Interlinked Transactions in Cash Cropping Economies: The Determinants of Farmer Participation and Performance in the Zambezi River Valley of Mozambique

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Abstract. This paper investigates the determinants of participation and performance of tobacco contract farmers, and the effects of participation on overall crop and household incomes in the Zambezi Valley of Mozambique. We test the existence of threshold effects in land holdings and educational attainment to identify the types of farmers that benefit. Several results stand out. First, participation in the schemes is driven by factor endowments, asset ownership and alternative income opportunities, and very little by demographic factors. Second, we find no returns to education in tobacco; this result is consistent with previous research in Mozambique but surprising in an agronomically demanding crop like tobacco. Third, there appear to be economies of scale in tobacco production, perhaps through more efficient use of hired labor. If true, tobacco could drive greater economic differentiation through the growth of "emergent" or commercial smallholder households – something that has been conspicuously lacking in Mozambique to date. Fourth, farmers without wage income are more likely to grow tobacco; since other research shows that wage labor has driven most income growth in Mozambique over the past six years, tobacco could be inequality reducing. Tobacco growers also hire much more labor than non-growers, contributing to second-round inequality reducing effects. Further analysis, preferably in a general equilibrium framework, is needed to understand how the simultaneous forces of economic differentiation and spreading of economic benefits will affect income distribution. Potential adverse environmental impacts also deserve far more attention than they have received to date.

JEL Codes: C21, D1, L1, J43, Q12.

Keywords: Contract farming, selection bias, treatment effects, threshold effects, household income.

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1. Introduction

Contract farming is a pervasive institutional arrangement for cash cropping throughout the developing world. The persistence of this approach derives from two factors. First, smallholder farmers' low shadow wage rates give them substantial cost of production advantages over larger farmers, especially on crops requiring high labor input. Second, small farmers often are cash constrained and have poor access to input and credit markets. As a result processors, needing raw material to amortize fixed investments, provide these farmers with inputs (and possibly other services) on credit, and attempt to recover that credit upon purchase of the output.

These arrangements have been analyzed at length for at least two decades (Minot, 1986; Glover and Kusterer, 1990; Little and Watts, 1994). However, empirical assessments based on detailed household level data and controlling for possible selection bias in participation, are relatively rare[1]. In this paper, we focus on tobacco contract farming schemes in the Zambezi Valley of Mozambique. We develop two versions of sample selection models (Heckman, 1979; Greene, 2003) to investigate the determinants of farmer participation, the determinants of net income from tobacco once in the scheme, and the effect of participation on overall crop income and total household income. A key contribution of this paper is its investigation of threshold effects of education and land

[1] See Warning and Key (2002) for a recent example with a much smaller sample size and fewer independent variables than we use here. See also Jayne et al (2004) for application in a panel data set.

holdings; rather than focusing on the average effect of participation, we ask *what type* of farmer benefits from participation.

Section two of the paper describes the study area and sampling procedures. Section three compares participants and non-participants, while Section four presents our conceptual and empirical models, and results. We close with a discussion of policy implications.

2. Study Area Sample and Comparison of Means

The study covered monopsony "concession" areas for Mozambique Leaf Tobacco (MLT), and DIMON-Mozambique, both operating tobacco contract farming schemes in Tete Province. The survey covered 159 farmers among growers (117) and non-growers (42), using a stratified random sampling procedure. Households were interviewed twice: in March 2004 and September 2004. See Benfica *et al.* (2005) for more details.

Participants and non-participants are not statistically different in terms of demographic characteristics such as household size, labor endowments, education, and age of the head (Table 1). Household headship is almost statistically significant with non-growers more than twice as likely to be female-headed.

Growers have greater farm assets and are much likely to hire agricultural labor. Use of animal traction is low, and differences among households are not statistically significant, but sampled growers are nearly twice as likely as sampled non-growers to use this technology. Sampled growers are 50% more likely to use fertilizer on maize, but this difference too is not statistically significant. Notably, all farmers are much more likely to

use fertilizer than are farmers in other areas of the country[2]. Non-growers have more diversified incomes, though the only statistically significant difference is in the proportion earning wage labor income. Growers have much higher mean household and agricultural incomes, both total and *per capita*.

