ELSEVIER

Agricultural Economics 28 (2003) 39–50

AGRICULTURAL ECONOMICS

www.elsevier.com/locate/agecon

Cash cropping and food crop productivity: synergies or trade-offs?

Jones Govereh [a], T.S. Jayne [b,*]

[a] *Food Security Research Project, Lusaka, Zambia*

[b] *Department of Agricultural Economics, Agriculture Hall, Michigan State University, East Lansing, MI 48824-1039, USA*

Received 25 January 2001; received in revised form 24 January 2002; accepted 10 April 2002

Abstract

The case for promoting export-oriented cash crops in Africa has generally been based on their direct potential contribution to agricultural productivity and small farmer incomes. A relatively neglected avenue of research concerns the synergistic effects that cash cropping can have on other household activities, including food production. The conventional view that cash crops compete with food crops for land and labour neglects the potential for cash crop schemes to make available inputs on credit, management training, and other resources that can contribute to food crop productivity, which might otherwise not be accessible to farmers if they did not participate in cash crop programs. This article builds on previous research by hypothesising key pathways by which cash crops may affect food crop activities and empirically measuring these effects using the case of cotton in Gokwe North District in Zimbabwe. Analysis is based on instrumental variable analysis of survey data on 430 rural households in 1996. Results indicate that—after controlling for household assets, education and locational differences—households engaging intensively in cotton production obtain higher grain yields than non-cotton and marginal cotton producers. We also find evidence of regional spill-over effects whereby commercialisation schemes induce second round investments in a particular area that provide benefits to all farmers in that region, regardless of whether they engage in that commercialisation scheme. The study suggests that the potential spill-over benefits for food crops through participation in cash crop programs are important to consider in the development of strategies designed to intensify African food crop production.

Keywords: Africa; Zimbabwe; Cash crops; Cotton; Productivity; Food security

1. Introduction

Meeting the challenge of raising rural incomes in Africa will require some form of transformation out of the semi-subsistence, low-input, low-productivity farming systems that currently characterise much of rural Africa. In some areas of eastern and southern Africa, food crop intensification was formerly promoted through state-led programs integrating subsidised credit, input delivery and crop purchase by state marketing boards that operated even in remote farming areas (Rohrbach, 1988; Byerlee and Eicher, 1997; Putterman, 1995). However, these policies eventually accumulated large budget deficits and became financially unsustainable, leading to an often sudden withdrawal of services to farmers and an associated stagnation or decline in the use of cash inputs on food crops (Jayne and Jones, 1997). Farmers in many countries are purchasing less hybrid seed and/or less fertiliser for food crops than during the former

* Corresponding author. Tel.: +1-517-355-0131; fax: +1-517-432-1800.
E-mail address: jayne@msu.edu (T.S. Jayne).

0169-5150/02/$ – see front matter
PII: S0169-5150(02)00066-X

period of controlled marketing.[1] Renewed growth in African agriculture will require financially sustainable intensification of existing cropland, since most of the high-potential farmland in Africa is already under production.

High-value cash crops represent one potential avenue of crop intensification. Evidence from other parts of Africa indicates that farm incomes and productivity can benefit from engaging in cash crops with well-developed channels for procuring inputs on credit and marketing the crop (Dione, 1989; Goetz, 1993; Von Braun and Kennedy, 1994; Kelly et al., 1996; Poulton et al., 1998; Dorward et al., 1998). But the active promotion of non-food cash crops in Africa is often impeded by perceptions that they compete with food production and exacerbate household food insecurity.[2] The effects of shifting to more commercially-oriented cropping patterns on the allocation of households' resources are complex and need to be more fully understood to guide agricultural policy formation. In addition to the direct effect of cash cropping on household incomes, there may be important indirect effects of cash cropping on the productivity of other household activities such as food cropping. These potential synergies between cash crops and food crops have been generally neglected in food crop research and extension programs,[3] although they may have important implications for programs designed to promote smallholder food crop productivity growth.

This paper studies the synergies between cash cropping and food crop productivity at the household level using the case of Gokwe North District in Zimbabwe. The paper theorises two potential pathways by which cash crop schemes may affect food crop productivity and then empirically measures these effects. Results are based on econometric analysis of cross-section household survey data collected in 1996. The findings suggest that, especially under conditions of credit and input market failures, participation in cash crop schemes may enable households to acquire key inputs and skills which they can use to increase the productivity of other enterprises in their crop mix. A better understanding of why and how these synergies occur can help in the design of policy strategies to intensify food crop production in Africa.

2. Conceptual framework: synergies between cash crops and food crops

Economists have long advocated specialisation and commercialisation as part of a broader strategy of comparative advantage. The underlying premise is that markets allow households to increase their incomes by producing that which provides the highest returns to land and labour, and then using cash to buy household consumption items, rather than being constrained to produce all the various goods needed for consumption (Timmer, 1997). While this concept of comparative advantage is well accepted under the assumption of frictionless markets, in reality the process of commercialisation involving non-food cash crops can be impeded by risks and costs in the food marketing system. Food market failures give rise to the well-understood non-separability of household production and consumption decisions, which accounts for the potential breakdown of agricultural commercialisation strategies based on comparative advantage (Singh et al., 1986; Fafchamps, 1992). These arguments form a large part of the foundation of the long-standing critique of cash crop promotion in Africa.

