Cost-Benefit Analysis of the Cocoa Livelihoods Program in Sub-Saharan Africa

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Abstract

Billions of dollars flow into low-income countries each year to help alleviate poverty. Assessing the effectiveness of these dollars is necessary to measure program success and to allocate such funds among competing projects. This study measures the impact of the first phase of the Cocoa Livelihood Program (CLPI), a current World Cocoa Foundation project sponsored by the Bill and Melinda Gates Foundation. The project seeks to improve the livelihood of over 200,000 small cocoa producers in Sub-Saharan Africa via training, crop diversification and farmer based organizations. Using data collected from 2,048 pre and post CLPI interviews of cocoa producers in Ghana, Cote d'ivoire, Nigeria and Cameroon, the economic impact of the CLPI program can be estimated. The results show that yield enhancements attributable to CLPI are 36%, 38%, 49% and 24% in Ghana, Côte D'Ivoire, Nigeria and Cameroon, respectively. Using a total program cost of $158-$200 per beneficiary and estimated annual benefits of $86-$152 per beneficiary over 25 years, the benefit- cost ratios were estimated to range from $13 to $22 for every dollar spent on human capital development.

1. Introduction

Cocoa market liberalization throughout West Africa during the Structural Adjustment Programs (SAPs) in the mid-nineteen eighties has fostered competition in the local cocoa markets and has increased the producer's share of cocoa revenues. However, simultaneous institutional reforms during the liberalization process have resulted in decreased levels of public goods such as research and extension in the agricultural arena throughout West Africa. In response, the research and extension service gap left by the SAP's has been partially filled by Non-Governmental Organizations (NGOs) as well as official foreign assistance from governments.[1] The donors (private, NGO's and governments) who remain active in funding development programs in low income-countries are increasingly searching for higher resolution metrics useful for evaluating the effectiveness of any funding decision. Thus, to adequately measure the impacts of a development programs, monitoring and evaluation teams must be inherently results-oriented using appropriate data to support claims (UNDP, 2009). However, evaluating the full impact and success of donor sponsored development programs in low income-countries has proved challenging due to difficulties inherent with measuring impacts at the individual producer level. According to Duflo et al. (2008) studies evaluating development programs at the producer level presuppose these programs to be limited in space and scope, hence these studies fail to account for accumulated costs and/or benefits that persist beyond the program implementation period. Development programs to facilitate human capital acquisition such as a Farmer Field School (FFS) can generate benefits that persist beyond the funded project life span.

Secondly, these studies are highly reliant on randomized controlled trials (RCTs) for impact evaluation of programs which inadequately estimate the combined effect of programs that have multiple components (Gunning and Elbers, 2013). By ignoring the post-training intertemporal dimension of development programs, such as the impacts of accumulated human capital acquired during training and the interaction of their multiple components in project evaluation, researchers may not fully capture a program' total net

[1] A list of all abbreviations and their definitions is given in the Appendix.

benefits. Therefore, comprehensive program evaluation approaches must be utilized when evaluating programs with multiple components to give future donors a complete estimate of project investment returns.

With these points in mind, this study analyzes phase one of the Cocoa Livelihood Program (CLPI), a current World Cocoa Foundation (WCF) project sponsored by the Bill and Melinda Gates Foundation. The CLPI seeks to double the income of approximately 200,000 smallholder cocoa-growing households in Ghana, Cote d'Ivoire, Nigeria and Cameroon. On-the-ground, primary data were collected from 2,048 cocoa farms in Ghana, Ivory Coast, Cameroon, and Nigeria both pre and post CLPI. Using this rich dataset and applying a difference-in-differences modeling method, this study sets out to (1) estimate the annual yield increases associated with the CLPI, (2) estimate the net present value (NPV) of these benefits over the 25 year productive life of a cocoa tree (noting that while CLPI is only funded for four years, the resulting accumulated human capital is amortized over the productive life of the tree), and (3) estimate the benefit-cost-ratio (BCR) for the CLPI program in each of the project's four West African countries.

2. Literature Review

2.1 Cocoa Production in Sub-Saharan Africa

Cocoa is the largest agricultural commodity exported in Sub-Saharan Africa (SSA) at about seven billion US dollars in 2012 and six billion in 2011 (UN Comtrade, 2013). Approximately 70% of the world's cocoa exports originate from West Africa: in 2010/11 Côte d'Ivoire accounted for 37% of world cocoa exports, followed by Ghana (24%), Nigeria (7%) and Cameroon (6%) (ICCO, 2012a). Cocoa exports account for 15% of GDP in Côte d'Ivoire, 11% in Ghana, 3% in Cameroon and 1% in Nigeria[2]. Over 90% of cocoa production in these countries is produced by about two million small scale household farms, on two-to-four hectare plots6 and productivity ranging from 300-400kg/ha and with low input usage (WCF, 2009, 2014b). Cocoa accounts for 60-90% of the income of cocoa producing households in SSA (the majority of which live on less than $2/day (WCF, 2012)) with a per capita daily income estimated in the range of $1.09 to $1.76 (Fairtrade Foundation, 2011; WCF, 2009). The low income of cocoa producers is a function of low productivity per hectare as well as low farm gate prices: Ghanaian cocoa farmers receive approximately 70% of the free on board (FOB) price of cocoa; however, Ivorian cocoa farmers receive 40% of the FOB price due to export taxes imposed by the government. Other drivers of low prices in Côte d'Ivoire, the largest world cocoa producer, include little or no access to market information, misunderstanding of quality requirements, high transport cost and individual rather than group selling (Wegner, 2012).

According to Fairtrade Foundation, (2011), the current share of the price of chocolate paid by consumers in high income countries received by cocoa producers has decreased from 16% to 6% since the 1980s.

Cocoa productivity of 436kg/ha, 595kg/ha, 292kg/ha and 383kg/ha, respectively in Ghana, Côte d'Ivoire, Nigeria and Cameron, is relatively low compared to yields of 345kg/ha, 460kg/ha 556kg/ha and 894kg/ha, respectively, in Brazil, Colombia, Indonesia and Malaysia, (FAO, 2014). The low cocoa productivity in

[2] Derived from cocoa export share estimates retrieved from ICCO (2010, 2012b) and exports of goods and services (% of GDP) estimates retrieved from the World Bank (2013)

West Africa can be partially attributed to the limited knowledge of improved production techniques and farm management skills (Wegner, 2012). Of more critical concern in SSA is farmer's access to inputs such as fertilizers and financing to enhance productivity. Field tests in Ghana and Côte d'Ivoire by Yara, a global fertilizer company, have demonstrated that yield can be increased by over 300% with a combination of good agricultural practices and appropriate input application (IDH, 2011).

2.2 Impact of Structural Adjustment Programs on Cocoa

The SAPs instituted by the World Bank and International Monetary Fund in the mid nineteen eighties led to the liberalization of the cocoa market throughout West Africa. The main objective of the SAP in Sub-Saharan Africa was to improve economic efficiency by linking the domestic cocoa market to the world market through greater 'pass-though' of the world cocoa price to the farmer. Nigeria was the first to liberalize in 1986, followed by Cameroon (1994), Côte d'Ivoire (1998-2002) with Ghana having a partial liberalized cocoa sector since 1992-93 regulated by the Ghana Cocoa Board (COCOBOD) (Gilbert, 2009). Gilbert (2009) suggests that two main liberalization models emerged in SSA via the SAPs. The first is the pure liberalization model, where the government is absent from the sector so farmers face low taxation but are constrained by few public services, such as agricultural extension, as typical of Nigeria and Cameroon. The second is the partial liberalization model in which the government remains active in the sector while farmers pay significant levels of taxation but obtain a high level of services (farmer training, input subsidies and seed distribution) as typified by Ghana. Gilbert (2009) finds that Côte d'Ivoire sits between these two institutional structures and manages to experience all the drawbacks of liberalization without any of the potential benefits of state involvement. The reform process in Côte d'Ivoire is characterized by high export taxation, low farm gate price, and little extension service to farmers. Also in Côte d'Ivoire local companies are absent from cocoa export due to multinationals dominating the sector.

