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The Economics of Smallholder Organic Contract Farming in Tropical Africa

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Summary. — The paper examines the revenue effects of certified organic contract farming for smallholders and of adoption of organic agricultural farming methods in a tropical African context. The comparison in both cases is with farming systems that are "organic by default." Survey data from a large organic coffee contract farming scheme in Uganda are reported and analyzed using a standard OLS regression and a full information maximum likelihood (FIML) estimate of the Heckman selection model. The analysis finds that, controlling for a range of factors, there are positive revenue effects both from participation in the scheme and, more modestly, from applying organic farming techniques.

Key words — organic farming, contract farming, profitability, coffee, Africa, Uganda

1. INTRODUCTION

As the market for certified organic agricultural products has grown over the recent years, organic activists, NGOs, and some donors have promoted certified organic export production in a number of tropical African countries. This paper is a preliminary assessment of the resulting schemes, focusing broadly on the revenue effects of participation relative to conventional farming. While this subject is well covered in the literature on organic farming in Northern countries, where conclusions converge on a finding of similar levels of profitability for the two farming systems (since price premiums and lower non-labor input costs compensate for organic agriculture's normally lower yields), [1] none of the handful of existing economic studies of organic farming in the tropics (Bacon, 2005; Bray, Sanchez, & Murphy, 2002; Carpenter, 2003; Damiani, 2002; Lyngbaek, Muschler, & Sinclair, 2001; Van der Vossen, 2005) report comprehensive farm budget-related survey data.

Assessment of the revenue effects of certified organic relative to conventional (non-organic) farming in tropical Africa has to take into account two differences between farming systems there and in developed countries. Firstly, conventional agriculture in developed countries is industrial in character, while that in tropical Africa is generally semi-industrial or non-industrial. For example, fertilizer consumption levels in tropical Africa are a fraction of those in other developing regions, and are falling. [2] This has implications both for changes in farmers' outlays on synthetic inputs and for changes in yields, when conversion takes place. Also it has implications for the extent to which farmers in tropical Africa who are certified to organic standards have to adopt a new set of farming practices in order to maintain soil fertility and thus remain economically viable, as they have to in developed countries.

Secondly, the institutional context for both conventional and organic agriculture in developed countries is deeper and more extensive than in tropical Africa. This means that in Africa little or no public assistance is available for conversion, while private credit and domestic savings are generally too low to support independent conversion—implying that organic farming in tropical Africa is a realistic option only for very large-scale operators or in the context of privately financed and coordinated contract farming schemes. [3] However, participants in such schemes may be selected by scheme owners rather than self-recruited. In other words, transposing a participation effects focus to tropical Africa requires close attention to variables confounding the independent effects of adoption of organic agricultural systems, including the prevalence of non-(certified) organic farming systems that are "organic by default," as well as organization of smallholder certified organic agriculture in contract farming schemes.

Recent years have also seen an increase in interest in all types of contract farming arrangements for smallholders in tropical Africa, in a context of rising concern that African smallholders are being excluded from remunerative value chains, whether these are for exports or for higher-value products sold on domestic markets (Hazell, Poulton, Wiggins, & Dorward, 2007; Reardon *et al., 2008*). Contract farming is seen as a solution to problems such as declining public investment and private market failure, said to underlay exclusion, since it increases economies of scale and thereby reduces private traders' transaction costs (Dorward, Fan, Kydd, *et al.,* 2004; Poulton, Gibbon, Hanyani-Mlambo, *et al.,* 2004;

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Simmons, 2002; Warning & Key 2002). On the other hand, Havnevik, Bryceson, Birgegård, *et al.* (2007) and Little and Watts (1994) challenge whether contract farming schemes generate sustainable income benefits for participants, [4] while others claim that they increase rural inequalities since—also in pursuit of lower transaction costs—it is typically only better-off smallholders that are recruited to them (Key & Runsten, 1999).

In assessing the extent to which certified organic contract farming schemes have positive revenue effects for smallholders, a question pertinent to the evaluation of both organic agriculture and contract farming as possible routes out of Africa's well-advertised problem of agricultural stagnation and decline, [5] we explicitly take into account the problem of non-random selection into schemes. This entails controlling for the possibility that observed positive revenue differences between participants and non-participants will reflect differences in farmers' factor endowments or abilities, rather than the unique impact of participation itself. [6] A second research question concerns the unique contribution of organic farming methods, as opposed to the scheme participation as such, to any positive revenue benefits that are found.

These questions are examined with the survey data collected in Uganda in 2006 from participants in Kawacom (U) Ltd.'s Sipi organic coffee contract farming scheme, as well as from a control group of non-organic coffee smallholders in the same area, using a standard OLS regression and a full information maximum likelihood estimate of the Heckman selection model. A limiting factor for the validity of findings on the second research question is the relatively short period since the scheme's certification (in 2000–01). This means that smallholder rates of adoption, and experience in using recommended organic farming methods, are likely to be restricted. Therefore, their full potential benefits arguably remain to be seen.

The remainder of the paper is organized in four sections: Section 2 describes the Sipi scheme and its context in greater detail, and provides descriptive statistics on its participants relative to the control group. Section 3 describes the data collection and analysis methods used. Section 4 presents the empirical analysis of the two hypotheses and discusses the results. Section 5 concludes.

2. THE SIPI ORGANIC ARABICA SCHEME AND ITS CONTEXT

Uganda is one of the two leading exporters of certified organic produce by value in tropical Africa (the other being Kenya). At the time of the survey there were between 20 and 25 certified organic exporters, while total organic exports were worth just under $7 million annually (Gibbon, 2006). Organic exports were dominated by the traditional cash crops, led by coffee, and were overwhelmingly to the European market. With a few exceptions, all organic export operations were organized as contract farming schemes. Most such schemes were supported to different degrees by one or more donor. [7]

Coffee is central to Uganda's rural economy, with an estimated 350,000 smallholder producers. Coffee also has been Uganda's single most important export good since the late 1960s, but its relative importance has declined over the last decade due to falling prices, wilt disease affecting Robusta coffee, and the rise of non-traditional exports. [8] Production peaked at 254,000 tons in 1996–97, but has since 2004 been oscillating around 150,000 tons (equivalent to 3% of global output). Uganda produces Robusta and Mild Arabica coffees, and a little Hard Arabica. Arabica accounts for about 20% of coffee exports. Against the overall trend, Arabica production increased from 15,000 tons in 1993 when the sector was liberalized to 35,000 tons in 2007, with troughs in 1998–1999 and 2000–02. Growth was stimulated by rising prices during 1994–95, 1997–98, and 2004–08, while the major price slump of 1999–2003 (the global coffee crisis) led to a temporary decline in output.

