

Market Structure and Productivity Growth in Ghanaian Cocoa Production

Andrew Zeitlin*
Centre for the Study of African Economies
University of Oxford

June 27, 2005

Abstract

This paper argues that market structure, and in particular the degree of competition among Licensed Buying Companies, is an important determinant of productivity in the Ghanaian cocoa industry. This issue is studied in the context of a two-year doubling of cocoa output at the national level. Evidence from microeconomic data confirms a significant increase among existing farmers, although this rate of increase is smaller than that observed at the national level. Analysis of production reveals an economically significant and statistically robust relationship between village-level Licensed Buying Company competition and the level and growth rate of total factor productivity.

*Address for correspondence: andrew.zeitlin@economics.ox.ac.uk. I wish to thank Francis Teal, Måns Söderbom, Justin Sandefur, and the participants of a CSAE seminar for helpful comments. Thanks are due to Marcella Vigneri for generously making available the first round of data and to the Ghana Cocoa Board for facilitating collection of the second. This research would not have been possible without the invaluable assistance of numerous other colleagues in Ghana. Financial support from the Global Poverty Research Group is gratefully acknowledged.

1 Introduction

The past few years have borne witness to remarkable growth in the output of Ghana's cocoa sector. Apparently responding to changes in producer prices, cocoa output doubled from 2001/02 to the 2003/04 crop year (International Cocoa Organization 2004/05). Growth of this magnitude is clearly unusual in a sector whose growth rate has been modest at best over the last decades; this is vividly illustrated in Figure 1. However, the mechanisms allowing this expansion and the distribution of its effects are not well known. The present paper therefore seeks to explain sources of growth in the cocoa sector.

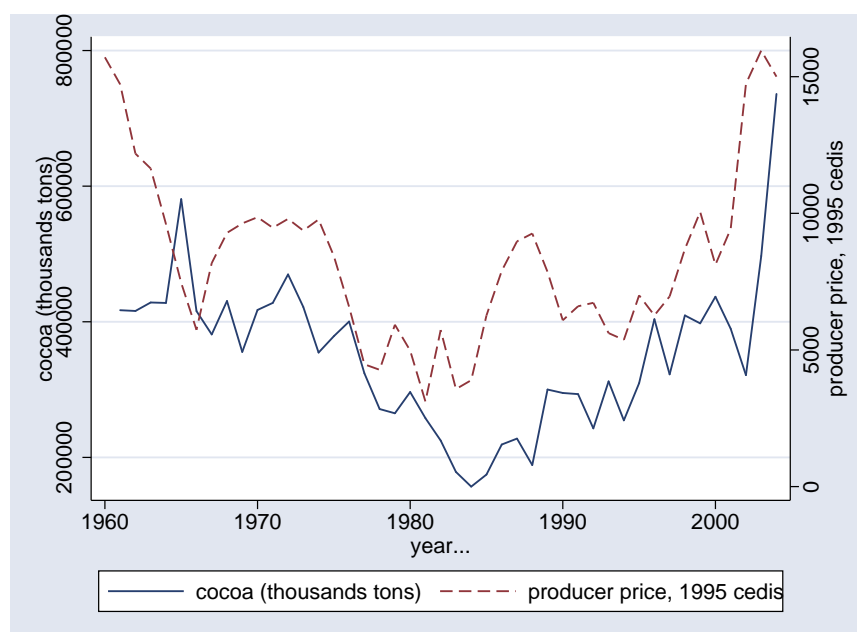
This paper conducts an empirical analysis, based on a panel of cocoa farmers interviewed following the 2001/02 and 2003/04 production seasons. In studying cocoa production, the paper makes use of farmer-level production data as well as household and village characteristics. The data allow an econometric study which addresses biases due to time-invariant, unobserved characteristics, as well as biases introduced by measurement error and by limited violations of the hypothesis of strict exogeneity. An unbiased portrayal of the process of production is important both for understanding the contributions of both increased factor intensity and of productivity growth.

Indeed, in a sector characterized by yields far below those suggested by experimental study (Teal and Vigneri 2004), there is particular interest in factors explaining changes in total factor productivity. This paper advances the hypothesis that the institutional context—emphasizing here the local degree of competition among Licensed Buying Companies, as will be explained below—has been a crucial determinant not only of the level of productivity but also of its growth rate.

A concern for shared growth motivates an analysis of the distribution of these effects. Competitive mechanisms to promote productivity growth may or may not exacerbate existing inequalities in the sector. For this reason, the analysis is extended to consider the interaction of producer wealth or productive capacity and the Licensed Buying Company competition that underlies productivity growth. No evidence is found to suggest that these competitive market institutions have deleterious distributional effects.

The paper proceeds as follows. Section 2 summarizes basic demographic, productive, and institutional characteristics relevant to cocoa production during the periods considered. Section 3 analyzes the sources of production and growth, finding a powerful effect of marketing institutions and surprisingly little effect from alternative explanations for growth. This analysis is applied to a consideration of distributional implications in Section 4. Finally, Section 5 concludes.

Figure 1: Cocoa Prices and Production in Ghana, 1960–Present



Source: International Cocoa Organization

2 Descriptive Statistics

The evidence gathered in this paper suggests that, underlying the change in cocoa output, there have been important changes in the composition of the cocoa-growing population and the methods of cultivation employed. This paper uses data from the two rounds of the Ghana Cocoa Farmers' Survey, collected by the CSAE. Survey rounds took place in the late summer of 2002 and in the early fall of 2004. In each case, questions about cocoa production pertained to the preceding cocoa season—that is, September to August of 2001/02 and 2003/04.

The original 500 farmers were selected as a representative sample of cocoa farmers in the Ashanti, Brong Ahafo, and Western Regions of Ghana. Selection was based on those who identify cocoa farming as an income source in the Ghana Living Standards Survey 4 of 2000. Farmers come from 25 villages, with the most in the Western Region, followed by Ashanti and Brong Ahafo. (see Table 1 below for details). Of the original sample of 500 farmers interviewed in 2002, 443 were successfully re-interviewed in 2004.

Sample attrition was in many cases explicable, owing either to death (7 farmers) or migration (12 farmers). Hospitalization (1), inebriation (1), and police custody (1) combined with more mundane logistical problems to explain the rest. In the analysis that follows, attention is focused only on members of the panel interviewed in both waves.

As suggested by the dramatic change in aggregate cocoa output, there have been some dramatic changes in the rural and productive environment considered here. Household characteristics, the productive process, and the institutional context are described below.

2.1 Demographics of cocoa-growing population

Demographic characteristics of farmers interviewed are provided in Table 1 and are briefly explained here. Immediately striking is the large (more than 17%) decline in household size over the two-year period studied. This serves to foreshadow an important distinction between the number of workers and the number of days worked. At the same time, within the panel there has been little change in the characteristics of household heads. Taking the characteristics in Table 1 in turn, the change in the age of household heads reflects only the passage of time. There is a nearly imperceptible shift towards more male household heads, which serves primarily to highlight for the reader that the identity of household heads need not be the same. For this reason—if not the more insidious one of measurement error—the percentage of household heads to have completed primary school (henceforth variable `pschool`) appears to have decreased very slightly.

Some indication of the changing financial standing of cocoa farmers are suggested by the remaining characteristics. Consistent with the rise in output, the (self-reported) percentage of respondent’s income accruing from cocoa production has increased, though only by a small margin. Two proxies for farmer wealth are used in the analysis: the value of farm animals (livestock and poultry) and the value of agricultural equipment.¹ Both have increased substantially in real terms. Access to bank accounts has not changed significantly over the time period (henceforth variable `bank`). On the other hand, the fraction of farmers who report having borrowed money for use on the cocoa farm has decreased. Comparison of this variable across years is problematic, however. The intended question in both years is whether the respondent has *ever* borrowed money, meaning that in theory the response could only increase. It would appear in this case that, at least

¹Agricultural equipment is restricted to a subset of equipment types that were included in both rounds of the survey: spraying machines, cutlasses, hoes, and cocoa harvesters.

