Does Intercropping Improve the Outcomes of Export Assistance Among Kenyan Smallholders?

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Abstract— **Commodity export markets provide opportunities for gains from trade in developing economies, but smallholding farmers remain least likely to access these markets due to unscalable factors, risks of monocropping, meeting international regulations, and volatile cash crop prices. This paper uses randomized control trial data from western Kenya that gave smallholders access to export assistance and credit services, thus remedying issues of price dispersion and imperfect export and credit markets found in the smallholder literature. An ecological adaptation of production possibilities theory hypothesizes that intercropper income should be equal to or greater than that of monocroppers, ceteris paribus. A series of difference-in-difference empirical approaches finds that program participation interacted with intercropping has a positive but statistically insignificant effect on non-wage agricultural income per acre. Results confirm the expected sign from theory and show that researchers and development practitioners should not forgo intercropping given small scales.**

I. Introduction

Commodity export markets provide opportunities for gains from trade and income generation among the world's poorest farmers. These smallholding farmers, however, remain least likely to access these markets due to unscalable factors, risks of monocropping, meeting international regulations, and volatile cash crop prices. Traditional smallholder agricultural practices such as intercropping, the practice of growing multiple crops in a field, can mitigate risk by means of crop diversification and soil management. It remains to be seen whether the benefits of intercropping translate to success in exporting when smallholders finally access global markets.

Using randomized control trial (RCT) data, this study asks: Does intercropping improve the outcomes of export assistance among Kenyan smallholders? While incomes were previously found by Ashraf, Giné, & Karlan (2009) to increase from export assistance at a statistically insignificant level, perhaps farmers who practiced intercropping experienced more positive results. Results found a positive but statistically insignificant relationship between non-wage agricultural income per acre and RCT participation interacted with intercropping.

Section II surveys the literature, finding that the relationship between exporting and intercropping remains contested. Section III describes the RCT implementation and summary statistics. Section IV sets up the theoretical framework for the study, drawing from a synthesis between economics and ecology developed in Ranganathan, Fafchamps, & Walker (1991), and Section V applies this to an empirical framework. Empirical results in Section VI show positive but statistically insignificant effects of RCT participation interacted with intercropping on income per acre. While a few data limitations handicapped the study, results encourage further study and development practice linking intercropping and exportation as a means to boost incomes without scaling land and capital inputs.

II. Literature Review

According to economic and ecological literature, intercropping contributes positively to input and overall productivity. A number of studies demonstrate that intercropping maize and beans contributes to higher soil productivity and quality by keeping and replacing nitrogen among plant roots (Altieri, 1999; Hödtke, de Almeida, & Köpke, 2016; Peter & Runge-Metzger, 1994). Other studies explore the positive relationship between intercropping and labor productivity (Lai et al., 2012; Norman, 1977; Okigbo & Greenland, 1977). Alene & Hassan (2003) note how productivity increases in soil and labor can interact to improve overall efficiency use of inputs with intercropping. Also, studies suggest that yields and overall farm productivity increase when smallholders intercrop (Alene & Hassan, 2003; Arslan et al., 2015; Lai et al., 2012). Relatedly, yields have lower variability, which reduces production risk (Achoja et al, 2012; Arslan et al., 2015; Dorsey, 1999; Just & Candler, 1985; Okigbo, 1978; Rodriguez, Rejesus, & Aragon, 2007). Studies consistently find evidence that smallholder farmers, much like those featured in this study, are risk averse. (Carter, 1997; Schaefer, 1992).

Additionally, a large number of studies show that intercropping has substantial effects on output market outcomes. Allison-Oguru, Igben, & Chukwuigwe (2006) note how Nigerian smallholders who intercropped experienced higher revenues than those who did not. Numerous studies find that intercropping increases profitability via some combination of increasing yields, improving input efficiency, and decreasing risk and income sensitivity to crop prices (De Groote et al., 2012; Dorsey, 1999; Lai et al., 2012; Manda et al., 2016; Peter & Runge-Metzger, 1994; Rodriguez, Rejesus, & Aragon, 2007; Saka, 2015). In sum, efficiency and productivity gains of intercropping often lead to increased agricultural profits in domestic markets.