Quality is a key competitive factor in the international market for Mild Arabica. The most important coffee bean quality attributes are physical defects and cup defects (undesired taste characteristics), which are affected mainly by processing and handling. The quality of Ugandan coffee deteriorated rapidly in the first few years after liberalization in the early 1990s as exporters rushed to establish market share through aggressive procurement practices, *inter alia* through buying unripe or poorly processed beans (Ponte, 2002). Similar practices were observed in the 2005 and 2006 seasons, when rising export prices following a period of production decline caused a new scramble for coffee. [9]

Since the late 1990s, some Ugandan exporters have tried alternative modes of coffee procurement to the predominant open market one that relies on several layers of middlemen. The resulting schemes often involve certification to various sustainability standards (organic, Utz Kapeh, Fair Trade, and proprietary) as well as allowing other forms of product differentiation such as bean quality and geographical origin. The central motive for their establishment was to protect trading margins during the coffee crisis. A facilitating factor has been the availability of donor support. The schemes often resemble contract farming in their design, although with sometimes low levels of commitment on the part of both buyer and farmers. One of the earliest and largest is the Kawacom Sipi Organic Arabica scheme.

The Sipi scheme is operated by Kawacom (U) Ltd., that is a subsidiary of the international commodity trading house Ecom Agroindustrial Corporation. [10] Kawacom is the third largest exporter of conventional coffee from Uganda (UCDA, 2007), and is the biggest exporter of organic coffee. The scheme is situated on the northern slopes of Mount Elgon in Kapchorwa District in eastern Uganda. Farms are situated in a contiguous area at 1,650–2,150 m.a.s.l. The area was chosen due to its favorable agro-climatic conditions and because the then dominant buyer in the region, Bugisu Cooperative Union, had only a weak presence. Mobile phone network coverage was established in 2000, and in 2003 a new tarmac road significantly improved accessibility. This eased procurement but also intensified competition for organic coffee from other traders.

The project encompassed 3,870 organic farmers in 2005, most of whom were registered and certified in 2000–01. Except for the location in the scheme area, there were no barriers to entry. Registration is free, and as a result it encompasses 62% of all households in the area. Organic certification is to both the EU and US standards, and is paid for by Kawacom. [11] A group certification system is used, based on an elaborate internal control system (ICS). The central component of the ICS is an annual or semi-annual farm inspection performed by locally recruited company field officers. The latter have been trained in organic farming methods, they run demonstration farms and they conduct occasional training. The field officers give technical advice during the farm inspections and monitor the performance of each farmer in terms of his/her compliance to the organic standards and other project requirements. Very few farmers have been evicted from the project on account of non compliance, however. The annual third party certification consists of reviewing ICS documentation as well as visits to selected farms and collection points.

Project farmers are required to follow certain production and on-farm processing practices, most of which are specified in a contract issued to each farmer by Kawacom at the time of registration. The practices are those necessary to conform to organic standards and others known to improve the physical quality of coffee beans in terms of size, moisture content, appearance, and aroma. In addition, the technical advice disseminated emphasizes farm practices—mainly but not exclusively organic—that should enhance yield per area unit. Kawacom purchases only dry parchment coffee from scheme farmers, that is, beans whose pulp has been removed through wet-processing (hand pulping) and subsequent fermentation and sun drying. The most common reasons for rejecting coffee are excessive moisture and foreign matter content. In such cases, the farmer can reprocess the coffee or sell it off-scheme. In rare cases, coffee is rejected on suspicion that it was harvested on non-certified farms.

In 2005, Kawacom procured 715 tons of organic coffee from the scheme, or 198 kg per farmer on average. The coffee is purchased at designated collection points and stored for later transportation to a factory in Kampala, where it is further processed and graded for export. The farmer is paid cash on delivery. Kawacom buys all the coffee offered for sale by its organic farmers during the main buying season, irrespective of the size of its organic orders. Any surplus is sold as conventional. Prices are communicated daily by mobile phone through the network of field staff and contact farmers. The contract obliges Kawacom to pay an organic premium if the coffee is "of suitable quality." The size of the premium is not specified and there has been no direct price negotiation between Kawacom and the farmers. In 2005, Kawacom paid a price premium of about USH 300, or 15% above the prevailing price in the Mount Elgon area. This premium reflects both an organic premium realized at the export level, the higher quality of organic coffee, and price competition from other traders operating in the scheme area.[12]

In summary, Kawacom employs various means to enable and induce growers to comply with its organic and quality standards: regular farm inspections, group training and individual advice, input provision (on a very limited scale), a policy of rejection of sub-standard and suspected off-scheme coffee, a price premium, and a procedure for de-registering farmers who consistently or grossly violate project standards and rules.

Table 1 compares the mean values of selected variables, for a sample of 112 scheme participants and a control group of 48 non-participant farmers in the same area (see Section 3 below). The two groups differ in their endowments of key production factors. Scheme participants operate larger farms, cultivate more coffee trees, and have larger family labor endowments (proxied by household size). A higher proportion of scheme participants also has farming as their primary occupation (in terms of time spent) than is the case for the control group.

Table 1. *Descriptive statistics for certified organic farmers and non-organic farmers*

Variable	Unit	Certified organic	Non-organic	χ^2/z-statistics
(a) Sample characteristics				
Respondents	Count	112	48	–
No use of organic practices	% Group	20.5	39.6	6.3*
Use of >2 organic practices	% Group	33.9	12.5	7.74**
Farming as primary occupation	% Group	83.0	75.0	1.39**
(b) Household characteristics (means)				
Whole farm size	1000 m^2	10.8	7.9	−2.5*
Productive coffee trees	Count	650.1	308.1	−4.0**
Coffee farm altitude	1000 m.a.s.l.	1.9	1.8	−3.6**
Age of household head	Years	46.3	47.1	−0.0
Education of household head	No. years	6.9	6.6	−0.3
Household size	Count	7.2	6.2	−2.3*
Dependents (<6 years)	% Household	20.0	20.0	0.1
(c) Household revenue (means)				
Total household revenue	1000 USH	1424.6	1235.5	−1.6
Total crop revenue	1000 USH	679.6	374.1	−2.4*
Total non-crop revenue	1000 USH	655.7	852.2	1.0
Total coffee revenue	1000 USH	566.0	176.7	−6.0**
Net coffee revenue	1000 USH	518.8	154.5	−6.2**
(d) Variable coffee production and processing costs (means)				
Sales expenses (transport)	1000 USH	0.9	0.1	−3.6**
Hired labor (food, wages)	1000 USH	32.6	18.4	−2.4*
Equipment and inputs	1000 USH	13.7	7.2	−3.3**