Even though the liberalization process has led to increased competition in internal markets and has increased the producer's share of the world prices (with the exception of Côte d'Ivoire), institutional reforms add an additional dimension. Before the SAPs, some of the parastatals (an agency owned or controlled wholly or partly by the government) were responsible for providing a range of rural services such as marketing and distribution of agricultural inputs and outputs and could also include provision of extension services and credit (Ahmed and Lipton, 1997). Scaling down the activities of parastatals and replacing them with private institutions has led to a decline in extension services, agricultural research, and rural banking that play an integral role in tree crop production enterprises like cocoa (Nyemeck et al. 2008; Wilcox and Abbott, 2006). This decline in public funding, together with a decline in official development assistance to SSA of about 35% between 1980 and 2005 in real terms, resulted in fewer funds to implement agricultural development programs in SSA and across the low-income world (Cabral, 2007).

The absence of free or subsidized fungicides, herbicides, fertilizers, and technical training following liberalization led to declining per hectare yields and increasing revenue volatility for cocoa producers, particularly for the rural poor who live on marginalized land susceptible to weather and yield variability (Nyemeck et al., 2008). Such variability can lead to lower output, sale of productive assets, reduced consumption, and/or reduced investments in education if problems persist (Hill and Torero, 2009). Currently agricultural loans to cocoa farmers come in the form of input packages, primarily through programs offered to farmer based organizations like the Cocoa Abrabopa Program (CAP) in Ghana: where farmers are supplied inputs (fertilizer, pesticides and fungicides) on credit, and extension services for which farmers repay the cost upon selling their crop, or through programs offered to individual farmers by non-governmental organizations (NGOs) such as the WCF-CLPI.

2.3 Developmental Assistance in the Cocoa Industry

Despite the importance of cocoa in providing income for more than two million households, producers face issues such as (1) yield loss due to pests and diseases (30% loss annually), (2) outdated farming techniques and limited availability of improved cocoa varieties, (3) limited organizational support, (4) education and health issues, and (5) labor practices which often involve children working on cocoa farms at the expense of attending school (ICI, 2011). To minimize the occurrences of the aforementioned issues, a global movement, backed by leading firms in the world's cocoa and chocolate industry, has arisen to help ensure that cocoa growing households and their communities are able to reap sustainable benefits form cocoa farming (ICI, 2011). As part of this movement, the World Cocoa Foundation (WCF) and the International Cocoa Initiative (ICI) were formed to collaborate with national plans enacted by governments. Since 2000, this global movement (in form of programs, partnerships, foundations) is working to (1) increase farmer's income through training programs, crop diversification and farmer organizations, (2) encourage sustainable cocoa farming that maintains or enhances the ecosystem, (3) eradicate child labor and improving the access of children to higher quality education (ICI, 2011). The ICI was established by the "Harkin-Engel Protocol," in 2002 in response to reports of child labor practices on cocoa farms in West Africa. ICI works to eliminate child labor in cocoa-producing countries by collaborating with the various players in the cocoa industry, national governments and civil society organizations. The World Cocoa Foundation (WCF) was founded in 2000 for the purpose of promoting social and economic development as well as environmental stewardship in cocoa-growing communities. Serving as a facilitator, WCF brings together donors, industry members, producing country governments, research institutes and non-governmental organizations to achieve its goals through public-private partnerships (WCF, 2014a).

2.4 The WCF Cocoa Livelihood Program (CLPI)

The WCF Cocoa Livelihood Program (CLP) is a ten-year program. Its first phase (CLPI) ended in January 2014 and the second phase (CLPII) spans from February 2014 to January 2019. The aim of CLPI, funded at 40 million dollars by the Bill and Melinda Gates Foundation and Matching Grants, was to double the income of approximately 200,000 smallholder cocoa-growing households in Ghana, Côte d'Ivoire, Nigeria and Cameron. The CLPI objectives were to (1) improve market efficiency and build capacity of farmers and farmer organizations, (2) increase production and quality of cocoa at the farm level, and (3) improve competitiveness by increasing farm diversification (Ndiaye et al. (2013). The program's key activities included: (1) professionalizing farmer organizations by providing training in leadership, governance, accounting, quality analysis and group marketing, (2) providing improved planting material and financing mechanisms for improved access to credit for inputs through collaborative credit schemes based on risk sharing of multiple private sector partners, (3) production and input training taught using either the Farmer Field Schools (FFS) or Video Viewing Clubs approaches, (4) farmer business skills training (FBS) which equipped farmers with tools for planning, economic analysis and decision-making built on technical recommendations for cocoa production, nutrition related issues and, farm and household financial management, and (5) providing Business Service Centers (BSC) which provided microfinance access to farmers (Ndiaye et al. (2013).

2.5 Past Impact Assessments of Development Programs

Gockowski et al. (2010) conducted a case study of Farmer Field School (FFS) implemented in Ghana to provide feedback in an effort to close the yield gap across the West African cocoa belt. Their results showed that yield enhancement attributable to FFS training was 14% per hectare for 225 randomly sampled cocoa farmers who were among the 829 cocoa farmers enrolled in the 30 field schools across Ghana. They concluded that farmers achieved this 14% yield enhancement mainly by increasing their own labor input and hiring more laborers, and selectively applying the set of field management (pruning, shade management, and proper phytosanitary control), and human capital knowledge acquired in the FFS training. The case study concluded it was clear that the FFS training had statistically significant impacts on the beneficiary farmer's productivity.

In 2007 Opoko et al. (2009) conducted an impact assessment of the Cocoa Abrabopa Program (CAP) in Ghana under the auspices of Wienco's Farmer Based Organization (FBO), Cocoa Abrabopa Association (an FBO working with cocoa farmers with the objective to improve livelihoods, established by Wienco, a cocoa input dealer), and the Center for the Study of African Economies. Through CAP, farmers were supplied inputs (fertilizer, pesticides and fungicides) on credit, and extension services which they repaid upon selling their crop. Both CAP and CLPI are similar in that producers obtain inputs on credit. The study analyzed data on 83 non-participating farmers and 158 participating farmers collected from the 2007/08 and 2008/09 growing seasons in Ghana. The study estimated that the program resulted in a 43% revenue increase for participating farmers, and subsequent revenue to cost ratio of 2.5. The study also found that inappropriate use of inputs in terms of timing and application rates was a common production problem, thus increasing farmers access to inputs is only one part of the solution: training and other human capital pertaining to proper input usage is also needed.

Norton et al. (2013) conducted a cost-benefit analysis of a portion of CLPI in Ghana, but from a limited sample of producers from the 2010/11 growing season. Their results showed that the CLPI in Ghana increased average cocoa yield by 75.24% per hectare. This increased yield, if incorporated into an optimal phased replanting rotation, would have increased net present value (NPV) by $401.00 per hectare annually. Using a training cost of $252, they estimated the BCR of CLPI at 80:1 Even though the current study and Norton et al. (2013) seek to estimate yield enhancement attributable to CLPI, they differ in methodology and the scope of the data used. Norton et al. (2013) used data on only CLPI participants from Ghana and only one growing season (2010/11) whereas this study uses data from both CLPI and Non-CLPI participants collected from both pre- (2009/10) and post (2012/13) CLPI periods across all CLPI countries. Unlike Norton et al. (2013) which utilized a conventional regression approach, this study employs the more robust difference-in-differences model. Of importance, the Norton et al. (2013) study used 239 farmer observations in Ghana while this study utilizes 2,048 farm level observations from Ghana, Cote d'ivoire, Nigeria and Cameroon to estimate CLPI yield enhancements in each country.