Consensus on intercropping outcomes divides, however, in the context of exporting. Two major studies relate intercropping to income generation by means of export. Both coincidentally took place in Kenya. Dorsey (1999) finds that small Kenyan farms experienced higher income per hectare by having both high rates of crop diversification and specialization. The results of Dorsey (1999) at first seem contradictory, but they stem from intercropping producing substantial amounts of crops for export (specialization) as well as other crops for household and domestic market consumption (diversification). These results are consistent with the predominating notion in the literature that intercropping is more productive and profitable than monocropping for smallholders.

On the other hand, Minot & Ngigi (2004) discover that French bean monocropping in Kenya resulted in higher smallholder yields and incomes than maize-bean intercropping. Minot & Ngigi (2004) note, however, that their results do not incorporate the implicit labor costs of household labor. Given that crops like French beans are more labor-intensive than intercropping with maize, they may have underestimated production costs. Despite these results, Minot & Ngigi (2004) do not completely discount intercropping and conclude that more perfect markets, (homogenous price dispersion, reduced transaction costs and credit constraints, and improved information and access to exporters) remain the crucial components to export success.

The results in the literature on the complementarity of intercropping and exporting are inconclusive, but Minot & Ngigi (2004) specifically note the importance of more perfect markets. The RCT data used in this study, and explained in the following section, include an intervention that relaxed information and credit constraints for smallholder exporters. This intervention allows study of the counterfactual desired in Minot & Ngigi (2004), asking: Does intercropping improve the outcomes of export assistance among smallholders?

III. Data Description

Ideal data to assess this question would allow regressing the income generated from export cash crops on the quantity of crop sold. The data would be able to distinguish between crops sold from intercropped fields and those from monocropped fields, all while controlling for related production endowments and other technology. An RCT in Ashraf, Giné, & Karlan (2009; 2015) in collaboration with the Abdul Latif Jameel Poverty Action Lab at the Massachusetts Institute of Technology provides much of these data, available through Harvard University's Dataverse. Their study introduced export assistance and credit services to farmers in the Kirinyaga district of Kenya through a non-governmental organization called DrumNet. The baseline survey was conducted in April 2004 with the follow-up survey in May 2005.

To participate in DrumNet, farmers needed to belong to a self-help group (SHG, also known as a farmers' association), express interest in exporting cash crops through their SHG, have some irrigated land, and at least a week's worth of wages, or approximately 10 USD, in DrumNet's Transaction Insurance Fund (TIF). Participants in the treatment group first embarked on a four week Good Agricultural Practices course to ensure crop quality suitable for export to the EU. This was followed by placement into joint liability groups of 5 for each farmer chosen for treatment who met the TIF requirement. Farmers could take on loans up to four times the size of their TIF collateral. DrumNet distributed seeds (primarily French beans and baby corn) and other inputs shortly after group placement. It later negotiated prices with farmers after harvest and forwarded quality produce to exporters. Loan payments and TIF savings were deducted by DrumNet from gross sale of produce, and remainders were credited to farmers in private savings accounts. The offer of the Good Agricultural Practices course, production inputs, and the facilitation of sending crops to exporters comprised the "export assistance" treatment. The offer of TIF savings accounts and loans comprised the "credit" treatment.

Farmers' entrance into the control group of no DrumNet services and the two treatment groups, DrumNet services with credit and without, was randomized. Randomization minimizes biases of self-selection because treatment is assigned instead of taken up voluntarily. With minimized biases, inter- and intra- group characteristics are likely to resemble each other excepting treatment and eliminate most problems of endogeneity. Preliminary analysis by Ashraf, Giné, & Karlan (2009) found no significant characteristic differences in the data within and among control and treatment groups.

Further attention is necessary to account for differences between monocroppers and intercroppers. A summary of variables of interest is featured in Table 1. The total number of observations is 1,109 members across the baseline and follow-up periods. The variables of interest are non-wage agricultural income per acre (dependent variable), a dummy equal to 1 if farmers practice any form of intercropping French beans or baby corn (maize) and 0 otherwise, and a list of controlled variables that affect production and income including household size, field size, machine or animal use, pesticides use, land quality, and distance from sale. Intercropped field size is also included to show how much total production uses intercropping.