Notes: Variables, unless described here, are explained in the text. The definition of "organic practices" excludes the non-use of synthetic inputs (see Section 3). Total household revenue was calculated as the sum of gross crop revenue, revenue from the sale of livestock less livestock purchases, and income earned in off-farm activities. Non-crop revenue is the sum of the latter two. Net coffee revenue is total coffee revenue minus all costs given under group (d); family labor inputs and land purchases are not included in the calculation of costs. m.a.s.l. are Metres above sea level. USH are Ugandan Shillings (US$1 = USH 1,777 as at 2005). For group (a), significance tests report χ^2-statistic from cross-tabulation; for groups (b)–(d) significance tests report the z-statistic from a Wilcoxon rank-sum test.
Source: Author survey.
* Significant at 5% level.
** Significant at 1% level.

As may be expected, a significantly larger proportion of scheme participants uses organic practices for coffee farming, although one-fifth of them do not apply any. While no significant difference is found in the total revenue earned by certified and non-certified households, certified farmers earn higher revenue from the sale of coffee and from all crop sales, and their net coffee revenue is about three times greater than for the non-certified farmers. All data refer to 2005.

3. METHODOLOGY

(a) *Data collection and methods*

The household survey of certified organic farmers and non-certified farmers used a questionnaire administered to heads of households by trained enumerators. It covered information on household demographics, farm area, number of coffee trees, farm equipment, expenditure over the previous two seasons on labor and other inputs and assets and on processing and marketing, as well as production, sales, and farm and non-farm income. As is common in farm budget-related surveys in Africa, no attempt was made to collect data on family labor inputs. This is because subjects typically find it more difficult to recall such inputs relative to hired labor ones, because of the difficulty in attributing accurate time values to some family labor tasks such as supervision, and because of the difficulty in applying a common metric to labor by children and by adults.

In order to assess the extent to which organic and other farm practices were adopted and/or enforced as a result of contracts, data also were collected on farmers' use of a range of farm practices recommended during inspections and training, in most cases through physical observation by the enumerator. Organic practices were operationalized in terms of a range of positive farming interventions. Non-use of synthetic inputs, the central regulatory requirement for organic certification, was treated as a condition qualifying such positive interventions to be recorded, rather than as an organic practice in itself. In other words, the handful of farmers found to have used synthetic inputs were excluded from the consideration in terms of having followed organic practices, whether they in fact followed such practices or not. The positive interventions considered were use of organic pesticides, mulching, animal manure, and composting (including mixing leguminous residues into the soil). This group of interventions, rather than others that may be counted as organic such as intercropping, and use of trap crops, were selected for consideration for four reasons. Firstly, they had been promoted by the scheme from its inception, unlike, for example, planting agroforestry trees, which was a recent addition. Secondly, their use was not contingent on physical or similar factors, unlike the use of soil erosion measures that depend on slope. Thirdly, they were not applied for the reasons unrelated to organic coffee production, unlike intercropping with food crops including leguminous cover crops, which is a traditional food security strategy. Fourthly, there had to be enough observations of them to render analysis meaningful.

A two-stage random sampling method was used for the selection of both scheme participants and the control group. Scheme participants were randomly sampled in a number of parishes chosen purposively to reflect the range of agro-ecological conditions in the scheme area, using a list of registered farmers provided by Kawacom. Sampling of the control group population was performed randomly, from the lists prepared by village leaders in nearby parishes chosen to match the (range of) agro-ecological conditions represented in the sampling frame for scheme participants.

(b) *Analytical methods*

For empirical analysis, two specific null hypotheses can be formalized. These are *Hypothesis I*—there is no significant difference in revenue between certified organic and non-certified farmers, controlling for other relevant determinants and *Hypothesis II*—there is no significant revenue effect from the application of organic farming practices, controlling for the participation in the organic contract farming scheme and other relevant factors. Together these indicate that we are concerned with evaluating the effects of different farming activities on the household revenue. If we conceive of these activities as forms of intervention (analogous to, say, a labor training program), it is evident that we face a treatment evaluation problem.

The literature dealing with how treatments can be rigorously estimated is vast and cannot be reviewed here (see Blundell & Costa Dias, 2002; Heckman, 1979; Vella & Verbeek, 1999). To provide an organizing framework for discussion, however, the evaluation problem can be stated as a system of equations involving an outcome of interest (y) and a selection equation for treatment (t) over observations i. In general form these are

$$y_{1i} = \boldsymbol{x}_i'\beta_1 + u_{1i}, \quad (1)$$

$$y_{0i} = \boldsymbol{x}_i'\beta_0 + u_{0i}, \quad (2)$$

$$t_i = 1(\boldsymbol{z}_i'\beta_1 + v_i > 0), \quad (3)$$

where y_{1i} refers to the outcome for treated respondents ($t_i = 1$) and y_{0i} for the control group ($t_i = 0$); u_{ki} are the error terms. Note that the participation Eqn. (3), which is an indicator function, invokes a latent variable framework in which the selection factors (z) capture the propensity to participate above a threshold. The above can be summarized in the following general switching model:

$$y_i = \boldsymbol{x}_i'\beta_0 + t_i\boldsymbol{x}_i'(\beta_1 - \beta_0) + u_{0i} + t_i(u_{1i} - u_{0i}). \quad (4)$$

Differences in regime between participants and non-participants refer to the extent to which the treatment has an effect only through the intercept of the joint outcome equation. The assumption of non-distinct regimes is made frequently (Ravallion, 2005), and is reasonable in this case given that the scheme is relatively recent and there is substantial similarity between the control and treatment groups as regards demographic characteristics and location (see Table 1). Consequently, in Eqn. (4) we restrict $\beta_1 = \beta_0 = \beta$ excluding the intercept terms, thus giving the familiar reduced form common coefficient model for outcomes over a single treatment

$$y_i = \boldsymbol{x}_i'\beta + t_i\alpha + u_{0i} + t_i(u_{1i} - u_{0i}), \quad (5)$$

where α captures the treatment effect given by the difference in intercepts of Eqns. (1) and (2).