However, there are other less well-understood non-separabilities between crop choice and access to inputs and training and other investment decisions that need to be considered in understanding the normative

[1] For evidence from eastern and southern Africa, see Jayne and Jones, 1997; Howard and Mungoma, 1997; Kherallah et al., 2002.

[2] The World Bank and other donors have come under renewed criticism from civil society groups contending that support for cash cropping in Africa benefits mainly foreign marketing firms and reduces the amount of food available for consumption. Consider the following except from a full page advertisement in the New York Times on 18 January 2000, by a lobby group called "Turning Point Project", representing over 60 NGOs and research foundations: "Globalised industrial-style agriculture does not grow staple foods for the hungry, or for their communities. Global corporations favour luxury high profit items: flowers, potted plants, sugar cane, beef, shrimp, cotton, coffee, soybeans for export to wealthy countries. Local people are often left with nothing. In Africa, where severe famines occurred in the past decade, newly industrialised agriculture does not produce staple foods, but record crops of ... cotton and sugar cane! For export. As export crops and livestock use up available land, small farmers are forced to use marginal, less fertile lands. Staple food production for local use plummets, increasing hunger."

[3] For informative exceptions, see Goetz, 1993 and Dione, 1989.

and positive implications of agricultural commercialisation strategies. For example, farmers with limited cash income may be able to afford key inputs only if provided on credit; and in many areas agricultural credit tends to be available primarily through interlocked cash crop schemes (Dorward et al., 1998). The case for cash cropping has generally been based on the direct contribution that *these crops* can have on farm incomes. A relatively neglected avenue of research concerns the effects that cash cropping can have on the productivity of other household activities. The following sections classify two potential pathways by which cash cropping may affect the productivity of other crops: (1) *household-level synergies*; and (2) *regional spill-over effects*.

2.1. Household-level synergies

Household-level synergies occur when the household's participation in a commercialised crop scheme enables it to acquire resources that otherwise would not be available, for use on other enterprises in the crop mix. There are several pathways of this type. Under conditions of constrained access to farm credit, households' ability to intensify food crop production may depend on their participation in cash crop schemes. Strasberg (1997), for example, finds that under credit and input market failures in northern Mozambique, participation in cotton outgrower schemes was the primary means of acquiring cash inputs for use in food production. In parts of Central Province, Kenya, smallholders engaging in coffee production obtained through their coffee co-operatives access to credit, inputs, extension services and equipment for use not only on coffee but also on food crops. The coffee co-operatives' explicit support of members' food crop production was based on the premise that this would raise their ability to sustainably and profitably participate in coffee production, which would in turn provide longer term benefits to the company (Govereh et al., 1999). In Zambia, farmer application of pesticides acquired through participation in cotton outgrower schemes benefited grain yields as well as cotton due to 'wind drift' (Fereidoon et al., 1996). Due to crop rotation, maize can benefit from residual fertiliser acquired on credit from participation in cotton schemes and applied to plots on which cotton was grown the year before (Dione, 1989). Access to these inputs on credit was not assured for households choosing to concentrate their farming activities on food crops alone. These examples indicate the potential non-separability between crop choice decisions and access to resources and opportunities.

Agricultural commercialisation may have an indirect impact on food productivity via its effects on animal traction adoption. When faced with poorly functioning credit markets, cash cropping can provide a needed source of cash for purchasing lumpy assets such as animal traction equipment and draught power which can also be used to intensify food crop production.[4] In Mali, 70% of the farmers surveyed by Dione (1989) perceived cotton production and use of fertiliser as the two most important conditions determining the profitability of animal traction adoption. Rental markets for oxen and plough usage do exist in many areas but oxen owners typically reserve the perceived optimal time for animal traction functions for their own plots, leaving renters with the option to rent weakened oxen at sub-optimal times. Cash-generating crops can help farmers overcome capital constraints on the purchase of lumpy assets and inputs, which can be used to expand food crop as well as cash crop production (Von Braun and Kennedy, 1994).

Promotional support and training of cash crop producers by private firms may also raise the productivity of existing household resources devoted to food crop productivity. In Zimbabwe, the Department of Agricultural and Technical Services (AGRITEX) co-operates with private fertiliser and pesticide manufacturing firms in training farmers at the Cotton Training Institute. One important part of the training program focuses on pest scouting. Farmers get extensive training in determining the critical stages of economic injury to a cotton stand. Mariga (1994) argues that cotton instills discipline in farmers because of its stringent husbandry requirements. Such knowledge not only improves cotton management skills but improves the overall quality of farm husbandry. For example, farmers with knowledge of cotton pest

[4] Animal traction's contribution to food crop production has been observed to involve elements of both area expansion (by allowing more land to be cultivated than under hand-hoe plowing technology) and yield improvement (through timeliness of land preparation, planting and weeding). See Govereh, 1999.

scouting may be better able to determine the stage at which maize stalk-borers or grain weevils cause economic injury. Mariga (1994) asserts that such investments in human capital through participation in cash crop programs has had a positive spill-over effect on food crop productivity.