The mean of the dependent variable (non-wage agricultural income per acre) is 25,994.6 Kenyan shillings (225.10 USD) with a standard deviation of 58,859.22 shillings. This signals a skew rightward resulting from a few outliers of very large income. There remains a slight rightward skew as well in the intercropping dummy, where the mean value is 0.77 with a standard deviation of 0.42. Since the mean is not 0.5, it should be noted that the number of intercropped cash crop plots is larger than those that are monocropped. Intercropped field size is on average approximately 40 percent of total field size, showing modest level of diversification of all crops without taking into account the other 60 percent of remaining land.

Machine or animal use, land quality, and pesticide use are more evenly distributed with means closer to 0.5. Household size, field size, and distance from sale are non-normally distributed and skewed to the right. Histograms for these variables are featured in Figures 1, 2, and 3, respectively. Three observations were deleted in household size due to suspected input error. Attention will be paid in the next section regarding the impact of non-normally distributed data found in household size, field size, and distance from sale.

A more refined method to assess the validity of these groups (monocroppers and intercroppers) is through a two-sided t-test, which determines whether the means of the groups for variables are statistically significantly different from each other. The t-test results are available in Table 2. Three independent variables, machine or animal use, household size, and land quality, point to a statistically significant difference in the distributions of the variables. These difference are significant at the $p \leq 0.1$, $p \leq 0.05$, and $p \leq 0.01$ levels, respectively, meaning there is little likelihood that the true means are equal to each other. For further analysis, regressions should take these household characteristic variables into account to remedy the incomplete randomization among intercroppers and monocroppers. Finally, it is worthy of note that no statistically significant difference exists between the means of the groups regarding the dependent variable. There remains, however, a larger distribution of outcomes among intercroppers, which may portend heterogeneity of outcomes attributable to intercropping interacting with RCT participation.

IV. Theoretical Framework

Economic theory provides a framework with which to assess the effectiveness of intercropping in terms of yields and income generation. Ranganathan, Fafchamps, & Walker (1991) adapt the ecological concept of the land equivalency ratio to production possibilities theory. After a brief introduction to the concept of the land equivalency ratio, a model for production efficiency between two crops can be used to determine whether intercropping produces more, equally, or fewer yields than monocropping with implications for trade.

The land equivalency ratio (LER) measures the yields of intercropping against those of monocropping. In essence, the ratio expresses how much more or less a given plot of land can produce of crops by intercropping over monocropping. If the LER is greater than 1, then intercropping produces greater yields than monocropping, *ceteris paribus*. If the LER equals one, intercropping yields equal monocropping yields, and an LER less than 1 means intercropping produces fewer yields than monocropping. The LER is given by (1) and is the summation of the ratios for each crop i of intercrop yields over monocrop, "pure stand," yields.

$$LER = \sum_{i=1}^{M} \frac{Yield\ of\ Intercrop}{Yield\ of\ purestand} \tag{1}$$

As Ranganathan, Fafchamps, & Walker (1991) note, the values of the LER correspond to the coefficients applied to a standard Cobb-Douglas production possibilities frontier (PPF) as shown in Figure 4. The PPF demonstrates all possible output bundles between two crops, x and y, while holding constant resources and technology. The PPF is always downward sloping because resources and technology must be diverted from one product to another in order to produce more of the latter.

An LER of 1 is equivalent to monocropping and a direct 1:1 tradeoff between crops. It is thereby represented by curve A. Curve A is straight because there is no change in opportunity cost by switching crops when the LER equals 1. An LER greater than 1 means intercropped species complement each other to increase yields, which corresponds to a concave curve like B. Its concavity comes from the varying opportunity costs of having disproportionate amounts of one crop, which decreases the complementarity of intercrop production. Finally, an LER less than 1 means crops compete for resources, and so their mixture decreases overall production and creates a convex curve like C. The convexity of curve C arises from the high opportunity costs of expanding production of a second, competitive crop. Thus, if intercropping uses complementary crop species that support each other's mineral needs, productivity for a given level of a crop should be greater under intercropping than other methods.

The PPF model posits that the income generated from complementary intercropping will always be equal to or greater than that of monocropping. Figure 5 imposes an arbitrary price ratio, represented by the dotted lines, to establish three optimal points given by the points where the negative price ratios are equal to the marginal rate of transformation between crops. All optimal points for monocropping are below or equal to the output of complementary intercropping, meaning the latter always meets or exceeds the income of the former.