3. Farmer Selection and Performance, and Effects of Participation

In this section we wish to explain (a) the determinants of tobacco income among growers, and (b) whether, and for whom, participation in the contract farming scheme affects total income from all crops and total household income from all economic activities. To accurately explain these relationships, we have to account for unobserved factors that may affect both the likelihood of participation and the performance of farmers (Greene, 2003; Warning and Key, 2002). We do this by applying a two-stage Heckman model in two contexts: (a) a Sample Selection Model for the determinants of tobacco income among growers, and (b) a Treatment Effects Model to assess the impact of contract faming on overall cropping and total household income. The first step in both models uses all the observations in the sample to estimate the Probit Model:

$$\Pr(c_i = 1 \mid z_i) = \Phi(\gamma z_i) \qquad (1)$$

where c_i indicates participation in the cash cropping scheme, z_i is vector of exogenous determinants of participation, and γ is a vector of coefficient estimates for the z_i.

The second step is a selection adjusted Ordinary Least Squares (OLS) regression to cover two models.

[2] Nationally, about 4% use fertilizer on some crop. Fertilizer is part of the input package for tobacco, and is also available in nearby Malawi.

The Tobacco Income Determinants Model uses the selected sample (c_i=1) to run

$$y_i = \sum_{j=2}^{4} \alpha_j^0 A_{ji} + \sum_{k=2}^{3} \delta_k^0 E_{ki} + \beta x_i + \rho\lambda(\gamma z_i) + u_i \qquad (2)$$

where A_{ji} (owned land area quartiles), E_{ki} (education attainment dummies), and x_i, are a subset of z_i from the first stage.[3] The inverse mills ratio, IMR (λ), is obtained for each observation i as $\lambda_i = ø(\gamma z_i)/\Phi(\gamma z_i)$, where $ø(\gamma z_i)$ is the normal density function.

Equation (2) returns estimates of the determinants of cash cropping net income, α_j^0, δ_k^0, and β´s, and the sample selection bias coefficient ρ.

The Threshold Treatment Effects Model uses the full sample to run:

$$y_i = \beta x_i + \varphi c_i + \sum_{j=2}^{4} \alpha_j^0 A_{ji} + \sum_{j=2}^{4} \alpha_j c_i A_{ji} + \sum_{k=2}^{3} \delta_k^0 E_{ki} + \sum_{k=2}^{3} \delta_k^0 c_i E_{ki} + \rho h_i(\gamma z_i) + u_i \qquad (3)$$

where, C_i is the participation dummy, A_{ji} refers to owned land area quartiles and E_{ki} are education attainment dummies, as described in (2). All land and education variables are interacted with the participation dummy to test for threshold effects. The hazard ratio, h_i, for each observation i is computed from (1) as $h_i = \phi(\gamma z_i)/\Phi(\gamma z_i)$ if $c_i = 1$, and $h_i = \phi(\gamma z_i)/[1 - \Phi(\gamma z_i)]$ if $c_i = 0$ where $h_i = \phi(\gamma z_i)$ and $\Phi(\gamma z_i)$ are respectively the density and distribution functions of the standard normal evaluated at z. The model generates estimates of the treatment-effects and threshold coefficients γ, α_j's and δ_j's, the β´s (effects of other variables), and the sample selection bias coefficient (ρ). We test for sample selection bias under a null hypothesis of ρ=0.

[3] Elements excluded from z_i are known as exclusion restrictions.

3.1. Farmer Participation and Performance in Contract Farming

Probit results in Table 2 indicate that household participation in contract farming is more associated with technology, income diversification opportunities and asset endowments than with demographic characteristics. While point estimates indicate that female headed households are less likely to engage in tobacco production, the statistical significance of that result is not strong. As expected, the availability of draft power, the value of hand tools, and (though not quite significant) the value of other production and marketing equipment, including bicycles, are positively associated with participation.