2.2. Regional spill-over effects

Regional effects occur when a commercialisation scheme attracts investments to a region which provide widespread spill-over benefits to all farmers in that region regardless of whether they engage in that commercialisation scheme. For example, the promotion of input-intensive cash crops can make key inputs more readily available in the area, for use on food or cash crops. Dione (1989) found that the introduction of cotton to southern Mali increased the demand for fertiliser, which subsequently stimulated private investment by input manufacturers, distributors and retailers. These investments made fertiliser and other inputs more accessible and profitable not only for use on cotton (which was the primary impetus for the expansion of input supply in these areas) but also for farmers who only produced staple food crops. These examples highlight the potential synergies between input-intensive cash crops and subsistence crops.

Regional spill-over effects can also occur when agricultural commercialisation spurs private investment in market infrastructure that improves the productivity of other farm activities, including food crop production. It has been observed that private investment in transportation infrastructure to support cash crop activities has also raised the returns to smallholder grain production and grain traders' operations (Strasberg, 1997).

The general inductive argument built up from these cases is that commercialised crop production and marketing programs may create important synergies with more subsistence-oriented crops. These potential synergies arise from both household-level and regional-level spill-over effects. Whether these synergies actually arise depends on the perspectives and approaches that marketing firms adopt toward smallholders (e.g. whether credit is provided under terms that are not available in 'open markets', whether the input and output marketing system that develops to support the cash crop induces auxiliary private sector response in service provision and infrastructural investments that support food crop production). The remainder of this paper examines these issues based on the case of cotton in Gokwe North District of Zimbabwe.

3. Data and sampling frame

The data used in this study is based on a multiple visit survey of 480 rural households in 1996. The survey was designed and implemented under the Project on Integrated Assessment of Trypanosomosis Control Strategies and Their Impacts. This component of the overall project was a collaboration between The International Livestock Research Institute, The University of Zimbabwe, The Regional Tsetse and Trypanosomosis Control Program and The Department of Veterinary Services, Tsetse Control Branch of Zimbabwe.

Gokwe North District was selected for implementing the survey. Gokwe is a major cotton producing area and has been a destination for internal immigrants seeking the fortunes associated with cotton. The influx of immigrants into Gokwe is often dubbed "the white gold rush". A four-stage stratified sampling procedure was adopted to select study sites within Gokwe North. The first stage involved purposive selection of three cluster areas that experienced early, mid and recent tsetse fly clearance. Each cluster area falls under Natural Region III (moderately high agro-ecological potential). They are found along the major drainage systems with soils that are moderately well drained, sandy clay loam or clay. These soils have high agricultural potential and no farmers in the sample applied any supplementary nutrients. The most limiting input was animal traction because the soils (vertisols) are hard and difficult to work manually.

During the second stage, two wards were purposively selected from each of the cluster areas. Selection of two wards per cluster area provided an opportunity to identify differences in local administration that could have affected the settlement process. In the third stage, two villages were purposively selected within each ward: one village had the best access to services in 1996 and the other village had the worst access to services at that time. At the fourth stage, a random sample of 40 households, representing approximately 15–25% of the village population, was drawn from each village. The resulting sample size

was 482 households. Households were interviewed for information on demographics, farm and non-farm activities, agricultural practices and asset holdings.

4. Research questions and method of analysis

The conceptual framework in Section 2 suggests that the intensity of cotton production in Gokwe North may potentially influence the productivity of a farmer's other crops. This section develops a model for measuring (1) the determinants of cotton commercialisation at the household level, and (2) the contribution of cotton commercialisation to food crop yields and production.

Some key descriptive features of the data are important in guiding model specification. Cropping patterns in Gokwe North are concentrated on two crops. Maize accounts for 47.4% of cropped area, while cotton accounts for 45.2%.[5] However, there are clear differences in the reasons for growing these crops: 100% of the cotton production was marketed, while 93.8% of the maize production was consumed on the farm. Cotton sales contributed 83.6% of the value of marketed crop income. In this area of Zimbabwe, agricultural commercialisation is virtually synonymous with expanding cotton cultivation.

The major inputs in the cotton system that may give rise to household-level synergies with food crops are draught equipment, herbicides, pesticides and sprayers. These purchases are made from cotton traders who are in local village centres or from larger dealers in town centres. The key technologies in the maize production system are hybrid seed and animal traction. Fertiliser is not commonly used in these areas because the soils do not have nutrient deficiencies that require the use of inorganic fertiliser. Traction is a key production input because the soils are heavy and difficult to work with a hand hoe. Traction equipment is important both in expanding the household's cultivable land and in allowing for more timely planting.

