PRODUCTION CHANGES IN GHANA COCOA FARMING HOUSEHOLDS UNDER MARKET REFORMS[♣]

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Abstract

The Ghana cocoa market has been extensively liberalised over the period since the mid 1980s. Three issues have been prominent in research on agricultural supply response to liberalisation. The first has been the size of the supply elasticity, the second the response to reduced subsidies on inputs, the third whether innovation will occur. In this paper we investigate these three issues by estimating a production function for cocoa in Ghana drawing on two household surveys covering the period from 1991 to 1998. The estimated production function allows identifying the factors underlying the change in output. It is shown that for most regions the whole rise in cocoa production occurring over the period, of about 6 per cent per household, was accounted for by a rise in land and non-labour inputs. The data is consistent with a constant returns to scale technology in which total factor productivity was unchanged in almost all regions. There were offsetting changes in factor use: the labour to land ratio fell while the non-labour to land ratio rose. Thus the analysis of the micro data shows that, contrary to much of the discussion of the effects of trade reform, the contribution of non-labour inputs to cocoa production has increased both relative to land and, very substantially, relative to labour. The reform period has seen a rise in the ratio of both land to labour and of non-labour input to labour which have increased labour productivity. Reform has not led to innovation in techniques which raise total factor productivity.

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1 Introduction

The issue of how agricultural markets respond to price liberalisation is a central issue in development policy and one that has been surrounded by much controversy. One concern has been the size of the price elasticity of response. A second has been the effects of removing subsidies on inputs which are often an important policy intervention by governments. A third has been whether innovation, in the sense of adopting new techniques leading to a rise in total factor productivity, is possible by means of liberalisation. The Ghana cocoa sector offers an opportunity to explore all three issues. From the early 1970s until the mid 1980s Ghana's cocoa output fell due to the combination of an overvalued exchange rate and heavy taxation of cocoa effected by means of a monopsonistic marketing board (see Figure 1). From the mid 1980s markets have been liberalised. First a substantial devaluation of the nominal exchange rate had by the early 1990s largely eliminated the black market premium. Real prices to producer rose and, as we show, subsides were reduced on inputs so that the real prices of inputs rose far faster than the Consumer Price Index. An element of competition was also introduced into the marketing of cocoa[1] although the monopsonistic price setting by the Cocoa Board has been retained. Official data suggests yields of 300-400 kg/ha. These are about one third of the level in other countries and one tenth those achieved on experimental farms in Ghana.[2] If liberalisation can lead to improved productivity there seems plenty of scope with known technologies.

In this paper we propose to investigate these issues by assessing how the expansion of cocoa production in Ghana in the 1990s was effected. In the next section we show that micro survey data for cocoa farming households shows a rise in output almost exactly the same as that given by the macro data. We then investigate the issues of how this rise was effected by the estimation of a production function in section 3. In section 4 we use this production function to show how the removal of controls on non-labour inputs has affected productivity. As our data covers two years we can measure whether technical progress has occurred. A final section concludes.

2 Cocoa production and productivity: the macro and micro data

We begin with the macro data. Table 1 looks at three key agricultural macroeconomic indicators: land harvested, production levels and cocoa yields. These data, obtained from FAO's official statistics, show that an increase in both total area under cocoa cultivation (76%) and in the level of production (37%) occurred between 1990/91 and 1997/98. The production increase is considered to be largely a result of the expansion of the area cultivated to cocoa, namely the westward movements towards

[1] In 1993 Ghana started the liberalisation of its cocoa sector through the domestic deregulation of its state -controlled marketing board; 18 licensed private buying firms have progressively entered the domestic sector as competitors (at least in principle) to the Cocobod for the internal purchase of the crop.

[2] Indonesia, which has one of the best performances among major producing countries in terms of average yields, appears to achieve close to one tonne per hectare per year (ICCO (1998); FAOSTAT (2003)). Experimental yields on cocoa farms in Ghana have been of the order of 2471kgs/ha (Cocoa Research Institute, 1973).

unoccupied virgin forests of Western and southern Brong Ahafo regions (Gerken, et al. (2001); Ministry of Finance (1999)). However this macro data implies a substantial drop of 29% in land productivity.

Is the micro evidence consistent with this macro picture? The micro data we draw on to answer these questions is the nationally representative Ghana Living Standards Survey. These surveys were conducted in four rounds between 1987 and 1998. The present study uses the last two cross sections of the data covering the years 1991/92 and 1998/99. In this study cocoa production refers to the crop years 1990/91 and 1997/98. Households were interviewed between September 1991 and September 1992 in the third round of the survey, and between April 1998 and February 1999 in the fourth round. The relevant questions on crop production, sales and inputs use were asked with reference to the 12 months preceding the interview date. This explains why the reference points in time in this paper are the *crop-years* preceding the actual survey: 1990/91 and 1997/98.

The GLSS data covers detailed information on households' incomes and expenditures, agricultural production levels, background data at the community level, and prices for the most important food and non-food items entering their consumption basket. The agricultural section, from which most variables used in this study are drawn, contains details on the crops grown and harvested, the costs incurred, and various aspects on agricultural assets such as households' land holdings and tenancy arrangements, farm equipment and livestock. Out of the 3253 (GLSS3) and 4277 (GLSS4) households originally surveyed, we identified respectively 505 and 790 cocoa observations.

We define cocoa-households as all those respondents who satisfied simultaneously the condition of harvesting/selling any cocoa as well as those reporting cocoa as the most (or second most) important crop grown in terms of annual revenue. This double restriction was imposed because of the different levels of aggregation at which information on cocoa production was recorded in the GLSS; the size of cocoa holdings at the farm level, the volume of output and sales at the crop level, and expenditure figures on inputs at the household level. As certain key variables were only collected at the household level we need to use the household as the unit of observation.

We noticed that in both rounds of the data a number of cases (i.e. cocoa households according to the definition given above) did not report information about the land holdings on which the corresponding production occurred. Further inspection of these cases revealed that part of these apparently 'land-less' cocoa farmers were sharecroppers, caretakers or in general households unable to quantify the size of the holdings on which they were growing cocoa. As these observations did not enter our econometric analysis, our sample was further reduced to 374 observations in 1990/91 and 680 in 1997/98[3].

Table 2 presents some characteristics of the cocoa-farming households sampled in the GLSS data. The general picture shows the dominant presence of male-headed cocoa-farming households,

[3] The appendix discusses in detail the potential selectivity bias induced by the omission of these observations which account for 17 percent of the total number of cocoa farmers surveyed in 1991/92 and 1998/99.

with household heads being on average 50 years old. The data show that in absolute terms the level of education of household heads has increased between 1991 and 1998 from just above five to nearly six years of education, a rise of 11 per cent. The average size of cocoa farms has not changed significantly, while the percentage of hired labour increased by 7 percentage points (the only statistically significant change occurred over the period analysed).

The data also shows a high percentage of revenue from cocoa-sales in cocoa-households' income. Although this proportion has not increased considerably in the 1990s, the sampled percentage has remained stable around 50% suggesting that cocoa production remains the major source of income for those farmers that are still in the sector.

Table 3 presents the key variables relevant for cocoa production analysis in levels and in their logarithmic transformation. Because a few large outliers tend to dominate the distribution of most of these indicators, our comments on the changes observed over time will be almost entirely based on the logged data. The far right column with the aggregate figures shows the key facts about the expansion of cocoa farming from the micro data. First the household's average amount of cocoa produced has increased by 6 percent. Second, as the average size of land holdings owned or operated by households increased by 5 percent, cocoa acreage yields on average have remained unchanged. Third, non-labour inputs have increased by 13%. As Figure 2 shows this rise which, as explained in the appendix, is a measure of the rise in inputs not a measure of expenditure, is mainly the result of increased inputs of insecticides and fertilisers. Total labour use decreased significantly by 28 percent, a trend driven by the corresponding drop in the family labour component (36 percent). On the other hand, the percentage of hired labour appears to have increased by 7 percentage points. The rise in output and large decrease in labour input imply that labour productivity has increased by 33%. The regional composition of these figures shows significant declines of both output and farm size in the Eastern region. This is consistent with the shift out of cocoa cultivation which has occurred in this region since the late 1930s.