2.6 The Difference-in-differences Model

An often used method in preliminary analysis of impact of policy intervention, and upon which many other methods including the difference-in-differences are formulated is the one group before and after intervention design. To motivate the advantages of the difference-in-differences model, consider the simplest design as given in Meyer (1995, p. 154):

$$Y_{it} = \alpha_0 + \beta_0 X_{it} + \varepsilon_{it} \qquad \mathrm{E}\left[\varepsilon_{it} \middle| x_{it}\right] = 0 \qquad (1)$$

where Y_{it} is the response variable of interest (in our applications, cocoa yields) for the i^{th} individual in period t, $t = 0, 1$ and i = 1… N. The variable X_{it}, is a binary variable indicating treatment group which takes on a value of 1 if $t = 1$ in the post-intervention period and 0 otherwise and ε_{it} is the customary error term that is identically, independently distributed with mean zero and independent of treatment status. Using data from both pre- and post- intervention periods, β_0 can be estimated as the causal effect of the intervention and can be shown to be equal to the average difference in the pre and post intervention outcomes. For β_0 to be the true experimental effect ideal conditions must prevail. For example, there can be no other factor that changed over time that could have induced the observed effect other than the stimulus. An alternative, and preferred model specification, illustrated by Meyer (1995), is to include both experimental and control groups for which observations are available in both pre and post intervention periods. Such a model can be specified as:

$$Y_{it}^{j} = \alpha_0 + \alpha_1 X_{1t} + \alpha_2 X_2^{j} + \beta_0 X_{3t}^{j} + \varepsilon_{it}^{j} \qquad (2)$$

The outcome variable is now superscripted by j for group, experimental (j = 1) and control group (j = 0). The variable X_{1t} is a binary variable which takes on the value one in post-intervention period (t = 1) and zero in in pre-intervention period (t = 0). The variable X_2^j is a binary variable that takes on the value of one for experimental group and zero for the control group. The variable takes on the value of one if j = 1 and t =1, 0 otherwise. The coefficient α_0 is the constant term; α_1 is a time effect common to both control and experimental groups. It captures how the outcome changes over time due to unobservable factors other than the experimental intervention. The coefficient α_2 is the experimental group specific effect (average permanent differences between the experimental and control group), and β_0 is the effect of the intervention after controlling for the effects of time and permanent differences between the experimental and control groups.

The logical extension of equation (2) is to incorporate the influence of other independent (control) variables that affect the outcome variable independently of the experimental stimulus (CLPI programs). Thus the regression equation:

$$Y_{it}^{j} = \alpha_0 + \alpha_1 X_{1t} + \alpha_2 X_2^{j} + \beta_0 X_{3t}^{j} + \delta_0 Z_{it}^{j} + \varepsilon_{it}^{j} \qquad (3)$$

Where $Y_{it}^{j}, X_{1t}, X_2^{j}$ and X_{3t}^{j} are defined as in equation (2) and Z_{it}^{j} a vector of independent (control) variables. In this study, we specify and estimate equation (3) to estimate yield enhancement attributable to CLPI. The formal model specification is described in the next section.

3. Methodology and Data

3.1 CLPI Program Packages

Our goals are to estimate: (1) the yield enhancement attributable to the two main training programs (Farmer Field School (FFS), Farmer Business School (FBS)) and the input credit package (ICP) offered as part of the CLPI program, and (2) subsequent changes in profits per hectare attributable to the CLPI programs. The CLPI delivers its programs in four specific conceptualizes program packages (bundles of training and services) (WCF, 2011). The four roadmap packages presented in Fig. 1 are: (1) Full CLPI package that includes FFS, FBS, and ICP (Full). (2) FFS and FBS only package (FBP), (3) FFS only (FFSP) package and, (4) FBS only package (FBSP). The roadmaps are designed so that the ICP can only be obtained by farmers having both FFS and FBS. The experimental design implied by the combinations of programs allow for identifying the individual impacts of FFS or FBS the marginal impact of FBS (FFS) given FFS (FBS) and the marginal impact of ICP given both FFS and FBS.

3.2 Specification of the CLPI Impact Evaluation Model

To estimate the yield enhancement attributable to the various CLPI, a semi-log linear regression model was specified in the framework of equation 3 and estimated by ordinary least squares. The outcome variable (dependent variable) was the natural log of the cocoa yield of the i^{th} farmer from in period *t* measured in kg/ha. The natural log of yield was adopted to facilitate cross-country comparisons of program impacts. The binary variable coefficients can readily be converted into estimates of the percentage yield increase attributable to these variables. This is particularly convenient for estimating the impact of the CLPI program packages since all these variables are categorical (binary). The only continuous variable is farm size and years of formal education, and they are entered in log form so that its coefficient can be interpreted as elasticities. The model can be written as:

$$LNYIELD_{it}^{j} = \alpha_0 + \alpha_1 YR_t + \alpha_2 CLP^{j} + \beta_0 PROG_t^{j} + \delta_1 PRECIP_{it}^{j} + \delta_2 INPUTS_{it}^{j} + \delta_3 DEMO_{it}^{j} + \delta_4 LOC_{it}^{j} + \varepsilon_{it}^{j} \quad (5)$$

The variables YR and CLP denote a year effect and membership in the experimental group, respectively. The vector PROG contains variables for the four policy variables denoting the form of intervention (FULLP, FBP, FFSP and FBSP) for which the *ith* farmer participated in the treatment group. The vector PRECIP contains variables (*SUPR1, SUPR2* and *SUPR3)* for precipitation of the season's average precipitation measured in millimeters for the main crop flowering, main crop maturity and light crop maturity for the i^{th} farmer[3]. The vectors INPUTS, DEMO and LOC contains variables, productions inputs, farmer and farm demographics, and location respectively. All of the independent variables are defined in Table 1. Four different models presented in equation five were estimated for each country.

3.3 Net Present Value

Given the estimated yield increases from the various full CLPI package (FULLP) from equation (3), a Net Present Value (NPV) of total benefits can be calculated using the methods implemented in Mahrizal et al. (2013)[4]. To comprehensively measure the costs and benefits of CLPI which likely extend beyond the project life span, a NPV model was implemented to predict the intertemporal net benefits resulting from human capital investments. By calculating the full extent of intertemporal benefits, the holistic economic return on CLPI can be estimated. The Mahrizal et al. (2013) approach is used in this study to calculate the

[3] Generally, there are two main harvest of cocoa within a growing season, the main crop in October-March and the mid-crop in May-August with the whole season spanning from January to December (CRIG, 2010). Cumulative precipitation for the main crop flowering and maturation periods was taken as the precipitation from the preceding January through May, and preceding June through October respectively. For the light crop, cumulative precipitation for the main crop flowering and maturation periods was taken as the precipitation from the preceding June through October, and preceding December through March respectively.

[4] Mahrizal et al. (2013) solved for the optimum replacement rate (ORR) and initial replacement year (IRY) of cocoa trees that maximize a 50-year NPV for a one-hectare, Ghanaian cocoa farm by employing a phased replanting approach. Using cocoa production data collected by Sustainable Tree Crop Program (STCP) and International Institute of Tropical Agriculture (IITA), the study found that the annual ORR and IRY are 5%–7% and 5-9 years, respectively, across the three production systems studied: (1) Low Input, Landrace Cocoa, High Input, (2) No Shade Amazon Cocoa, and (3) High Input, Medium Shade Cocoa. The authors estimated economic gains that exceed currently practiced replacement approaches by 5.57%–14.67% across production systems.

maximum NPV for both pre- and post- CLPI intervention periods. Given the optimum replacement rate (ORR) and initial replacement year (IRY), the annual NPV is estimated as a function of projected cocoa prices, costs of labor and inputs, inflation rate and discount rate. The NPV per hectare is estimated as the sum of the discounted NFV in each year using a 25-year, parabolic shaped average lifecycle yield curve of a cocoa tree in Ghana based on research conducted by the International Institute of Tropical Agriculture (IITA) shown in Fig. 2. Using the optimal ORR and IRY which maximize NPV, a baseline NPV was estimated as the maximum potential profit per hectare that cocoa farmers could achieve given current production practices without any CLPI package. It is assumed that that cocoa farmers behave rationally to maximize their profits before the CLPI program was implemented. Because of a number of real-world constraints—including access to credit to buy fertilizer—Ghanaian farmers are most likely do not actually behave in this manner. To control for the farmer behavioral effect in estimating CLPI benefits, it is necessary assume farmers behave in the same way in terms of economic goals so as not to confound that impact of CLPI with adopting a better optimizing strategy at the same time.

