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Research Paper

Determinants of cocoa production in the Ashanti region

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The economic benefits of cocoa in Ghana include foreign exchange, employment and provision of raw materials for both domestic and international industries. For these reasons, there has been a government intervention in the cocoa industry that brought forth policies including increased producer price and also cocoa pest and disease control programme (CODAPEC) to stimulate cocoa production. However, studies investigating factors influencing cocoa production in Ghana are very scarce. This study obtained Ordinary Least Squares (OLS) estimates from a Cobb-Douglas production function using cross section data obtained from 251 farmers. The respondents were selected using Random sampling technique. Questionnaires were administered to respondents and the items comprised farmers' production years, farm size, family labour, hired labour, farm age, bags of fertilizer, Number of times of mass spraying and total Revenue. The dependent variable was output. The Log-Linear regression results showed an adjusted co-efficient of determination of 0.972. It was found that the total revenue and hired labour variables had significant influence on cocoa production. Both variables were significant at 1%. The number of times of mass spraying and farm size variables were statistically insignificant. This study could have important policy implication for government to increase producer price of cocoa.

Key Words: Ordinary Least Squares,Cobb-Douglas production function, Log-Linear regression, Cocoa, and Co-efficient of determination

INTRODUCTION

In Ghana, cocoa occupies a key position in terms of foreign exchange revenues, domestic incomes, and employment. Cocoa contributed about 3.4% to gross domestic product annually and an average of 29% to total export revenue between 1990 and 1999 (COCOBOD, 2000) and 22% between 2000 and 2002 (COCOBOD, 2009). The Ghana Cocoa Board (COCOBOD) signed a $1.5 billion pre-export trade finance facility for the purchase of cocoa for the 2010/2011 season. Ghana's export earnings in 2007 amounted to $4,214 million in merchandise trade (14% annual increase, GNA 2008). For 2008, merchandise exports totalled $5,275.33 million. This shows a significant increase in the overall export earnings of Ghana in 2008 compared to 2007. The

increase is mainly attributed to the rise in world price for cocoa (Economic Report Ghana, 2008).

From 2002-2003, the volume of cocoa produced in Ghana grew at an average yearly rate of 16% (ODI, 2004). In the 2003/2004 production year Ghana recorded an output of over 600,000 tonnes (GNA, 2004) and by 2008/2009 Ghana had achieved an output of 710,000 tonnes. According to Teal and Vigneri (2003) the increase in cocoa production is due to the increase in producer price of cocoa from less than GH¢100 to GH¢420, fertiliser use and a government sponsored mass-spraying exercise beginning in 2001.

Despite the significant achievement in cocoa production the early 2000, scores of studies have identified certain factors that have contributed to the dwindling cocoa production levels in Ghana. Paramount among these factors are the ravages caused by cocoa capsids (Heteroptera: Miridae) and diseases such as swollen shoot caused by cocoa swollen shoot virus and black pod caused by the fungi *Phytophthora palmivora* and *P. megakarya*.

Edwin and Masters, (2003) tested the magnitude of correlation between cocoa yield and hybrid variety use in Ghana. They found that hybrid variety have higher output than the traditional cocoa types. Anim-Kwapong and Frimpong, (2005) studied the impact of climatic conditions on cocoa production in the New Tafo Akim. They also reported that over 60% of the variation in cocoa produced could be explained by the preceding year's total annual rainfall, total rainfall in the two driest months and total sunshine duration. Other factors identified included bush fires and drought in Ghana during the 1980's.

Indeed, the past studies discussed above have evaluated limited number of explanatory variables and do not take into consideration the recent measures adopted by Ghana COCOBOD. This study proposes to investigate cocoa production by extending the number of explanatory variables to capture the recent measures adopted by the Ghana COCOBOD. The variables included: farm size, family labour size, Hired labour size, bags of fertilizer, Total revenue received by farmer from cocoa production in Ashanti region.

Rao, (1989) used cross regional data from India, and found an inverse relationship between yields and farm size holds for traditional agriculture experiencing technological change. These results are confirmed by Rao, (1994). The results show that land and labour have a negative effect on the elasticity of gross value of output per unit of land while capital has a positive effect.

Bateman, (1965) regressed production of coffee as a function of the lag price of producer price and soil humidity. Bateman used time series data in the estimation of the model. He found that prices have a serious positive impact on production. Soil humidity was also identified to have positive impact on coffee production.

