women may

consider this a price worth paying on the grounds that increased income from groundnut benefits the entire household as well as women's drudgery is alleviated. Obviously, the scale of mechanization is due to matter. The sheller used in our intervention is manually operated handy equipment, albeit the 20 times higher efficiency. Large-scale fuel-driven mechanization would certainly be another story with which women may opt out of farming (Brandth, 1995). Yet, large-scale mechanization occurs only with rising wages accompanied by the development of off-farm sectors and consequently improved overall livelihood (Wang et al., 2016; Otsuka et al., 2015). In this regard, discussions around the gender implication of commercialization and mechanization may as well focus on the impact on smallholders, since large-scale farmers are already better off by definition, and the impacts on smallholders is less evident. Moreover, intervention with shellers does not mean full-scale mechanization, since lifting (harvesting) and stripping are also identified as tedious labor intensive processes handled by women (Tsusaka et al., 2016b). The full-scale post-harvest mechanization may deliver more distinct gender outcome. On a related note, consideration should be given to whether the impact in question is for a short term or a long term. While the middle and bottom rows in Table 12 represent short-term (i.e., one year) effects, the top row result may represent a longer-term effect as the treatment group had received 3 years of intervention. This suggests that the positive gender effect of small-scale mechanization may be weak at first but then strengthen later on.

5. Concluding Remarks

While many believe in negative gender implications of commercialization and mechanization of a 'women's crop', there is a dearth of empirical evidence to either support or refute the concept. Contrary to the common notion, we found evidence that commercialization and mechanization of a 'women's crop' does not disempower women, based on the micro-level assessment of intra-household gender dynamics in Zambia and Malawi, by utilizing the women's crop tool. Although the dominant narrative sees commercialisation as a zero sum game in which women and men compete for autonomous control, the women groundnut growers also regarded commercialisation as an opportunity for greater cooperation that could benefit the household as a whole. Two forces certainly exist: (1) men taking control away from women and (2) increased household income at least partially benefiting the women. It depends on the context which of the two forces prevails. Our result and discussion suggest that the latter force may be actually dominant in resource-poor rural settings.

The women welcomed post-harvest mechanization, which reduced their drudgery in hand shelling, notwithstanding the men's increased involvement in the process. In our view, the gender consequence of mechanization depends on certain attributes of mechanization, such as the scale of mechanization (large vs. small; full vs. partial) and the duration of adoption. Our result and discussion suggest that the positive gender effects of small-scale mechanization may grow over time. It must be noted, however, that our stance is not to advocate gender indifferent policies and institutions that blindly promote mechanization. Instruction and training sessions should be crafted in the way that women and men are both targeted for sensitization.

Further exploration of the intra-household trade-off between autonomy, drudgery, and income should help reinforce our evidence and contribute to deeper understanding of the issue. In all likelihood, we argue that mechanization and commercialization of smallholder agriculture do not necessarily disempower women farmers.

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