The Low Input Landrace Cocoa (LILC) production system described in Afari-Sefa et al. (2010) and Gockowski et al. (2011) was assumed as the baseline production practice: this system uses unimproved local landrace cocoa varieties with moderate shade levels. The study assumes farmers use pesticides and fungicides but no inorganic fertilizer in the baseline scenario. Secondly, this study assumes that once farmers complete the full CLPI program (i.e. completes both FFS and FBS and gains access to ICP), they can access input credit which translates to fertilizer adoption and increased production costs. Therefore the model cost structure is adjusted so all CLPI graduates implement the High Input Medium Shade Cocoa (HIMSC) production system described in Afari-Sefa et al. (2010). As a result, input costs increase by 60% annually. The adjustment obtained from Afari-Sefa et al. (2010) allows for more accurate estimation of profit because the large yield increases attributable to CLPI imply higher production costs[5]. Finally it is assumed that the yield enhancement estimated in equation (3) attributable to the full CLPI package (FULLP) is a constant percentage gain, above those cocoa producers who were not exposed to any of the CLPI packages (baseline scenario) throughout the productive life of the cocoa tree as illustrated in Fig. 2.

The NFV and NPV for the 25-year productive life of the cocoa trees per hectare were estimated as follows:

$$NFV_{jt} = \left[YIELD_{jt}\left(1+g_j\right)\cdot P_{jt}\left(1+r_{jt}\right)^t\right] - C_{jt}\left(1+r_j\right)^t \qquad (4)$$

$$NPV_j = \sum_{t=1}^{25} \frac{NFV_{jt}}{\left(1+r_{dj}\right)^t} \qquad (5)$$

Where $YIELD_{jt}$ is the yield in kg/ha of cocoa in period t for a given hectare for country j, and depends upon the age of trees on that hectare as shown Fig. 2. The variable g is the yield enhancement attributable to the full package (FULLP) for country j, where $g = 0$ represents the baseline yield. The expressions $P_{jt}(1+r_{jt})^t$ and $C_{jt}(1+r_{jt})^t$ are the price of cocoa and cost of cocoa production in period t in country j, compounded by country *j's* inflation rate r_{jt}, respectively. The variable r_{dj} is country *j's* discount rate. Dividing equation 5 by 25 (average productive life a cocoa tree) gives the annual average NPV of profit per hectare for each country. Like Tisdell and Silva (2008), this study assumes no salvage value for cocoa trees, hence we do not account for the salvage value in the NPV. Using the yield, cost and inputs outlined in Afari-Sefa et al. (2010) and Gockowski et al. (2011), and the optimal ORR and IRY estimation by Mahrizal et al. (2013), the baseline NPV was estimated at $g = 0$.

[5] Afari-Sefa et al. (2010) and Gockowski et al. (2011) estimated costs and returns are for one hectare of unimproved cocoa planted at 3 x 3 m spacing (1,100 plants per hectare) for with no nursery cost for LILC and HIMSC. The only difference between the cost estimates of LILC and HIMSC is the use of inorganic fertilizer.

The baseline daily wage for labor was fixed at $2.22, $2.59, $3.88 and $2.00 respectively for Ghana, Côte d'Ivoire, Nigeria and Cameroon, per the 2011 daily minimum wage retrieved from ILO (2012). Insecticide and fungicide prices for Ghana were respectively fixed at $6.17/liter and $1.85/sachet per their respective current market prices in 2010 terms, fertilizer price was taken as the price farmers paid for the CLPI fertilizer credit package which is estimated at $13.52/50kg in 2010 terms (Antista, 2014), and the cost of all other inputs and materials were taken from Afari-Sefa et al. (2010) and Gockowski et al. (2011). Given that COCOBOD marketing board sets the price of cocoa in Ghana, the farm gate price (FGP) for Ghana was set at 77.81% of the net Free-On-Board (FOB) price: the share of the farmers price was estimated as the average for the 2010/13 period obtained from Government of Ghana (2011, 2012, 2013, 2014). For Côte d'Ivoire, Nigeria and Cameroon, the FGP as a share of the FOB price was set at 49.0%, 74.1% and 73.5% respectively, per the 2000/11 period annual averages retrieved from ICCO (2010, 2012b). The FOB price was set at the average ICCO price of $3.53/kg observed in January, 2010 (ICCO, 2014).

Unlike Ghana where were it was possible to obtain data on input prices, cost and yield curves for both the LILC and HIMSC production system, no such data were available for Côte d'Ivoire, Nigeria and Cameroon. Thus calibration of the Ghanaian prices and cost and yield outlines for both the LILC and HIMSC production systems to suit the three other countries was needed. Price Level Indexes (PLI)[6] obtained from World Bank (2011) were used to calibrate the Ghanaian input prices for Côte d'Ivoire Nigeria and Cameroon. Using PLI obtained from World Bank (2011), the PLI for Côte d'Ivoire Nigeria and Cameroon were estimated at 104.55, 104.47 and 104.09 respectively

[6] PLLs are standardized indexes expressing the price level of a given country relative to another. They are estimated by dividing a countries' Purchasing Power Parity by its respective dollar exchange rate. Countries with PLIs less than 100 have price levels that are lower than that of the base country and PLIs greater than 100 have price levels that are higher than that of the base country. Generally, PLLs are preferred to exchange rate when comparing because PPPs evolve slowly, whereas exchange rates can change quickly (World Bank, 2014)

(Ghana=100). Yield outlines for the three countries were estimated by adjusted the Ghanaian yields obtained from Afari-Sefa et al. (2010) and Gockowski et al. (2011) by multipliers estimated from country fixed effects regressions for yield using annual country yield data retrieved from FAOSTAT (2014) for the period 1993-2012.

The regressions were estimated as:

$$LNYIELD_{jt} = \beta X_{jt} + \gamma Z_{jt} + \upsilon_t \qquad (8)$$

Where *LYIELD* is the natural log of country *j*'s cocoa yield in time *t*, **X** is vector which contains dummy variables indicating the country (Côte d'Ivoire, Nigeria, and Cameroon with Ghana acting as the control country). The variable **Z** is denotes a matrix that includes an intercept term, a trend variable, autoregressive terms and variable that are believed to influence yield. The multipliers were then taken as the exponent of the coefficients on the respective country's dummy variable. The calibrated unit cost of inputs and the yield multipliers are presented in Table 2 and the yield curved generated for each country in Fig. 2. By setting inflation at 10.1%, 2.8%, 11.3% and 2.2% per year respectively for Ghana, Côte d'Ivoire, Nigeria and Cameroon, per the 2010/13 average (ADB, 2014), the prices of labor and inputs are projected in the models to rise at these rates. The discount rates were held constant at 11.65%, 3.5%, 7.1% and 3.2% per year respectively for Ghana, Côte d'Ivoire, Nigeria and Cameroon, per the 2010/13 annual average deposit rate (IMF-IFS,2014).

3.4 Benefit Cost Ratio

The benefit cost ratio of CLPI can be estimated as:

$$BCR_{CLPI}^{j} = \frac{\left(B_{CLPI}^{j} - B_{0}^{j}\right)}{C_{CLPI}} \qquad (9)$$

Where ($B^j_{CLPI} – B^j_0$) is the difference between the baseline NPV (no training) and the post CLPI NPV (with FULLP). Therefore the estimated NPV for country *j*, estimated from equation seven in $/ha. The variable C_{CLPI} is the total cost of CLPI per beneficiaries, which is assumed to occur at time 0 (2009/10). The total cost of CLPI per farmer who benefited directly from the program was estimated at $151, $128, $200 and $130, respectively in Ghana, Côte d'Ivoire, Nigeria and Cameroon.