We now assess the extent to which the production increase observed at the household level is consistent with the macro statistics presented earlier. Two figures are needed to carry out this exercise. The first, which we already have from Table 3, is the change in the average amount of cocoa harvested at the household level. The second is the change in the cocoa farmers' population. The top half of table 4 shows these data obtained from the census on Ghana's household population by region. The number of households in Ghana's six cocoa growing regions has increased by 29.7% between 1991 and 1998. Over the same period the total proportion of cocoa farming household has remained stable, accounting for 16% of the total number of households in each year[4]. It is estimated that in 1998 there were about 700,000 cocoa farmers in Ghana (Wallis (2000b); Wallis (2000a); Commodity Risk

[4] Standard errors for the values of the proportion of cocoa farming households were calculated using the following formula: $SE=((p)(1-p)/n)^{1/2}$. Where p=proportion of cocoa farming households, n= sample size.

Task Force (2000); EC (2000)). The GLSS data for the same year indicates an estimated number of 496.000 cocoa growing households. This number is consistent with the 700,000 figure if one considers that each household typically accounts for more than one cocoa farmer[5] allowing for spouses and family member selling out their labour to non family owned farms. Therefore, combining the estimated increase in household population (29.7%) with the average increase in the level of household cocoa production (6%), we get a 37% rate of cocoa production growth - exactly the number given by the macro data. While the micro data is wholly consistent with the macro for the increase in output there is no evidence from the micro data of any fall in yields per hectare and there is strong evidence that labour productivity has risen. The source of this rise is investigated in the next section.

3 Cocoa Production Functions

Having established that the micro data on supply response is consistent with the macro we now turn to considering the factors that underlie the increase in output by estimating cocoa production functions. In the following analysis we have dropped all observations from the Volta region due to the insufficient number of observations for individual years (table 3). With this exclusion the focus of the econometric analysis is restricted to those areas where cocoa has been predominant in the country for the last twenty years.

In addition to the basic agricultural production inputs such as land, labour, and non-labour inputs, a number of household and non-household characteristics are expected to have important effects on the level of cocoa production. Accordingly the basic specification to be estimated is as follows:

$$\begin{aligned} ln(cocoa) = \beta_1 + \beta_2 ln(farmsize) + \beta_3 ln(Input) + \beta_4 ln(Labour) + \beta_5 \frac{L_H}{L_T} + \beta_6 ln(farm\ value) + \\ + \beta_7 hhh\ age + \beta_8 Dhh\ edu + \beta_9 hhh\ sex + \beta_{10} ln(rain\ + \gamma T \end{aligned} \quad (1)$$

Where:

cocoa = kilos of cocoa produced
farm size = total hectares of cocoa farms cultivated by each household
input = amount of non labour input use
labour = Man-days of labour (both household and hired)
L_H/L_T = % of hired labour in total labour
hhh age = age of the household head
hhh sex = dummy =1 if household head is male
Dhh edu = dummy = 1 if household head has primary school education
farm value = value of all land holdings owned/operated by the household on which any cocoa is growing

[5] In the GLSS, the definition of household includes a group of people who have usually slept in th e same dwelling and continuously shared the cost of their meals for at least nine months .

rain = regional amount of rainfall

T = time trend = 1 if year==1997, the measure of TFP

The soil quality of different farms is believed to cause important variations in the effect of farm size on agricultural production (Berry, et al. (1979); Lamb (2003)). In our estimates we seek to control for this by using the self-reported value of cocoa holdings as a control for land quality. Moreover, the above equation explicitly accounts for the effect of the percentage of hired labour. Why is this important? Total labour used in production is a function of hired and household labour but might not be correctly measured by adding up the two components if these have different productivity levels. The dual labour-market model hypotheses that small family-owned farms, which characterise most cocoa farms in Ghana, are endowed with a relatively large supply of family labour which they tend to employ beyond the point at which marginal productivity equals the prevailing market wage rate. Therefore, when analysing cocoa production functions, it is important to allow the effect of hired labour to be identified separately, as this is equivalent to testing the different productivity of the labour components (see box 1 in appendix for the mathematical derivation of this term).

Three aspects are of primary relevance to our econometric investigation: a) whether there are significant regional differences that might bias the interpretation of a pooled regression, b) if production technology is non-homothetic, i.e. if constant returns to scale are rejected, and c) the contribution of land, non-labour and labour inputs and the relative importance of the hired labour component.

Table 5 reports the results of cocoa production functions based on equation 1 in two different panels. Ordinary least square regressions (OLS) are compared to two stage least square estimates (2SLS) to allow for measurement error in the labour variable. For each estimation method regional and pooled estimates are presented. The basic production function model allows pooling across regions and time, and that regional regressions are reported to show the anomaly of the Ashanti TFP proxy. The pooled regression can be read as representing the *average* impact of each explanatory variable on the aggregate level of household cocoa production. We will use this average production function in interpreting the growth pattern for cocoa in Ghana bearing in mind the regional differences apparent from the Table.

The OLS findings show that land and non-labour inputs have consistently significant effects in all regions. The derived measure of labour input is significant only in Western and more pronouncedly in Central where it exhibits a 38% effect on cocoa output. On the other hand, the percentage of hired labour is statistically significant only in Western region where the parameter estimate implies that hired labour is almost four times more productive than household labour. The control for land quality has an overall effect on cocoa production of 3 percent, which confirms our prior expectations that this indicator matters in identifying the effect of different types of land holdings. When looking at the pooled regression, land and non-labour inputs have the strongest effect with estimated coefficients of respectively 33 and 25 percent. The coefficient on labour is 0.12 but it is not statistical significant. The coefficients on the age, sex and education dummy variables of the household head have the expected signs but only age and sex seem to matter. The time trend dummy, which is the measure of total factor productivity, is positive but not statistically significant. The regional regressions clearly show that the Ashanti coefficient (42 percent) on TFP dominates across all regions (where the point estimates are otherwise negative though insignificant) determining the positive sign of the parameter in the pooled regression. Regional changes in the amount of rainfall over the two cross sections have a negative but not statistically significant effect on output. Finally, in the pooled regression the null of constant returns to scale in cocoa production was rejected.

In order to probe the data further we need to instrument labour as this is the variable is most likely to be affected by measurement problems (the appendix explains in further detail how this indicator was constructed). The results of this are shown in the right hand side of table 5[6]. Constant returns to scale now hold across all regions and in the pooled regression. We focus our discussion on the pooled regression's output since virtually all variables exhibit the same signs across the regions considered (with the exception of Brong Ahafo where the negative parameter estimates, though, are not significant). The estimated coefficient on land is equal to 0.32, and significant at the 1 percent level, which compares consistently to 0.33 in the OLS model. The control for land quality and the sex of the household head are still positive, while the education coefficient remains insignificant[7]. The estimated coefficient on labour has now dramatically increased to 0.33, more than twice than in the OLS (0.12) and is significant at the 5 percent level. The coefficient on the percentage of hired labour is not significant implying that hired labour is as productive as the household component.

