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Returns to Agricultural Public Spending in Ghana

Cocoa versus Noncocoa Subsector

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INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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ABSTRACT

Using public expenditure and agricultural production data on Ghana from 1970 to 2012, this paper assesses the returns to public spending in the agricultural sector, taking into consideration expenditures on agriculture as a whole and then separately for expenditures in the cocoa versus the noncocoa subsectors. Production functions for the agricultural sector as a whole are estimated first, and then separately for the two subsectors, to obtain elasticities of land productivity with respect to total and sectorial agricultural expenditure. Different regression methods and related diagnostic tests are used to address potential endogeneity of agricultural expenditure, cross-subsector dependence of the production function error terms, and within-subsector serial correlation of the error terms. The estimated elasticities are then used to calculate the rate of return (ROR) to expenditures in the sector as a whole and within the two subsectors.

The elasticities are estimated at 0.43 for total agricultural expenditure; 0.13 for aggregate expenditure in the noncocoa subsector; and 0.19–0.53 for expenditure in the cocoa sector, depending on aggregation or disaggregation of expenditure on the Ghana Cocoa Board and other industry costs. The ROR is estimated at 141–190 percent for total agricultural expenditure, 124 percent for expenditure in the noncocoa subsector, and 11–39 percent for expenditure in the cocoa subsector. The relatively higher ROR in the noncocoa subsector is mostly due to a much lower expenditure-to-productivity ratio. Implications are discussed for raising overall productivity of expenditure in the sector, as well as for further studies, such as obtaining actual time-series data on some of the production factors in the two subsectors and obtaining information on the quality of sectorial expenditures to model different time-lag effects of spending in the different subsectors.

Keywords: agricultural expenditure, cocoa, Ghana, rate of return

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ABBREVIATIONS

2SLS	two-stage least squares
ADC	Agricultural Development Corporation
AIC	Akaike information criterion
CAADP	Comprehensive Africa Agriculture Development Programme
GDP	gross domestic product
GHS	Ghanaian cedi
GLSS	Ghana Living Standards Survey
IV	instrumental variables
LM	Lagrange multiplier
OLS	ordinary least squares
R&D	research and development
ROR	rate of return
SUR	seemingly unrelated regression
TFP	total factor productivity

1. INTRODUCTION

Raising agricultural productivity and sustaining high agricultural growth rates are major strategic objectives of African governments, not only to accelerate overall economic development but also to reduce poverty and hunger in the continent. In 2003, the heads of state and government in the continent adopted the Comprehensive Africa Agriculture Development Programme (CAADP) to help achieve the above objectives; the leaders committed to spend 10 percent of government expenditure on the agricultural sector in an agreement popularly known as the Maputo Declaration (AU 2003). Since then, various processes at national, regional, and continental levels have been put in place to ensure evidence-based planning and implementation and to monitor and evaluate progress in achieving expected outcomes. CAADP seems to have raised the political profile of agriculture; contributed to more specific, purposeful, and incentive-oriented agricultural policies; and promoted greater participation of multiple state and nonstate actors in agricultural policy dialogue and strategy development (AU-NEPAD 2010, 2014). However, allocation of the 10 percent of government expenditure to agriculture has been an issue, and very few countries have achieved the target. Between 2003 and 2014, Africa as a whole achieved 3.2 percent of this goal on average per year (IFPRI 2015a), and only 13 countries managed to surpass the target in any year since 2003, with several countries cutting back over time (Benin and Yu 2013).

A fundamental concern with the expenditure allocation issue is the question of optimality, which requires knowing the returns to different types of public spending. For example, are African leaders allocating a low share of total expenditure to agriculture because they are not getting as much return compared with the expenditure in other sectors? Because African leaders have also signed on to various charters that demand similar or larger shares of public expenditures—such as the 2001 Abuja Declaration, which calls for 15 percent of the national budget to be spent on the health sector, or the 2007 Year of Science and Technology, which calls for 1 percent of gross domestic product (GDP) to be spent on science and technology—it is difficult to see how leaders can make significant shifts in expenditures across different sectors to meet the Maputo Declaration target. As such, emphasis must be placed on the question of optimality in allocating the agricultural expenditure budget, which also requires knowing the returns to different types of agricultural expenditures. For example, there is concern over the increasing shift in agricultural expenditures toward subsidies (Jayne et al. 2013), which is consistent with the continuous debate on how much to spend on research and development (R&D) versus subsidies, on food crops versus export crops, or on recurrent versus capital items.