Producers accept world crop prices upon the elimination of trade barriers. If the world price rests above the domestic price, then the country exports the crop. According to classical Ricardian trade theory, producers derive this comparative advantage from technology that allows them to produce at a lower price. It is possible intercropping may serve as such a technology and establish a price advantage. This is likely the case with Kenyan smallholders switching to horticulture crops bound for wealthy European markets who pay a global premium for a product that uses globally cheaper inputs.

This result depends on whether the assumption of constant resources and technology remains intact. It is expected that endowments of land, labor, and capital as well as non-intercropping technologies, such as pesticides, will differ across individuals and affect output rates. Data description from the previous section found this to be true between monocropping and intercropping groups regarding household size, machine and animal use, and land quality. Nonetheless, a proper model specification can account for these issues.

V. Empirical Framework

The theoretical understanding of intercropping granted by the PPF translates rather directly to a specification for an outcomes like non-wage agricultural income per acre, a descaled measurement isolating income from crop sales:

$$y_it = \beta_0 + \beta_1 T_{it} + \beta_2 A_{it} + \beta_3 IC_{it} + \beta_4 T_{it} A_{it} + \beta_5 T_{it} IC_{it} + \beta_6 A_{it} IC_{it} + \beta_7 T_{it} A_{it} IC_{it} + \gamma V_{it} + \epsilon_{it} \tag{2}$$

where y equals income generated for time t and household i. T is a binary variable equal to 1 if household i belongs to any treatment group and 0 otherwise. A is a binary variable that equals 1 if the time period t is the follow-up, post-program period. IC is also a binary variable equal to 1 if household i intercropped cash crops. Present are the first (single variable), second (two variables), and third (all three binary variables) orders necessary to test the interaction of treatment placement, time, and intercropping. V is a vector of control variables for household i at time t, including household size, machine or animal use, soil quality, pesticide use, field size, and distance from sale. These variables proxy endowments, technologies, and costs in hopes of both recovering the broken assumptions of theory, accounting for statistically significantly different means, and isolating the interaction effect of RCT program participation and intercropping. Finally, ϵ_{it} is the error term with mean zero.

The sign of β_7 tests the hypothesis that intercropping participants experienced improved program outcomes over their monocropping peers by interacting time, treatment, and intercropping. If positive, the coincidence of intercropping and RCT program participation contributed positively to income generation. If negative, the converse is true. The coefficients β_1, β_2, and β_4 are expected to be positive as they should mirror the results of Ashraf, Giné, & Karlan (2009). The coefficient β_4 interacting time and treatment could be negative, however, because its result could be reconstructed once interacted with the likely positive effect of intercropping on income. The coefficient β_3, the effect of intercropping, is expected to be positive as it relates to outcomes like yields and income. The signs for the intermediary coefficients of β_5 and β_6, are ambiguous, but their interpretation is not useful and is thus ignored. Additionally, generated LER estimates from the data using (1) will validate or cast doubt upon the connection between the data and the theory established in this section. The LER can discern the validity of the theory as it applies to the data and regression results, but is unlikely to cast doubt upon the results of the regression themselves. It will prove a helpful tool in conceptualizing the outcomes presented in the regressions.

VI. Empirical Results

Before any presentation or analysis of econometric results, a glance at the calculated LER should determine expectations for regression results as well as the adequacy of production possibilities theory in explaining intercropping production trends in the data. In the context of the data used, the LER measures average yields of intercropped over monocropped maize, beans, French beans, and coffee. Data on yields for other crops were unavailable but represent only 12 percent of cultivated area in the dataset, so the estimation should retain most of its precision.

The LER estimate for the data equals 3.12, which means that the crops in question have a complementary relationship in the data and that, on average, 212 percent more land is required of monocroppers to match the yields of intercroppers. With regards to production possibilities theory, the PPF is concave and should establish that intercroppers earn more per acre from growing the same crops as monocroppers, all else equal.

The results for an initial regression of equation [2] are featured in column (1) of Table 3. It defines RCT treatment simply as placement into either treatment group, otherwise known as intent-to-treat (ITT). Ashraf, Giné, & Karlan (2009) warned against use of other treatment definitions, such as treatment on the treated (TOT), as they would likely overlook spillover effects by measuring only RCT compliance. The regression uses robust standard errors to account for issues of heteroskedasticity.