According to Mamingi (1996), Agricultural production can be viewed in terms of aggregate production, sub-sectoral production and individual crop production. Bond (1983) concludes that both individual crop and aggregate crop production show a positive response to price. This positive relationship of agricultural production to price is shared by both developed and developing countries (Mamingi, 1996). In support of these views, a paper by Gafar (1997) on how agricultural production responds to price in Jamaica concludes on his econometric findings that agricultural production responds positively to price.

However, Bond (1983) was very sceptical when it comes to agricultural production in sub-Saharan African countries. He repeated that agricultural production was unresponsive in the developing countries than the developed countries, and he attributes this to the fact that most of the farmers prefer leisure to income, after attaining a certain income target.

Nerlove, (1956) found that farmers react not to last year's price, instead to the expected price, and this expected price depends solely, to a limited extent, on last year's price. He, therefore, disagree with many authors who directly attribute current production to last year's price. To Nerlove (1956) this error has accounted for too low production response to certain commodities.

Bond, (1983) identified some factors affecting agricultural production which included poor transportation networks, inadequate research and extension facilities, unavailability of credit, shortages of fertilizer and other inputs, and lack of consumer goods on which the farmer can spend his income. However, Bond agreed on the difficulty involved in measuring these factors. To him considering only price effect on production will not give a true explanation of production. Sloman, (2006) argued agricultural production equation may relate current production only to prices in the previous periods because of delays which are incorporated in the process of production. This is typical of perennial agricultural products. For example this year's quantity of cocoa produced is a reflection of last year's price.

Agbeniyi et al. (2010) used the logistic (logit) probability model to estimate the relationship between the use of fertiliser and cocoa production in Nigeria. They treated fertiliser use as a dependent variable of which they regressed on other factors such as age of farmer (years), level of education of farmer, household size, farm size (hectares), association membership of farmers and cocoa output (tonnes). They found that how much fertiliser is used was heavily determined by the level of education. Those with higher (Tertiary education) levels of education were found to have a higher efficiency in the use of fertiliser.

Anim-Kwapong and Frimpong, (2005) used multiple regression analysis and found that over 60% of the variation in Cocoa produced could be explained by the combination of the preceding year's total annual rainfall,

total rainfall in the two driest months and total sunshine duration. Examination of the standardized residuals against the fitted values showed that the model adequately fitted the data. However, the histogram of residuals showed clearly that factors other than those in the model had significant influence on the results as indicated by the value of the regression coefficient of determination (R^2) of 0.61.

Similarly Teal et al (2004) identified cocoa price as another determinant of cocoa production in Ghana. That is the output price of cocoa has effect on production decisions. However, Teal et al (2004), found that the output price of cocoa has a long run effect on production rather than a short run production.

Teal and Vigneri, (2004), identified that the production of cocoa estimated is of the Cobb-Douglas form. The variables used included the fraction of paid workers employed by farmer at a particular time, productivity-enhancing inputs (such as use of insecticide, government spray machines), local institutional variables and farmer characteristics hypothesized to influence productivity. Controls for the region were included in local institutional variables. Under these specification coefficients corresponding to logarithmic variables can be interpreted as elasticity. The parameters of this specification were estimated by Ordinary Least Squares (OLS). The study found that coefficient of farm size is significantly below unity.

Edwin and Masters (2003) tested the magnitude of correlation between cocoa yield and hybrid variety use in Ghana. They used two stage least squares (2SLS) method in their estimation process. In this study they categorized varieties of cocoa seeds into two groups. Following local usage, they categorized all pre-1980 varieties as "traditional", and refer to all later releases as "new". Results showed that hybrid adoption is closely correlated with yield, increasing yield by at least 51 percent, and cocoa yield increases with fertilizer use. Interaction effects between variety adoption and input use were not significant, indicating that the productivity of new varieties is not conditional on input use, but tree age is clearly significant particularly when entered as age squared, indicating that yields decline mainly at high levels of age.

Gyimah-Brempong and Apraku, (1987) estimated a production function of cocoa in the logarithmic form to account for elasticity. In their analysis elasticity with respect to world price and domestic price of cocoa were determined. In their study too time series data was modelled in a Cobb-Douglas production function. This implies that logarithmic transformation was significantly used to aid in the linearization of the model. They found that production was very responsive to price changes both local and international.