Table 1: Household Summary Statistics

year	2001/02			2003/04		
Ashanti Region	113 obs.			113 obs.		
Brong Ahafo Region (BA)	98 obs.			98 obs.		
Western Region	232 obs.			232 obs.		
variable	mean	sd	obs	mean	sd	obs
HH size	6.9	2.6	443	5.7	2.5	443
Age HH head	51	15	439	53	15	439
HH head male	.82	.38	441	.83	.38	434
HH head primary school educ.	.73	.44	441	.67	.47	433
Pct. income from cocoa	75	22	443	79	21	443
Has other income source	.86	.34	419	.64	.48	443
Val. farm animals owned*	2,544,677	24,193,978	442	3,399,849	27,495,128	443
Val. agric. equipment*	360,709	823,036	443	1,862,932	33,276,107	443
Has bank account	.45	.5	442	.44	.5	443
Has ever borrowed money	.51	.5	439	.25	.43	443
Val. tot. remittances rec'd*	115,548	539,627	408	54,850	391,003	412
Did not receive remittances	.86	.35	408	.96	.197	412

* Values in constant 2002 cedis.

Source: Ghana Cocoa Farmers Survey 2002, 2004

in 2003/04, respondents have wrongly interpreted the question as asking whether they have borrowed money *in the last year*. Finally, the average value of remittances received by farmers has decreased, and the fraction of farmers who received no remittance at all has increased. On the whole, then, these data suggest changes to the composition of cocoa growing households and to the financial means available to them during the period studied. This study will suggest some linkages between these trends and changes in cocoa production.

2.2 Cocoa Production, Inputs and Productivity

As reported in Table 2, average output in the panel has increased by 34 percent over the two-year period studied. This is remarkable in its own right, but captures only part of the aggregate growth in the sector; a variety of explanations may explain this divergence. Most obviously, growth could have come from other regions or from new farmers in the regions studied. The latter possibility highlights difficulties inherent in maintaining a representative sample of a growing sector. However, this finding needs to be reconciled with the incubation period of cocoa trees, since normally three to five years are required before they begin to bear. This can be explained on the basis of sampling method. For the survey of the 2001/02 crop year, farmers were chosen on the basis of the 2000 Ghana Living Standards Survey (GLSS) to be representative of the population of people *actually receiving income from cocoa production*. The survey therefore would have missed farmers who were new to cocoa production altogether and whose trees were not yet bearing by 2000.

On the other hand, it is also likely that the aggregate data overstate the dynamism of Ghanaian cocoa production. Price differentials between Ghana and its neighbors drive the smuggling of cocoa, as argued for example by Bulir (2002). Since domestic price changes affect these local differentials, the aggregate statistics may aggregate output flexibility.

While it may not be possible to explain all of the sector's growth with the data at hand, there is no a priori reason to believe that the effects identified here will not hold for other cocoa producers. As discussed below, farmers in the panel have combined extensive and intensive means of output expansion; classical economic theory suggests that they equate the ratio of marginal benefits to that of marginal costs from the different means. If for example the unobserved growth in the sector is due to the cultivation of new lands, it seems likely that the observed expansion will be more intensive in form. The costs of extensive expansion seem likely to increase in the long

Table 2: Cocoa Production Summary Statistics

year variable	2001/02			2003/04		
	mean	sd	obs	mean	sd	obs
kg cocoa	1,268	1,454	443	1,700	2,013	443
cocoa ha.	6.3	6	443	7.5	7.8	441
owned cocoa ha.	5.4	6	443	6.7	7.7	441
yield (kg./ha.)	250	259	443	277	276	441
output per labor- day	8.7	16	418	5.9	10	410
no. farms oper- ated	2	1.1	443	2.1	1.1	441
no. farms owned & operated	1.7	1.2	443	1.9	1.2	441
tot. farm ha. (including other crops)	7	6.8	443	8.2	8.5	441
men days	42	83	435	164	501	443
women days	44	69	437	93	236	442
child days	8.7	29	442	14	56	443
annual days	36	240	439	65	271	434
contract days	160	428	437	265	434	442
nnoboa days	30	146	442	23	89	431
tot labor days	328.14	617.53	421	640.01	930.21	421
fertilizer kg.	0.45	2.6	429	5.1	12	443
insectide use	0.86	0.35	442	0.94	0.24	442
use own spray machine	.82	.38	440	.88	.33	442
use govt spray machine	0	0	443	.92	.27	440
any spray ma- chine	0.82	0.38	440	0.98	0.12	443
hybrid use	0.79	0.41	443	0.67	0.47	443
hybrid share	0.58	0.39	443	0.48	0.41	441

Source: Ghana Cocoa Farmers Survey 2002, 2004

run, as new areas will become more congested; and the benefits of extensive expansion seem likely to decrease, as the best lands get planted first. Given this likely long-run trend away from extensive expansion, it seems important to identify the intensive means to output growth.

In Table 2, several types of labor inputs are identified. Household labor is divided among men, women, and children, with the latter defined as those under the age of 14. Paid labor may either be annual labor (paid on an annual basis and typically paid a share of output) or contract labor (paid on a short-term basis and typically paid a fixed wage). Finally, Nnobo labor represents a traditional labor-sharing arrangement used primarily for the harvesting of cocoa. For each of these labor types, Table 2 reports the number of person-days. There has been a dramatic increase in the number of days worked; this trend appears to be consistent across labor types.

Other productive inputs have also increased. Mean cultivated cocoa acreage has increased by more than 19 percent. Perhaps most dramatically, mean fertilizer use has increased from a mere 0.45 kg to 5.1 kg. There has been an increase of eight percentage points in the fraction of farmers using insecticide (for reasons of measurement error in the quantities of insecticide, attention is focused on a binary indicator variable here). The use of mechanical spraying machines is observed in two forms. As captured in the indicator variable `own spray`, it may be that farmers use a machine of their own (possibly borrowed). Farmers may also receive spraying assistance from a government spray ‘gang’ as part of a program begun in 2002/03; receipt of government spraying assistance is indicated by variable `govt spray`. Finally, the variable `spraymch` is defined to take a value of one if either `own spray` or `govt spray` equals one and to take a value of zero otherwise. Preliminary evidence suggests that the coverage of the government spray program has been quite good.

Turning to measures of productivity, mean yields have increased by 10.8 percent, while output per labor day has actually declined (not surprising given diminishing returns and the dramatic increase in total labor days). Choice of tree type is generally considered to be an important determinant of productivity (e.g., Edwin and Masters (2003)), but data on the precise usage of tree types from the 2001/02 study are rather coarse, making an assessment of this choice difficult. For each of their cocoa plots, farmers in 2001/02 were asked what type of trees they grow; whereas in 2003/04 they were also asked the share of land devoted to each tree type. Thus it is hoped that further research will allow more detailed study of this topic. Nonetheless, two measures of this technology choice have been constructed on the basis of available information. First, the indicator variable `hybrid use` takes a

value of one if a farmer uses hybrid trees on any of his or her plots. Second, the variable **hybrid share** is a weighted average (with weights given by the cocoa acreage of each plot) of the share of hybrid trees on each plot, where these shares are crudely estimated as one divided by the number of tree types present on the plot (Tettah Quashie and Amazon being the other principal types) if there are hybrid trees, or zero otherwise.