Unexpectedly, larger households appear less likely to grow tobacco, though this result is not quite statistically significant. Warning and Key (2002) found a similar result in Senegal. Also surprising, in light of the means comparisons in Table 1, is that households with more land appear no more likely than others to grow tobacco. Households with access to alternative sources of income, especially livestock and wages, are less likely to participate in the contract farming schemes.[4]

Previous work in nearby areas of Mozambique suggested that households with access to wage labor markets tended to maintain access to them over time, and were unlikely to invest earnings from those activities in agriculture (Tschirley and Benfica, 2002). In this light, our finding that households with wage labor income are less likely to growth tobacco raises an interesting question: has the cash cropping scheme provided additional income earning options to those households with lesser access to wage labor markets? If so, will this pattern result in broader-based income growth? The possibility that cash cropping schemes in these areas may be inequality reducing deserves further

[4] Hausman tests for each of these income diversification variables failed to reject the null hypothesis of exogeneity.

analysis.

The insignificant coefficient on lambda in the second step suggests the absence of sample selection bias[5]. Key results include:

- Female headed households earn less from tobacco than their male counterparts;
- Land has no effect on net tobacco income until the fourth land area quartile, when it has a large and highly significant effect;
- Value of hand tools and other equipment are positively associated with tobacco income; and
- Agro-ecology matters. Farmers operating in mid-altitude areas of the north (Macanga-MLT and Mualadzi-DIMON) have profits similar to those in Angónia-MLT (the omitted dummy also in a mid-altitude area), while those in Luia-DIMON and Marávia-MLT in the lower and drier south have statistically lower profits.

3.2. The Effects of Contract Farming on Total Crop and Household Income

In this model we consider two OLS regressions in the second stage: determinants of net crop income and of total household income. Explanatory variables are identical in each regression (Table 3).[6] The models return an adjusted R^2 of 0.44 and 0.43, respectively.

The construction of our interaction terms (CF with two education dummies and

[5] A specification with continuous education and land variables in both steps gave a significant coefficient on lambda, but similar patterns and magnitudes on other coefficients.
[6] We used exactly the same selection equation applied in the previous section, and so do not emphasize the probit results here.

three land area dummies) means that the coefficient on CF reflects the effect of participation in the contract farming scheme of households in the lowest land area quartile (the omitted land dummy) who also have no formal education (the omitted education dummy). Effects of participation for other households are captured by the sum of the coefficients on CF and the relevant interaction terms. Table 4 reports the combined effects and F statistics for tests of the joint significance of these variables.

The models find no returns to education in agriculture, regardless of a household's participation status in the contract farming schemes. Education beyond three years does significantly increase total household income, likely reflecting higher off-farm earnings of more educated households; participation in contract farming by such households almost entirely *offsets* this advantage, though this effect is not significant. These results are consistent with Walker *et a.l*'s (2004) national analysis, and with Tschirley and Benfica (2002). Nonetheless, it's surprising that, even in a crop that requires careful management and pays high premiums for quality, education seems to have no impact.

Three results stand out related to land holdings. First, as shown by the similar magnitudes of the land area coefficients in both regressions of Table 3, the impact of larger land holdings on agricultural income is almost entirely reflected in total household incomes; households with more land do not appear systematically to be giving up off-farm incomes. Second, the impact of larger land holdings stabilizes or falls for non-participants after the third land area quartile – agricultural incomes of fourth quartile non-participants are not substantially different from those of third quartile non-participants, and household incomes are actually lower in the fourth quartile. Finally, as in Table 2,

participation in contract farming has no impact on overall crop income until the fourth quartile, when its effect is very large. This result suggests the presence of economies of scale in tobacco production (at least within the land area sizes seen in this sample), perhaps through more efficient use of hired labor. If true, the result suggests the possibility of substantial growth in coming years in the number of "emergent" or commercial smallholder households, driven by profit opportunities in tobacco. This class of farmers has been conspicuously lacking in Mozambique to date (Walker *et al.*, 2004). Interestingly, even these large tobacco growers do not appear to give-up off-farm income (see "combined effects" in Table 4)[7]. The ready availability of experienced labor in the area may be a key factor driving this result.