Given our hypothesis that a household's grain crop productivity may be related to its involvement in cotton production, we develop an indicator of cotton commercialisation. We define the household's cotton commercialisation index, CCI_i, as the value of cotton sales over total crop production for household i. This index is neutral with respect to farm production, and measures the household's involvement in cotton relative to its total farm output. This index ranged from zero (for 19% of the cases) to 96% across the sampled households, with a mean of 42%. We model cotton commercialisation as a function of exogenous household characteristics, X_i, and administrative zone dummy variables, D_i:

$$\mathrm{CCI}_i = \alpha_0 + \alpha_1 X_i + \alpha_2 D_i + e_i$$
$$(i = 1, \ldots, 453 \text{ households}) \quad (1)$$

We specify models of Y_i and Y_i/A_i, the gross value of food output per household and per hectare output of food crops[6], as:

$$Y_i = b_0 + b_1 X_i + b_2 \mathrm{CCI}_i + b_3 \mathrm{RS}_i + b_4 D_i + u_i \quad (2)$$

$$\frac{Y_i}{A_i} = b_0' + b_1' X_i + b_2' \mathrm{CCI}_i + b_3' \mathrm{RS}_i + b_4' D_i + u_i' \quad (3)$$

where RS_i, represents regional spill-over effects; e_i, u_i and u_i' are residual terms.

Because cotton commercialisation and food production are endogenously determined, an instrumental variables approach was used to estimate both (2) and (3). The appropriateness of this approach, however, is contingent on finding instruments that are correlated with CCI_i but not food production or yields. Instrumental variables for cotton commercialisation were: the distance from each household to the nearest cotton buying outlet and the number of cotton sprayers owned by the household. Definitions of the specific exogenous, endogenous and instrumental variables and their expected signs are found in Table 1.

What is the hypothesised pathway by which food crop productivity in (3) is related to the intensity of household cotton production? The presence of *household-level synergies* is measured by the effects of cotton commercialisation in (2) and (3). The

[5] The remaining 8% of cropped area is devoted to groundnuts, sunflower, millet and sorghum.

[6] This is admittedly a partial measure of land productivity, but it was not possible to construct more sophisticated measures of multi-factor productivity due to the paucity of information on land rental values and seasonal wages.

Table 1
Description of variables included in models

	Anticipated sign		
	Commercialisation index (CCI_i)	Grain production (Y_i)	Grain production per hectare (Y_i/A_i)
Endogenous variables			
Cotton commercialisation index—value of cotton production divided by value of total crop production (%)		+	+
Exogenous variables (X_i)			
Farm size: combined size of all arable plots including the garden (ha)	+	+	−
Family size: total household number of adult equivalents (persons)	+	+	+
Education: household-head's years of formal education (years)	+	+	+
Farm capital: value of working farm implements and draft animals (Z$)	+	+	+
Migrant settler: dummy variable = 1 if family migrated to Gokwe North since 1950	?	?	?
Certified farmer: dummy variable = 1 if household member has completed an intensive public extension program	+	+	+
Gender: dummy variable = 1 if female headed household	−	?	?
Village-level mean cotton yield (kg/ha)		+	+
Locational dummy variables (D_i)			
Zone 1: dummy variable = 1 if household resides in village cleared of tsetse flies in the early period (1965–1976)	+	?	?
Zone 2: dummy variable = 1 if household resides in village cleared of tsetse flies in the mid period (1976–1984)	+	?	?
Regional spill-over effects (RS_i)			
Cotton traders: number of cotton input traders and buyers based in each village in 1996	+	+	+
Instrument variables (Z_i)			
Sprayers: number of cotton sprayers owned by household	+	IV	IV
Distance to marketing depot: average distance from village to the cotton marketing depot (km)	−	IV	IV

measurement of *regional spill-over effects*, RS_i, requires a exogenous village-level indicator of cotton commercialisation. The variable chosen to represent regional spill-overs was the number of retail dealers distributing cotton inputs and buying seed cotton, and is intended to measure the extent of village-level investment in cotton-related service provision. We hypothesise that as the density of cotton-related services increases, such services will increasingly benefit food crop production in that area. However, to the extent that the density of cotton traders and grain output are both driven by underlying agro-ecological factors, RS_i could be endogenous. We include administrative zone dummy variables, D_i, in each model to control for unobserved agro-ecological and infrastructural effects across locations, but there may still be some variation within zones so the results should be interpreted cautiously. In recognition of this, we estimate models (1), (2) and (3) both with and without the inclusion of the regional spill-over term (the village-level number of retail cotton dealers) to examine the robustness of the model. Additionally, we estimate a separate maize yield model that includes mean village-level cotton yields to further control for unobserved locational factors.

Unfortunately, data on households' allocation of fertiliser and other inputs on food crops were not available, hence we must model the effects of cotton

Table 2
Household characteristics according to cotton commercialisation index in Gokwe North District, Zimbabwe, 1995–1996

Characteristics	Cotton commercialisation index[a]				
	Non-cotton growers (0%)	First tercile (1–66%)	Second tercile (67–82%)	Third tercile (>82%)	Total
Sample size (*n*)	80	118	110	122	430
Land size (ha)	4.39	5.62	5.66	7.87	6.04
Fallow area (ha)	1.29	0.78	0.71	0.78	0.85
Family size (number)	5.9	6.4	6.8	6.6	6.5
Farm capital investment (Z$)	2254	4353	5120	6806	4855
Animal draft teams (number)	0.36	1.09	1.20	1.65	1.14
Used animal draft power (%)	42	74	75	79	70
Family head years in school (years)	4.5	5.9	6.0	6.8	5.9
Master farmer certified (%)	2	6	12	11	8.4
Female headed (%)	21	11	11	11	13.0
Grain yield (kg/ha)	1165	1443	1037	1007	1167
Grain output (kg per capita)	481	495	331	263	385
Total crop income/ha cropped (Z$)	1690	2271	2340	3001	2396
Total crop income per capita (Z$)	639	1492	1525	2822	1732
Grain self-sufficient (%)	59	81	50	41	57
Grain selling households (%)	20	42	25	21	27
Distance to market (km)	27.5	25.2	23.5	22.6	24.5

Source: Own calculations using Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Gokwe North District, Zimbabwe, 1995–1996.