As the present setting is non-experimental, we cannot assume that the choice to participate in the scheme is purely random. Given the available data, which do not include repeated measures for each household, three main types of estimator can be employed to deal with endogenous selection. The first of these is matching estimators, which require (*inter alia*) that selection into the program occurs only on the observed variables (i.e., $E[u_{ki}|x_i, t_i] = 0$). In such cases, propensity score matching can be used; or, where parametric assumptions apply, a standard OLS regression of the form given by Eqn. (5) is consistent as long as all relevant selection variables are included as regressors. However, if the assumption of participation on observables is doubted, then matching methods will be biased and either instrumental variable (IV) or Heckman selection models (Heckman, 1979) are appropriate. It is generally recognized that the latter are more robust, particularly for small samples; however, they are sensitive to both model specification and distributional assumptions (Blundell & Costa Dias, 2000; Heckman, LaLonde, & Smith, 1999, Chapter 31). As a result, it is recommended to augment vector z in Eqn. (3) with variables that do not enter the outcome equation. This amounts to placing exclusion restrictions on vector x, analogous to an IV identification strategy. Tests for heteroscedasticity and collinearity between the selection and outcome equations are advised in order to check for deviations from the underlying assumptions required for consistency and robust inference. Following Puhani (2000), the collinearity test applied here uses the inverse Mills ratio (Heckman's λ) estimated from the full information maximum likelihood (FIML) model as the dependent variable in an OLS regression against the structural variables in the outcome equation. A large F-statistic (a high R^2) would then indicate the presence of significant collinearity.

The question of heterogeneous treatment concerns how the treatment effect is specified. A standard approach is to assume homogeneous effects only, implicitly treating individual deviations from the average effect as white noise is not correlated with the participation decision (conditional on x). Allowing for correlation between the participation decision and the individual treatment effect adds substantial complexity to the analysis and interpretation of results. Given this paper's modest aims, simplicity is paramount and a homogeneous framework is assumed. Even so, it is important to note that Heckman selection estimators remain consistent under the assumption of heterogeneous effects, while IV estimators are invalidated (Blundell & Costa Dias, 2000).

The above discussion indicates that unless selection on observables can be guaranteed, a Heckman model would be most appropriate. As there is no prior reason to discard the possibility of unobserved selection factors, the hypotheses are investigated *via* a simple OLS specification as well as a FIML estimation of the Heckman model. The latter incorporates a test for sample selection bias, indicating whether OLS results may be biased. The FIML method differs from the (original) two-step estimation approach as the selection and outcome equations are estimated jointly, thereby enhancing asymptotic efficiency (Puhani, 2000). To check for robustness we also report results from alternative estimators, as well as relevant misspecification tests.

Before describing the empirical specification, it is necessary to reflect on the nature of the "treatments." As noted previously, two effects need to be distinguished—(i) participation in the organic scheme and (ii) use of organic farming techniques. Although Table 1 confirms that farmers in the control group also employ some organic techniques, it also suggests that certification is a strong predictor of the number of techniques used. For example, approximately 34% of the certified farmers use two or more organic techniques compared to only 13% of the control group. As a consequence, we consider participation in the scheme to be the main potential source of selection bias. The number of organic practices used is taken to be a second-order decision that is not subject to selectivity bias once we have controlled for scheme participation and other household characteristics. The validity of this approach is investigated empirically in Section 4 through an analysis of the determinants of the two treatments.

In terms of empirical implementation, the OLS estimates are based on Eqn. (5) where the vector $x' = [1\ x_1]$ defines a parsimonious set of structural regressors affecting both the outcome and the participation decision. These are whole farm size (log.), number of productive coffee trees (log.), altitude above sea level, age of the head of household, his/her education (in number of years), and the size of the household. Both hypotheses are tested simultaneously by including the two treatments as additional regressors; these are a dummy variable for participation in the scheme (C) and the number of organic practices used (P). In all specifications, the dependent variables (y) refer to the logarithm of components of the household revenue. For ease of exposition we focus only on gross crop revenue and net coffee revenue as described in Section 4; however, the results from alternative dependent variables are comparable and support the overall analysis. [13]

For the FIML selection model, Eqns. (3) and (5) are estimated simultaneously (for details see Greene (2002)). The vector of selection variables z is partitioned, $z' = [1\ x_1\ z_1]$, where z_1 refers to the exogenous predictors of participation that do not enter the outcome equation. For these, we use two dummy variables that proxy for the orientation of the household toward agriculture as well as its long-term welfare status. The former (non-crop) is constructed from the ratio of non-farm revenue to total revenue, taking the value of one for those falling in the top tercile and zero otherwise. This indicator is strongly associated with comparable indicators such as households stating their primary occupation as agriculture and those in receipt of a salary income. Thus, we interpret it to be capturing the "deep" structure of household revenue generation. The welfare indicator (walls) takes a value of one if the walls of the household are made of brick and zero otherwise. Once again, it is assumed that this variable changes only slowly and therefore is exogenous to the outcome variable(s) over the measurement period.

4. EMPIRICAL FINDINGS

(a) *Hypothesis tests*

Moving to the results, it is useful to review whether concerns regarding endogenous selection are warranted. Table 2 reveals the extent to which the observed levels of the two treatment variables can be attributed to the structural regressors. Scheme participation (certification, C) is modeled using a binomial probit estimator. The results show that specific household endowments relating to coffee production, farm altitude and the "instruments" (z_1) are significant predictors of participation. At a minimum, this suggests that certification is non-random and underlines the relevance of techniques that account for endogenous selection. The significance of the two exclusion restriction variables (non-crop, walls) also supports the feasibility of employing IV and Heckman selection methods. Use of organic practices (P) is a count variable, and therefore is modeled by a Poisson regression. In addition to the variables entering vector x (see above), the specification also conditions on scheme participation and the number of inspections received from scheme managers (due to a potential training effect). The results show that only scheme participation (C) is a material partial correlate of the number of techniques used. Moreover, the overall model has weak explanatory power as indicated by the insignificance of the χ^2 and pseudo-R^2 measures. In sum, these results support the chosen empirical strategy in which scheme participation is considered to be the primary potential source of selection bias, while the use of organic practices is conditionally random.