The Sargan-Hansen tests support the validity of the instruments, and the findings on the coefficient on labour being almost three times higher than in the OLS model is consistent with our concerns that this variable is measured with error[8]. Total factor productivity is positive but not statistically significant, with the sign of the coefficient entirely driven by Ashanti region (where it shows a 67 percent increase significant at 1 percent) as in the OLS regressions. Among the household head characteristics included, only the sex of the household head is found significant in differentiating amongst different cocoa-producing families.

[6] The results of the first stage regressions are reported in table A3 in the appendix.

[7] We have experimented using alternative measures of human capital such as the number of years in schooling of the household head and its quadratic term, or a dummy on whether the household head has secondary education, but the results were not different from the ones presented in this section.

[8] A Hausman test statistic (t) on the statistical difference in the labour coefficients across the two models was also constructed as follows: $Hausman\ test\ stat = \frac{\hat{\beta}_{IV} - \hat{\beta}_{OLS}}{\sqrt{var(\hat{\beta}_{IV}) - var(\hat{\beta}_{OLS})}} \overset{a}{\cong} N$. Under the null hypothesis both OLS and IV are consistent (OLS efficient), under the alternative only IV is consistent (and OLS is biased). The value obtained contrasting the two pooled regressions was 1.86 which is significant at the 6 percent level. Based on the observed increase in the value of the parameter estimate and on the result of the Hausman test we rejected the nul l in favour of the IV model.

Finally, since production function regressors are often assumed to be endogenous, we tried a specification instrumenting both labour and non-labour inputs[9]. Using the Hausman test we could not reject the null hypothesis that the explanatory variables are weakly exogenous (results are available from the authors upon request). Therefore weak exogeneity of these parameters was assumed.

To sum up, the results from cocoa production function estimates show that, after controlling for measurement error bias in the labour input variable, we were able to estimate a CRS production function for cocoa production. On average the point estimate for TFP is at 5 per cent but this is not statistically significant. Regional differences may matter but the evidence is far from compelling. We are now equipped with all the information needed to identify the sources of growth in households' cocoa production.

4 Accounting for the Growth of Cocoa Production

We now re-present the results of the production function in a growth accounting framework. Table 6 presents the results obtained using the estimated coefficients from the IV model (shown in the right-hand panel of table 5) and the changes in the underlying data from table 4.

The net effect of labour inputs on output was negative; land and non-labour inputs account for most of household output growth. Clearly virtually all the increase in total output is due to the expansion in the number of households. None at all of aggregate output growth is due to a rise in total factor productivity. The broadly similar rises in land and household output means, as already noted, that land productivity did not rise. The rise in both the land and non-labour to labour ratios observed in table 4 will have increased the marginal product of labour. These outcomes suggest that the expansion of cocoa output has been effected by a very similar method to that which has occurred in the past. Increases in land and labour with a constant technology have brought about the increase in output, there has been no innovation in techniques to increase TFP.

The implication of the results is that the return to labour on the farm rose substantially over this period. Table 7 shows the inference of the data and the regressions. The value of the marginal productivity of labour doubled in constant price cedi terms and increased by nearly 90 per cent in constant US$ terms. Most of this value rise was due to the rise in the marginal product of labour, which increased by 60 per cent, rather than due to output price increases. As we have shown, virtually all of this rise was due to increases in non-labour to land ratios rather than any underlying rise in TFP. We have no evidence from the production function that hired labour is more productive than household labour. Comparing marginal productivity with wages is complicated by the fact that hired labour is such a small proportion of total labour - on average only 25 per cent (Tables 2 and 3). The data strongly suggests that most farmers do not use hired labour and the rise in marginal productivity

[9] Land is not considered a variable input in agricultural production, and was therefore not instrumented.

has been driven by the decline in household labour (Table 3) suggesting that the implicit price of labour within the household has been rising. There is no evidence for a rise in market wage rates.[10]

While there is substantial uncertainty about measuring the costs of labour to the household we have rather clear evidence that TFP has not been rising and that land productivity has been virtually static. The rise in imputed labour cost and the fall in labour supply suggest one possible reason for the lack of innovation in new technology, which is labour using. While that at present remain speculation it is clear from the analysis that the underlying problem facing the cocoa sector is its failure to innovate.

5 Conclusions

This paper has analysed the evolution of cocoa production growth in Ghana in the 1990s: a period of agricultural reforms that was expected to significantly affect the sector due to both macro liberalisation and the internal liberalisation of cocoa marketing. In the introduction we noted three issues which have been the focus of much controversy. The first is the size of the supply elasticity, the second is the role of subsidies on inputs and the third is the possible role of technical change in effecting rises in cocoa production. We have been able to address each of these issues.

In estimating the production function we have found evidence for constant returns to scale. If this is correct - and we acknowledge that our estimates for hired labour are problematic - then this represents indicative evidence of the absence of scale inefficiency in cocoa production in Ghana. The rise in output is the net result of rising output and input prices. Our results also shed light on the issue of subsidies. We have been able to show that the measure of non-labour inputs increased despite substantial real increases in their price. This is consistent with liberalisation having provided a framework by which inputs, although no longer subsidised, are used because they are now available.

Finally, and most unambiguously as far as our data is concerned, we have shown that output growth was almost entirely due to the traditional method of expanding output by means of additional land. Of the 37 per cent increase in output over this period only 6 per cent was due to increased output per household, the rest was due to the expansion of the number of households. Labour productivity was increased in part due to the expansion on non-labour inputs and land but mainly due to the large declines in labour input. We have argued that such an outcome is consistent with rises in the implicit price of labour to the household, market labour remaining a small source of labour supply. The lack of innovation in new crop technologies may be due to the fact that they are labour using and land saving whereas it is labour that is scarce for the household.

[10] Daily wage rates are available from the community questionnaire and show no rise in real cedi wage rates and virtually identical nominal US$ wage rates in the two years (Table 8). Teal (2000) shows for the period 1992 to 1996 falls in real wages for unskilled worked in Ghana's manufacturing sector.

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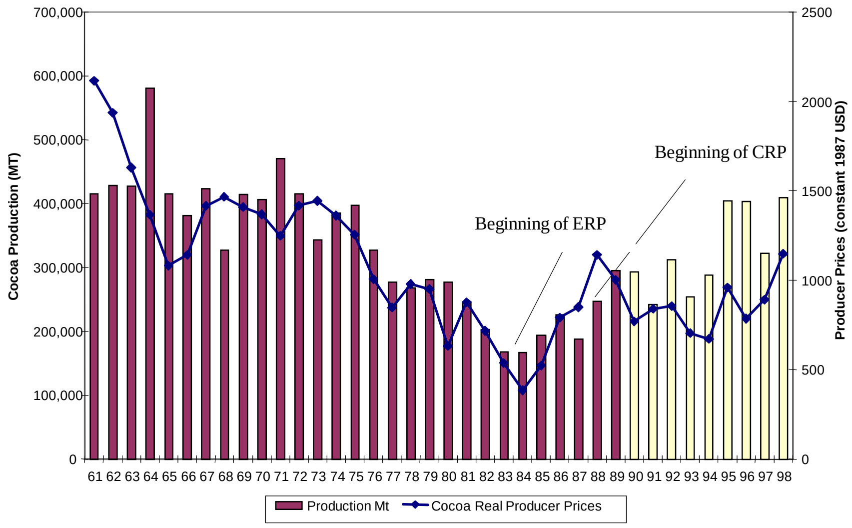
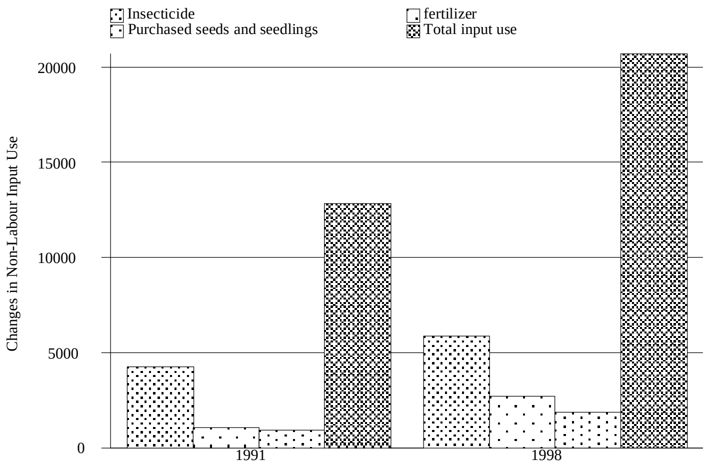
FIGURE 1
GHANA'S COCOA PRODUCTION (MT) AND PRODUCER PRICES (CONSTANT 1987 USD)



Source: *Faostat database and Ghana Cocoa Board.*
Note: The clear bars show the period covered by the analysis of this paper.