2.3 Institutional Context

Ghanaian cocoa policy has been gradually liberalized since the mid-1980s; for more details of this process see for instance Varangis and Schreiber (2001), this process has included the relaxation of price. The present analysis considers in particular the gradual replacement of the Ghana Cocoa Board (Cocobod) in its function as direct purchaser of cocoa with a group of Licensed Buying Companies (LBCs). The first LBCs were allowed to purchase cocoa domestically, buying and selling at prices fixed by the Cocobod, in the 1992/1993 season. Between the 2001/02 and 2003/04 surveys presented here, more than 25 distinct LBCs can be identified as operating in the three regions studied. This suggests the enthusiasm with which firms have entered this market in the decade or so since its inception. The process of liberalizing the export market continues, as the Cocobod has with effect from October of 2000 authorized limited, direct exports (Ghana Cocoa Board 2004).

This paper will argue that in spite of the fixed purchasing price, competition for producers' output by LBCs remains an important institutional feature—indeed, a driver of growth—in the cocoa sector. Varangis and Schreiber argue that competitive cocoa-purchasing markets stimulates efficiency and reduces the costs of delivery to port, resulting in a higher price for producers: “In countries with [stabilization fund or marketing board] systems... growers receive substantially less than growers in countries with effective competition among buyers” (Varangis and Schreiber 2001, p. 42). This claim is based on a comparison across countries; however, it is generally difficult to separate the competitive purchasing mechanism itself from (perhaps implicit) forms of taxation. The present paper seeks to address this challenge of identification by use of a microeconomic survey in which government taxation is uniform at any given time but localized differences in competition provide a way to identify the benefits of the purchasing system itself.

Table 3 presents a summary of statistics used to characterize this institutional environment. Competition among LBCs is on one level suggested by the thick presence among these companies. As indicated in Table 3, farmers

Table 3: Institutional Context: Summary Statistics

year variable	2001/02			2003/04		
	mean	sd	obs	mean	sd	obs
no. lbc in village	3.2	1.5	443	3.3	1.7	443
no. lbc sold	1.5	1.1	443	1.2	0.44	443
village lbc per farmer interviewed	0.17	0.12	443	0.18	0.15	443
lbc switches	.	.	0	1.1	1.2	443
lbc hhi	0.50	0.19	443	0.54	0.21	443
any lbc loans	0.16	0.37	443	0.22	0.41	443
any lbc inputs on credit	0.045	0.21	443	0.11	0.31	443
any lbc input subsi- dies	0.045	0.21	443	0.16	0.37	443
tot lbc loans	0.20	0.51	443	0.24	0.48	443
tot lbc inputs on credit	0.05	0.24	443	0.11	0.34	443
tot lbc input subsi- dies	0.05	0.24	443	0.18	0.44	443
pct lbc loans	0.13	0.32	443	0.2	0.38	442
pct lbc inputs on credit	0.04	0.19	443	0.1	0.3	442
pct lbc input subsi- dies	0.03	0.15	443	0.16	0.37	442

Source: Ghana Cocoa Farmers Survey, 2002 & 2004

in the sample reported an average of 3.2 LBCs in their village in 2001/02 and an average of 3.3 LBCs in 2003/04, while they sold to approximately 1.5 and 1.2 LBCs on average in these years, respectively. A concise indicator of local LBC concentration is given by the variable `lbc hhi`, a Hirschman-Herfindahl Index. This is defined here as the sum of squared market shares² at the village level, so that village-level monopoly receives a HHI of 1, and as average market shares decrease, the HHI approaches 0 in the limit. The average LBC HHI in the sample appears relatively steady across time at a value of slightly more than 0.5 and with a standard deviation of around 0.20.

However, as argued by Barrett (1997) in the case of Madagascar’s grain intermediaries, it will not always be the case that a decrease in concentration leads to competition at a disaggregated level. In the presence of transaction costs, the mere presence of potential competitors is not a guarantee of competitive behavior. Fafchamps (1999) further conjectures that factor markets will suffer from these transaction-cost effects even more severely than product markets. These findings seem to call for evidence of *realized* as opposed to *potential* competition.

By exploiting the panel dimension of the data, such supporting evidence is indeed available. The variable `lbc switches`, as reported in Table 3, is constructed as the sum of LBCs sold to in the 2001/02 season but not in 2003/04 (“drops”) plus LBCs sold to in 2003/04 but not in 2001/02 (“adds”). This reveals substantial churning beneath the surface: while the number of LBCs to which farmers sell has remained relatively constant, the mean number of LBC switches between the two periods is 1.1. By definition, switches are the sum of the net change in the number of farmers’ LBCs plus two times additions of LBCs that are offset by drops of others. Since the net change is 0.3, the total of 1.1 switches implies that there were an average of 0.4 drops, offset by an average of 0.4 adds. In other words, an average of 0.7 LBCs from which farmers purchased cocoa were dropped between 2001/02 and 2003/04—nearly half of the average 1.5 LBCs to which farmers sold.

To support the hypothesis that this competitive flux has implications for cocoa productivity, it is useful to have an indicator of the mechanisms of competition. While the Cocobod technically sets only a price floor, implying that there might be price competition among village level oligopsonistic LBCs, in practice LBCs almost never offer a higher price. On average in the

²Village-level market shares are based on cocoa sold by farmers in the sample. In the absence of information on the exact amount of cocoa sold to each LBC, market share is approximated by dividing each producer’s cocoa output equally among all LBCs to which they sold.

two years studied, fewer than 10 farmers report receiving a price higher than the official price from their primary LBC. The absence of price competition is confirmed by Varangis and Schreiber (2001, p. 63).

Nonetheless, LBCs provide several services to cocoa producers. Varangis and Schreiber argue that private competition has benefitted farmers, because LBCs have sought to win producer loyalty by providing such various services as inputs, school improvements, and utility poles (2001, p. 65). Three principal services are highlighted here: the provision of inputs on credit, the provision of subsidies for inputs, and the provision of loans outright (including, for example, lean-season consumption loans).³ In each case, farmer and LBC-specific indicator variables take a value of one if the service was provided. The prefix ‘any’ indicates the maximum of this indicator variable across all of the farmer’s LBCs; the prefix ‘tot’ corresponds to the sum; and the prefix ‘pct’ corresponds to the frequency of LBCs providing each service. Each of these services seems to be on the increase, although there is large variation in all cases. The diverse experiences of LBC clients and the changes in these experiences over time suggest plausible mechanisms that may link LBC competition to productivity and growth in the sector. This hypothesis is investigated in Section 3 below.

3 Cocoa Production, Market Structure, and Productivity Growth

To investigate the hypothesis that Licensed Buying Companies may affect the level and growth rate of productivity on cocoa farms, it is necessary to apply an empirical specification accommodating an analysis of both of these effects. At the same time, it is important to recognize sources of bias that typically plague econometric analysis of farm production; for example, the endogeneity of factor choices with respect to unobserved productivity determinants.

Based on efforts to address these issues below, this section presents analysis supporting the claim that Licensed Buying Company competition has improved productivity and that LBCs seem to positively affect the growth

³The first two of these are observed ex-post. For these variables, it is known whether credit or subsidies for inputs were actually received. On the other hand, the provision of general-purpose loans is only known as a recall of an ex-ante decision; that is, farmers were asked their reasons for choosing to sell to each LBC, and a farmer and LBC-specific indicator variable ‘lbc loans’ takes a value of one if the provision of loans formed part of their answer.

rate of productivity as well. To begin, an econometric specification is introduced that will allow investigation of these issues. Available instruments for addressing problems of endogeneity are further introduced. Subsequently, results are presented, first without and then with endogeneity addressed. Finally, the paper returns to the issue of specification, testing both the validity of instruments used and the necessity of doing so.