The coefficients for treatment, after, and intercropping are all positive, as predicted by theory. Intercropping interestingly has a large effect that is statistically significant at the $p \leq 0.1$ level. The treatment and after interaction also maintains its positive but statistically insignificant coefficient from Ashraf, Giné, & Karlan (2009), featured in column (5). The coefficients for the other two second order interactions are negative with that of treatment and intercropping statistically significant at the $p \leq 0.1$ level. These signs do not match predictions, but their interpretive value remains minimal. The third order interaction term interacting after, treatment, and intercropping is positive and insignificant at the $p \leq 0.1$ level, confirming only in sign the prediction of production possibilities theory and the LER derived from the data. The triple interaction also has the greatest magnitude of all coefficients excepting the constant.

Most control variables match the prediction of theory and previous studies. Household size has a negative sign, which results from the rising dependency ratios of larger households (McCulloch & Otas, 2002; Muriithi & Matz, 2015). Farm size and income per acre are inversely related and significant at the $p \leq 0.01$ level, which results from decreasing returns of scale among labor-intensive smallholders (Von Braun, Hotchkiss, & Immink, 1989). Related to this finding is that of the inverse relationship between income per acre and machine or animal use, which stems from their use on larger, though less efficient, smallholdings. Land quality contributes positively to income as a component of total factor productivity (Witcover, Vosti, Carpentier, & de Araujo Gomes, 2006). The case is the same for pesticide use, which is positive and statistically significant at the $p \leq 0.1$ level. Distance from sale does not match theory's prediction of transaction costs, but results remain statistically insignificant at the $p \leq 0.1$ level. This likely stems from outliers that, because input error is not suspected, do not warrant exclusion from analysis and will be corrected for in another regression using a logarithmic transformation.

The sign and magnitude of these results remain when using clustered errors at the SHG level, featured in column (2). Clustered errors recognize unobserved heterogeneity at the group level as a tradeoff for not recognizing unobserved heterogeneity among individuals. Concerning the data at hand, farmers received treatment at the SHG level, which posits an appropriate identifier for difference across groups as it corresponds to both treatment designation and likely avenues for spillover effects. Significance remains the same except for the treatment and intercropping interaction, which no longer has significance, and the triple interaction term, which becomes significant at the $p \leq 0.01$ level. Clustered errors, however, do not account as much as robust standard errors for heteroskedastic error biases that affect statistical inference.

A logarithmic transformation of the data is featured in column (3) to account for nonnormality caused by outliers and skewed distributions. The signs and general magnitude of previous results remain excepting the after-treatment interaction, machine and animal use, and distance from market. The interaction of after and treatment turns negative but statistically insignificant, which falls within the analysis of Ashraf, Giné, & Karlan (2009) in that the program was not found to have a statistically significant effect on income per acre. Machine and animal use turns positive but statistically insignificant, reflecting theory in that capital deepening should increase smallholder productivity and income; decreasing returns to scale may have been overestimated. Finally, distance from market turns negative and statistically significant at the $p \leq 0.01$ level. This result matches theory on transaction costs and demonstrates the overall improvement of the logarithmic transformation on the previous regression in matching theoretical predictions.

The triple interaction remains positive but loses its statistical significance at the $p \leq 0.1$ level. The interaction of program participation and intercropping thus had a positive impact on non-wage agricultural income per acre, but it is not statistically discernable from zero. These results have robustness at the SHG level as shown in column (4). These results again resemble those of Ashraf, Giné, & Karlan (2009) in that the program had no statistically significant impact on income per acre. It also relates back to the statistically insignificant difference between dependent variable outcome means found in the t-tests of Section III.

These final results reflect the direction predicted by theory, but not the magnitude. While the LER value of 3.12 shows soils are conducive to intercropping, the LER may have overestimated the effect of intercropping on income. A high LER could have resulted from pesticide use, which would inflate the perceived effect of intercropping on yields and income per acre. Sadly, the LER does not decompose to account for the effect of pesticides in these data and therefore cannot be re-estimated.

VII. Conclusion

This study asked whether intercropping improved the outcomes of export assistance among Kenyan smallholders. The use of RCT data and its intervention of export assistance and credit services corrected for imperfect price dispersion and markets that plagued Minot & Ngigi (2004). Results reflected the expectations of the production possibilities theory derived in Ranganathan, Fafchamps, & Walker (1991) with non-wage agricultural income per acre increasing with intercropping. The results were not statistically significant, however, when accounting for heteroskedasticity and nonnormality. Results have a sense of internal validity in that they reflect the overall program conclusions of Ashraf, Giné, & Karlan (2009). It is possible that data overestimated the LER by neglecting pesticides.