This paper contributes to addressing the knowledge gap by using data on Ghana from 1970 to 2012 to estimate the returns to public expenditure on different agricultural subsectors—specifically, cocoa versus noncocoa. Ghana, which is among the African nations whose leaders have committed to CAADP and the other various charters mentioned earlier, is faced with similar expenditure allocation issues. In fact, how much the government of Ghana spends on the sector has come under increasing scrutiny, following substantial discrepancy in the allocation stated in budget statements versus what is reported as actually being spent (Benin 2014). The amount spent to support the development of the food crop subsector versus what is spent to support the cocoa subsector, for example, is a long-standing issue that is reflected in the government's sector development policy and investment plan (MOFA 2007, 2010).

2. CONCEPTUAL FRAMEWORK

The returns to public spending in the cocoa versus noncocoa subsectors are based on estimates of production functions in the two subsectors in which public capital and private capital are complements in the production process; thus, an increase in public expenditure that leads to an increase in the public capital stock raises the productivity of private capital and other factors in production (Aschauer 1989; Barro 1990). The productivity effects of public spending can be categorized according to different pathways of impact. These effects include the following:

- Technology-advancing productivity effects, which typically derive from the yield-enhancing technologies of public expenditure in agricultural R&D
- Human capital–enhancing productivity effects, which typically derive from public expenditure in agricultural education, extension, and information, which all help raise the knowledge and skills of farmers and those engaged in agricultural production (Schultz 1982)
- Transaction cost–reducing productivity effects, which derive from public expenditure on infrastructure (such as storage facilities, market information, and feeder roads) in the agricultural sector, which in turn contributes to improved access to input and output markets and thus reduces the cost of agricultural inputs and technologies (Sadoulet and de Janvry 1995)
- Crowding-in productivity effects, which is a second-order effect in which the increase in public capital causes an increase in private capital

In addition to the various channels through which productivity effects of public agriculture expenditure may materialize, the literature also shows that the effects are not the same for all types of expenditure. Also, the effects often materialize with a lag rather than contemporaneously. See Benin (2015) for further discussion.

To estimate the impact of agricultural public expenditure via the various channels, it is necessary to acquire time-series data that are disaggregated for different types of spending (such as R&D, extension, market development, irrigation, and subsidies), inputs (such as land, labor, and capital), and output in the cocoa and noncocoa subsectors are needed. The main data constraint with this paper is on public agriculture expenditure, which were compiled for agriculture as a whole and disaggregated for the cocoa and noncocoa (which is made up of noncocoa crops, livestock, forestry, and fishery) subsectors from 1958 to 2012. The expenditure data on the cocoa subsector can be further disaggregated by expenditure on the Ghana Cocoa Board and other industry costs; however, the dates available are from 1970 to 2012 only, which are the years used in the econometric estimation for consistency in the comparative analysis of the results associated with the different levels of disaggregation. The data on different types of spending, such as R&D, extension, market development, irrigation, and subsidies, could only be disaggregated for short periods, which are insufficient for a reliable econometric estimation. More is provided on the data later in this paper.

Production Function and Elasticities

Given the data constraints, let the aggregate production function for the cocoa and noncocoa subsector *s* in year *t* be modeled as

$$Y_{st} = A_{st} * f(L_{st}, K_{st}, D_{st}, \boldsymbol{Z}_t), \qquad (1)$$

where *Y* is the value-added of agricultural output, *L* is labor or the number of agricultural workers, *K* is the value of private capital and other intermediate inputs, *D* is agricultural land, ***Z*** is a vector of other factors (such as climate and agroecology) affecting agricultural output that are not necessarily subsector specific, and A is a measure of total factor productivity (TFP). Equation (1) can be rewritten in terms of per unit agricultural land as follows:[1]

$$y_{st} = A_{st} * f(l_{st}, k_{st}, Z_t), \quad (2)$$

where $y = Y/D$, $l = L/D$, and $k = K/D$ to represent value-added, labor, and capital per unit agricultural area, respectively. To capture the productivity effect of agricultural public expenditure, G, equation (2) can be modified as follows:

$$y_{st} = A_{st} * f(l_{st}, k_{st}, Z_t^y, G_{st}, \dots, G_{st-q}) + e_{st}^y \quad (3a)$$

$$G_{st} = h(y_{st}, Z_t^G) + e_{st}^G, \quad (3b)$$

where $\boldsymbol{Z}^y$ and $\boldsymbol{Z}^G$ are used to differentiate the vector of other factors that affect y and G, respectively; q is a positive integer representing the maximum lagged effect of G; and e^y and e^G are random error terms in equations (3a) and (3b), respectively. Because public expenditure is modeled directly in equation (3a), rather than the conceptual counterpart of public capital in addition to an equation on public expenditure–public capital transformation, equation (3a) may be interpreted as a reduced-form production function. Assuming a Cobb-Douglas production function, the elasticity of land productivity with respect to agricultural public expenditure can be obtained from equation (3a) (ignoring equation (3b) for now), either separately for the individual time-lagged effects (ϑ_{st-q}^{yG}) or together for the total effect (ϑ_s^{yG}):

$$\vartheta_{st-q}^{yG} = \frac{\partial y_{st}}{\partial G_{st-q}} \quad (4a)$$

$$\vartheta_s^{yG} = \sum_{q=0}^{N} \vartheta_{st-q}^{yG}, \quad (4b)$$

where ∂ refers to the partial derivative and q = 0, 1, ..., N. The elasticity is interpreted as the percentage change in land productivity (y) due to a 1 percent change in agricultural public expenditure (G).

Rate of Return

With the estimated elasticities ($\hat{\vartheta}_{st-q}^{yG}$), the ROR can be estimated as the discount rate (r) that equates the net present value of marginal productivities ($\hat{\vartheta}_{st-q}^{yG} * \bar{y}_s * \bar{D}_s$) over the relevant time (that is, q = 0, 1, ..., N) to an initial public agriculture expenditure (G_{s0}), equivalent to 1 percent of the annual average agricultural public expenditure in subsector s (or $0.01 * \bar{G}_s$):

$$\sum_{q=0}^{N} \frac{\hat{\vartheta}_{st-q}^{yG} * \bar{y}_s * \bar{D}_s}{(1+r)^t} = G_{s0}, \quad (5)$$

where $\bar{y}_s$ is the annual average value-added per hectare in subsector s and $\bar{D}_s$ is the annual average agricultural land area in subsector s.

Endogeneity of Public Expenditure and Other Issues in Estimation

Considering the effect of equation (3b) in the analysis, because a change in G (dG) may derive from a change in y (dy), the elasticities represented in equations (4) may be overestimated if $\frac{dG}{dy} > 0$ and underestimated if $\frac{dG}{dy} < 0$.[2] Furthermore, because a change in y (dy) may derive from a change in e_t^y, G

[1] Alternatively, we could have divided through by L or K to arrive at similar results, though with different interpretations—for example, labor productivity instead of land productivity.

[2] The subsector subscript s has been dropped to simplify the presentation in this section.

may be influenced by the same unobservable factors that influence *y*—that is, G_t is correlated with e_t^y or $E[e_t^y|G_t] \neq 0$. These issues reflect the potential endogeneity of *G*, which, if not addressed, may render the estimates of the elasticities by ordinary least squares (OLS) biased and inconsistent. The literature discusses at least three sources of the endogeneity—simultaneity of *y* and *G*, omitted explanatory variables in equation (3a), and measurement errors in *G*—and the different ways to address each of them.

With respect to simultaneity of *y* and *G*, higher agricultural output and productivity may, for example, raise the tax base or revenues that *G* depends on, meaning that *y* and *G* may be simultaneously determined. This also implies that a change in unobservable factors e_t^y that cause a change in *y* may potentially cause a change in *G*, so that G_t becomes correlated with e_t^y. The standard approach for addressing this type of endogeneity problem is instrumental variables (IVs), which must satisfy two requirements: the instrument(s) must be correlated with G_t, and they must be orthogonal to e_t^y. The vector of variables $\boldsymbol{Z}^G$ specified in equation (3b) becomes critical here in terms of determining G_t or identifying equation (3b). The estimation is done in a two-stage procedure or a two-stage least squares (2SLS). In the first stage, *G* is regressed on $\boldsymbol{Z}^G$ and all the exogenous variables in equation (3a). Then, the results are used in a second-stage estimation of equation (3a). Variables on political processes and institutions have been shown to work well as instruments for expenditures (for example, Cox and McCubbins 1986; Lindbeck and Weibull 1993; Benin et al. 2012), which is why they are exploited in this paper.