[a] Cotton commercialisation is defined as value of cotton sales divided by value of total crop production; this variable ranges from zero (i.e. household does not grow cotton) to 100% (cotton constitutes 100% of the household's crop output).

commercialisation on food production and draw inferences about the causes rather than model the effects of cotton commercialisation on food crop input use explicitly.

5. Characteristics of commercialised smallholder farmers

As a prelude to the econometric analysis, we provide some descriptive insights on four categories of farmers: those households not growing cotton (about 19% of the sample), and three relatively equal groups of the remaining households stratified into terciles according to their involvement in cotton production as indicated by the cotton commercialisation index (Table 2). We see that mean land holding size is greater for cotton growers than non-cotton households, and that land holdings increase with the intensity of cotton production. Fallowed area, on the other hand, is greater for non-cotton households. Cotton growers have accumulated more draught animals and farm capital assets (mostly draught and pesticide equipment) which enable greater area to be put under cultivation. To acquire draught cattle in Gokwe North District, 53% of the farmers use income from cotton, 20% use a combination of cotton and maize income and 18% use wage savings. Intensity of cotton production also appears to be higher for households having a 'master farmer',[7] those that are male-headed, and those located relatively close to a cotton buyer.

We also find prima facie support for the oft-cited assertion that cash crops are grown at the expense of household food production. Results in Table 2 indicate that per capita grain production is highest for the non-cotton households and the lowest tercile of cotton producers. These households produce roughly 85% more grain per capita than households in the most intensive cotton production tercile. Almost 60% of the non-cotton producers are grain self-sufficient as opposed to 41% for households in the top cotton

[7] These are households that have passed an agricultural husbandry training course by the national extension service.

production tercile. However, the fact that farmers in the highest tercile still manage to produce 263 kg of grain per capita on average indicates that even the most intensive cotton producers secure at least some portion of their food needs through own production.

Moreover, the results in Table 2 also show that household cotton commercialisation is associated with higher gross per capita crop income. Households in the top cotton tercile have about four times the crop income per capita and almost double the crop income per cultivated hectare as non-cotton producers. While households not growing cotton tend to have higher levels of grain production, clearly the commercialised cotton producers are in a better position to buy their residual food needs from local markets using cotton revenue. They are also in a better position to afford cash inputs for food crop production from local dealers who sell almost exclusively on a cash basis only. These observations are consistent with evidence found in other studies of agricultural commercialisation (Von Braun and Kennedy, 1994; Strasberg, 1997). However, these bivariate figures do not provide any clear insights into the effects of cotton commercialisation on household grain production or productivity, which we address in Section 6.

6. Econometric results

6.1. Determinants of cotton commercialisation

Many factors are involved in accounting for the wide differences observed in cotton commercialisation across the sample. As shown in Table 3, column (a), the proportion of cotton in total production (CCI) is positively associated with farm size, education of the household head, the value of farm capital, the number of cotton sprayers and a relatively early clearing of tsetse from the village in question. Family size, households that are female-headed and distance from the nearest cotton buyer are negatively related to cotton commercialisation. Despite their statistical significance, differences in farm size, family size and farm capital all have relatively small effects on the CCI, holding other factors constant.

The most important factors associated with cotton commercialisation are arguably educational levels, the distance from the farm to the nearest cotton buyer and villages that were cleared of tsetse fly relatively early. A difference of 5 years education is associated with roughly a 9% difference in the predicted CCI. A difference of 10 km distance to the nearest cotton buying outlet is associated with a 6.8% decline in the CCI. The share of cotton in total crop production for households in villages that were cleared of tsetse fly relatively early in the settlement of Gokwe North was about 10% higher than in households in areas cleared relatively recently. This may be because areas with early tsetse fly clearance have had more time to accumulate draught animals and traction equipment, which are shown to be significantly associated with the intensification of cotton production.

6.2. Effects of commercialisation on food production

Columns (b) and (c) of Table 3 show the instrumental variable (IV) models for household grain production. The IV results point to an absence of household-level synergies between cotton and grain production. The share of cotton in total crop production is associated with neither a strong increase nor a decline in total grain production. While cotton commercialisation apparently does not contribute to grain production, there must be countervailing positive effects on grain output that offset the substitution of land from grain to cotton. We examine this issue in Section 6.3.