3.1 Specification

The econometric specification, as suggested above, has three main goals: First, it should allow for individual fixed effects, possibly correlated with regressors of interest, which have a bearing on the level of productivity. Second, it should investigate time-varying determinants of the level of productivity—these may be of direct interest (as in the case of LBC competition) in addition to their importance in light of the possibility of omitted variable bias. And third, the specification should allow for the possibility that both productive inputs as well as determinants of productivity may impact both the level and the growth rate of productivity. Again, this is important because of the direct interest in routes to productivity growth as well as the danger of omitted variable bias, as will be discussed in further detail below.

Production is modelled as taking a modified Cobb-Douglas form. It allows for individual-specific growth rates in a manner similar to that of Nickell (1996). In principle—although the distinction is perhaps less important with the present two-period panel—Nickell’s specification is extended slightly to allow for the individual growth-rates to vary over time. Accordingly, it is assumed that the output (in logs) of farmer i at time t is determined by the equation

$$y_{it} = \beta x_{it} + \delta w_{it} + \left(\sum_{s=1}^t \gamma_{i,s} \right) + \eta_i + \varepsilon_{it}, \quad (1)$$

where x_{it} gives productive inputs in logs; w_{it} are determinants of total factor productivity (TFP). The η_i are time-invariant, farmer-specific, unobserved characteristics that may be correlated with inputs, x_{it} , or productivity determinants, w_{it} , of interest and hence may be a source of bias. The concern that the ε_{it} may also be correlated with contemporaneous, observed factors will be set aside only momentarily.

The growth rate, γ_{it} , in Equation 1 is allowed to vary with (possibly a subset of) the lagged levels of x and w , as follows:

$$\gamma_{it} = \gamma_0 + \gamma_x x_{i,t-1} + \gamma_w w_{i,t-1}. \quad (2)$$

Without loss of generality, since correlation has already been allowed between the fixed effects and the observed regressors, it is assumed that $\gamma_{i,1} = 0$ for all farmers, i . It is assumed that γ_0 is common across all farmers and so uncorrelated with observables. In a two-period panel, it is not possible to address higher-order (e.g., growth rate) fixed effects by way of differencing, so this concern is deferred for future work. Furthermore, a time and farmer-specific stochastic component of the growth rate is omitted without loss of generality here, since this would be indistinguishable from the production shock, ε_{it} .

Noting the equivalence of fixed-effects and first-differenced estimators in a two-period panel, it will subsequently be convenient to refer to a differenced specification for estimation purposes. Differencing the data eliminates biases due to correlation between the fixed effects, η_i , and variables of interest. The result of this transformation can be written as

$$\Delta y_{it} = \beta \Delta x_{it} + \Delta w_{it} + \gamma_0 + \gamma_x x_{i,t-1} + \gamma_w w_{i,t-1} + \Delta \varepsilon_{it}. \quad (3)$$

The econometric importance of taking into account growth-rate effects of productive variables is suggested by Equations 3 and 1. If the lagged level of a variable $x_{i,t-1}$, say, is omitted from the empirical analysis, and if the series of x is not perfectly persistent (in which case $E[x_{it}|x_{i,t-1}] = x_{i,t-1}$), then estimates of β will be biased. Assuming, for example, an autoregressive coefficient for x between zero and one and that the true values of β and γ_x are positive, for example, the estimate of β will be downward biased. This econometric concern augments the economic one that the values of the γ parameters—in other words, the determinants of the growth rate—are of particular importance to the long-run prospects of the sector.

Even if growth rate effects are properly specified, problems of endogeneity may still pose a concern. In the present specification, the problem of simultaneity suggests a concern that there may be correlation between the ε_{it} and (a subset of) the x_{it} or w_{it} . Insofar as instrumental variables are available, a two-stage least squares (2SLS) procedure may be used to address such endogeneity. In the usual way, this requires sources of exogenous variation in the variables of interest. For example, given external instruments z_{it} and an endogenous subset of regressors $x_{it}^E \in x_{it}$ —momentarily assumed scalar for expositional simplicity—the dual requirements that the instruments be partially correlated with the endogenous variable, conditional on the observed exogenous variables in Equation 1:

$$E \left[x_{it}^E z_{it} | x_{it}^{\setminus E} \right] \neq 0, \quad (4)$$

and z_{it} must not have a direct effect on the dependent variable:

$$E[y_{it}|x_{it}, z_{it}] = E[y_{it}|x_{it}]. \quad (5)$$

Before turning to the availability of instruments that may resolve this problem, it merits noting that instrumental variables approach may help to mitigate attrition bias in the presence of classical measurement error. Since differencing the data to resolve the problem of fixed effects will decrease the ‘signal-to-noise’ ratio, worsening the measurement error problem, the potential value for instrumental variables estimation in this context is increased, even in the absence of simultaneity. Where measurement error is suspected to be particularly severe, as with labor inputs, this approach will be particularly important. The combined concerns of measurement error and simultaneity suggest a conservative approach, instrumenting short-run variable factors, labor, fertilizer, and insecticide use.

To address these issues, the approach below will employ a combination of ‘external’ and ‘internal’ instruments. External instruments used are: changes in the log of household size; changes in whether the household head has received preschool education (reflecting some turnover in the identity of household heads); changes in access to a bank account; both indicators and values of recent (last 3 years) cocoa expansion or replanting, bearing in mind the delay between the dates of planting and first bearing. The exclusion restrictions underlying the use of these instruments are discussed further and tested in Section 3.2.3.

Drawing on the work of Arellano and Bond (1991), it may be possible to use lagged levels of variables of interest as instruments in the first differenced equation (Equation 3). This instrumenting strategy is valid in the case where the regressor is endogenous only in the first-differenced transformation, that is, Δx_{it} is correlated with $\Delta \varepsilon_{it}$ *only* because lagged output affects current inputs by virtue of its correlation with the lagged error term ($E[x_{it}\varepsilon_{i,t-1}] \neq 0$). In this case, under the hypothesis that the potentially endogenous x_{it} is *predetermined* with respect to contemporaneous errors, one-period lagged levels provide valid instruments for the differences in right-hand-side variables. Stated more precisely, this requires the assumption that $E[x_{it}\varepsilon_{is}] = 0$ for all $s \geq t$. Then the first-period level, say $x_{i,1}$, will be correlated with the second-period difference $\Delta x_{i,2}$ (necessary for satisfaction of the condition in Equation 4) so long as the dependent variable does not follow a random walk. It is important to note that, for the first-period level to satisfy the condition of excludability with respect to the difference specification, as in Equation 5, the potential instrument must

in the first place not have direct, growth-rate effects. This is easy to see: if it has growth effects, then the lagged level should be included directly in estimating Equation 3.

3.2 Results

In accordance with the concerns expressed above, OLS and instrumental-variables estimates are presented in this section. In general, it is expected that movement from a levels to a fixed effects specification will increase the effect of attrition bias, pushing coefficients towards zero. As discussed above, instrumental variables estimation under the assumption of predetermination may reduce this bias; this will also address endogeneity introduced by the first-differenced transformation if right-hand-side variables are predetermined but not strictly exogenous. Furthermore, the depression of coefficients caused by ignoring growth-rate effects will be shown in the results below.