Regarding the omitted explanatory variables in general, suppose that agriculture expenditure is influenced by agroecological and climatic factors—say, for example, that a lower amount is spent in relatively poor rainy years compared with other years. Suppose further that these factors, represented by C_t, which also affect *y*, are omitted as explanatory variables in equation (3a). They will then be captured in the new error component—say, φ_t^y (where $\varphi_t^y = C_t + e_t^y$)—so that G_t becomes correlated with φ_t^y. IV or 2SLS are still the standard approaches for addressing this source of endogeneity, in which the instruments must be correlated with G_t and orthogonal to φ_t^y.

With respect to measurement errors in *G*, suppose that the observed value G_t* is equal to the true unobserved value G_t plus the measurement error μ_t, according to

$$G_t^* = G_t + \mu_t. \quad (6)$$

The consequence is that the measurement error will be captured in the new error component in equation (3a)—say, ω_t^y (where $\omega_t^y = \mu_t + e_t^y$)—so that G_t becomes correlated with ω_t^y or $E[\omega_t^y|G_t] \neq 0$. Because the problem is that the measurement error μ_t is correlated with G_t*, the standard solution is also IV—that is, finding a variable correlated with G_t* but not with μ_t—though this is not as difficult as when G_t is correlated with e_t^y in equation (3a) (Griliches 1997; Greene 1993). Observed outputs of G_t may be used as instruments—for example, number of research scientists, number of agricultural technologies generated, or amount of fertilizers and improved seeds distributed to farmers.

Because the productivity effects of public spending tend to materialize with a lag or can persist long after the period of the initial investment, identifying the optimal lag N becomes critical. To accommodate degrees-of-freedom issues, however, the choice of the lag is influenced by the length of the time-series data. We try up to a 10-year lag, in line with the Holtz-Eakin, Newey, and Rosen (1988) recommendation of the lag length being up to a third of the total time span of the data. However, we use the Akaike information criterion (AIC) and adjusted *R*-squared to determine the appropriate lag length (Greene 1993). The optimal lag length is determined by the minimum AIC and the maximum adjusted *R*-squared, which we found to be three years.

3. DATA SOURCES AND EMPIRICAL APPROACH

Data and Sources

The main data constraint with this paper is with public agriculture expenditure (G_s), which we have managed to compile from various national and international sources from 1958 to 2012 in the aggregate for agriculture as a whole and separately for the cocoa and noncocoa subsectors. The noncocoa subsector includes noncocoa crops, livestock, forestry, and fishery (see Table 3.1 for details). Expenditures on cocoa can be disaggregated further for the Ghana Cocoa Board (mostly for administration and research) and general industry costs (mostly for inputs and marketing), but only from 1970 to 2012. Data on total government expenditure (*TE*), which is used to calculate nonagricultural expenditure ($NG = TE - G$), were also obtained from the above sources.