3.5 Data and Data Sources

The data were collected from two surveys conducted for the WCF by third party organizations on qualitative and quantitative information about cocoa farmers and their production practices. These data were collected from the 2009/10 and 2012/13 cocoa growing seasons in Ghana, Nigeria, Cameroon and Cote d'Ivoire. The 2009/10 survey was the baseline conducted by Mathematica in order to measure key economic and social indicators before the CLPI implementation. The 2012/13 was conducted by IPSOS Public Affairs for the impact analysis at the completion of CLPI. The data used in this study were the survey responses for which an individual farmer participated in both surveys. The total sample size was 2,048 after identifying those farmers who were surveyed both pre- and post- CLPI. Given that CLPI was in its implementation stage during the baseline survey, it is assumed that reported yields in the pre-CLPI phase were not influenced by the program; thus all farmers in the baseline are assumed to not have received any of the CLPI training packages.

The relevant survey data collected for this study were: farmer location, farmer and farmer household demographics, farm size in ha, cocoa productivity in kg/ha, inputs used in production (these includes chemical fertilizers, fungicides, herbicides, insecticides, and labor) which were mainly binary (yes or no usage of specific inputs in the last twelve months). Respondent participation in the various CLPI programs was also recorded. Data on yields were self-reported by farmers along with farm size and as such could be underestimated or overestimated, and data on input usage was mainly binary (yes or no usage of specific inputs) without the application times or quantities of these inputs and as such was not able to properly account for their influence on yield. Also farmers were not asked about the age and replacement rates of cocoa trees on their farm; as such the study does not account for the influence of tree age on cocoa yield.

Daily precipitation data (mm) were collected from aWhere at the village level for both 2009/10 and 2012/13 cocoa growing seasons with data available for only Ghana and Côte d'Ivoire. Awhere provides daily weather observations on weather variables including, but not limited to: precipitation (mm), minimum and maximum temperatures (^{o}C), and growing degree days with a flexible threshold that can be adjusted online. This study only uses daily precipitation data. These data were available at a five arc-minute resolution, or about nine kilometer square grid cells. The weather data were collected by a combination of global meteorological on-the-ground stations and orbiting weather satellites. These data were the approximate equivalent of having a ground station every nine kilometers. The advantage for this study of using data at this resolution was that individual villages had unique weather data unless multiple villages were contained within the same 9^2 km grid cell.

4. Results

4.1 Descriptive statistics for the dependent and independent variables

The descriptive statistics of the dependent and independent variables are presented in Table 3. Average cocoa yield aggregating both growing seasons across all four counties was estimated at 383kg/ha. Average cocoa yield was higher in the 2012/13 growing season relative to the 2009/10 season with the highest average yields recorded in Nigeria (854.5 kg/ha), followed by Côte d'Ivoire (416.1 kg/ha), Ghana (412.6 kg/ha) and Cameroon (194.2 kg/ha). The average farm size across all countries for the two seasons was estimated at 3.7ha: The largest farms were recorded in Cameroon at 4.1ha, followed by Côte d'Ivoire (3.8ha), Ghana (3.7ha), and Nigeria (3.1ha). Inorganic fertilizer usage for the 2012/13 season was highest in Ghana and Nigeria at 33.1%, and followed by Côte d'Ivoire (20.3%) and Cameroon (8.5%). Package exposure shows that the FFS only package has the highest proportion in terms of package exposure of 30.3%, this is followed by the Full package (13%) and then FBS only package (4.4%). Table 3 also shows that the proportion of the Full package exposure was highest in Cameroon at 29.4%, and followed by Nigeria (28.1%), Côte d'Ivoire (7.5%) and then Ghana (6.6%). The study had a total of 40 districts in the sample: 17 form Ghana, 14 from Nigeria, 5 from Côte d'Ivoire and 4 from Cameroon. Mean cumulative precipitation levels in Ghana were estimated at 191.04mm, 413.18mm and 153.60mm for the main crop flowering (SUPR1), main crop maturation (SUPR2) and light crop maturation (SUPR3) periods respectively. Mean seasonal cumulative precipitation levels in Côte d'Ivoire were estimated at 232.28mm, 393.89mm and 151.94mm for SUPR1, SUPR2 and SUPR3, respectively.

4.2 Regression Results for CLPI Impact

Table 4 presents the regression estimates for all four countries. As expected, the coefficient of determination was relatively low across all four models since the data are cross-sectional. Because of the cross sectional nature of the sample, the study used White (1980) heteroscedasticity consistent estimates of the coefficient covariance matrix estimation to obtain consistent estimates of the coefficient standard errors.

CLPI Impact

The coefficient of the variable CLP, which was statistically insignificant in all four countries shows that all things being equal, there does not seem to be any detectable differences between by farmers who were exposed to at least one CLPI package and those farmers who had no CLPI package exposure. This means the sample seems to be random. Of the four CLPI packages, only FULLP was consistently significant ($P<0.05$ or better) in all four counties, with an associated yield increase of approximately 36.3%, 37.7%, 49.2% and 35.0%, respectively in Ghana, Côte d'Ivoire, Nigeria and Cameroon. This implies that farmers in all four countries who were exposed to FULLP have an increase yield compared to farmers who were not exposed to any of the CLPI packages. It is not surprising that the other packages that did not include the input credit package component of CLPI are not consistently significant given that FFS only teaches good agricultural practices to farmers and may not necessarily increase yields without the additional use of inputs. The focus of FFS is increased adoption of good production practices to enable farmers better manage their cocoa farms. The immediate impact of FFS should be improved production skills to enable cocoa farmers to better manage their farms through fertilizer use and prevention of pest and disease (Nalley, 2013). Secondly, FBS may not necessarily increase cocoa yields but rather increase the adoption of good business practices among farmers which in turn will help shift the farmer's perceptions from farming as a lifestyle to farming as a business and have less of a direct effect on yield.

Precipitation

During the main crop flowering period in Ghana, precipitation (SUPR1) increased yield by 5% for every 1% increase in daily precipitation. In Ghana the weather variables (SUPR2 and SUPR3) were insignificant. None of the weather variables (SUPR1, SUPR2 and SUPR3) were significant in Côte d'Ivoire. This general lack of significance is surprising and suggests that more research is necessary to better identify how weather variables should be formulated to identify the weather's impact on yield. Nonetheless research done by Faisal (1969) on yield of cocoa from a large-scale experiment over seven years in Ghana suggest that there was a positive association between yield and rainfall during the periods mid-February to mid-April, from July to mid-October and at the beginning and end of the year, but a negative association during other periods.

Inputs

Farm size was consistently significant ($p < 0.01$) in all four countries, for every 1% increase in farm size, production decreased by no less than 0.28%. This was expected because farmer's labor resources are typically finite so that yields tend to be higher on smaller farms because the farmers have more labor per hectare (Teal et al.,2006). The fertilizer variable (FERT) was significant ($P < 0.1$) in all four countries with associated yield increases of 20.9%, 22.1%, 25.9% and 18.5% in Ghana, Côte d'Ivoire, Nigeria and Cameroon, respectively, given the application of inorganic fertilizer. The use of pesticides (PEST) was significant ($P < 0.01$) in only Nigeria with associated yield improvements of 39.10%. The herbicide variable (HERB) was significant in only Côte d'Ivoire ($P<0.01$) and Nigeria ($P<0.1$) with associated yield increase of 25.9% and 39.1%, respectively, given the application of herbicide. The labor variable (LBR) was significant in Ghana ($P<0.05$), Côte d'Ivoire ($P<0.05$) and Cameroon ($P<0.01$), with associated yield increase of 13.9%, 11.6% and 33.6% respectively, given the usage of hired labor. The relationship is not surprising given that the majority of the farmers in the sample have small farms which average 3.7ha, and as indicated by Teal et al.(2006), smallholder farmers are endowed with more labor per hectare and labor has a positive relationship with cocoa yields.