Female headed households earn lower crop incomes, but differences in total incomes are not statistically significant; this suggests that diversification into off-farm activities by female headed households reduces gender inequality. Ownership of equipment beyond hand tools appears to increase agricultural incomes: though the coefficient is not quite significant in the agricultural income regression, it is significant in the total income model and its magnitude is nearly identical.

4. Summary of Policy Implications

Key results from this analysis relate to the impacts of education, land holdings, and access to wage labor. The lack of returns to education in a crop as demanding as tobacco is surprising. Perhaps the best interpretation is that great scope remains for improving field practices, yields, and profitability; as companies strengthen their extension efforts and more farmers have more time to learn proper techniques, we expect

[7] Comparable analysis on national agricultural household data, limited to villages with tobacco growers, gives similar results.

more educated farmers to begin earning higher returns from tobacco.

Results on land holding size and access to wage labor may tell an interesting story. Tschirley and Benfica (2002) showed that those with wage labor income tend to maintain it for long periods of time. Boughton *et al.* (2005) showed that most income growth throughout the country over the past six years has come from off-farm incomes, especially wage labor. The research in this paper shows that households with such income are less likely to grow tobacco; households *without* such income are the ones taking advantage of the tobacco opportunity (Tables 1 and 2). As a result, tobacco cultivation may reduce income inequality. However, many smaller farmers earn negative profits from tobacco, while larger farmers tend to earn large positive profits. Over time, this pattern could drive substantial expansion in the number of "emergent" smallholder farmers in the area. Those left behind will be the smaller farmers who also have little access to wage labor opportunities.

This paper has not formally explored the growth linkage effects of tobacco cultivation. We know from Table 1 that one linkage effect is through the hiring of labor. Farmers unable to earn profits in tobacco and without access to more stable salary income are likely to be beneficiaries. Currently, however, some of this labor is supplied by Malawians; continuation of an open border migration policy is important for continued expansion of the sector.

Technological and environmental spillovers need to be more closely examined. On the positive side, growers and non-growers both are far more likely to apply fertilizer on food crops than are farmers in other areas of the country. On the negative side, the rate of tree cutting by tobacco growers far surpasses the rate of planting (Benfica, *et al*.,

2005). Long-term consequences could be quite negative if these trends are not halted.

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Table 1. Comparison of Means for Tobacco Growers and Non-Growers

Selected Variables	Type of Farmers (mean values)			Statistical Significance of the Difference		
	Tobacco Contract Growers	Non-Tobacco Growers		t-Stat	P > | t |	Significance Level of the Difference [1/]
Demographic Characteristics						
Female Headed Households – Percent	5.13	11.90		- 1.49	0.14	
Education of HH Head – years	3.22	2.76		1.00	0.32	
Age of Household Head – years	38.50	40.52		- 0.95	0.34	
Labor - Adult Equivalents	3.45	3.68		- 0.88	0.38	
Farm Assets						
Total Area – hectares	6.94	4.36		2.84	0.01	**
Reported Value of Manual Tools - $US	28.63	15.59		2.16	0.03	*
Reported Value of Equipment - $US	66.60	36.63		2.58	0.01	**
Use of Animal Traction – percent	7.69	4.76		0.64	0.52	
Use of fertilizer in Maize – Percent	32.47	21.42		1.35	0.18	
Use of Hired Labor						
Permanent Labor – Percent Using	71.79	30.95		4.98	0.00	**
Income Diversification - Percent						
Livestock	93.98	96.15		- 0.44	0.66	
Self-employment	60.15	53.85		0.56	0.55	
Wage Labor Employment	24.81	53.84		- 3.03	0.00	**
Household Income - $US						
Net Household Income	1,815.28	1,022.48		2.35	0.02	*
Net Household Income per capita	318.06	174.70		2.36	0.02	*
Net Agricultural Income	1,572.70	595.47		3.11	0.00	**
Net Agricultural Income per capita	274.23	98.26		3.18	0.00	**
Wage Labor Income	80.76	122.35		- 0.92	0.36	
Self-employment (non-agricultural)	90.24	185.90		- 1.14	0.26	
Livestock Income	90.11	79.50		0.35	0.73	
Number of observations	117	42				

[1/] Significance levels: [+] 10%, * 5%, ** 1%. Source: Zambezi Valley Cotton and Tobacco Concession Areas Study, 2004.