FIGURE 2
CHANGES IN COCOA-FARMING HOUSEHOLDS INPUT USE† (CONSTANT 1991/92 PRICES): 1991-1998



Source: Authors' calculations from GLSS data

†The heights of the bars are proportional to the means of each category to which they refer.

*The variable total input use a more comprehensive measure of non-labour inputs used by the household. In addition to chemicals purchased, this includes items such as: storage of crops, purchased seed, irrigation, bags, containers, petrol/diesel/oil (to operate spraying machine and mist blowers), transport of crops, hand tools (local and imported), repairs/maintenance, other (unspecified) crop costs. This is the variable entered in the regression analysis.

TABLE 1
COCOA PRODUCTION, YIELD AND AREA HARVESTED (a)

Crop Year	Area Harv ('000 ha)	Yield (Kg/Ha)	Production ('000 Kg)
1990/91	693	423	268
1991/92	721	384	277
1992/93	711	398	283
1993/94	694	391	271
1994/95	843	412	346
1995/96	1025	394	403
1996/97	1062	342	363
1997/98	1220	300	366
Changes over the period as a whole (%)			
	76	-29	37

Source: FAOSTAT Database

(a) Crop production figures include the quantities of the commodity sold in the market (marketed production). When the production data available refers to a production period falling into two successive calendar years and it is not possible to allocate the relative production to each of them, it is usual to refer production data to that year into which the bulk of the production falls (http://www.fao.org/waicent/faostat/agricult/pr_ele-e.htm). This rule applies to cocoa. The production period is divided into two seasons, with the bulk of the harvest being sold between September and February of any given *crop* year. We therefore calculated the average across two calendar years in order to make a meaningful comparison with the GLSS household data.

TABLE 2

GLSS DATA[a]: CHARACTERISTICS OF COCOA-FARMING HOUSEHOLDS

				No of Observed Households[b]	
Characteristics	**1991/1992**	**1998/1999**	**Difference** (98 – 91)	**1991/1992**	**1998/1999**
HH head Gender (% male)	72% (0.03)	74% (0.03)	0.02	371	673
HH head Age	47 (0.88)	49 (0.93)	2	371	673
If hh head attended school (% yes)	12% (0.02)	14% (0.01)	0.02	371	673
School years completed by HH Head	5.24 (0.27)	5.84 (0.29)	0.60	371	673
Household size	5 (0.15)	5 (0.14)	0	371	673
Farm size (hectares)[c]	1.65 -	2.02 -	0.37 -	371	673
% Of hired labour	22% (0.02)	29% (0.02)	0.07***	371	673
Revenue from cocoa[d] ('000 Cedis)	112.48 (13122.52)	129.01 (13598.53)	16.53	371	673
Revenue from all crops ('000 Cedis)	210.86 (20008.22)	228.54 (21747.37)	17.68	371	673
% Revenue from cocoa	53%	56%	0.03	371	673
***Producer Price Changes*[e] (Cedis/Kg.)**					
Producer Prices (nominal)	251,2	1800,00		467	718
Producer Prices (real)	251,2	266,02		467	718

Notes: a) Figures – unless noted otherwise - are mean values, standard errors are in parentheses. T-test of difference between means. H_o: mean(1998/99) - mean(1991/92) = 0. b) The figures were calculated using non-missing observations *for all* variables with the exception of producer prices. The latter were computed using the values of any cocoa sale reported, to get the most accurate representative figure to reconcile the micro with the macro data. c) Median values are reported in place of the mean to control for the skewness of these variables in levels. The test on the statistical difference between the means is based on its logarithmic value. d) Constant 1991/92 prices. e) These are median unit values obtained by dividing the value of cocoa sales by the amount sold, and perfectly match the macro figures from the Cocobod statistics. These figures were computed using the values of *any* cocoa sale reported to the get most accurate figures to reconcile the micro with the micro data.

TABLE 3
REGIONAL MEANS OF COCOA PRODUCTION VARIABLES

Data in levels

		Western	Central	Eastern	Volta	Ashanti	B. Ahafo	Total
No. Households	**1990/91**	137	71	100	14	112	71	505
	1997/98	227	130	123	16	132	54	682
Cocoa farming hh	**1990/91**	29%	14%	15%	3%	15%	16%	16%
(as % of total pop.)	**1997/98**	34%	22%	16%	3%	12%	9%	16%
	Change	0.05	0.08	0.01	0.00	-0.03	-0.07	**0.00**
Cocoa harvested (kg)	**1990/91**	628	483	433	128	334	623	489
	1997/98	922	395	266	128	441	1353	626
	% change	47%	-18%	-39%	0%	32%	117%	**28%**
Cocoa farm size (ha)[a]	**1990/91**	1.97	1.65	1.21	1.35	2.43	2.83	1.65
	1997/98	2.48	1.65	1.21	0.22	1.62	2.63	2.02
	% change	26%	0%	0%	-84%	-33%	-7%	**23%**
Cocoa yield (kg/ha)	**1990/91**	355	230	442	158	217	504	340
	1997/98	493	231	331	216	263	287	353
	% change	39%	0%	-25%	87%	21%	-43%	**4%**
Non-lab. Real input exp	**1990/91**	13.04	12.34	8.05	3.30	16.10	10.47	12.03
(constant 1991-92 prices)	**1997/98**	32.29	11.94	8.08	3.04	17.68	11.50	18.89
('000 Cedis)	**% change**	148%	-3%	0%	-8%	10%	10%	**57%**
Tot lab days	**1990/91**	132	118	101	129	160	158	134
(Yearly man/days)	**1997/98**	108	82	83	102	118	118	101
	% change	-18%	-31%	-18%	-21%	-26%	-25%	**-24%**
Household labour	**1990/91**	103	88	74	114	120	133	103
(Yearly man/days)	**1997/98**	69	57	65	76	68	68	66
	% change	-33%	-35%	-12%	-33%	-43%	-49%	**-36%**
% Of hired labour	**1990/91**	0.20	0.22	0.26	0.12	0.25	0.18	0.22
(Man/days)	**1997/98**	0.28	0.31	0.23	0.29	0.31	0.35	0.29
	change	8%	9%	-12%	142%	6%	18%	**7%**
Labour productivity	**1990/91**	6.46	4.51	6.05	1.24	3.34	5.93	5.19
(kg cocoa/man-days)	**1997/98**	11.40	6.32	4.11	1.45	5.43	19.49	8.37
	% change	77%	40%	-32%	17%	62%	229%	**61%**
Real input exp./ha	**1990/91**	7.62	5.62	8.39	2.97	12.26	5.43	8.31
('000 Cedis)	**1997/98**	18.17	6.24	11.75	8.35	12.83	4.27	12.71
	% change	138%	11%	40%	181%	5%	-21%	**53%**
Man-days lab./ha	**1990/91**	97	109	165	99	128	73	118
	1997/98	81	65	190	433	102	49	103
	% change	-17%	-41%	15%	337%	-20%	-33%	**-13%**