4.3 Estimated Returns to the CLPI

Table 5 presents the annual NPV estimates for the yield increase associated with exposure to the full CLPI package (FULLP) across the four countries in Table 4. Using the procedure developed by Mahrizal et al. (2013), the optimum replacement rate (ORR) of cocoa trees in all four countries was estimated to range between 5%-6%. The optimal initial replacement year (IRY) ranges from year 7 to year 8 in Ghana, Côte d'Ivoire and Cameroon and from year 4 years in Nigeria. The differences in IRY and ORR across the four countries are partly due to the differences in economic variables which influence NPV. Here these variables mainly included inflation rate and discount rates: Nigeria had the lowest IRY because its inflation rate was higher that than its discount rate. It is more beneficial to attain steady state (a state in production when revenues become stable over tine) much quicker. Given the solution to the ORR and IRY in each country, the annual NPV for 25 years associated to exposure to the full CLPI package were estimated at $530, $561, $538 and $448 respectively for Ghana, Côte d'Ivoire, Nigeria and Cameroon: these new NPVs were 33%, 26%, 39% and 24% above the baseline NPV in their respective countries.

If all 196,735 participant farmers (Ghana (69,270), Côte d'Ivoire (52,515), Nigeria (42,739) and Cameroon (32,211)) from all four countries should experience the gain in NPV associated with CLPI, there will be a total annual gain in NPV of approximately $24,574,966: the highest being in Ghana $9,127,517 followed by Nigeria ($6,512,324), then Côte d'Ivoire ($6,162,289) and finally by Cameroon ($2,772,835). The estimated increase annual NPV from the CLPI program across all four countries comes to average annual NPV increase of $125 per beneficiary farmers: this means that for the 2 million cocoa producing households who earn a per capita daily income from cocoa production of $1.09-$1.76 ($400-$640 annually), the $125 increase in NPV equates to a 19%-31% increase in annual income from cocoa production.

4.4 Benefit-Cost Ratio

The benefit cost ratio was estimated as the difference between the baseline NPV (no training) and the full CLPI package (FUULP) estimated NPV divided by the cost of the CLPI program per participant. The results presented in Table 5 show that the estimated NPV increase resulted in estimated BCR's for a 25 year period of 22:1, 23:1, 19:1 and 17:1 for Ghana, Côte D'Ivoire, Nigeria and Cameroon, respectively. These ratios imply that every dollar spent on human capital development resulted in a $22, $23, $19 and $17 increases in NPV for participating cocoa producers in Ghana, Côte d'Ivoire, Nigeria and Cameroon, respectively.

It should be noted that like Norton et al. (2013), these estimates are considered to be conservative given that (1) training cost decreases over time as training mechanisms become efficient; Norton et al. (2013) estimated the cost of CLPI per beneficiary at $252 which is 66% higher than this study's estimates of $151 given that more farmers have been reached since the Norton et al. (2013) study, and (3) the estimated NPV's are on a per hectare basis, hence while the cost of the CLPI is fixed, the benefits which may increase with one more additional hectare will cause the BCR's to also increase; for example if all farmers were assumed to have 1.5 hectares of cocoa farms, the return on human capital investment will now be estimated at $33, $34, $29 and $25 respectively Ghana, Côte d'Ivoire, Nigeria and Cameroon. But such expansions might force other cocoa farmers out of cocoa production so that the countrywide effect would diminish. The estimates are not conservative if the impact of larger supply causes a decrease in price. A sensitivity analysis of the CLPI estimated BCR's in Table 6 indicates that the minimum yield increase that farmers would have to achieve in order to have their estimated NPV cover the full cost of the program is estimated at 18.0%, 24.4%, 37.2% and 23.4% respectively Ghana, Côte d'Ivoire, Nigeria and Cameroon. This studies results indicate that the estimated CLPI yield enhancement appear to be robust given the magnitude of the difference between the yield increase for break-even scenario and the CLPI for all four countries (Ghana ;18%, Côte d'Ivoire ;13%, Nigeria;12% and Cameroon;12% in Table 6).

5. Conclusion and Recommendations

Institutional reforms during the Structural Adjustment Programs (SAPs) in West Africa and the subsequent liberalization of cocoa markets have resulted in decreased levels of public goods such as research and extension. While the research and extension service gap has been partially filled by NGOs and other private donors, those donors who remain active in funding development programs in low income countries are starting to require higher resolution metrics useful for evaluating the effectiveness of all development programs. Using data from 2,048 on-the-ground farm observations in Ghana, Côte D'Ivoire, Nigeria and Cameroon, from pre and post CLPI intervention periods (2009/10 and 2012/13 growing seasons) and applying a difference-in-difference estimation method, this study estimated yield enhancement attributable to the CLPI, a current WCF project aimed at doubling the income of cocoa-growing households in SSA. Using those yield enhancements, a NPV model was used to estimate the value of CLPI over the 25-year lifecycle yield curve of a cocoa tree. The programs goal was to increase business skills, pruning techniques, and introduce best management practices, all of which build human capital. Thus, the full benefits of the program should persist long after the official, four-year training is over.

We assumed the gains from CLPI would last 25 years—the fruitful life of a cocoa tree—and this allowed estimating the BCR of CLPI for four Sub-Saharan Africa countries: Ghana, Nigeria, Cameron and Cote d'Ivoire. The results from the difference-in-difference estimation of yield enhancements attributable to CLPI were 33%, 26%, 39% and 24% per hectare annually in Ghana, Côte d'Ivoire, Nigeria and Cameroon, respectively. The results indicate that for every dollar spent on human capital development via the CLPI resulted in producer gains of $22, $23, $19 and $17 in Ghana, Côte d'Ivoire, Nigeria and Cameroon, respectively. One potential limitation of the study is the scope of the data in terms of how they were measured. Where the data was mainly binary, a more appropriate measure will be to have it in a scalar form.

About 48.5% of the population lives on $1.25 or less per day and a majority of cocoa producers live in small, rural, impoverished households, measuring the impact of research and extension service by agricultural development programs such as the CLPI can generate information needed to illustrate the potential of skill attainment to alleviating poverty, particularly when trying to encourage prospective donors to participate in outreach programs.

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Tables

Table 1:

Description of regression independent variables

Variable	Meaning	Form
	Time Effect, Treatment Group and CLPI Variables	
YR13	Takes on the value one in post-CLPI period and zero in in pre-CLPI period	Dummy
CLPI	Indicator for CLP experimental Group	Dummy
FULLP	Indicator for participation in the full CLPI package	Dummy
FBP	Indicator for participation in the FFS and FBS only package	Dummy
FFSP	Indicator for participation in the FFS only package	Dummy
FBSP	Indicator for participation in the FBS only package	Dummy
	Precipitation in millimeters	
SUPR1	Season's average precipitation for the main crop flowering	Natural Log
SUPR2	Season's average precipitation for the main crop maturation and light crop flowering	Natural Log
SUPR3	Season's average precipitation for the light crop maturation	Natural Log
	Inputs	
SIZE	Farm size in ha	Natural Log
FERT	Indicator for usage of inorganic fertilizer	Dummy
PEST	Indicator for usage of pesticide	Dummy
HERB	Indicator for usage of herbicide	Dummy
LBR	Indicator for usage of hired labor	Dummy
HLBOR	Indicator for usage of household labor	Dummy
	Farmer and Farm Demographics	
GENDER	Indicator for Male	Dummy
EDU	Farmer's years of formal education t	Natural Log
FBO	Indicator for Farmer Based Organization membership	Dummy
PRUN	Indicator for pruned farm in the past year	Dummy
IMPRVAR	Indicator for new improved varieties of cocoa planted in the past four years	Dummy
MLC	Indicator for underestimated annual cocoa yield because light crop yields were not recorded	Dummy