Table 2. Determinants of Net Income from Tobacco Production

Explanatory Variables	Parameter Estimates							
	1st Stage: Participation [1/]				2nd Stage: Net Income from Tobacco			
	Coeff	z	P > | z |	LS[2]	Coeff	t-stat	P > | t |	LS[2]
Demographics [3/]								
Female headed household	- 0.375	0.84	0.40		- 405.56	1.95	0.05	*
Age of household head	- 0.013	0.89	0.38		- 5.44	0.82	0.42	
Labor adult equivalents	- 0.154	1.29	0.20		106.51	1.26	0.21	
Education: 1-3 years	- 0.071	0.20	0.84		- 148.86	0.66	0.51	
Education >3 years	0.024	0.06	0.95		17.55	0.07	0.94	
Assets and Technology [4/]								
Area_Q2	0.333	0.92	0.36		247.07	1.36	0.18	
Area_Q3	0.027	0.06	0.95		- 78.32	0.34	0.74	
Area_Q4	0.500	0.96	0.34		780.34	2.30	0.02	*
Use of Animal traction	1.198	2.35	0.02	*	198.83	0.48	0.63	
Value of manual tools	0.023	1.70	0.09	+	8.47	1.79	0.08	+
Value of other equipment	0.004	1.22	0.22		3.86	1.51	0.13	
Diversification Activities								
Has livestock income	- 1.026	1.90	0.06	+				
Has Self-employment income	0.257	0.89	0.37					
Has wage labor income	- 0.879	2.88	0.00	*				
Agro-Ecological Effects								
Mid-Altitude								
Macanga – MLT	- 0.831	2.15	0.03	*	30.78	0.10	0.92	
Mualádzi – DIMON	0.161	0.43	0.67		83.19	0.41	0.69	
Angónia – MLT (dropped)								
Lower Altitude								
Marávia – MLT	- 0.361	0.85	0.40		- 600.79	2.68	0.01	**
Luia – DIMON	- 0.543	1.17	0.24		- 787.16	3.72	0.00	**
Lambda (Inverse Mills Ratio)					229.53	1.03	0.31	
Constant	1.544	1.85	0.07	+	- 170.74	0.41	0.68	
Number of observations	159				117			
Wald chi2 (18)	45.25							
Prob > chi2	0.0004							
Pseudo R2	0.25							
Log pseudo-likelihood	- 81.62							
F (16, 100)					4.12			
Prob > F					0.0000			
R – Squared					0.46			
Root MSE					913.62			

[1/] Probit equation for participation, 1 if participates, 0 otherwise. [2/] Level of significance (LS): + 10%, * 5%, ** 1%. [3/]No schooling (Education=0) is excluded. [4/] Quartile 1 (Area_Q1) is excluded. Source: Zambezi Valley Tobacco Concession Areas Study, 2004.

Table 3. Effects of Tobacco Contract Farming (CF) on Net Agricultural Income and Net Total Household Income: Model with Land and Education Threshold Effects