The argument below proceeds in three steps. First, the estimated coefficients on inputs of production are discussed. It is argued that increases in factor intensity are likely to have played a major role in the expansion of cocoa output. Second, determinants of total factor productivity are considered. Central to the argument put forward in this paper, evidence is provided to support the hypothesis that competition among Licensed Buying Companies has been important for the level and the growth rate of total factor productivity. Following this, tests of specification (and the instrument set in particular) are discussed in Section 3.2.3.

3.2.1 Factors of Production

Results of the OLS and 2SLS estimation of the production of (the log of) cocoa are presented in Tables 4 and 5, respectively, with first-stage regressions for all 2SLS estimation procedures contained in the Appendix. The OLS results of Table 4 are expressed in terms of the levels specification of Equation 1, even though the fixed-effects estimates were obtained by first-differencing the two-period panel. Accordingly, but in an abuse of notation, the TFP growth-rate effects—in other words, the determinants of γ_{it} in Equation 1—are written with the prefix ‘t × L.’. This is intended to indicate that these variables are interactions of the respective lagged levels with a time dummy, taking a value of one in the second period and zero otherwise. The estimates were obtained in more straightforward fashion, by simply including the lagged levels in estimation of the first-differenced equation (Equation 3).

OLS estimates begin in Column (1) with a straightforward levels estimation that ignores growth-rate effects but attempts to control for determinants of productivity. These determinants are of interest in themselves and that threaten to bias coefficients on observed factors of production. Column (2) addresses time-invariant, unobserved farmer characteristics by means of a first-differenced transformation. While there is in fact some time-series variation in gender, age (beyond the trend, of course), and education of the household head, it was deemed that these were due to only a very few changes in household head, often attributable to measurement error, and so these controls are omitted from the difference specification for sake of parsimony. Column (3) includes hypothesized determinants of growth, with regional controls⁴ and village size included to ensure that the LBC HHI is not biased by omission of this variable. Finally, Column (4) of Table 4 presents an expanded set of theoretical determinants of growth rates.

Several factors of production are considered. Four of these are continuous variables: the log of land in hectares, `ln ha. cocoa`; the log of total labor days, `ln labor days`; the fraction, `frac paid days`, of these days that were paid labor (contract or annual, as defined in Section 2.2); and the log of 50 kilogram bags of fertilizer used, `ln fertilizer`. Indicator variables are also included for insecticide use (`insecticide`), and government or private spray machine use (`govspray` or `ownspray`, respectively).

The two-stage least squares estimates presented in Table 5 allow for the endogeneity of the changes in total labor days, the fraction of paid labor, fertilizer quantity, and insecticide use in the difference specification, while allowing for farmer-specific fixed effects and maintaining the assumption of predetermination in the levels, as described in the previous section. The estimated equation is therefore of the form in Equation 3. The dependent variable in all columns of Table 5 is the change in the log of cocoa output; prefix ‘D.’ in right-hand-side variables refers to the difference between 2001/02 and 2003/04, and prefix ‘L.’ refers to the lagged level of these variables. Column (1) omits growth-rate effects; Column (2) allows a basic set of determinants of TFP growth, and Column (3) considers a broader set of growth-rate determinants, as was done in the OLS estimations of Table 4.

In general the results conform to earlier studies of cocoa production in Ghana. As has been argued with respect to the ‘inverse-productivity’ relationship between land and yields by Lamb (2003), it is likely that measurement error depresses estimated returns to farm size in a fixed effects

⁴Brong Ahafo, or BA, the Western Region are specifically identified, with the Ashanti Region omitted.

specification. Thus it is not surprising to find that the movement to a first-differenced specification from Column (1) to Column (2) reduces the coefficient on land. Indeed, point estimates for labor inputs, fertilizer use, and insecticide and private and government spray machine indicators all drop after differencing; statistical significance of labor is lost. Columns (3) and (4) introduce growth-rate effects. As suggested above, the omission of these effects may bias estimates of the determinants of the level of production, but the differences observed with respect to productive inputs is rather small. Discussion of the differences between specifications of Column (3) and (4) is deferred to the discussion of determinants of TFP, below.

However, it should be noted that these first-differenced estimates obtained by OLS are still somewhat higher than those obtained elsewhere: cf. the repeated cross-section analysis in Teal and Vigneri (2004), who suggest an OLS coefficient on the log of cocoa land of 0.332 with a standard error of 0.041. If this effect were to hold up after instrumenting for variable inputs, it would be consistent with the presence of omitted variables (e.g., land quality) that are inversely related to farm size. The econometrician would face a trade-off in evaluating the relative biases of measurement error and persistent omitted variables such as land quality.

However, the land coefficient in the present OLS results may also be inflated if there is attrition bias in correlated inputs, such as labor use. The sources of this attrition bias is addressed in Table 5 by use of instrumental variables. As mentioned above, that approach further mitigates the possibility that short-term variable inputs (here referring to all productive inputs discussed previously with the exception of land) are predetermined but not strictly exogenous, so that the difference specification is biased. Indeed, comparing Columns (1), (2), and (3) in Table 5 with the parallel specifications of Columns (2), (3), and (4) in Table 4, significant differences emerge. While the coefficient on land is only slightly reduced, there are economically statistically significant increases in point estimates for labor and fertilizer quantities. The apparent effect of instrumenting is consistent with measurement error, and the apparent effect of accounting for growth-rate determinants may perhaps help to explain the upward trend in coefficients from Columns (1) to (2) and (3) of Table 5.

The coefficient on participation in the government spray program merits brief attention here as well, due to its policy implications. In the (favored) 2SLS estimation procedures, the coefficient on participation in this program is positive but not statistically significant. This may be due to the fact that participation is measured with some error: experiences with this program vary, and not all farmers report having received the full (four visit) routine.

Thus further study that investigates the implementation of this program appears to be required in order to identify its effects with any confidence.

The F statistic reported at the bottom of Table 4 and the χ^2 statistic at the bottom of Table 5 correspond for a test of constant returns to scale in the variable inputs land, (total) labor, and fertilizer. While the OLS estimation rejects this hypothesis, 2SLS estimation procedures that allow for growth-rate effects (columns (2) and (3) of Table 5) cannot reject the hypothesis of constant returns to scale, even at a 10 percent confidence level. In light of the economically and significantly significant effects of these variable inputs, and of the possibility of relatively high—if not constant—returns to scale, it seems that increases in factor inputs go a long way to explaining output expansion within the panel. The dramatic increase in fertilizer application seems to have been particularly important in this context.

3.2.2 Determinants of Productivity

Estimates of the returns to factors of production are important in the context of this paper not only in their own right but also because they allow an analysis of the determinants of the level and growth rate of total factor productivity (TFP). The view taken in this paper is that estimation of these TFP effects should be undertaken jointly with estimation of the returns to traditional factors of production because of the danger of omitted variable bias.

Turning to the variable of interest, the results of both OLS and 2SLS estimation procedures reveal a large and significant effect of LBC competition on both the level and the growth of TFP (bearing in mind that the LBC HHI decreases as average market shares decrease). The magnitude of the TFP level effect—given by the coefficient on `lbchhi` in Table 4 and the coefficient on Δ `lbchhi` in Table 5—increases when the growth-rate effect is introduced, as expected. Comparison with Table 5 reveals that these effects are stronger after instrumenting for productive inputs. The observed effect of LBCs is robust to the inclusion of both regional controls and a host of other plausible determinants of productivity growth: the share of owned land of all farmed land, the share of hybrid trees, and the gender and education of the household head. The effect of LBC competition does not seem to be driven by village size, and the inclusion of squared village size makes no difference to the result of interest.

It is worth stressing the economic significance of these results. The standard deviation of the LBC HHI in 2001/02, as given in Table 3, is 0.19. This implies that even under the relatively conservative estimates Table ??