Table 2

Estimated Cost of Inputs for Production and Yield Multipliers

Country	[a] Yield Multiplier	[b] Wage ($/Day)	[c] Pesticide ($/l)	[c] Fungicide ($/50g)	[c] Fertilizer ($/50kg)
Ghana	1.00	2.22	6.17	1.85	13.52
Côte d'Ivoire	1.67	2.59	9.54	2.86	20.91
Nigeria	0.91	3.88	7.03	2.11	15.41
Cameroon	0.96	2.00	9.94	2.98	21.79

Note:
[a] Ghana =1 estimated from results from country fixed effects.
[b] Denotes data retrieved from ILO (2012)
[c] Denotes data estimated using Price Level Indexes (PLI) obtained from World Bank (2011)

Table 3:

Descriptive Statistics for Regression Variables

	Ghana		Côte d'Ivoire		Nigeria		Cameroon	
	2009/10	2012/13	2009/10	2012/13	2009/10	2012/13	2009/10	2012/13
Sample	350	350	400	400	121	121	153	153
[a]Yield	284.3	412.6	284.6	416.1	376.8	854.5	264.4	264.9
(kg/ha)	(187.2)	(285)	(210.5)	(306)	(232.6)	(675.6)	(124.5)	(194.2)
SIZE	3.7	3.7	3.8	3.8	3.1	3.1	4.1	4.1
(ha)	(3.0)	(3.0)	(2.9)	(2.9)	(2.7)	(2.7)	(2.7)	(2.7)
	Time Effect, Treatment Group and CLPI Variables (%)							
YR13	-	100	-	100	-	100	-	100
CLPI	44.3	44.3	50.8	50.8	63.6	63.6	33.3	33.3
FULLP	-	6.6	-	7.5	-	28.1	-	29.4
FBP	-	-	-	-	-	-	-	-
FFSP	-	33.7	-	43.3	-	13.2	-	3.9
FBSP	-	4.0	-	-	-	22.3	-	-
	Precipitation (mm)							
SUPR1	320.6 (64.9)	-	381.9 (128.9)	-	-	-	-	-
SUPR2	533.9 (92.2)	264.8 (68.1)	393.6 (136.2)	286.9 (40.8)	-	-	-	-
SUPR3	533.9 (92.2)	264.8 (68.1)	393.6 (136.2)	286.9 (40.8)	-	-	-	-
	Inputs (%)							
FERT	49.1	33.1	11	20.3	8.3	33.1	5.2	8.5
PEST	80.6	92.3	52.5	66.3	94.2	95	88.2	91.5
HERB	31.4	54.6	24.8	34.5	27.3	53.7	17	43.8
LBR	61.1	76.3	59.5	42.8	84.3	96.7	60.1	60.1
HLBOR	51.1	97.7	46.3	94.8	68.6	88.4	62.7	97.4
	Demographics							
GENDER (%)	55.7	55.7	89.8	89.8	84.3	84.3	89.5	89.5
EDU	6.9	6.9	4.4	4.4	7.8	7.8	7.4	7.4
(Years)	(4.1)	(4.1)	(3.9)	(3.9)	(5.0)	(5.0)	(3.8)	(3.8)
FBO (%)	16.3	29.4	22.5	32.8	17.4	34.7	31.4	25.5
IMPRVAR (%)	49.7	72	25.5	39.8	52.9	83.5	33.3	71.2
PRUN (%)	68.6	86.9	59.3	75	76	88.4	53.6	81.7
MLC (%)	8.6	2.3	-	5	-	8.3	-	39.9
No. Districts	17	17	5	5	14	14	4	4

[a] Denotes estimations that excludes observations with missing light crop.
[b] Denotes the dependent variable.
Parentheses denote standard deviation.

Table 4:

Regression Results

Country	Ghana	Côte D'ivoire	Nigeria	Cameroon
YR13	3.49**	0.23	0.32**	-0.04
CLPI	0.04	0.02	0.04	0.05
FULLP	0.31***	0.32**	0.40**	0.30**
FFSP	-0.02	0.07	0.06	0.03
FBSP	-0.19	-	0.39**	-
SUPR1	0.50**	-0.01	-	-
SUPR2	0.61	0.05	-	-
SUPR3	-0.27	0.10	-	-
SIZE	-0.32***	-0.28***	-0.30***	-0.30***
FERT	0.19***	0.20***	0.23**	0.17*
PEST	-0.01	0.01	0.30***	-0.03
HERB	0.04	0.23***	0.33*	0.06
LBR	0.13**	0.11**	0.03	0.29***
HLBOR	0.05	0.23***	0.10	0.02
GENDER	0.13**	0.05	-0.1	0.01
EDU	0.003	-0.005	0.01	-0.07
FBO	0.10*	0.16***	0.04	0.12*
PRUN	-0.05	0.04	-0.25**	-0.04
IMPRVAR	-0.09	-0.08	0.29**	-0.01
MLC	-0.41**	0.04	-0.43**	-0.41***
CONSTANT	0.13	4.35***	4.99***	5.7***
Regression Statistics				
Sample	700	800	242	306
DF	662	775	210	285
R-Square	34.2%	20.1%	45.3%	28.0%
Akaike	0.430	0.570	0.442	0.297
Districts	17	5	14	4

Note:
Significance levels: * $P<0.10$, ** $P<0.05$, ***$P<0.01$

Table 5:

Summary of Net Present Value (NPV) and percentage change in NPV over two production cycles (25 years) for the LILC production system with estimated yield increases from CLPI.

Country	CLPI Yield Increase	IRY (ORR)	Baseline NPV	CLP I NPV[a]	NPV Change	CLP I Cost/ Farmer[b]	BCR
Ghana	36.30%	8, (5.9%)	$9,957	$13,251	33.10%	$151	22
Côte d'Ivoire	37.70%	8, (5.9%)	$11,091	$14,025	26.40%	$128	23
Nigeria	49.20%	4, 5.8%)	$9,651	$13,461	39.50%	$200	19
Cameroon	35.00%	8, (5.9%)	$9,050	$11,202	23.80%	$130	17

[a] This includes 60% increased input costs per year, modeled after High Input Medium Shade Cocoa (HIMSC) in Afari-Sefa et al. (2010).
[b] Estimated beneficiaries exclude the additional 20,000 farmers trained through the matching grants.

Table 6:

Sensitivity Analysis of the CLPI Estimated Benefit Cost Ratio

	Ghana			Côte D'ivoire		
Yield increase	NPV	NPV Change	BCR	NPV	NPV Change	BCR
Baseline[a]	$9,957	0.0%	0.0	$11,091	0.0%	0.0
CLPI[bd]	$13,251 [d]	33.1%	19.3	$14,025	26.4%	17.2
75% of CLPI	$11,709 [d]	17.6%	10.2	$12,081	8.9%	5.8
Breakeven [c]			18.0%			24.4%
	Nigeria			**Cameroon**		
Yield increase	NPV	NPV Change	BCR	NPV	NPV Change	BCR
Baseline[a]	$9,651	0.0%	0.0	$9,050	0.0%	0.0
CLPI[bd]	$13,461[d]	39.5%	22.3	$11,202	23.8%	12.6
75% of CLPI	$9,746 [d]	1.0%	0.6	$9,709	7.3%	3.9
Breakeven[c]			37.2%			23.4%

Note:
[a] Denotes estimate for pre CLPI scenario, modeled after Low Input Landrace Cocoa (LILC) production system.
[b] Denotes estimate for post CLPI scenario, modeled after High Input Medium Shade Cocoa (HIMSC) production system.
[c] Denotes yield increase necessary to make the BCR equal to one
[d] Estimate includes 60% increased input costs per year due to introduction of inorganic fertilizer