Table 2. *Probit model for scheme participation and Poisson model for use of organic practices*

Dependent variable	Certified organic (C)		Organic practices (P)	
	Beta	s.e.	Beta	s.e.
Whole farm size	0.06	(0.19)	0.02	(0.09)
Trees (no.)	0.39*	(0.16)	−0.08	(0.08)
Altitude	5.79**	(1.73)	−0.10	(0.68)
Age	−0.02+	(0.01)	0.01	(0.00)
Education	0.00	(0.04)	0.01	(0.02)
Household size	0.07	(0.06)	0.01	(0.03)
Non-crop	−0.63*	(0.27)	−0.16	(0.15)
Walls	0.47+	(0.26)	0.01	(0.12)
Certified (C)	–	–	0.43*	(0.19)
Inspections	–	–	−0.02	(0.07)
Constant	−12.42**	(3.53)	0.44	(1.42)
N	147		147	
Log-like.	−66.7		−231.6	
R^2 (pseudo)	0.23		0.02	
χ^2	40.7**		9.9	

Notes: Variables and models are as discussed in the text; standard errors (s.e.) are robust (Huber/White/Sandwich); samples exclude missing observations and outliers, defined as households with net coffee revenue ±3.5 standard deviations from the mean.
Source: Authors' calculations; undertaken using Stata 8 (probit/poisson).
+ Significant at 10% level.
* Significant at 5% level.
** Significant at 1% level.

Results for the models encompassing the two main hypotheses are set out in Table 3. Estimates for both the OLS and FIML estimators are reported for the dependent variables of interest. Four main results can be highlighted. The first is the strong goodness-of-fit of all models, given by the relatively high R^2 and χ^2-statistics, which are significant at the 1% level. Secondly, the estimated coefficients are highly comparable across the different models and estimators, also running in the expected directions. For example, size of the farm and number of productive trees are both significantly and positively associated with gross crop revenue; however, whole farm size is not associated with net coffee revenue once more specific characteristics of the household's coffee endowment are controlled for. The results of the selection equations (part (ii) of the table) are also consistent with the results from the individual probit model for scheme participation. Together these findings indicate that the models are well specified and are able to explain a substantial proportion of variation in the dependent variables.

The third issue refers to the problem of endogenous selection. This is captured by the adjusted ρ-statistic, which is the hyperbolic arctangent of the correlation (ρ) between the residuals in the selection and outcome equations. For gross crop revenue, selection bias is not significant, and therefore the OLS results are likely to be consistent. In contrast, for net coffee revenue the outcome and selection equations cannot be considered independent (at the 5% level). Thus, moderate selection bias exists and the OLS results may not be reliable. The difference between these findings relates to the fact that the organic scheme does not embrace non-coffee crops.[14] Thus, issues of selection have a narrow domain and may be marginal in the context of each household's overall crop production. With respect to the FIML model for net coffee revenue (column D), the collinearity and heteroscedasticity tests are insignificant at the 5% level. This indicates that the assumptions underpinning the FIML approach are not substantially violated and, therefore, these estimates can be preferred. In any case, robust standard errors are used to address any remaining heteroscedasticity (which cannot be rejected at the 10% level).

The final observation refers to the coefficients on the treatment variables (certification and use of organic practices). The most striking result is a consistent positive significant effect from the participation in the scheme. This is observed in both the gross crop revenue and net coffee models. Given the empirical strategy applied, these estimates control for other observed determinants of revenue, the use of organic techniques and any unobserved (latent) selection bias. In other words, we can reject the null of Hypothesis I and conclude that there is a positive treatment effect *ceteris paribus*. As is expected given the semi-log specification, the relative magnitude of the participation effect is larger for net coffee revenue, simply reflecting the point that coffee revenue is only one component of gross crop revenue. The results for the use of organic practices also are relatively clear-cut. With respect to the gross crop revenue, no significant effect can be found. This implies that there is no measurable gain at the level of gross crop revenue from augmenting the use of organic practices holding all other variables constant, including scheme participation. Once again, this is not the case for the specific net coffee revenue component. Here, we find a modest positive effect from the use of organic practices, approximating a 9% increase in net coffee revenue for a one unit increase in the number of practices applied. However, this result is only significant at the 10% level, suggesting that some additional caution is warranted in interpretation. We discuss the economic significance of these results in subsection (b) below.

Finally, to confirm the robustness of the results, Appendix 1 compares results for alternative estimators using net coffee revenue as the dependent variable. Although the treatment coefficients are not directly comparable due to the different approaches used to deal with selection bias, a consistent story emerges that is independent of the specific estimator used. The expectation of no effect in Hypothesis I is rejected strongly; similarly, Hypothesis II also can be rejected, but should be done so more cautiously—organic practices also appear to generate a consistent positive revenue effect, but this is only observable when net coffee revenue is the dependent variable.

Table 3. *Regression results for effect of certification and organic practices on agricultural revenue*

Dependent variable	Gross crop revenue (log.)				Net coffee revenue (log.)			
Model	(A) OLS		(B) FIML		(C) OLS		(D) FIML	
	Beta	s.e.	Beta	s.e.	Beta	s.e.	Beta	s.e.
(i) Outcome equation								
Whole farm size	0.35**	(0.09)	0.34**	(0.08)	0.12	(0.09)	0.11	(0.09)
Trees (no.)	0.52**	(0.06)	0.47**	(0.07)	0.71**	(0.08)	0.65**	(0.08)
Altitude	−1.63*	(0.66)	−2.21**	(0.76)	−2.27**	(0.70)	−3.02**	(0.80)
Age	−0.00	(0.00)	−0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Education	0.03	(0.02)	0.03+	(0.02)	0.02	(0.02)	0.02	(0.02)
Household size	−0.01	(0.02)	−0.02	(0.02)	−0.02	(0.02)	−0.02	(0.02)
Practices (*P*)	0.05	(0.05)	0.05	(0.05)	0.09+	(0.05)	0.09+	(0.05)
Certified (*C*)	0.38*	(0.15)	0.78**	(0.30)	0.78**	(0.16)	1.31**	(0.27)
Constant	9.50**	(1.36)	10.64**	(1.56)	10.85**	(1.46)	12.30**	(1.69)
(ii) Selection equation								
Whole farm size			0.04	(0.21)			0.05	(0.20)
Trees (no.)			0.44*	(0.17)			0.41*	(0.16)
Altitude			5.58**	(1.49)			5.58**	(1.39)
Age			−0.02+	(0.01)			−0.02*	(0.01)
Education			−0.01	(0.04)			0.00	(0.04)
Household size			0.04	(0.06)			0.05	(0.06)
Non-crop			−0.67**	(0.26)			−0.77**	(0.24)
Walls			0.50*	(0.25)			0.49*	(0.25)
Constant			−11.89**	(3.27)			−11.72**	(3.15)
ρ (adj.)			−0.40	(0.24)			−0.49*	(0.19)
N	132		132		147		147	
Log-like.	−130.4		−194.3		−160.4		−225.4	
R^2	0.60		–		0.61		–	
F-statistic/χ^2	32.71**		249.8**		24.66**		205.8**	
Collinearity test	–		0.85		–		0.82	
Heteroscedasticity test	2.86		2.35		9.30		10.77+	