A number of limitations exist for this study and its implications. First, results do not take into account any adoption or abandonment of intercropping. The resulting bias is not likely to be significant, however, because intercropping as a traditional practice is not one to be quickly abandoned, nor did DrumNet ever encourage monocropping. Second, this study does not separately assess both treatment groups, which may bias results downward if credit services had an impact on income masked by grouping treatments together. Also, the external validity requires substantial attention to local environmental conditions since the benefits of intercropping rely heavily on local soils and crops. Finally, cash crop analysis was undertaken at the household level, the only level available for dependent variable outcomes. Future study of crop level outcomes would more directly measure how intercropping affects income generated.

Nonetheless, my results show that intercropping farmers are shown to be just as, if not more, capable of income generation as monocroppers when both export. The theory behind intercropping and the positive, though statistically insignificant, effect intercropping had on exporter income warrant further attention from researchers and policymakers. Future research could better substantiate the interaction of intercropping and exporting by better randomizing across agricultural practices and by studying crop level outcomes. It could also pay closer attention to scale in data and theory because the benefits of intercropping experience large decreasing returns to scale, a dynamic only tangentially mentioned in this study.

Ashraf, Giné, & Karlan (2009) explain the difficulties smallholders have in meeting EU quality regulations, but nothing in their description of such regulations prevents smallholding intercroppers from coordinating with organizations like DrumNet to capture gains from trade. Thus, the failure of this study to reject intercropping as a sustainable, income-generating agricultural practice in a global market means that policymakers and development practitioners can still see intercropping as a potential, though small, stopgap to food insecurity, environmental degradation, and rural poverty.

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Appendix

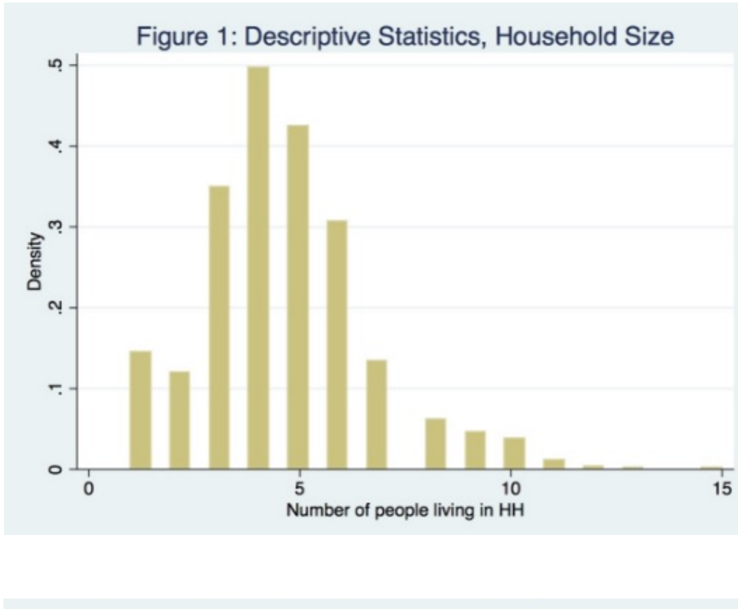
Figure 1: Descriptive Statistics, Household Size
Density
0
.1
.2
.3
.4
.5
0
5
10
15
Number of people living in HH

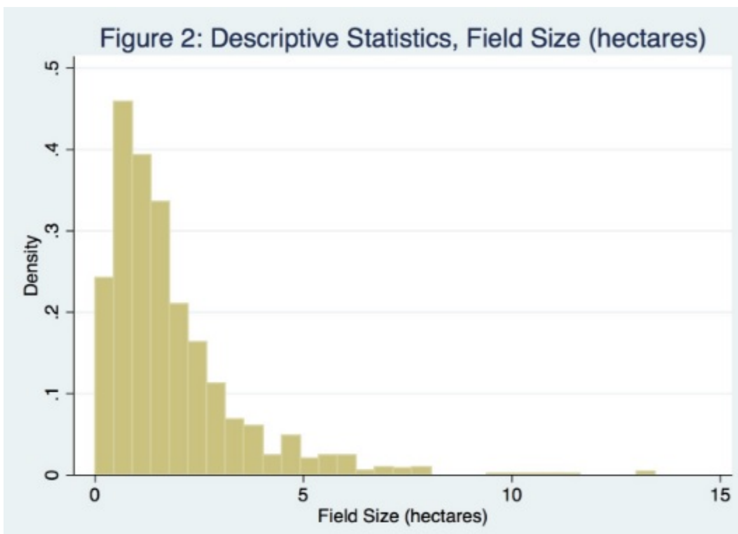
Figure 2: Descriptive Statistics, Field Size (hectares)
Density
0
.1
.2
.3
.4
.5
0
5
10
15
Field Size (hectares)