Data in Logarithmic

		Western	Central	Eastern	Volta	Ashanti	B. Ahafo	Total
Cocoa harvested (kg)	**1990/91**	5.91	5.48	5.35	4.59	4.87	5.70	5.44
	1997/98	6.05	5.27	4.83	4.04	5.31	6.13	5.50
	% change	14%	-21%	-52%	-55%	44%	43%	**6%**
Cocoa farm size (ha)	**1990/91**	0.71	0.40	0.06	0.44	0.65	0.84	0.52
	1997/98	0.89	0.57	0.02	-0.94	0.42	1.08	0.58
	% change	18%	17%	-4%	-138%	-22%	24%	**5%**
Cocoa yield (kg/ha)	**1990/91**	5.20	5.08	5.29	4.15	4.22	4.86	4.92
	1997/98	5.16	4.7	4.81	4.98	4.89	5.05	4.92
	% change	-4%	-38%	-48%	83%	67%	19%	**0%**
Labour productivity	**1990/91**	1.27	0.87	1.00	-0.16	0.02	0.85	0.78
(kg cocoa/man-days)	**1997/98**	1.58	1.01	0.60	-0.38	0.87	1.55	1.11
	% change	31%	14%	-40%	-22%	85%	71%	**33%**
Non-lab. real input exp	**1990/91**	8.92	8.77	8.36	7.85	9.18	8.77	8.80
	1997/98	9.32	8.90	8.29	7.83	8.99	8.83	8.92
	% change	39%	13%	-7%	-2%	-19%	6%	**13%**
Tot lab days	**1990/91**	4.67	4.63	4.37	4.75	4.85	4.86	4.67
(Yearly man/days)	**1997/98**	4.48	4.27	4.24	4.43	4.43	4.58	4.39
	% change	-19%	-36%	-13%	-32%	-42%	-28%	**-28%**

Source: Author's calculation based on GLSS3 and GLSS4. a) Median values. The data on farm size, yields and inputs per hectare are based on a smaller sample excluding all the observations discussed in section 2.1 that did not report the size of the land holdings on which cocoa production occurred.

TABLE 4
MATCHING THE MACRO AND MICRO DATA ON COCOA PRODUCTION GROWTH

~ *PROJECTIONS FROM CENSUS ('000)* ~							
Year	Western	Central	Eastern	Volta	Ashanti	B. Ahafo	Total
***1.** All Households*							
1991	350	380	480	310	540	330	2,390
1998	420	540	570	380	740	450	3,100
***2.** Percentage Change in Total Number of Households*							
%Δ	20.00%	42.11%	18.75%	22.58%	37.04%	36.36%	**29.71%**
~ *GLSS POPULATION ESTIMATES* ~							
Year	Western	Central	Eastern	Volta	Ashanti	B. Ahafo	Total
***3.** All Households*							
1991	483	515	659	409	733	454	3,253
1998	664	604	738	607	1,083	581	4,277
***4.** Cocoa Farming Households*							
1991	137	71	100	14	112	71	505
1998	227	130	123	16	132	54	682
***5.** Percentage of cocoa farming households in the GLSS*[a]							
1991	28%	14%	15%	3%	15%	16%	16% (0.006)
1998	34%	22%	17%	3%	12%	9%	16% (0.006)
***6.** Estimates of Cocoa Farmers' Household Population ('000) (applying **5.** to **1.**)*							
1991	98	53	72	9	81	53	382
1998	143	119	97	11	89	41	496
% Δ	**1.46**	**2.24**	**1.35**	**1.22**	**1.22**	**0.77**	**1.30**
***7.** Log of household average cocoa production (kilos)*							
1991	5.91	5.48	5.35	4.59	4.87	5.70	5.44
1998	6.05	5.27	4.83	4.04	5.31	6.13	5.50
***8.** Proportional Change in Cocoa Production*							
%Δ	**1.14**	**0.79**	**0.45**	**0.48**	**1.44**	**1.43**	**1.06**
Estimate of Cocoa Production Growth (combining the total %Δ in 6. and 8.)							
	66%	**77%**	**-39%**	**-41%**	**76%**	**10%**	**38%**

Source: Projections from Census from documentation to GLSS data, and author's calculations from GLSS data. Notes: a) These figures are derived counting all cocoa growing households who harvested any positive quantity of cocoa in each given crop year.

TABLE 5
ESTIMATING HOUSEHOLD COCOA PRODUCTION AT THE REGIONAL AND AGGREGATE LEVEL

	OLS						IV 2SLS					
Dependent variable is Log (cocoa harvested)	**Western**	**Central**	**Eastern**	**Ashanti**	**B Ahafo**	**Pooled**	**Western**	**Central**	**Eastern**	**Ashanti**	**B Ahafo**	**Pooled**
Log of cocoa farm size	0.237***	0.319***	0.299***	0.421***	0.379*	0.333***	0.226***	0.332***	0.278***	0.390***	0.378**	0.318***
	(0.068)	(0.095)	(0.083)	(0.091)	(0.193)	(0.042)	(0.067)	(0.095)	(0.079)	(0.094)	(0.184)	(0.043)
Log of input expenditure (constant prices)	0.223***	0.343***	0.312***	0.140*	0.288**	0.248***	0.202***	0.364***	0.228*	0.084	0.286**	0.204***
	(0.056)	(0.105)	(0.080)	(0.075)	(0.140)	(0.037)	(0.065)	(0.114)	(0.125)	(0.090)	(0.141)	(0.043)
Log of labour input	0.169*	0.376**	0.004	0.091	-0.159	0.118	0.311	0.228	0.318	0.356	-0.149	0.334**
	(0.098)	(0.188)	(0.150)	(0.191)	(0.278)	(0.073)	(0.248)	(0.221)	(0.320)	(0.257)	(0.452)	(0.137)
Percentage of hired labour	0.448*	0.163	-0.454	0.234	0.866*	0.155	0.472**	0.080	-0.032	0.337	0.870*	0.265
	(0.232)	(0.443)	(0.398)	(0.385)	(0.485)	(0.172)	(0.463)	(0.378)	(0.607)	(0.450)	(0.194)	(0.186)
Log (farm value+1)	0.048***	0.024*	0.001	0.010	-0.014	0.025***	0.047***	0.022*	-0.003	0.007	-0.014	0.025***
	(0.011)	(0.012)	(0.014)	(0.014)	(0.025)	(0.006)	(0.011)	(0.013)	(0.015)	(0.014)	(0.024)	(0.006)
Dummy = 1 if hh head is male	0.327**	0.111	0.289	0.121	-0.107	0.287***	0.284*	0.130	0.238	0.083	-0.110	0.248***
	(0.158)	(0.177)	(0.197)	(0.200)	(0.386)	(0.092)	(0.160)	(0.165)	(0.182)	(0.204)	(0.390)	(0.094)
Age - Economic Head†	0.014***	0.013***	0.007	0.001	0.005	0.004*	0.012**	0.013***	0.006	0.000	0.005	0.003
	(0.004)	(0.005)	(0.006)	(0.005)	(0.008)	(0.002)	(0.005)	(0.005)	(0.006)	(0.005)	(0.008)	(0.002)
Dummy==1 if head has primary education	0.256	-0.003	-0.268	0.090	-0.847	0.008	0.275*	0.015	-0.269	0.156	-0.842	0.008
	(0.156)	(0.184)	(0.194)	(0.239)	(0.996)	(0.103)	(0.150)	(0.189)	(0.194)	(0.247)	(0.865)	(0.102)
Y98	-0.053	-0.044	-0.525***	0.424**	-0.139	0.023	-0.014	-0.101	-0.481***	0.514***	-0.138	0.055
	(0.123)	(0.180)	(0.171)	(0.185)	(0.263)	(0.232)	(0.183)	(0.187)	(0.166)	(0.255)	(0.116)	(0.105)
Log of total annual rainfall per region						-0.024						-0.030
						(0.098)						(0.235)
Constant	1.564***	-0.338	2.328***	2.794***	3.720**	1.876*	1.183	0.147	1.660**	2.099**	3.695*	1.703
	(0.583)	(1.279)	(0.691)	(1.014)	(1.639)	(1.078)	(0.843)	(1.254)	(0.830)	(1.054)	(1.893)	(1.094)
Observations	292	173	184	237	84	970	292	173	184	237	84	970
R-squared	0.42	0.38	0.32	0.21	0.24	0.31	0.42	0.38	0.30	0.19	0.24	0.29
CRS Test: $\beta_{Land} + \beta_{Lab} + \beta_{Non\text{-}Lab\ input} = 1$	10.65	0.03***	6.86	3.54**	1.77***	15.82						
Prob>F	0.001	0.864	0.01	0.061	0.188	0.000						
Degrees of freedom	(1, 282)	(1, 163)	(1, 174)	(1, 227)	(1, 74)	(1, 959)						
Chi-sq(1)							1.47***	0.14***	0.52***	0.72***	1.18***	1.65***
p-value							0.23	0.71	0.47	0.39	0.28	0.20
Sargan Hansen statistics (over identification test of all instruments):							1.822***	3.383***	5.64***	8.199***	3.363***	19.602**
Chi-sq(1) p-val							0.177					
Chi-sq(4) p-val								0.496	0.23		0.499	
Chi-sq(6) p-val										0.224		
Chi-sq(11) p-val												0.05