Notes: Variables and models are as described in the text; collinearity test reports the *F*-statistic from a regression of Heckman's λ against structural regressors in (i); heteroscedasticity test reports the χ^2-statistic from a Breusch–Pagan (LM) test also against structural regressors in (i); robust (Huber/White/Sandwich) standard errors are given; samples exclude missing observations and outliers, defined as households ±3.5 standard deviations from the mean of the dependent variable.
Source: Authors' calculations; undertaken using Stata 8 (reg/treatreg).
+ Significant at 10% level.
* Significant at 5% level.
** Significant at 1% level.

(b) *Economic significance*

It is all very well finding statistically significant results. But are they plausible from an economic perspective? Economic significance can be evaluated by calculating the size of the estimated treatment effects relative to the counterfactual of no treatment. As per standard practice, we estimate expected revenue for each household conditional on participation and no participation. The average treatment effect (ATE) is simply the mean difference between these two estimates over all individuals, or formally: $\text{ATE} = E[y_i|x_i, t_i = 1] - E[y_i|x_i, t_i = 0]$. Using the FIML results for net coffee revenue, Table 4 presents the estimated gain from scheme participation by different sub-groups. The average effect is a revenue increase of USH 170,430 per household, equivalent to a gain of 75% in net coffee revenue relative to the counterfactual of no participation. For those households that actually participated in the scheme, the increase is slightly lower at 67% (*vs.* 96% for the control group), reflecting the higher likelihood that households with larger coffee farming assets become involved.

Obviously, these are substantial effects; however, a focus on point estimates can be misleading. The 95% confidence interval around the coefficient on scheme participation ranges from 0.78 to 1.82 for the FIML model; the comparable OLS inter-

Table 4. *Average effect of scheme participation (organic certification) on net coffee revenue, by group*

	Organic certified?		
	No	Yes	All
No. organic practices in use			
0	153.72	203.16	182.34
	(92.32)	(61.33)	(74.38)
1	65.18	130.21	121.73
	(103.86)	(63.62)	(68.87)
2	153.02	174.08	166.59
	(94.97)	(71.05)	(79.56)
⩾3	77.18	207.77	191.45
	(104.03)	(69.2)	(73.55)
All	137.23	182.96	170.43
	(95.71)	(67.02)	(74.88)
Median test, over organic (*C*): 0.14 (pr = 0.71)			
Median test, over practice (*P*): 6.56 (pr = 0.26)			

Notes: For each group, figures give (mean) expected revenue increment in 1000 USH arising from participation in the scheme *versus* the counterfactual of no participation holding all other factors constant, including number of organic practices; figures in parentheses report the raw value as a percentage of estimated net coffee revenue in the counterfactual scenario; median test reports the relevant χ^2-statistic.
Source: Authors' calculations.

val is 0.46 to 1.10 which (given these coefficients can be interpreted directly) translates into a relative revenue gain from the participation ranging from around 60% to 200%. Thus, although the effect of participation is economically significant, undue stress should not be placed on the precision of the results. In any case, the revenue impact is smaller when viewed in terms of gross crop revenue or total household revenue. For example, the estimated (overall) ATE is equivalent to 12% of observed total household revenue for certified farmers or 14% for non-certified farmers. These are credible orders of magnitude and give credence to the overall direction of the results.

With regard to the effect of using organic techniques, the nature of the specification suggests a constant proportional gain in net coffee revenues from each additional technique applied. The estimated 90% confidence interval (CI) indicates that these effects range from around 1% to 18% of net coffee revenues. This is not unreasonable as an average effect, especially given the relatively crude way in which organic practices have been operationalized. The insignificance of organic practices at the level of gross crop revenue also is comprehensible once we recall net coffee revenue is approximately 66% of the gross crop revenue (for all farmers). Thus, given the modest effect of organic practices at the specific level of coffee revenue, one might only expect to see a significant positive effect at a broader level (gross crop revenue) if the benefits of these techniques are applied to crops other than coffee alone. However, both the recent establishment of the scheme and the difficulty that farmers face in generalizing the application of certain organic farming techniques to all the crops they cultivate suggest that more general spillovers are yet to be realized.[15] As such, the absence of a more general effect from organic practices is in line with reasonable expectations.

(c) *Economic interpretation*

Finally, how do these results cohere with what we know about the economics of certified organic smallholder farming in tropical Africa? The existence of a considerable treatment effect accruing purely from the participation in the scheme may be explained with reference to the price premiums offered to certified farmers in the context of the workings of the coffee market. As a scheme member, a price premium from selling organic coffee is only available for produce that has been processed. While in the conventional market processed coffee beans also command a price premium, this is subject to the vagaries of the market and usually is lower. Moreover, processing is costly in terms of time, labor, and equipment, suggesting that in the conventional market the decision to process represents an investment with uncertain returns. The existence of a price premium for scheme members may act to offset the risks associated with processing and, therefore, is likely to increase the extent to which farmers engage in these value-added activities.