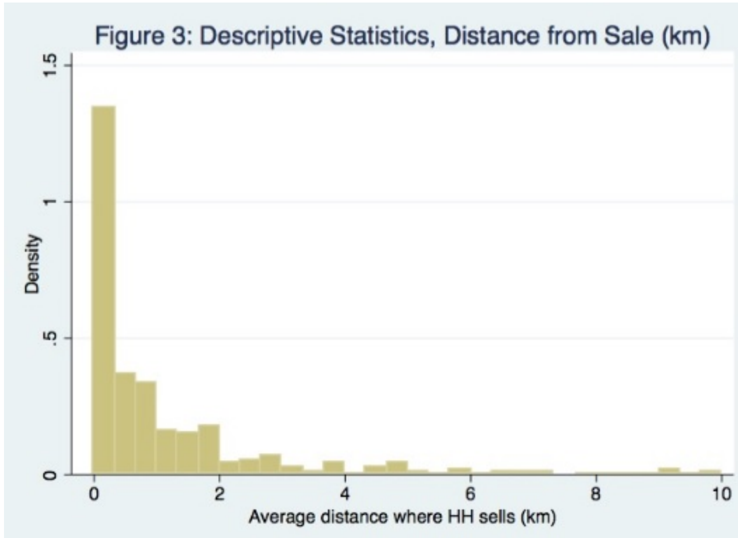

Figure 3: Descriptive Statistics, Distance from Sale (km)

Figure 4: Production Possibilities
Frontier Model of Intercropping

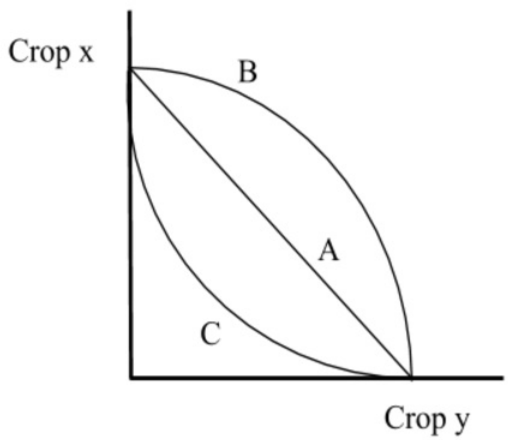

Figure 5: Production Possibilities Frontier
Model of Intercropping with Price Ratio

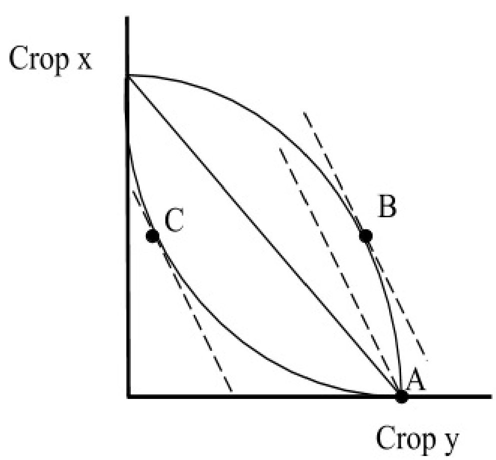

Table 1: Summary Statistics of Variables

	(1)	(2)	(3)	(4)	(5)
VARIABLES	N(farmers)	mean	st.dev.	min.	max.
Non-wage agricultural income per acre (Kenyan Shillings)	1,094	25,994.6	58,859.22	0	833,670.6
Intercropped cash crops (yes=1)	1,109	0.77	0.42	0	1
Household size	1,109	4.6	2.05	1	15
Field size (hectares)	1,109	1.81	1.63	0	13.44
Machine or Animal use (yes=1)	1,109	0.06	0.23	0	1
Use of pesticides (yes=1)	1,109	0.91	0.28	0	1
Land quality	1,042	-0.03	1.01	-1.96	2.3
Distance from sale (km)	1,030	1.92	7.49	0	153.4
Intercropped field size (hectares)	1,109	0.75	0.76	0	5.5