Notes: Robust standard errors in parentheses. For coefficient estimates the following notation holds: * significant at 10%; ** significant at 5%; *** significant at 1%. For diagnostic tests, *, **, *** denote non-rejection of the null hypothesis at respectively 10%, 5% and 1%. Table A3 in the appendix shows the first stage regression of the IV estimates as well as the different instruments used for the labour input variable. † This variable was dropped in the 2SLS pooled regression due to its statistical insignificance and entered as an instrument for labour.

TABLE 6
PRODUCTION GROWTH DECOMPOSITION OF COCOA GROWING HOUSEHOLDS: 1991-98

	Western	Central	Eastern	Ashanti	Brong Ahafo	Total[a]
Total Cocoa Production Growth (kg)						
	0.08	**-0.10**	**-0.48**	**0.24**	**-0.04**	**0.06**
Total Input Growth						
Land	0.04	0.05	-0.01	-0.09	0.09	0.02
Labour	-0.06	-0.10	-0.02	-0.15	0.02	-0.05
Other Inputs	0.07	0.06	-0.03	-0.01	0.02	0.02
Total	**0.05**	**0.01**	**-0.06**	**-0.25**	**0.13**	**-0.01**
Total Factor Productivity						
	-0.01	**-0.10**	**-0.48**	**0.67**	**-0.14**	**0.02**
Unexplained Residuals						
	0.04	**-0.01**	**-1.09**	**-0.18**	**-0.04**	**0.05**

Notes: a) Entering the effect of rainfall in the growth column of the pooled regression did not change the contribution of labour, non-labour inputs and TFP. Therefore this table omits the corresponding figure as it does not add any significant value to the interpretation of the results.

TABLE 7
CALCULATIONS OF AVERAGE AND MARGINAL LABOUR PRODUCTIVITY IN THE COCOA SECTOR

Year	Nom. Prod. Pr. (Cedis/kg)	CPI 90	Real Prod. Pr. (1990 = 0)	Lab. Prod. kg. /(men days)	Mg. productivity per person per day	Value of Mg prod'ivity per person per day (real ' 90 cedis)	Off. Exch. Rate	WPI 90	Value of Mg. prod'ivity per person per day (USD)	Value of Mg. prod'ivity per person per day (real ' 90 USD)
1990	224	1.00	224.00	5.19	1.71	383	326.33	1.00	1.17	1.17
1997	1,800	6.06	297.03	8.37	2.76	820	2050.17	1.10	2.42	2.20

EXPLANATION OF VARIABLE CALCULATIONS:

Value of marginal productivity in the cocoa sector per day (real '90 cedis)	Mg productivity * real prod. Price
Value of marginal productivity in the cocoa sector per day (USD)	Mg productivity* Nominal prod. Prices converted in USD
Value of marginal productivity in the cocoa sector per day (real '90 USD)	Mg productivity* Nominal prod. Prices converted in USD/WPI

TABLE 8
AGRICULTURAL DAILY WAGES FROM THE COMMUNITY QUESTIONNAIRE

	CEDIS	'90 CEDIS	US$
1990	565.9	565.97	1.73
1997	3420.1	564.4	1.67

APPENDICES

A1 SAMPLE SELECTION

When analysing the GLSS data, 17 percent of the observations on cocoa farming households (i.e. 17 percent of the respondents reporting a positive amount of cocoa harvested and sold) did not provide any information relative to the size of their cocoa holding. In the econometric analysis of this study, these observations were dropped since farm size is a central variable of interest. Yet we need to worry about the potential selectivity bias that could arise by omitting such a large share of the sampled population. In econometric terms the estimates might be affected by a form of endogenous selection.

In very simple terms the problem can be outlined as follows. Consider two different equations. The "outcome" equation (Newey, et al., 1990), identifies what factors determine the level of households' cocoa production:

$$y^*_{1i} = x'_{1i}\beta_1 + \varepsilon_{1i}$$

Where y^*_{1i} is the amount of cocoa harvested entering the regressions for positive (i.e. reported) values of cocoa farms, so that

$$y_{1i} = \begin{cases} y^*_{1i} & if \;\; y^*_{2i} > \\ 0 & else \end{cases}$$

The "selection" equation looks as follows:

$$y^*_{2i} = x'_{2i}\beta_2 + \varepsilon_{2i}$$

The expression above explains what factors might determine the probability of observing a household reporting the size of its cocoa farm. The structure of the error term in these two equations is as follows:

$$\begin{pmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_1^2 & \sigma_1\sigma_2 \\ \sigma_1\sigma_2 & \sigma_2^2 \end{pmatrix}\right]$$

Here $\sigma_1\sigma_2$ are different from 0. It is useful to define

$$D_i = \begin{cases} 1 & if \;\; y^*_{2i} > 0 \\ 0 & else \end{cases}$$

Then (y_1, D) provide the observed information on the endogenous variables. In our case, the selection bias derives from the potential non-randomness of the observations not reporting the size of cocoa farms. In other words, if there is a systematic component characterising the households that did not report the size of their cocoa holdings (if, for example, these *censored* observations represent sharecropping households unaware of the size of the farm they cultivate), than the two errors ε_{1i} and ε_{2i} will be correlated. The potential dependence between the error terms ε_{1i} and ε_{2i} would therefore require introducing a non-linear selection correction term into the model for the observed dependent variable (the production function equation). To control for and test the significance of the non-randomness of sampled cocoa farmers a regression model with selection using Heckman's full maximum-likelihood estimator is used. The results are reported in table A1.1 below.