Poku (2009) analyse agricultural production and pricing policy nexus: a reflection of the Ghana cocoa industry. Previous studies on the effect of government intervention policy on cocoa production had been based solely on price policy, and some have been too descriptive. In Poku (2009) analysis, an attempt was made to consider both the effects of price and production policy on cocoa supply and wealth of the farmer. Poku (2009) results showed that real producer price which is a proxy for price policy influence farmers' decision in allocating their resources to the production of cocoa. Farmers double up their effort in pruning, weeding and spraying in the short-run, if real producer price is very motivating. Therefore, the higher the producer price, the more farmers would be willing to allocate their resources to the production of cocoa. The results also indicate that farmers plant more trees of cocoa to increase supply in the long-run, as a result of high real producer price.

Model specification

The Cobb – Douglas production function is used to estimate the elasticity of production with respect to farm size, hired labour size, family labour , age of farm, bags of fertilizer used, number of times of mass spraying per production season and total revenue. The Cobb – Douglas production function (CDPF) is used because of its simplicity and applicability. Also, the choice of the Cobb – Douglas Production Function (CDPF) is to aid in the estimation of the responsiveness of production of cocoa to changes in each of the factors already mentioned above. The Cobb-Douglas production function is expressed as:

$$\ln \boldsymbol{Q}_{(t)jth}=\Omega_0+\Omega_1 \ln \boldsymbol{F}_{jth} +\Omega_2 \ln \boldsymbol{L}^{h}_{jth}+ \Omega_3 \ln \boldsymbol{L}^{f}_{jth} +\Omega_4 \ln \boldsymbol{A}_{jth}+ \Omega_5 \ln \boldsymbol{Z}_{jth}+ \Omega_6 \ln TR_{(t-1)jth} + \Omega_7 \ln \boldsymbol{M}_{jth}+ v.... \quad (1)$$

where: $Q_{(t)jth}$ = cocoa output in bags by the *jth* farmer, F_{jth}= farm size in acres by the *jth* farmer, L^{h}_{jth}= hired labour size by the *jth* farmer, L^{f}_{jth}=family labour for the *jth* farmer, A_{jth}=Age of farm for the *jth* farmer, Z_{jth}= bags of fertilizer by *jth* farmer, M_{jth}=Number of times of Mass spraying and $TR_{(t-1)jth}$= total revenue of the *jth* farmer in 2015. Ω_0, Ω_1, Ω_2, Ω_3, Ω_4, Ω_5, Ω_6, and Ω_7, = parameters to be estimated. It should be noted moreover, that Ω_1, Ω_2, Ω_3, Ω_4, Ω_5, Ω_6, and Ω_7 are the elasticity with respect to F_{10jth}, L^{f}_{10jth}, A_{10jth}, Z_{10jth}, TR_{09jth} and M_{10jth}.

METHODOLOGY

The study used primary data. The data on price were obtained from COCOBOD. The others were obtained from randomly selected 251 cocoa farmers in the Ashanti region who responded to a set of questionnaires. This study relied purely on cross sectional data.

RESULTS AND DISCUSSION

This section has two parts: Descriptive Analysis and Log-Linear Regression Results

Descriptive analysis

Table 1 shows that the farm size of respondents was on average, 8.16 acres. But farmers had farm size ranging between one (1) acre and fifty (50) acres. Table 1 also indicates that farmers on the average hired labour for 5.82 times which is approximately six (6) times of labour hours (called *By-Day* in local parlance). That is farmers attempt to supplement their labour hours spent on the cocoa farm by hiring labour. From (Table 1), approximately four (4) members of respondents' nuclear family work on the farm (this figure from the table is 3.737052) but since we do not have a decimal in labour the approximate value of four (4) members is used). Moreover (Table 1) shows that on the average 6.60757 bags of fertilizer were used by farmers. From (Table 1) farmers received mass spraying of 1.97 times on the average, which is approximately two (2) times. From (Table 1), output was 10.63 bags on the average which is approximately equal to eleven (11) bags of cocoa per farmer. This value compared to the average farm size of 8.16 acres, gives 1.31 bags of cocoa per acre. On average a farmer obtained GH¢ 4465.22

Table 1. Summary of farmers and farm characteristics.

Variables	Mean	Standard deviation
Production years of farmer*	2.043825	0.0449024
Farm age	14.84861	0.5252849
Farm size	8.159363	0.4534617
Hired labour	5.816733	0.4616887
Family labour	3.737052	0.1419638
Fertilizer bags	6.60757	0.5230252
No. of times insecticides is used	2.880478	0.1109477
No. of times mass spray	1.976096	0.0625942
Output of cocoa	10.63147	0.7452175
Total revenue, 2015	4465.22	95.0575

*The years were measured as to the number of years the farmer has been with the farm.