Column (3), which estimates the full model by OLS and allows for growth-rate effects, an improvement in LBC competition by one standard deviation would result in a 29% increase in TFP in that year and an expected growth rate of TFP that is increased by 14 points.

The estimated determinants of TFP levels and growth are striking both for the robustness of the LBC effect and for the apparent *insignificance* of other factors. These are investigated in Column (3) of Table 5. It should be noted that the number of instruments here exceeds the number of villages, thereby precluding clustering of standard errors at the village level, so one should disregard confidence levels for village-level variables in this case. Neither ownership, levels of hybrid trees, gender, schooling, village size, nor even the presence of other income sources has a significant effect in either the OLS or 2SLS estimation procedures. Tests labelled ‘*excl F*’ and ‘*excl p*’ in Column (4) of Table 4 provides an F test of the joint exclusion of the additional growth rate variables (ownership, share of hybrid trees, household head age and gender, village size squared, and the presence of other income sources). It is not possible to reject the hypothesis that they are jointly insignificant, even at a 10 percent level. Since, if anything, inclusion of these other possible growth-rate effects increases the magnitude of the coefficient on the LBC growth-rate effect, this analysis does not suggest an omitted variable proxied by the presence of LBC competition.

Table 4: Ordinary Least Squares Estimation of Cocoa Production

	ln cocoa (kg.)	ln cocoa (kg.)	ln cocoa (kg.)	ln cocoa (kg.)
	(1)	(2)	(3)	(4)
Const.	5.287*** (.33)	.	.	.
trend	-.25** (.124)	.134 (.211)	.045 (.303)	.03 (.59)
ln ha. cocoa	.574*** (.061)	.402*** (.062)	.417*** (.067)	.424*** (.067)
ln labor days	.122*** (.037)	.053 (.035)	.049 (.035)	.033 (.039)
frac paid days	-.032 (.079)	-.142 (.092)	-.108 (.089)	-.109 (.1)
ln fertilizer (50 kg. bags)	.038*** (.007)	.015* (.008)	.024*** (.007)	.023*** (.007)
insecticide	.173 (.153)	.072 (.183)	.082 (.178)	.095 (.194)
ownspray	.018 (.126)	.015 (.145)	-.03 (.135)	-.03 (.138)
govspray	.186 (.114)	.018 (.193)	.131 (.152)	.111 (.157)
hybridshare	-.086 (.085)	-.043 (.072)	-.007 (.069)	.07 (.129)
lbchhi	-.669* (.406)	-1.013** (.394)	-1.57*** (.474)	-1.603*** (.52)
ownership	-.058 (.163)	-.133 (.151)	.0002 (.163)	-.027 (.163)
hhh male	.317*** (.105)	.	.	.
age hhh	.0006 (.003)	.	.	.
primary educ hhh	.009 (.082)	.	.	.
villsize	.002 (.01)	.	.	.
BA	-.074 (.281)	.	.	.
Western	.181 (.168)	.	.	.
t × L.lbchhi	.	.	-.754** (.38)	-.624* (.366)
t × L.ln fertilizer	.	.	-.015 (.02)	-.006 (.021)
t × L.villsize	.	.	.005 (.009)	-.016 (.03)
t × BA	.	.	.045 (.161)	.055 (.163)
t × Western	.	.	.26* (.14)	.262 (.165)
t × L.ownership	.	.	.	-.069 (.146)
t × L.hybridshare	.	.	.	.155 (.228)
t × L.hhhsex	.	.	.	.072 (.171)
t × L.pschool	.	.	.	.142 (.121)
t × L.villsize ²	.	.	.	.0005 (.0007)
t × L.otherincome	.	.	.	.032 (.143)
Obs.	790	368	368	346
R ²	.443	.186	.234	.243
F statistic	14.244	46.461	42.51	40.793
p-value	.0009	4.75e-07	9.62e-07	1.33e-06
excl F	.	.	.	1.101
excl p	.	.	.	.391

Notes: (i.) Robust standard errors reported, clustered by village. (ii.) F statistic and p -values correspond to a test of the hypothesis that $\beta_{\ln(ha\ cocoa)} + \beta_{\ln(labor\ days)} + \beta_{\ln(fertilizer)} = 1$.

Table 5: Two-Stage Least Squares Estimation of Cocoa Production

	$\Delta \ln(\text{cocoa, kg.})$	$\Delta \ln(\text{cocoa, kg.})$	$\Delta \ln(\text{cocoa, kg.})$
	(1)	(2)	(3)
Const.	-.34 (.292)	.31 (.53)	1.677 (1.346)
D.ln ha. cocoa	.37*** (.066)	.318*** (.069)	.319*** (.115)
D.ln labor days	.231** (.092)	.318*** (.083)	.329*** (.128)
D.frac paid days	.281 (.263)	.323 (.234)	.235 (.302)
D.ln fertilizer	.155** (.062)	.178*** (.046)	.215*** (.082)
D.insecticide	.457 (.315)	.511 (.322)	.454 (.363)
D.ownspray	-.312 (.251)	-.369 (.236)	-.391 (.294)
D.govspray	-.163 (.24)	.047 (.176)	.072 (.25)
D.hybridshare	-.019 (.107)	.27* (.15)	.266 (.213)
D.lbchhi	-.78 (.497)	-1.052* (.61)	-1.351** (.639)
D.ownershp	-.522** (.237)	-.315 (.249)	-.557 (.363)
L.lbchhi	.	-1.695** (.669)	-1.933** (.766)
L.lnfert	.	.103** (.043)	.141** (.067)
L.villsize	.	.002 (.011)	-.051 (.055)
L.hybridshare	.	.467** (.216)	.358 (.285)
BA	.	.2 (.265)	.092 (.243)
Western	.	.271 (.321)	.283 (.22)
L.ownershp	.	.	-.329 (.347)
L.hhhsex	.	.	-.218 (.296)
L.pschool	.	.	-.029 (.193)
L.villsize ²	.	.	.001 (.001)
L.otherincome	.	.	.011 (.236)
Obs.	339	339	322
e(j)	7.401	8.147	5.13
e(jp)	.388	.32	.644
e(jdf)	7	7	7
χ^2 statistic	2.734	2.347	.435
Degrees of freedom	1	1	1
p -value	.098	.126	.509
sheapr2 Dlnlabordays	.293	.224	.214
sheapr2 Dfracpaidd	.386	.387	.428
sheapr2 Dlnfert	.039	.051	.041
sheapr2 Dinsecticide	.42	.43	.483

Notes: (i.) Robust standard errors reported; clustered by village in Columns (1) and (2) but not (3). (ii.) χ^2 and related p -values correspond to a test of the hypothesis that $\beta_{\ln(ha\ cocoa)} + \beta_{\ln(labor\ days)} + \beta_{\ln(fertilizer)} = 1$.

3.2.3 Tests of Instruments

Table 5 reports Hansen's j statistic (along with p -values and degrees of freedom) as a test of overidentifying restrictions. This is consistent under heteroskedasticity and arbitrary correlation within clusters. In all cases the null hypothesis of valid instruments cannot be rejected. This may be seen as an endorsement of the hypothesis of predetermination for the internal instrument set. However, some caution is required here, as the limited external instrument set implies that this test will have relatively little power.