As expected, household grain production is significantly associated with farm size and the value of accumulated farm assets. An additional hectare of land owned is associated with about Z$ 150 more grain production (equivalent to about 120 kg of maize), other factors constant. The relationship between maize yields and farm size is even stronger when all other household variables are evaluated at their means for different farm size categories within the sample. We calculated the mean values for all other household variables for farms within the 20–30th percentile of farm size (2.80–3.66 ha) and for farms within the 70–80th percentile (6.28–9.71 ha). The predicted maize production for the two groups, based on model results in Table 3, column (c) are 972 and 1602 kg, respectively, a difference of roughly Z$ 800.

Households tend to have higher levels of grain production in locations that were recently cleared of tsetse fly. Households in the early and mid clearance areas

Table 3
Model results for commercialisation, food crop productivity and output equations

	Model 1: cotton commercialisation index (*OLS*)		Model 2: value of grain production per household in Z$ (IV)				Model 3: value of grain production per hectare (Z$/ha) (IV)					
	(a)		(b)		(c)		(d)		(e)		(f)	
	Coefficient	*t*-Statistics	Coefficient	*t*-Statistics	Coefficient	*t*-Statistics	Coefficient	*t*-Statistics	Coefficient	*t*-Statistics	Coefficient	*t*-Statistics
Endogenous variables												
Commercialisation index			−2.79	−0.19	1.09	0.08	14.13	2.04*	15.31	2.18*	12.15	1.23
Exogenous variables												
Farm size (ha)	1.18	3.23*	162.97	5.15*	140.48	4.37*	−69.45	−4.62*	−76.29	−4.88*	−70.47	−3.56*
Family size (number)	−0.8	−2.25*	28.82	1.05	36.24	1.34	20.22	1.55	22.45	1.70**	20.46	1.51
Education of head (years)	1.72	4.87*	1.41	0.04	−6.8	−0.19	−10.67	−0.63	−13.17	−0.77	−7.95	−0.47
Migrant settlers	−3.31	−1.26	596.9	3.00*	675.16	3.41*	2.45	0.03	26.23	0.27	18.64	0.24
Gender	−7.96	−2.25*	−292	−1.04	−279.71	−1.01	−41.65	−0.31	−37.92	−0.28	−64.9	−0.45
Value farm capital (Z$)	0.39	2.24*	50.12	3.16*	44.72	2.92*	7.72	1.05	6.61	0.86	7.99	1.02
Certified farmer	4.28	0.98	−422.75	−1.27	−314.31	−0.95	36.97	0.23	69.92	0.44	89.12	0.53
Early cleared grad	9.58	3.17*	−641.16	−2.49*	−633.35	−2.62*	−171.96	−1.41	−178.71	−1.45	−172.13	−1.36
Mid cleared grad	4.56	1.4	−1738.8	−6.53*	−1931.5	−7.13*	−838.51	−6.63*	−897.03	−6.81*	−870.05	−4.97*
Cotton traders					75.5	2.84*			22.94	1.78**	21.91	1.65**
Cotton yield, village-level mean (kg/ha)											0.09	0.30
Instrument variables												
Sprayers	8.34	4.03*										
Distance to cotton buyer (km)	−0.6	−2.74*										
Constant	60.37	8.97*	1547.3	2.12*	1032.7	1.391	910.4	2.62*	754.02	2.09*	909.55	1.92**
S.E.		23.884		1738		1713		826.5		832.7		813.7
N		424		424		424		424		424		424
Adj. R^2		0.264		0.263		0.278		0.193		0.194		0.204

Source: Own calculations using Socioeconomic Impact Assessment of Tsetse and Trypanosomosis Control Surveys, Gokwe North District, Zimbabwe, 1996–1997.

* Denotes statistical significance (one-tailed test) at the 5% level.

** Denotes statistical significance (one-tailed test) at the 10% level.

produced 1.5–3 tonnes less grain than households in locations cleared recently. As shown in model (1), smallholders in the early clearance areas have intensified into cotton to a greater extent, facilitated by the relatively longer period of time in which cattle and traction equipment could be accumulated.

When the number of cotton input traders is included in the model (column c), this variable is positively and significantly correlated with household grain output. The coefficients of the other statistically significant covariates remain relatively unchanged. While the main economic activity in most of these villages is cotton production, the presence of cotton traders had positive spill-overs on smallholder grain production. In 25% of the villages sampled, there were three or fewer cotton traders, while eight or more cotton traders were found in the top 25% of villages. Many of the inputs sold by these traders can also be applied to food crops. A shift from three to eight traders was associated with a Z$ 375 increase in household grain production (the mean level over the entire sample was Z$ 1665 in 1996 Z$).

As indicated earlier, it is plausible that there is an underlying association between the number of cotton traders in a village and the agro-ecological potential of that area. While we cannot rule out that this affects our results, we attempted to control for agro-ecological potential in the village sample selection process (Section 3) and further control for differences in tsetse fly clearance which reflect the timing of draught animal introduction into an area. Moreover, we control for household-level characteristics that would tend to also reflect geographic differences in productive potential (e.g. farm capital assets, landholding size, family size). Given the inclusion of these location and household-level variables controlling for grain production potential, it would seem reasonable to conclude that the association between the number of cotton traders and household grain crop production largely reflects the positive spill-over effects that service provision investments for cotton have on grain crop production.