This perspective is substantiated from a review of the distribution of average prices received by scheme participants and the control group as well as the proportion of their coffee crop (fully) processed. Plotted in Figure 1a, average prices received by the farmers who are not certified organic tend to be lower than those received by certified farmers and show much larger variance (dispersion). Approximately only 10% of farmers who are not certified organic receive at least the median price received by certified farmers. The tighter distribution of average prices received by certified farmers supports the existence of premium prices that are realized through processing.[16] Figure 1b plots the cumulative distribution of the proportion of the coffee crop fully processed. As can be seen, there appear to be stronger incentives to engage in processing for certified farmers—less than 10% of certified organic farmers process none of their crop compared to over 30% of the control group. One also notes that the same distribution for the control group is extremely disjointed, suggesting a distinct regime shift between engaging in processing and not doing so. Clearly, this is not the case for certified organic farmers as the distribution is much smoother. In addition to the price premium rationale, an additional explanation for this pattern recognizes that the

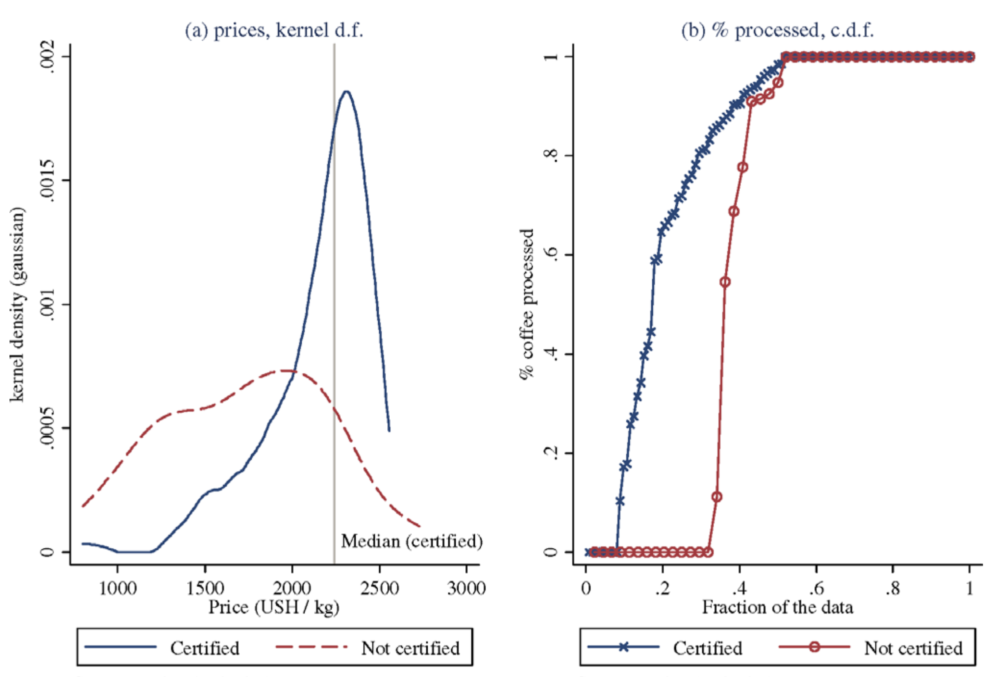

Figure 1. *Distributions of (a) average prices received and (b) proportion of coffee crop processed for certified organic farmers and non-organic farmers.*

Table 5. *Regression results for determinants of coffee yield per tree (log.)*

Dependent variable: yield per productive tree (log.)	Selection equation		Outcome equation	
	Beta	s.e.	Beta	s.e.
No. organic practices (P)	–		0.07^{++}	(0.04)
Certified (C)	–		1.01**	(0.23)
Constant	−12.11**	(3.23)	4.22**	(1.46)
Whole farm size	0.03	(0.2)	0.12^{++}	(0.08)
Trees (no.)	0.50**	(0.17)	−0.40**	(0.06)
Altitude	5.55**	(1.41)	−2.51**	(0.69)
Age	−0.02*	(0.01)	0.00	(0.00)
Education	0.00	(0.04)	0.02	(0.01)
Household size	0.05	(0.06)	−0.03	(0.02)
Walls	0.56*	(0.25)	–	
Non-crop income	−0.69**	(0.24)	–	
ρ (adj.)	−0.53**	(0.19)	–	
N		146		
Log-like.		−200.6		
χ^2		57.5**		

Notes: Model as discussed in the text; standard errors (s.e.) are robust (Huber/White/Sandwich); sample excludes missing observations and outliers, defined as households ±3.5 standard deviations from the mean of the dependent variable.
Source: Authors' calculations; undertaken using Stata 8 (treatreg).
$^{++}$ Significant at 15% level.
* Significant at 5% level.
** Significant at 1% level.

scheme introduced clearer quality criteria and more transparent measurement of quality and volume than in the non-organic market. Once again, this might act to reduce the risks of engaging in processing, thereby increasing the proportion of farmers gaining access to higher prices. Considered in this light, the effect of scheme participation supports arguments to the effect that contract out-grower schemes can help correct for classic market failures in developing country agricultural markets and thus yield positive welfare effects (see Sections 1 and 5).

In contexts where alternative farming systems are of an "organic by default" character, any relationship between "genuine" organic practices and revenue can be expected to operate through improved yields (see Section 2). This can be examined by employing yield per productive tree rather than revenue as the dependent variable in the same FIML model as before. The results are given in Table 5; they show that, controlling for selection bias, scheme membership and other plausible structural determinants of yields, there is a positive marginal effect from the use of organic practices. However, and as can be seen from the standard error for the latter coefficient, it is only significant at the 15% level reflecting both the small sample size and the way in which organic practices have been operationalized. Even so, the magnitude of the effect is analogous to that found when using net coffee revenue as the dependent variable—in this case, each additional organic practice generates a 7% increase in yield per tree on average. This result illustrates that the impact of organic techniques on net coffee revenue is likely to occur through improvements in yields and confirms the specificity of the effect for coffee as opposed to other crops.

5. CONCLUSION

We have analyzed the revenue effects of both participation in an organic coffee smallholder contract farming scheme and the application of recognized organic farming techniques. Controlling for a range of factors, including household endowments and non-random selection into the scheme, we find a positive individual effect from both these activities. Scheme participation (organic certification) is associated with an increase in net coffee revenue of around 75% on average, equivalent to 12.5% of mean (total) household revenue. This is accounted for by the enhanced incentives provided by the scheme to engage in processing of the coffee crop, thereby enabling farmers to access guaranteed price premiums. The effect of applying organic techniques is more modest. We estimate that each additional organic technique used generates a gain equal to around 9% of net coffee revenue, explained by a positive association between these practices and yield per tree. This provides evidence of positive revenue effects arising not only from the scheme itself, but also from the specific application of organic techniques.