Figures

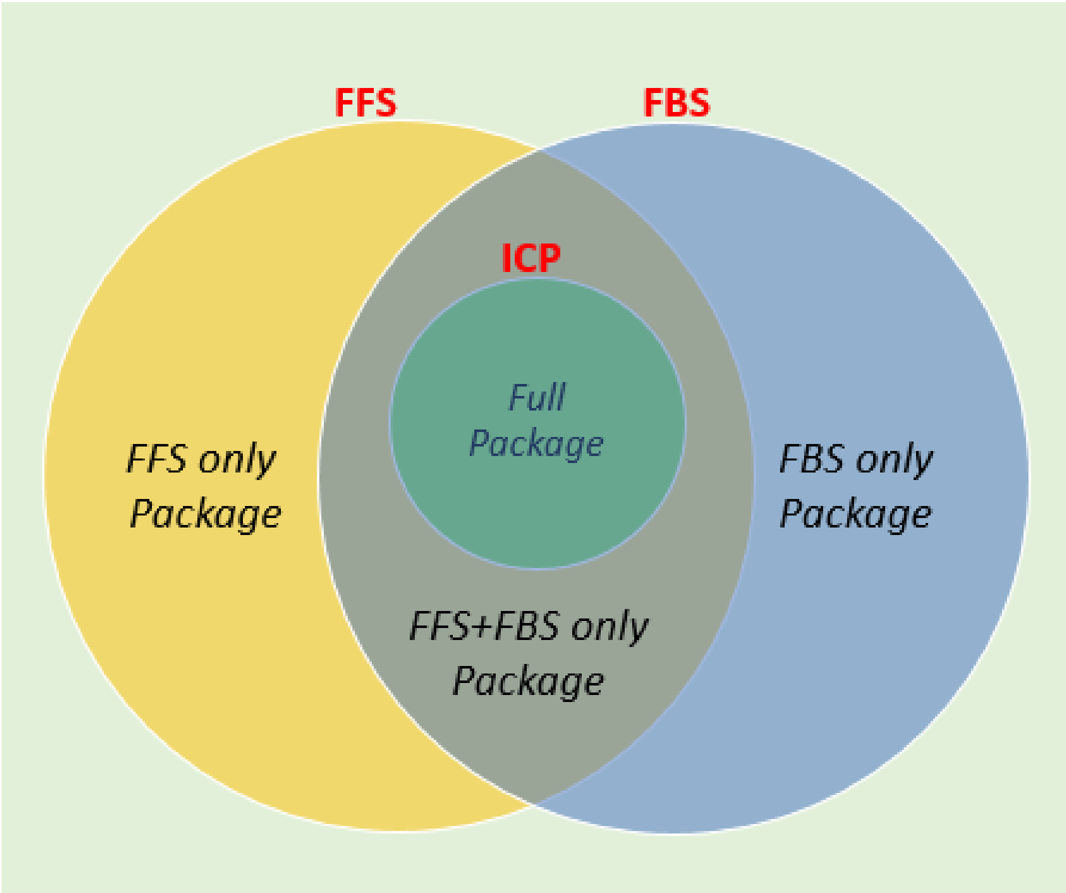
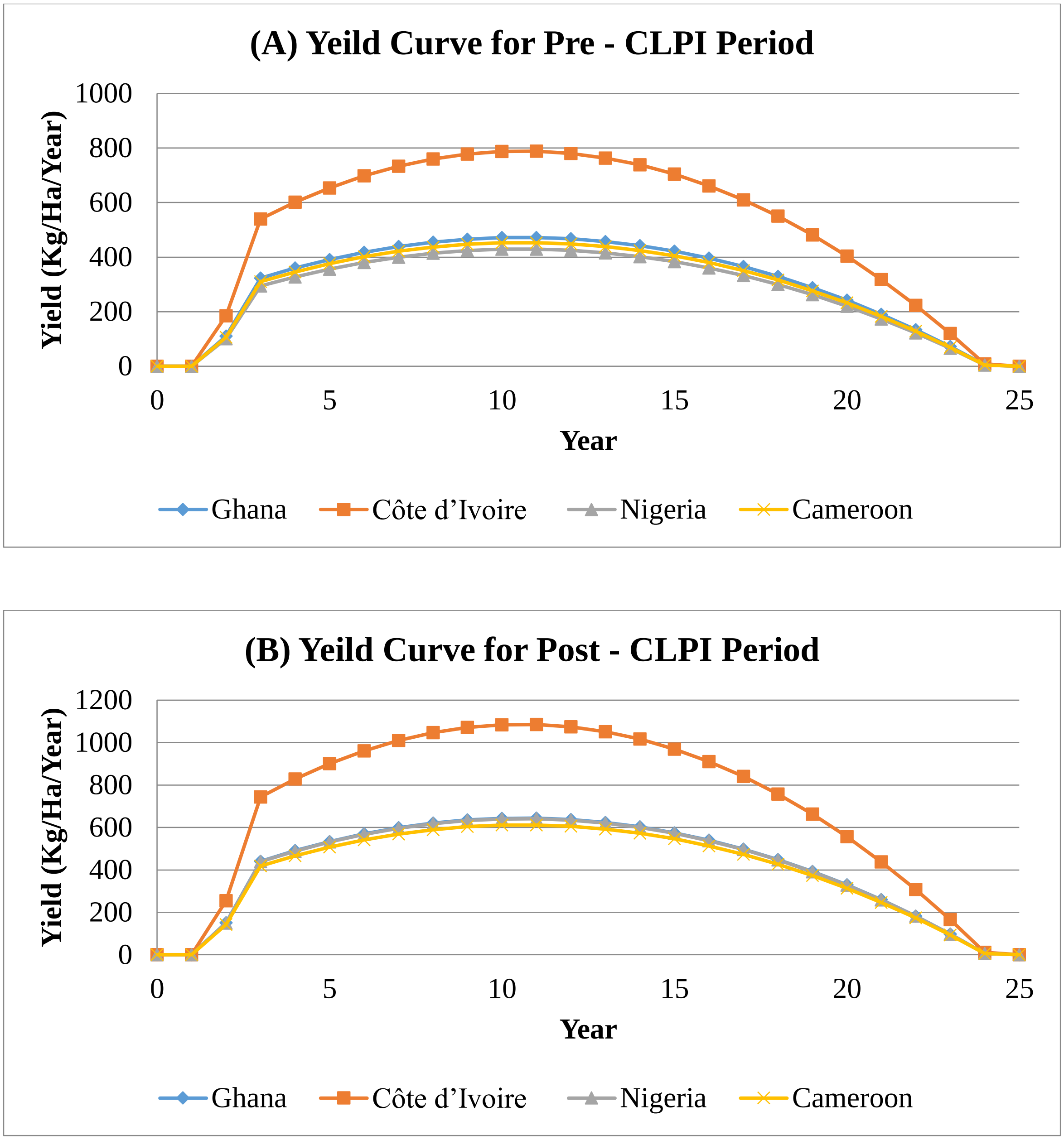


Fig. 1

CLPI Program Packages (bundles of training and services)



Source: Generated from production systems presented in Afari-Sefa et al. (2010) and Gockowski et al. (2011)

Fig. 2. Cocoa yield curves over one production cycle (25 years) in Pre and Post CLPI Periods in Ghana, Côte d'Ivoire, Nigeria and Cameroon

Appendix 1: List of Abbreviations

African Development Bank	ADB
Benefit Cost Ratio	BCR
Business Service Centers	BSC
Cocoa Abrabopa Program	CAP
Cocoa Foundation	WCF
Cocoa Livelihood Program	CLPI
Cocoa Livelihood Program	CLP
Farm Gate Price	FGP
Farmer Based Organization	FBO
Farmer Business School	FBS
Farmer Field School	FFS
Free-On-Board	FOB
Ghana Cocoa Board	COCOBOD
High Input Medium Shade Cocoa	HIMSC
Initial Replacement Year	IRY
Input Credit Package	ICP
International Cocoa Initiative	ICI
International Cocoa Organization	ICCO
International Monetary Fund-International Financial Statistics	IMF-IFS
Low Input Landrace Cocoa	LILC
Net Present Value	NPV
Non-Governmental Organization	NGO
Optimum Replacement Rate	ORR
Second Phase	CLPII
Structural Adjustment Program	SAP
Sub-Saharan Africa	SSA
United Nations	UN
United Nations Development Program	UNDP