TABLE A1

HECKMAN SELECTION MODEL FOR MISSING OBSERVATIONS IN COCOA PRODUCTION FUNCTIONS

	HECKMAN SELECTION MODEL		OLS REGRESSION
	Outcome equation	*Selection* equation	
Log of cocoa farm size	0.333*** (0.041)		0.333*** (0.042)
Log of input expenditure (constant prices)	0.249*** (0.037)	0.136*** (0.022)	0.249*** (0.037)
Log of labour input	0.119 (0.073)	-0.254*** (0.035)	0.119 (0.074)
Percentage of hired labour	0.155 (0.171)	0.049 (0.086)	0.155 (0.172)
Log (plot value+1)	0.025*** (0.006)		0.025*** (0.006)
Dummy = 1 if hh head is male	0.287*** (0.091)		0.287*** (0.092)
Age - Economic Head	0.004* (0.002)		0.004* (0.002)
Dummy==1 if head has primary education	0.007 (0.103)		0.007 (0.104)
Log of total annual rainfall per region	0.019 (0.230)		0.018 (0.232)
Y98	-0.021 (0.098)		-0.021 (0.100)
Number of crops grown by hh		**0.030***** (0.005)	
Number of farms cultivated by hh		**0.057***** (0.012)	
% of harvest received from sharecropped land		**-0.011***** (0.002)	
Dummy = 1 if household owns any land		**0.168***** (0.049)	
Inverse mills ratio			**0.058** (0.396)
Constant	1.869* (1.074)	0.406*** (0.072)	1.867* (1.083)
ρ	0.050 (0.244)		
σ	1.099 (0.035)		
λ	0.051 (0.268)		
Observations	1195	1195	970
Wald test of indep. eqns. (rho = 0)	0.04		
Prob>Chi-sq	0.851		
R-squared			0.31
Pseudo R-squared		0.03	

Notes: Robust standard errors in parentheses. For coefficient estimates the following notation holds: * significant at 10%; ** significant at 5%; *** significant at 1%.

The first two columns simultaneously estimate the two equations (the outcome and the selection one); a zero-restriction is needed to identify the system. Three indicators are introduced to identify the system: the number of crops grown by each household, the number of farms cultivated by each household, and the percentage of harvested received form sharecropping arrangements. All these variables turn out to be highly significant in the selection equation. Yet the Wald test on the independence of the two equations does not allow rejecting the null of independence. This is a first symptom that selectivity bias might not occur due to the omitted observations. We take a step further and, after deriving the inverse mills ratio (which indicates the extent of the potential selection bias) we enter this index in the OLS pooled regression. Once again, the coefficient on this index is not statistically different from zero. We therefore conclude that the observations which are dropped in the main analysis of this chapter due to missing values for the size of cocoa farms represent a random sub-sample: we need not to be concerned about selectivity bias.

A2 Non-LABOUR INPUTS IN COCOA PRODUCTION

In 1996-97 all subsidies on insecticides and fertilisers were removed as a part of the CRP's (Cocoa Rehabilitation Programme) long term programme to reorganise more efficiently the distribution of inputs to the farmers. The use of these chemicals is of crucial importance to control pests and diseases affecting cocoa trees and their yields (production per unit of land). The increase in the cost of inputs to the farmers which occurred as a result of this liberalisation strategy, was marked by the establishment of the "Cocoa Inputs Company LTD"[11]. This operated a network of stores in each of the cocoa districts centres increasing de facto the supply of these inputs to the farmers.
How was this information extracted from the GLSS survey? This lists basic farming chemicals (fertiliser, pesticide, insecticide), as well as seeds and other items (such as tools used, and transport costs) as components of households' input expenditure. In order to transform the monetary variable into a quantity equivalent one, the following adjustments were made. Firstly, the inflation increase occurred between the two crop years (6.76), was lower than the increase in the cost of inputs to the farmers, which increased between a factor of 7.7 (for insecticides) and 9 (for fertilisers)[12]. We therefore used two separate *input cost deflators* defined as P^{1998}/P^{1991} to turn insecticide and fertiliser expenditure into volumes used. For all other non chemical inputs listed above, we simply deflated the 1998 expenditure figure by the inflation rate to get a quantity-equivalent variable. The two components were then added up together to give the variable used in the empirical analysis.

Figure 2 then shows an increase in the *volume* of insecticides and fertilisers used by cocoa farmers across the two years. This preliminary evidence might suggest that despite the persistently low use of inputs by cocoa farmers, their greater availability since 1996/97 has had a strong positive effect on the amount used.

A3 LABOUR INPUTS IN COCOA PRODUCTION

Labour input is a key component in cocoa production, yet in this study it is perhaps the most problematic variable to measure using the GLSS data. The types of labour used in cocoa farming can be

[11] This is in turn a subsidiary of the Ghana Cocoa Coffee and Sheanut Farmers Association (CCSFA) which in 1994 took over all input distribution functions from government's Cocoa Service Division. The set up of the Cocoa Inputs Company was justified by the need to sort out the operational inefficiency under which the earlier established CCSFA operated.

[12] CHANGE IN THE NOMINAL COST OF INPUTS

	Average cost of chemical inputs		P^{1998}/P^{1991}
Inputs	*1997*	*1998*	
Insecticide (cedis/litre)	2,585	20,000	7.74
Fertiliser (cedis/50kg bags)	4,000	36,000	9

broadly classified in four categories (Blowfield, et al. (1993); Blowfield (1995), Masdar (1998)): a) household labour, b) hired labour, c) caretakers, and d) communal labour (*nnoboa*)[13]. The GLSS does not distinguish among these categories since, as mentioned before, this survey was not specifically designed for cocoa producing households. We therefore used two derived measures for this production input.

Household labour. We count all household members aged 7 and above[14] whose working status in the agricultural sector was defined by the respondents either as *self-employed* or as *unpaid family worker*s. Secondly, we convert our original measure of household labour (number of household members) in 'man-days' of labour. 'Man-days' is defined as the product of persons employed and the average number of days worked by each individual. Of course this measure is both task specific (there are different requirements for clearing, weeding and harvesting operations) and individual specific (women and children ratios differ from men's ratios). Because this detailed information is not available in the GLSS, we estimate the average number of days worked by each individual per annum to be 40. This figure is based on the labour requirement figures reported in the limited literature available on this specific issue, and falls well within the range of these studies[15] (Blowfield, *op. cit.*, Masdar, *op. cit.*; Wood et al., *op. cit.*; Bloomfield, et al. (1992); Okali (1973)).

Hired labour. For this component we adopt a different procedure. An estimate of total expenditure on hired labour (if any) is recorded at the household level in the GLSS module on agricultural costs and expenses. In order to convert these payments into man-days, we need an estimate of the prevailing wage rate. Ideally it would be desirable to have wage rates at the household level, failing this a certain amount of aggregation has to be accepted. Village data are available from the community questionnaire for almost all clusters/villages where cocoa farmers were sampled. Where the information is not available, we select an estimate for it at the *lowest* level of aggregation; i.e. wages at the district level for GLSS4, and at the region level for GLSS3 (as no district level information was recorded in this round of the survey). The basic unit of analysis selected is the village average between male and female daily wages across the three tasks specified in the questionnaire: clearing, planting, and harvesting. This procedure assigns to each household village-specific wage rates. Therefore, if the household recorded any expenditure on hired labour, this figure is divided by the village-level estimates to derive man-days of hired labour. Moreover, the 1998/99 survey asks how many individuals worked on each farm, therefore we tried using these data to check our procedure. Unfortunately, this variable did not prove to

[13] N*noboa* is a particular form of labour exchange where labour is exchanged on a rotating basis. The labour is used for all types of farm work, but most commonly for weeding. Although no payment is made, the farm owner often serves food. There is a strong tendency for men and women to form separate nnoboa groups (reason: (physical strength difference calls for creation of *homogenous* labour groups). The primary function of nnoboa labour is to overcome labour shortages on one's own farms through an exchange of labour.