Explanatory Variables [1/]	OLS Parameter Estimates – Tobacco Areas							
	Net Total Agricultural Income				Net Total Household Income			
	Coef.	Robust S.E.	P |Z|>z	LS[2]	Coef.	Robust S.E.	P |Z|>z	LS[2]
Participates in CF	407.70	555.62	0.46		85.87	568.47	0.88	
Demographics								
Female head household	- 488.01	239.68	0.04	*	0.66	282.52	0.99	
Age of household head	4.85	10.32	0.64		15.85	11.04	0.15	
Labor Adult equivalents	25.44	98.06	0.80		- 3.99	105.43	0.97	
Education Threshold Effects [3]								
Education: 1-3 years	195.32	258.15	0.45		269.76	259.28	0.30	
Education >3 years	361.14	312.48	0.25		718.92	320.28	0.03	*
[Education : 1-3]*CF	- 482.02	572.20	0.40		- 452.16	581.29	0.44	
[Education >3]*CF	- 637.32	581.68	0.28		- 703.27	585.63	0.23	
Land Threshold Effects [4]								
Area_Q2	527.93	222.43	0.02	*	401.17	257.28	0.12	
Area_Q3	665.13	331.93	0.05	*	820.94	279.98	0.00	**
Area_Q4	723.32	396.06	0.07	+	691.65	359.09	0.06	+
Area_Q2*CF	- 129.33	349.50	0.71		4.26	377.02	0.99	
Area_Q3*CF	166.40	553.41	0.76		- 18.28	517.81	0.97	
Area_Q4*CF	1,305.86	631.67	0.04	*	1,575.96	652.95	0.02	*
Assets and Technology								
Use Animal traction	- 56.43	601.06	0.93		- 275.33	620.81	0.66	
Value of tools	8.59	9.14	0.35		5.72	8.82	0.52	
Value of equipment	4.31	2.81	0.13		4.38	2.39	0.07	+
Use of fertilizer in maize	12.99	250.38	0.96		- 22.13	244.14	0.93	
Agro-Ecological Effects								
Mid-altitude								
Macanga – MLT	165.83	371.25	0.66		- 159.92	345.50	0.64	
Macanga*CF	662.23	722.84	0.36		942.34	722.45	0.19	
Mualadzi – DIMON	774.05	459.01	0.09	+	423.32	419.30	0.32	
Mualadzi*CF	182.69	602.86	0.76		357.91	586.89	0.54	
Angonia – MLT	224.71	341.65	0.51		- 91.76	283.13	0.75	
Angonia*CF	141.48	553.88	0.80		265.72	545.30	0.63	
Lower altitude								
Maravia – MLT	- 12.51	410.23	0.98		- 244.43	382.95	0.52	
Maravia*CF	90.38	772.74	0.91		36.57	760.10	0.96	
Luia – DIMON (excluded)								
h (hazard ratio)	331.11	246.49	0.18		68.56	242.59	0.78	
Constant	- 1,101.09	793.64	0.17		- 679.39	773.48	0.38	
N	159				159			
F (27, 131)	4.11				4.92			
Prob > F	0.0000				0.000			
R – Squared	0.44				0.43			
Root MSE	1,207.00				1,258.10			

[1/] OLS regressors. [2/] Level of significance (LS): + 10%, * 5%, ** 1%. [3/]No schooling (Education=0) is excluded. [4/] Quartile 1 (Area_Q1) is excluded. Source: Zambezi Valley Tobacco Concession Areas Study, 2004.

Table 4. F-Tests of Joint Significance of CF and Education and Land Thresholds

	Net Agricultural Income Regression				Net Total Household Income Regression			
	Combined Effect	F(2,131)	Prob>F	LS[1/]	Combined Effect	F(2,131)	Prob>F	LS[1/]
CF-Education Threshold Effects								
CF and [Education : 1-3]*CF	(74)	0.40	0.67		(366)	0.40	0.67	
CF and [Education >3]*CF	(229)	0.61	0.54		(617)	0.92	0.40	
CF-Land Threshold Effects								
CF and Area_Q2*CF	279	0.33	0.72		90	0.01	0.99	
CF and Area_Q3*CF	574	0.28	0.76		68	0.01	0.99	
CF and Area_Q4*CF	1,714	2.26	0.10	+	1,662	2.91	0.05	*

[1/] Level of significance (LS): + 10%, * 5%, ** 1%. Source: Zambezi Valley Cotton and Tobacco Concession Areas Study, 2004.