Log- Linear Regression Results

The log- linear regression provided a co- efficient of determination (R^2) of 97.36% and adjusted co- efficient of determination of 97.2%. This means that at least 97.2% of the behaviour in log of output is explained by the log of the independent variables. The independent variables have fairly inelastic relationship with output (Table 2).Table 2 shows that production years of farmers which measure the experience of farmers on the farm had negative impact on output though it was statistically insignificant. This means that the more the experienced the farmer the woefully his or her output. The interpretation here is that the experience the farmers had do not match current trends of cocoa production and that training and retraining of farmers would therefore be an advantage. Hired labour had positive impact on production (0.1123988) and was statistically significant at 0.01 error level. This suggests that hired labour contribute favourably to production. Total revenue earned by famers in previous production period also influenced production positively (0.9730697) and moreover significant at 0.01 error level. Farm expenses in current production season are influenced by their revenue experience in the previous period. Given that farmers had good revenue last year it would motivate them to maintain their farms by way of hiring more labour which also had positive impact on production. Family size also showed a positive relationship with the output (0.094221) and was statistically at 0.001 error level. This means that those who are able to produce more had enjoyed the advantage of bigger family sizes. This could also mean that division of labour is likely to happen in the case of bigger family sizes. Number of times of mass spraying had negative impact on production (-1152931) and was statistically significant at 0.031.This is indeed contradictory to both theory and practice. But the reason could be that the mass spraying is done but not the right chemicals in their right proportions are applied. Though family labour was statistically insignificant, it had negative impact on production. Then the meaning is that social loafing could reduce the efficiency of family labour towards production since their reward for working is not felt directly. The co-efficient parameters maintained their signs.

Table 2. The Log- Linear Regression of Output and Non-Dummies.

Variables	Coefficients	T-Statistic	P-value
Ln production years of famers	-0.0630482	-0.91	0.364
Ln farmage	-0.0254473	-0.62	0.534
Ln hired labour	0.1123988	4.02	0.000*
Ln fertiliser bags	-0.0299866	-0.95	0.343
Ln no of times insect	0.0361213	0.81	0.422
Ln No Of Times Mass Spray	-0.1152931	2.19	0.031**
Ln Total Revenue, 2015	0.9730697	34.67	0.000*
Ln farmily size	0.094221	0.41	0.001*
Ln family labour	-0.04333	-0. 54	0.221
Constant	-4.623519	-29.31	0.000

*Statistically Significant at 1% error level,** Statistically Significant at 5% error level

CONCLUSION AND RECOMMENDATIONS

Farmers experience as per analysis had negative impact

on production. This is unusual relative to theory. In even the lay mans view, they say "*Experience is the best teacher*". This deviation from theory had several interpretations. Firstly, it could be that the extension services provided for farmers are outdated and therefore the experience they have had no much to current climatic changes. Farm age had a negative impact on production. Farms size had positive impact on production. It was found that hired labour had positive impact on production. Farmers showed that hired labour are able to work effectively and efficiently especially when given close monitoring and motivation. Family Labour had a negative impact on production. Fertilizer bags used had negative relationship with production. Farmers explained that the production of cocoa does not depend so much on the quantity of the fertilizer used when the soil quality is very high. Moreover, poor methods of fertilizer application could lead to inverse relationship between cocoa production and quantity of fertilizer applied. Farmers might have applied the fertilizer, however, in a wrong way it can have adverse effect on production. The results indicated a positive relationship between revenue and production. That is farmers are motivated by the revenue they generate from production. The producer price per bag of cocoa is fixed or predetermined by the government. This means that farmers' revenue can simultaneously be adjusted upward by both increase in price and quantity produce. In the nutshell the study showed that cocoa production was significantly explained by the independent variables. As per the aforementioned conclusion the study recommends the following: Educating Cocoa Farmers On Efficient Application of Fertilizer, Organization of Retraining Courses for Extension Officers, Subsidizing Farm Inputs, Upward Adjustment of Producer Cocoa Price, Improvement in Mass Spraying Exercise and Inclusion of Cocoa Production into The National Youth Employment Programme.

Authors' declaration

We declare that this study is an original research by our research team and we agree to publish it in the journal.

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