Table 2: Student t-Tests of Variables

VARIABLES	(1) N(Monocroppers)	(2) Mean	(3) N(Intercroppers)	(4) Mean
Treatment (=1)	251	0.64 (0.48)	858	0.62 (0.49)
Non-wage agricultural income per acre (Kenyan Shillings)	251	26,030.15 (43,365.39)	858	25,984.18 (62,701.51)
Household size	251	4.37** (1.91)	858	4.66** (2.08)
Field size (hectares)	251	1.74 (1.72)	858	1.84 (1.60)
Machine or Animal use (=1)	251	0.03* (0.19)	858	0.06* (0.24)
Use of pesticides (=1)	251	0.92 (0.28)	858	0.91 (0.28)
Land quality	235	0.18*** (0.99)	807	-0.09*** (1.01)
Distance from sale (km)	238	1.88 (5.73)	79 2	1.92 (7.93)

Standard deviations featured below *** p≤0.01, ** p≤0.05, *p≤0.1

Table 3: ITT results predicting non-wage agricultural income per acre[i]

VARIABLES	(1) Initial Regression	(2) Clustered errors by SHG	(3) Logarithmic transformation	(4) Logarithmic clustered errors by SHG	(5) Logarithmic results of Ashraf et al. (2009)
Treatment (=1)	584.7	584.7	0.045	0.045	-
	(5,986.53)	(7,562.72)	(0.235)	(0.337)	-
After (=1)	2,865.1	2,865.1	0.052	0.052	-0.107
	(8,342.42)	(4,328.68)	(0.278)	(0.292)	(0.097)
Intercropping (=1)	11,655.96*	11,655.96	0.038	0.038	-
	(6,778.52)	(8,341.29)	(0.233)	(0.294)	-
Interaction: Treatment and After	3,758.74	3,758.74	-0.003	-0.003	0.089
	(12,540.66)	(9,667.49)	(0.352)	(0.334)	(0.11)
Interaction: Treatment and Intercropping	-14,758.91*	-14,758.91	-0.228	-0.228	-
	(8,242.84)	(9,270.08)	(0.276)	(0.325)	-
Interaction: After and Intercropping	-15,140.42	-15,140.42**	-0.056	-0.056	-
	(10,454.67)	(6,234.1)	(0.324)	(0.378)	-
Interaction: Treatment, After, and Intercropping	24,313.2	24,313.2*	0.229	0.229	-
	(15,748.44)	(13,497.67)	(0.408)	(0.436)	-
Household size[i]	-1,484.87*	-1,484.87*	-0.089	-0.089	-
	(771.006)	(877.88)	(0.074)	(0.061)	-
Machine or Animal use (=1)	-10,257.26***	-10,257.26**	0.004	0.004	-
	(3,263.49)	(4,473.82)	(0.167)	(0.186)	-
Land quality	3,199.09**	3,199.09**	0.160***	0.160***	-
	(1,240.11)	(1,310.7)	(0.041)	(0.044)	-
Use of pesticides (=1)	15,326.76***	15,326.76***	1.267***	1.267***	-
	(5,249.45)	(4,907.56)	(0.194)	(0.205)	-
Farm size (hectares)[i]	-6,274.95***	-6,274.95***	-0.601***	-0.601***	-
	(1,052.28)	(1,250.03)	(0.05)	(0.061)	-
Distance from sale[i]	94.16	94.16	-0.099***	-0.099***	-
	(142.18)	(153.50)	(0.026)	(0.024)	-
Constant	28,461.79***	28,461.79***	8.429***	8.429***	-
	(6,726.9)	(7,400.33)	(0.271)	(0.365)	-
Observations	955	955	960	960	1,566[†]
N(Clusters)	-	35	-	35	-
Adj. R-squared	0.0571	0.0571	0.2142	0.2142	0.16
F-statistic	4.36***	4.97***	20.75***	27.47***	-

Robust/clustered errors featured in parentheses
*** p≤0.01, ** p≤0.05, *p≤0.1
i = logged in transformation
†= did not eliminate nonresponders to intercropping questions