Shea's partial- R^2 statistic is reported for each of the endogenous variables in the 2SLS specification, in order to give an indication of the explanatory power of the excluded instrument set. The relatively low partial- R^2 in the instrumenting equation for the difference in the log of fertilizer use is a cause for concern. This appears to stem from the fact that the lagged level of fertilizer could not be used as an instrument for the subsequent difference. The Hansen j -statistic rejects the instrument set when lagged fertilizer is included (not shown); it is clear that this would be the case from the statistical significance of the lagged fertilizer level in Columns (2) and (3) of Table 5. The specification shown remains valid if fertilizer use is predetermined in Equation 1. On the other hand, it is also possible that the lagged (that is, period 1) level of fertilizer would be rejected as an instrument because it is correlated with $\varepsilon_{i,1}$, in which case it is endogenous and should itself be instrumented. Testing this possibility may require a more powerful set of external instruments than is presently available. Nonetheless, it is argued that there is strong support for the central hypothesis that competitive market institutions have brought significant benefits to the level and growth rate of total factor productivity in cocoa production.

4 Extension: *Shared Growth?*

While LBC competition may provide incentives or means for farmers to improve total factor productivity, it need not be the case that these incentives will be equally distributed across the population. More generally, although competitive institutions have certainly been advocated as means to shared growth (see for instance Srinivasan (2000)), their distributional consequences have often been regarded with some skepticism.

There are many possible ways in which LBC competition could have detrimental effects for the distribution of cocoa farmers' incomes; examples can be drawn by analogy for a wide array of economic studies. Tournament-style reward systems by competing LBCs could provide incentives for only

the more productive of farmers. For example, in studying incentives to innovate in patent races, Christopher Harris and John Vickers (1987) suggest that the leader in an innovation race may have greater incentives to innovate. By analogy, if relatively unproductive farmers can see that they have little chance of winning any reward from the LBC, they may have comparatively little incentive to undertake productivity-enhancing innovations.

However, it need not be the case that LBC competition as a means to growth should have adverse effects on equality. For example, consider the possibility that LBCs respond to competition by offering insurance to producers. This may benefit output by reducing producers' distaste for risky investments or technologies. Such an effect may apply disproportionately to those producers who are the most risk-averse in absolute terms; it seems most likely to boost the production of poor farmers. The equality implications of LBC competition therefore seem ambiguous a priori.

One available strategy for testing inequality in growth effects is to include lagged levels of wealth or productive capacity and their interactions with the measure of LBC competition in the first-differenced specification. This is the approach taken in Table 6. If LBCs exacerbate inequality, then the interaction between measures of wealth and the LBC HHI should be negative: competition (implying lower HHI) should have an even stronger growth-rate effect for the wealthy.

In Table 6, three measures of initial wealth and productive capacity are considered. The first uses an indicator, `bigfarm`, that takes a value of one if the size of the farmer's cocoa lands in 2001 was greater than the median size for that year. The second uses an indicator, `animalwealth`, taking a value of one if the value of livestock and poultry in 2001 was above the median. A third proxy for wealth and productive capacity is defined in the variable `bigagequip`, taking a value of one for farmers with agricultural equipment valued in excess of the median. Both the lagged level of each and its interaction with the LBC HHI is added to the preferred 2SLS specification of Table 5, Column (2) for this purpose.

The evidence presented in Table 6 finds no support for the hypothesis that the benefits of competitive institutions accrue disproportionately to those of higher wealth or productive capacity. It should be noted first that none of the proxies employed have statistically significant growth-rate effects; indeed, each enters with a statistically insignificant negative sign. Moreover, coefficients on the various interaction terms in the difference specification are positive but insignificant. While one should clearly not put too much weight on the interpretation of these point estimates, they do seem to imply at least that the productive benefits of LBC competition are not

Table 6: Distributional implications of LBC-driven growth

	$\Delta \ln(\text{cocoa, kg.})$	$\Delta \ln(\text{cocoa, kg.})$	$\Delta \ln(\text{cocoa, kg.})$
	(1)	(2)	(3)
Const.	.807 (.635)	.52 (.567)	.818 (.603)
D.ln ha. cocoa	.251** (.118)	.319*** (.11)	.333*** (.106)
D.ln labor days	.274*** (.103)	.307*** (.104)	.253** (.098)
D.frac paid labor	.302 (.276)	.344 (.282)	.315 (.271)
D.ln fertilizer	.196*** (.074)	.185*** (.062)	.187*** (.063)
D.insecticide	.563 (.345)	.508 (.329)	.5 (.323)
D.ownspray	-.423 (.28)	-.368 (.258)	-.38 (.258)
D.govspray	.035 (.234)	.02 (.233)	.007 (.229)
D.hybridshare	.27 (.19)	.268 (.19)	.23 (.178)
D.lbchhi	-1.353** (.549)	-1.045** (.509)	-1.183** (.498)
D.ownership	-.361 (.279)	-.31 (.266)	-.287 (.268)
L.lbchhi	-2.021*** (.754)	-1.805** (.735)	-1.865** (.726)
L.lnfert	.125** (.062)	.113** (.054)	.124** (.056)
L.hybridshare	.385 (.257)	.46* (.264)	.41 (.255)
L.villsize	.001 (.011)	.0007 (.01)	.001 (.01)
BA	.214 (.205)	.239 (.203)	.157 (.205)
Western	.349* (.192)	.331* (.197)	.278 (.19)
L.bigfarm	-.569 (.397)	.	.
L.lbcxbigfarm	.447 (.714)	.	.
L.animalwealth	.	-.315 (.363)	.
L.lbcxanimalwealth	.	.276 (.675)	.
L.bigagequip	.	.	-.545 (.367)
L.lbcxbigagequip	.	.	.364 (.693)
Obs.	339	339	339
e(j)	7.303	6.59	6.724
e(jp)	.398	.473	.458
e(jdf)	7	7	7

Note: Statistics j , jdf , and jp refer to Hansen's j -statistic for the test of overidentifying restrictions and associated degrees of freedom and p -value. Robust standard errors computed.

skewed heavily towards wealthier farmers. This supports the view that market reforms are a potential mechanism for supporting growth without incurring great distributional costs.

5 Conclusions

This paper has analyzed the determinants of cocoa production, focusing on the role of market institutions in determining productivity. It is argued that competition among Licensed Buying Companies has not only a levels but also a growth rate effect on total factor productivity. These effects are of striking economic and robust statistical significance. Furthermore, they appear to come without an identifiable cost—and perhaps even with a benefit—in terms of underlying inequality.

It is important to emphasize some inherent limitations of the present study. First, it does not seem possible to capture all of the growth observed in aggregate (national) statistics on cocoa production. If the aggregate statistics are to be believed, it is suggested that the sampling frame in the first round of the survey may have allowed for beginner cocoa producers already ‘in the pipeline’ to go unsampled in that year, resulting in an underestimate of subsequent growth when these producers ‘came on line’. This may be less of a serious problem if the reversal in the direction of cocoa smuggling during the time period considered accounts for a significant portion of the change in the aggregate statistics: micro evidence may paint a more meaningful picture of long-run changes in output and productivity in response to price signals.

Secondly, in a two-period panel with official prices common across all farmers, it will not be possible to distinguish pure growth effects (e.g., some form of exogenous technological change) from responses to price incentives (e.g., the application of unobserved inputs in response to pre-announced changes in the returns to these inputs). For this reason, it is best to remain cautiously agnostic: it should only be suggested that the institutional change studied allows farmers to better respond to price incentives when prices increase, rather than claiming that it causes growth per se.

Nonetheless, these limitations may be resolved by future study. It is hoped that the economic relationship identified between Licensed Buying Companies and productivity changes in Ghanaian cocoa farming will contribute to an understanding of the relationship between institutions and growth. The institutions examined here seem to hold out the promise of acting as catalysts for future productivity growth.