6.3. *Effects of cotton commercialisation on food productivity*

Results in Table 3, model 3, highlight the complementary relationship between cotton commercialisation and household grain yield. Four results in column (d) show that the effect of the household commercialisation index on food productivity is positive and significant. Moving from the 25 to 75th percentile of the cotton commercialisation index is associated with a Z$ 370/ha increase in grain yields (equivalent to 296 kg at prevailing maize price levels), a 25% increase over mean grain yields in the entire sample. We cannot say precisely why households with intensive cotton production obtain higher grain yields than non-cotton and marginal cotton farmers because data on input usage on fields devoted to food crops is not available. However, as we have indicated earlier, cotton producers have access to key inputs such as credit and training through the cotton schemes that are either not accessible on credit terms to non-participating farmers, or simply not available to them at all.

Farm size has a significant and negative effect on maize yields. Other factors held constant, smaller farms were more productive in the use of land than large farms. The results suggest that maize yields decline by Z$ 44/ha (3.6% of mean yield levels in the sample) as landholdings increase by 1 ha, ceteris paribus. The inverse relationship between maize yields and farm size also holds up when all other household variables are evaluated at their means for different farm size categories.[8]

Family size makes a positive but imprecisely estimated contribution to grain yields. And households in areas cleared relatively recently from tsetse fly infestation tend to have higher grain yields than households in early-clearance areas, perhaps reflecting declining fertility due to the longer duration of cultivation in the latter areas. Demographic attributes such as family size, gender of the household head, and settler status do not have any important effects on grain productivity. Farmers that received master farmer training obtain higher grain yields than other farmers, but this effect is not statistically significant.

The inclusion of the regional spill-over variable in model 3 (column e) makes only a marginal contribution to the adjusted R^2 and has little effect on the coefficient estimates of the significant variables in column (d). Nevertheless, the effect of the regional spill-over

[8] Following the procedure explained in Section 6.2, the predicted maize yields for those households between the 20th and 30th percentiles of farm size versus those between the 70th and 80th percentile, based on model results in Table 3 column (e), are 726 and 462 kg/ha, respectively.

variable on food crop productivity is positive and significant at $P = 0.08$. Everything else constant, an additional cotton input retailer in the area boosts grain output by Z$ 22.9/ha. When village-level cotton yields are introduced in column (f) to further control for unobserved village factors, the CCI coefficient declines slightly and is imprecisely estimated. The effect of an additional cotton trader in the area has roughly the same effect as in column (e), and is barely significant at $P = 0.10$. Because the cotton retailers provide a range of services for farmers growing food crops, including inputs used in maize production, the growth of cotton appears to be associated with increased grain productivity.

7. Conclusions and implications

This paper addresses the potential for cash crop production to promote food crop productivity. We argue that in addition to the direct stimulus that cash cropping can have on household incomes, there may be important indirect effects of cash cropping on the productivity of other household activities such as food cropping. We have classified two potential pathways by which these benefits occur: *household-level synergies*, in which a farmer's participation in a commercialised crop scheme enables her to acquire resources that would otherwise not be accessible for use on other crops; and *regional spill-over effects*, which occur when a commercialisation scheme attracts new investments to a region thereby providing benefits to all farmers in that region, regardless of whether they engage in the commercialisation program. We find that farmers benefited from both of these pathways in the case of cotton production in Gokwe North District in Zimbabwe, although the case for household-level synergies is less clear-cut. Specifically, the econometric results indicate that—after controlling for household assets, education and training and locational differences—households that engage intensively in cotton production tend to have higher grain yields than non-cotton and marginal cotton producers. But because they allocate relatively less of their land to food crops, the intensive cotton farmers produce about the same amount of grain as the non-cotton farmers, other factors constant. We also find a positive association between the number of cash crop traders in a given village and the value of grain output produced per household and per hectare in that village, although these results should be interpreted cautiously due to the potential endogeneity of cotton traders in the models.

These findings call into question the frequently heard assertions that cash crop production comes at the expense of household food security. Certainly there are instances in which such problems have occurred, but our findings indicate that this cannot be considered a determinate outcome. Especially in the presence of credit market failures (which frequently occur in many areas of Africa where credit repayment is hindered by firms' inability to control the output market), low-resource farmers' ability to obtain inputs is constrained. Participation in cash cropping programs may allow farmers to overcome such market failures facing food crop input and credit supply. However, whether these complementarities actually materialise depends on whether cash cropping firms are able to continue to recoup their up-front costs and support farmers through purchase of the cash crop. A useful analysis of the strategic interactions between smallholders and cash crop trading firms is contained in Dorward et al. (1998).

The potential synergies or trade-off between cash crops and food crops have been generally neglected in food crop research and extension programs, although they may have important implications for programs designed to promote smallholder food crop productivity growth. To a large extent, agricultural and nutrition policies in the region have historically formulated rural development strategies with a food crop focus and have implicitly or sometimes explicitly regarded diversification into non-food cash crops as detrimental to household food security objectives. Our findings suggest that, to the contrary, there is some potential for high-value cash crops to promote food crop productivity. We hope that this article will succeed in stimulating further analysis of the complex interactions between smallholder commercialisation involving non-food crops and household food security and income growth in sub-Saharan Africa.