[14] Although active population is usually defined for an age range 15-64, it is common practice among cocoa farmers to use informally the help of their children at specific time of the year for tasks such as weeding, harvesting and breaking open cocoa pods.

[15] We also experimented with different *conversion factors*; respectively 30 and 50 days of labour and this did not change the point estimate of the relevant variable.

be reliable or usable since we found several cases where the respondent recorded a figure on hired labour expenditure but failed to report a positive number for individuals employed. Since, despite the wording of the question (*How many people were employed on the farm by sex?*), the information was silent as to which farms it referred to (the question was asked at the crop-level), we failed to make any use of this variable, and decided to use the procedure outlined above.

The two labour components derived are arranged in the specification of our regressions to allow different productivity levels for household and hired labour. Box 1 explains how we arrive at the logarithmic representation of the total labour variable used in the econometric analysis allowing for this differentiation in labour inputs productivity.

BOX 1:
DERIVATION OF REGRESSOR FOR LABOUR*

Each household has an endowment of labour L which is used in agricultural production, and is a function of household labour (L_F) and hired labour (L_H). Yet the total amount of labour employed might not be derived as the sum of the two components if the hired component is more productive and efficient than the household one. These two labour components can be either perfect or imperfect substitutes. In a peasant semi-subsistence economic context it is realistic to assume the occurrence of a dual labour market scenario (Berry and Cline (1979), Barrett (1996)) where smallholders hire-in relatively more (cheap) household labour on their farms, and where the hired labour will be more effective the higher the supervision control exercised by household labour. In order to allow for the imperfect substitutability of the two forms of labour, we use the following expression for total labour employed:

$$L^{\alpha} \equiv (L_F + \gamma L_H)^{\alpha}$$

The term γ therefore identifies the potential efficiency (i.e. productivity) wedge between the two components in the farm labour force. Through some simple manipulation, L can be re-expressed as follows:

$$(L_F + L_H) + L_H(\gamma - 1)$$

$$L\left(1 + (\gamma - 1)\frac{L_H}{L}\right)$$

When taking the log of L^{α}, we get:

$$\begin{aligned} logL^{\alpha} &\equiv \alpha logL \\ &\equiv \alpha logL + \alpha log\left(1 + (\gamma - 1)\frac{L_H}{L}\right) \end{aligned}$$

Since $\log(1+x) \cong x$ if $|x| <$, provided that (in rural peasant agriculture) the term $\frac{L_H}{L}$ is frequently a small fraction of total labour (usually not exceeding 30 percent), even allowing for γ to have values up to 3 (which would imply hired labour being three times more productive than household labour), the above approximation holds. It is possible to write the expression above as:

$$\equiv \alpha logL + \beta \frac{L_H}{L}$$

Where

$$\beta = \alpha(\gamma - 1)$$

Therefore through the estimates $\hat{\alpha}$ (the coefficient on total labour), and $\hat{\beta}$ (which combines the coefficient on the percentage of hired labour to the rate of substitution between the two forms of labour) we can easily derive the estimate of γ as follows:

$$\hat{\gamma} = \frac{\hat{\beta}}{\hat{\alpha}} + 1$$

*We wish to thank Marcel Fafchamps for suggesting this formulation.

TABLE A3

FIRST STAGE REGRESSIONS OF IV 2SLS COCOA PRODUCTION FUNCTION ESTIMATES

Dependent Variable is Log (Labour Input)						
	Western	**Central**	**Eastern**	**Ashanti**	**Brong Ahafo**	**Pooled**
Log (farm size)	0.025	0.056	0.089***	0.035	0.055	0.055***
	(0.046)	(0.050)	(0.034)	(0.043)	(0.068)	(0.021)
Log (non-lab. input)	0.099**	0.141***	0.202***	0.175***	0.191***	0.099***
	(0.043)	(0.051)	(0.047)	(0.045)	(0.063)	(0.027)
% of hired labour	-0.144	-0.434	-1.501***	-0.228	-0.685**	-0.449***
	(0.322)	(0.268)	(0.216)	(0.231)	(0.300)	(0.137)
Log (real farm value +1)	0.002	-0.008	-0.014	0.054	-0.013	0.004
	(0.006)	(0.006)	(0.034)	(0.043)	(0.020)	(0.012)
Dummy = 1 if male-hhh	0.276***	0.046	0.137	0.121	0.138	0.145***
	(0.105)	(0.095)	(0.105)	(0.098)	(0.126)	(0.053)
Age hh head	0.007***	0.004*	0.008***	0.005**	0.007**	
	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	
Dummy = 1 if hhh has primary edu.	-0.145	0.240**	-0.012	-0.104	-0.265	-0.142*
	(0.135)	(0.094)	(0.126)	(0.103)	(0.218)	(0.077)
Dummy = 1 if year is 1998/99	-0.299***	-0.318***	-0.174**	-0.343***	0.110	0.091
	(0.077)	(0.101)	(0.078)	(0.084)	(0.102)	(0.206)
Log (regional rainfall)						0.207*
						(0.120)
Constant	2.753***	1.454**	1.821***	2.131***	1.485**	2.638***
	(0.353)	(0.583)	(0.401)	(0.450)	(0.625)	(0.866)
Instrumental variables employed						
Log (hh size)	0.389***	0.637***	0.414***	0.510***	0.677***	0.385***
	(0.064)	(0.124)	(0.068)	(0.072)	(0.079)	(0.035)
No. crops harvested by hh		0.008				0.011**
		(0.008)				(0.005)
No. farm owned/operated by hh	-0.002	0.067**				0.026**
	(0.020)	(0.034)				(0.012)
% hh members working		1.325***				
		(0.209)				
Mean level of hh members education		-0.041***	0.033**	0.010	0.018	
		(0.016)	(0.016)	(0.020)	(0.018)	
Dummy = 1 if hh owns any land			-0.237	-0.122	0.012	
			(0.167)	(0.179)	(0.154)	
Log (loan received for agric. inputs)				-0.015	-0.012	0.016***
				(0.017)	(0.015)	(0.007)
Years of schooling of household head						0.030
						(0.019)
(Years of sch. of household head)^2						-0.003*
						(0.002)
% of harvest from sharecropped land				-0.002		-0.003**
				(0.003)		(0.001)
Log (real value all land owned by hh +1)			0.041	0.025	0.019	0.000
			(0.035)	(0.027)	(0.024)	(0.011)
% of hhs that own any cocoa land			-0.237	-0.122	0.012	
			(0.167)	(0.179)	(0.154)	
Log (real village-level daily wages)						-0.234**
						(0.101)
Amount of insecticides and fertilisers used						0.000
						(0.000)
(Amount of insecticides and fertilisers used)^2						0.000
						(0.000)
Log (age hh head)						0.249***
						(0.063)
Log (loan for inputs + 1)			-0.014	-0.015	-0.012	0.011*
			(0.015)	(0.014)	(0.018)	(0.007)
Dummy = 1 if hh owns any cocoa farm				-0.902*		
				(0.537)		
Observations	292	173	184	237	84	970
Adjusted R^2	0.32	0.49	0.54	0.47	0.67	0.40
Partial R-squared of excluded instruments:	0.13	0.32	0.20	0.25	0.53	0.21
F Test of excluded instruments:	20.38	15.28	8.72	10.79	15.96	22.69
Prob > F =	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Robust standard errors in parentheses. For coefficient estimates the following notation holds: * significant at 10%; ** significant at 5%; *** significant at 1%.