References

- ARELLANO, M., AND S. BOND (1991): "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations," *Review of Economic Studies*, 58(2), 277–97, London School of Econ; U Oxford.
- BARRETT, C. B. (1997): "Food Marketing Liberalization and Trader Entry: Evidence from Madagascar," *World Development*, 25(5), 763–777.
- BULIR, A. (2002): "Can Price Incentive to Smuggle Explain the Contraction of the Cocoa Supply in Ghana?," *Journal of African Economies*, 11(3), 413–39, Imf.
- EDWIN, J., AND W. MASTERS (2003): "Genetic Improvement and Cocoa Yields in Ghana," Mimeo, www.earth.columbia.edu/cgsd/documents/EdwinAndMasters-ExperimentalAgriculture-Final.pdf.
- FAFCHAMPS, M. (1999): "Networks, communities and markets in Sub-Saharan Africa: implications for firm growth and investment," University of Oxford, Centre for the Study of African Economies, Working Paper Series, No. 1999-108.
- GHANA COCOA BOARD (2004): "Export of Coocoa Regulations," available at http://www.cocobod.gh/pdf/Export_of_Cocoa_Regulations.pdf.
- HARRIS, C., AND J. VICKERS (1987): "Racing with Uncertainty," *Review of Economic Studies*, 54(1), 1–21.
- INTERNATIONAL COCOA ORGANIZATION (2004/05): "Quarterly Bulletin of Cocoa Statistics," Volume 31, No. 2.
- LAMB, R. L. (2003): "Inverse productivity: land quality, labor markets, and measurement error," *Journal of Development Economics*, 71, 71–95.
- NICKELL, S. J. (1996): "Competition and Corporate Performance," *Journal of Political Economy*, 104(4), 724–46.
- SRINIVASAN, T. N. (2000): "Poverty and undernutrition in South Asia," *Food Policy*, 25, 269–282.
- TEAL, F., AND M. VIGNERI (2004): "Production Changes in Ghana Cocoa Farming Households under Market Reforms," Centre for the Study of African Economies, Working Paper No. 2004-16.

VARANGIS, P., AND G. SCHREIBER (2001): "Cocoa Market Reforms in West Africa," in *Commodity Market Reforms: Lessons of Two Decades*, ed. by T. Akayima, J. Baffes, D. Larson, and P. Varangis, chap. 2, pp. 35–82. The World Bank, Washington, D.C.

6 Appendix

Table 7: First-Stage Estimates: Table 5 Column(1)

	(1)	(2)	(3)	(4)
	Dlnlabord	Dfracp	Dlnfert	Dinsecticide
Dlnhsize	.967*** (.319)	-1.22*** (.041)	-1.242* (.666)	-.025 (.029)
Dbank	.124 (.187)	.04* (.024)	.636 (.394)	-.01 (.017)
Dpschool	.138 (.398)	-.028 (.051)	-.612 (.837)	.026 (.037)
L2lnlabord	-.953*** (.124)	.052*** (.016)	.467* (.264)	.006 (.011)
L2fracp	1.013** (.401)	-.772*** (.052)	1.012 (.846)	.013 (.038)
L2insecticide	-.07 (.433)	.03 (.054)	1.189 (.876)	-.73*** (.039)
L2lnhsize	.499 (.317)	-.077* (.041)	-.036 (.67)	-.019 (.029)
Dlnvalexpand	.097 (.119)	.006 (.015)	.297 (.25)	.033*** (.011)
Dnoexpand	1.741 (2.17)	.087 (.268)	5.469 (4.546)	.607*** (.2)
Dlnvalreplant	.065 (.091)	.015 (.011)	-.11 (.187)	-.012 (.008)
Dnoreplant	1.226 (1.587)	.313 (.196)	-1.861 (3.248)	-.235 (.144)
Obs.	359	333	350	359
F statistic	5.142	13.102	2.013	49.228
R ²	.204	.482	.119	.763
χ ² statistic	80.891	261.304	18.074	403.243
Degrees of freedom	11	11	11	11
p-value	9.92e-13	0	.08	0

Notes: Partial effects of exogenous variables included in regression, but only excluded instruments shown for reasons of space. χ^2 and related p -values correspond to a test for the joint exclusion of external instruments.

Table 8: First-Stage Estimates: Table 5 Column(2)

	(1)	(2)	(3)	(4)
	Dlnlabord	Dfracp	Dlnfert	Dinsecticide
Dlnhsize	1.01*** (.328)	-1.19*** (.042)	-.48 (.593)	-.034 (.03)
Dbank	.197 (.193)	.039 (.024)	.573* (.347)	-.016 (.018)
Dpschool	.158 (.409)	-.019 (.052)	-.368 (.736)	.028 (.038)
L2lnlabord	-1.026*** (.131)	.041** (.017)	.785*** (.234)	.009 (.012)
L2fracp	1.127*** (.414)	-.771*** (.053)	.89 (.752)	.029 (.039)
L2insecticide	-.165 (.441)	.028 (.055)	1.311* (.775)	-.731*** (.04)
L2lnhsize	.601* (.328)	-.068 (.042)	.399 (.591)	-.021 (.03)
Dlnvalexpand	.071 (.123)	.008 (.015)	.346 (.22)	.035*** (.011)
Dnoexpand	1.174 (2.238)	.122 (.274)	6.384 (4.005)	.634*** (.206)
Dlnvalreplant	.069 (.093)	.015 (.011)	-.174 (.165)	-.014* (.008)
Dnoereplant	1.35 (1.615)	.316 (.199)	-2.88 (2.86)	-.274* (.147)
Obs.	349	323	350	349
F statistic	3.859	10.299	5.744	38.052
R ²	.215	.495	.334	.769
χ ² statistic	83.571	254.542	33.885	389.938
Degrees of freedom	11	11	11	11
p-value	3.00e-13	0	.0004	0

Notes: Partial effects of exogenous variables included in regression, but only excluded instruments shown for reasons of space. χ^2 and related p -values correspond to a test for the joint exclusion of external instruments.

Table 9: First-Stage Estimates: Table 5 Column(3)

	(1)	(2)	(3)	(4)
	Dlnlabord	Dfracp	Dlnfert	Dinsecticide
Dlnhsize	.98*** (.34)	-.119*** (.042)	-.48 (.593)	-.034 (.03)
Dbank	.155 (.201)	.039 (.024)	.573* (.347)	-.016 (.018)
Dpschool	-.019 (.437)	-.019 (.052)	-.368 (.736)	.028 (.038)
L2lnlabord	-.943*** (.139)	.041** (.017)	.785*** (.234)	.009 (.012)
L2fracp	1.009** (.437)	-.771*** (.053)	.89 (.752)	.029 (.039)
L2insecticide	-.403 (.46)	.028 (.055)	1.311* (.775)	-.731*** (.04)
L2lnhsize	.374 (.345)	-.068 (.042)	.399 (.591)	-.021 (.03)
Dlnvalexpand	.047 (.125)	.008 (.015)	.346 (.22)	.035*** (.011)
Dnoexpand	.709 (2.286)	.122 (.274)	6.384 (4.005)	.634*** (.206)
Dlnvalreplant	.094 (.095)	.015 (.011)	-.174 (.165)	-.014* (.008)
Dnoreplant	1.851 (1.659)	.316 (.199)	-2.88 (2.86)	-.274* (.147)
Obs.	332	323	350	349
F statistic	3.149	10.299	5.744	38.052
R ²	.225	.495	.334	.769
χ ² statistic	70.089	254.542	33.885	389.938
Degrees of freedom	11	11	11	11
p-value	1.17e-10	0	.0004	0

Notes: Partial effects of exogenous variables included in regression, but only excluded instruments shown for reasons of space. χ^2 and related p -values correspond to a test for the joint exclusion of external instruments.