Acknowledgements

The authors gratefully acknowledge funding for this research by the Food Security II Co-operative

Agreement (PCE-A-00-97-00044-00) between AID/Global Bureau, Office of Agriculture and Food Security, and The Department of Agricultural Economics at Michigan State University. The Agriculture, Natural Resources and Rural Enterprise Division, Office of Sustainable Development, Bureau for Africa, USAID (AFR/SD/ANRE) also supported this work. Additional financial support was provided by The International Livestock Research Institute, The University of Zimbabwe, The Regional Tsetse and Trypanosomosis Control Program, and The Department of Veterinary Services Tsetse Control Branch of the Ministry of Agriculture, Government of Zimbabwe. This article has benefited from the useful comments of Takashi Yamano, Maxwell Mudhara, Edward Mazhangara, Colin Poulton, David Tschirley and two anonymous reviewers.

References

Byerlee, D., Eicher, C. (Eds.), 1997. Africa's Emerging Maize Revolution. Lynn Reinner Publishers, Boulder, CO.

Dione, J., 1989. Informing Food Security Policy in Mali: Interactions Between Technology, Institutions and Market Reforms. Unpublished PhD Dissertation, Michigan State University, East Lansing, MI.

Dorward A., Kydd, J., Poulton, C. (Eds.), 1998. Smallholder Cash Crop Production Under Market Liberalization. CAB International, New York.

Fafchamps, M., 1992. Cash crop production, food price volatility, and rural market integration in the third world. Am. J. Agric. Econ. 74 (1), 90–99.

Fereidoon, J., Mulila-Mitti, J., Mitti, G., Phiri, E., 1996. Integrated Crop Management: A Guide for Sustainable Smallholder Farming. Integrated Crop Management/Food Legume Project, Department of Agriculture, Ministry of Agriculture Food and Fisheries, Zambia.

Goetz, S., 1993. Interlinked markets and the cash crop-food crop debate in land-abundant tropical agriculture. Econ. Dev. Cultural Change 41, 343–361.

Govereh, J., 1999. Impacts of Tsetse Control on Immigration and Household Accumulation of Capital: Zambezi Valley, Zimbabwe. Unpublished PhD Dissertation, Michigan State University, East Lansing, MI.

Govereh, J., Nyoro, J., Jayne, T., 1999. Smallholder Commercialisation, Interlinked Markets, and Food Crop Productivity: Cross Country Evidence from eastern and southern Africa, Paper Presented at the Fourth Agricultural Transformation Workshop, Nairobi, Kenya. USAID/Africa Bureau/Sustainable Development Division, Washington, DC.

Howard, J., Mungoma, C., 1997. Zambia's Stop-and-Go Maize Revolution. In: Byerlee, D., Eicher, C. (Eds.), Africa's Emerging Maize Revolution, Lynn Reinner Publishers, Boulder, CO.

Jayne, T., Jones, S., 1997. Food marketing and pricing policy in eastern and southern Africa: a survey. World Dev. 25 (9), 1505–1527.

Kelly, V., Diagana, B., Reardon, T., Gaye, M., Crawford, E., 1996. Cash Crop and Food Grain Productivity in Senegal: Historical View, New Survey Evidence, and Policy Implications, MSU Staff Paper 95 (05).

Kherallah, M., Delgado, C., Gabre-Mahin, E., Minot, N., Johnson, M., 2002. Reforming Agricultural Markets: Achievements and Challenges. Johns Hopkins University Press, Baltimore, MD.

Mariga, I., 1994. Cotton research and development. In: Rukuni, M., Eicher, C. (Eds.), Zimbabwe's Agricultural Revolution. Harare University of Zimbabwe Press, pp. 219–233.

Poulton, C., Dorward, A., Kydd, J., 1998. The revival of smallholder cash crops in Africa: public and private roles in the provision of finance. J. Int. Dev. 19 (1), 85–103.

Putterman, L., 1995. Economic reform and smallholder agriculture in Tanzania: a discussion of recent market liberalization, road rehabilitation, and technology dissemination efforts. World Dev. 23 (2), 311–326.

Rohrbach, D., 1988. The Growth of Smallholder Maize Production in Zimbabwe: Causes and Implications for Food Security. Unpublished PhD Dissertation, Michigan State University, East Lansing, MI.

Singh, I., Squire, L., Strauss, J., 1986. Agricultural Household Models: Extensions, Applications, and Policy. Johns Hopkins University Press, Baltimore, MD.

Strasberg, P.J., 1997. Smallholder Cash-Cropping, Food-Cropping and Food Security in Northern Mozambique. Unpublished PhD Dissertation, Michigan State University, East Lansing.

Timmer, C.P., 1997. Farmers and markets: the political economy of new paradigms. Am. J. Agric. Econ. 79, 621–627.

Von Braun, J., Kennedy, E., 1994. Agricultural Commercialisation, Economic Development, and Nutrition. Johns Hopkins University Press, Baltimore, MD.