Returning to the issues raised in the introduction to the paper, evidence has been generated in favor of the superior profitability of certified organic farming for smallholders in tropical Africa, relative to the dominant alternative scenario of farming systems that are "organic by default." However, this superiority is bound up with the organization of certified organic production in contract farming schemes. At the same time, evidence has been generated on the conditions under which smallholder contract farming schemes allow for superior farmer profitability. One condition is that they succeed in disseminating low-cost farming techniques that result in higher yields than those obtainable in the default scenario. On the other hand, currently more important in the Kawacom Sipi case is that they provide product marketing guarantees in relation to receiving a price premium for meeting given quality requirements. This appears to reduce smallholders' uncertainty about the net returns to processing of the coffee crop. In other words, the evidence presented here also supports the case for contract farming schemes with specific design features, rather than for contract farming schemes as such, as a route out of African agriculture's stagnation and decline. Of course, the order of importance between these contributing factors may change in the future, as low-cost and effective farming techniques such as organic ones become adopted more widely and deeply.

More generally, the results found here suggest the usefulness of further research in two main areas. The first concerns more detailed work on the economics of organic farming techniques in tropical Africa. Which techniques are most readily adopted, and why? Which generate the highest returns, and why? The other concerns a comparison of the design features of the plethora of new types of smallholder contract farming schemes that are emerging in tropical Africa in response to increased market differentiation in developed countries, in terms of their incentive effects for smallholders.

NOTES

1. For recent overviews see Nieberg and Offerman (2003) for Europe and Dmitri and Greene (2006) for the United States.

2. World Development Indicators (2006) gives Sub-Saharan African fertilizer consumption of 12.3 kg/hectare for 2002–03, as against 106.6 kg for South Asia and 89.5 kg for Latin America. Sub-Saharan Africa fertilizer consumption in 1989–91 was 14.2 kg/hectare.

3. In tropical Africa, organically certified large-scale commercial farming is found in Kenya (see Gibbon & Bolwig, 2007, pp. 25–38), Zambia (Parrott & van Elzakker, 2003, p. 110), and Gambia. In all cases production is for fresh vegetables for the UK market. In 2007, the total number of farms involved was not more than five or six.

4. The argument of Little and Watts (1994) is that, as smallholders alter their cropping patterns and invest in specific assets to optimize their benefits from schemes, their negotiating power declines relative to scheme owners.

5. For recent discussions of the extent and basis of African agriculture's crisis—and solutions to it—see *inter alia* Havnevik *et al.* (2007), Koning (2002), and World Bank (2007).

6. See Benfica, Tschirley, and Boughton (2006) and Warning and Key (2002) for a parallel research question in relation to contract farming schemes *per se*.

7. The Export Promotion of Organic Products from Africa (EPOPA) programme, funded by Sida, is the most important contributor to the development of the sector. It was supporting 18 organic exporters in 2007, including Kawacom.

8. In 2006, coffee made up 19.5% of the total export value. During the coffee boom in 1995 this figure was 67% (Bank of Uganda, 2006; UCDA, 2003).

9. Coffee procurement in Uganda is quite competitive. There were 24 exporters buying coffee in the 2006–07 season, with the top five accounting for 65% of the total purchases (UCDA, 2007).

10. Historically, Ecom traded coffee internationally under the name Esteve.

11. In 2003, the scheme was also certified to the Utz Kapeh standard, but this did not entail significant changes in grower requirements.

12. Non-organic traders in the project area are willing to pay a premium for organic coffee due to its superior physical quality. This also means that the farm-gate price within the project area is a little higher than in other parts of the area, to the benefit of local non-organic farmers and organic farmers selling off-scheme.

13. These are available on request from the authors.

14. Technically, certification is for farms and therefore covers all crops. But there are no certified organic traders for the non-coffee crops produced in the area.

15. Farmers in the scheme area also cultivated plantain bananas, maize, and legumes (in order of importance) in addition to coffee. The organic techniques referred to in this paper are applicable to these crops too, but the volume of organic material available to most farmers meant that its application was restricted to coffee.

16. Note that due to the complexities of the coffee market, prices available to farmers are not given but rather reflect a number of endogenous choices including the decision to engage in processing. Consequently, we have not used price as an explanatory variable in this analysis.

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APPENDIX 1. SUMMARY OF ALTERNATIVE REGRESSION RESULTS FOR NET COFFEE REVENUE (LOG.)

Model	(A) OLS		(B) Two-stage IV		(C) LIML		(D) FIML	
	Beta	s.e.	Beta	s.e.	Beta	s.e.	Beta	s.e.
Whole farm size	0.12	(0.09)	0.11	(0.10)	0.09	(0.11)	0.11	(0.09)
Trees	0.71**	(0.08)	0.59**	(0.10)	0.58**	(0.11)	0.65**	(0.08)
Altitude	−2.27**	(0.70)	−3.87**	(1.10)	−3.84**	(1.13)	−3.02**	(0.80)
Age	0.00	(0.00)	0.00	(0.01)	0.00	(0.01)	0.00	(0.00)
Education	0.02	(0.02)	0.02	(0.02)	0.02	(0.02)	0.02	(0.02)
Household size	−0.02	(0.02)	−0.03	(0.03)	−0.03	(0.03)	−0.02	(0.02)
Practice (*P*)	0.09+	(0.05)	0.13*	(0.05)	0.09+	(0.05)	0.09+	(0.05)
Certified (*C*)	0.78**	(0.16)	1.81**	(0.54)	1.89**	(0.54)	1.31**	(0.27)
Constant	10.85**	(1.46)	13.77**	(2.18)	13.91**	(2.28)	12.30**	(1.69)
Selection	–		–		−0.71*	(0.32)	−0.49*	(0.19)
N	147		147		147		147	
Log-like.	−160.4		−167.0		–		−225.4	
R^2	0.61		0.58		–		–	
F-statistic/χ^2	24.66**		23.35**		182.0**		205.8**	

Notes: Variables and models are as discussed in the text; robust (Huber/White/Sandwich) standard errors are given; LIML refers to limited information maximum likelihood, also known as the Heckman two-step estimator; 'Selection' variable refers to inverse Mills ratio (λ) for LIML and rho for FIML; in model (B), 'Certified' represents the fitted probabilities from a first stage probit as per Table 2 (main text); selection equations not reported; samples exclude missing observations and outliers, defined as households with net coffee revenue ±3.5 standard deviations from the mean.

Source: Authors' calculations; undertaken using Stata 8.

+ Significant at 10% level.

* Significant at 5% level.

** Significant at 1% level.