Table 3.1 Description of variables and data sources used in the estimations

Variable	Description/Disaggregation	Years of data	Data sources
Total expenditure (*TE*)	Total government expenditure in constant 2006 GHS, million	1958–2014	Stryker (1990); Quartey-Papafio (1977); World Bank (1960, 1978, 1985); Jebuni and Seini (1992); MOFEP (1995); IMF (1998, 2000, 2005, 2015); GOG (2005), Ghana Cocoa Board (2013); IFPRI (2015a, 2015b)
Agricultural public expenditure (G_s)	Government expenditure on agriculture in constant 2006 GHS, million:	1958–2013	
	• Expenditure on the cocoa subsector managed by the Ghana Cocoa Board, disaggregated by:	1958–2013	
	○ Expenditures on the Ghana Cocoa Board	1970–2013	
	○ Other industry expenditures	1970–2013	
	• Expenditure on the noncocoa subsector (such as noncocoa crops, livestock, forestry, fishery, and research)	1958–2012	
Agricultural valued-added per hectare (y_s)	Net output (gross output lees intermediate inputs) in constant 2006 GHS (*Y*) divided by agricultural land area (*D*)	1958–2014	Kapur et al. (1991); IMF (1998, 2000); GOG (2005); GSS (2010); Jedwab and Osei (2012); Coulombe and Wodon (2007); World Bank (2007, 2015); FAO (2015)
	Original values of *Y* in current GHS were deflated using the ratio of GDP in constant 2006 GHS to GDP in current GHS.		
	• Disaggregated into cocoa and noncocoa subsector	1960–2014	
Labor per hectare (l_s)	Economically active population engaged or seeking work in agriculture, hunting, fishing, or forestry (*L*) divided by agricultural land area (*D*) • Disaggregated into cocoa and noncocoa subsector	1961–2012	Benin and Nin Pratt (2016); GSS (1993, 2000, 2008, 2014); Teal and Vigneri (2004); Vigneri (2008); FAO (2015)
Capital ($k1_s$)	Gross fixed capital stock in constant 2006 GHS (*K1*) divided by agricultural land area (*D*) • Crop capital: land development, plantation and tree crops, and machinery and equipment disaggregated into cocoa and noncocoa subsector ($k1_{cs}$) • Livestock capital: animal stock, structures for livestock, and milking machines ($k1_l$)	1961–2012	Benin and Nin Pratt (2016); FAO (2015)
Fertilizer ($k2_s$)	Kilograms of nitrogen, phosphorus, and potassium nutrients consumed (*K2*) divided by agricultural land area (*D*) • Disaggregated into cocoa and noncocoa subsector	1961–2012	Teal and Vigneri (2004); Vigneri (2008); Aneani et al. (2012); Benin and Nin Pratt (2016); Obuobisa-Darko (2015); FAO (2005, 2015)

Table 3.2 Continued

Variable	Description/Disaggregation	Years of data	Data sources
Animal feed ($k3_s$)	Kilograms (maize equivalent) of edible commodities fed to livestock (*K3*) divided by agricultural land area (*D*)	1961–2012	Benin and Nin Pratt (2016); FAO (2015)
Rainfall (*R*)	Total rainfall in millimeters	1960–2013	HarvestChoice (2015)
Technology (*A*)	Dummy variable representing the level of technology at specific periods: 1961–1974 = 0, 1975–1983 = 1, and 1984–2012 = 2	1961–2012	Benin and Nin Pratt (2016)
Instruments (Z^G)		1958–2014	
• *GOV*	• Type of ruling government: 1 = military, 0, otherwise		Author's definition
• *PER*	• Three years following year of an agricultural public expenditure review: 1 = 1978–1980, 1998–2000, 2007–2009, 2013–2015; 0, otherwise		World Bank (1978); MOFA (1999, 2013); Kolavalli et al. (2010)
• SHA_s	• Share of agricultural expenditure (G_s) in total expenditure (*TE*)		See sources for expenditures

Source: Author's description based on cited literature.
Notes: GHS = Ghanaian cedi; GDP = gross domestic product.

Agricultural production data were also compiled from various national and international sources, as shown in Table 3.1. Data on agricultural value-added (*Y*) and land area (*D*) were already disaggregated for the cocoa and noncocoa subsectors. The data on labor (*L*), crop capital (*K1*), and chemical fertilizer (*K2*) were in aggregate form only; thus, we used information from various Ghana Living Standards Surveys (GLSS) and other studies to disaggregate the data for the cocoa and noncocoa subsectors. With respect to labor (*L*), the proportion of farmers who owned, cultivated, or worked on a cocoa farm was first obtained from the GLSS data (GSS 1993, 2000, 2008, 2014) and other studies (such as Teal and Vigneri 2004; Vigneri 2008) for the relevant survey or study years. Then, a linear extrapolation was used to fill in the proportion for the other years, with a resulting range of 13 percent in 1961 to 23 percent in 2012. This information was then used to disaggregate the total labor for the cocoa and noncocoa subsectors (L_s). Similar approaches were used to disaggregate crop capital (*K1*) and chemical fertilizer use (*K2*). For crop capital, the original data comprised the sum of the value of land development, plantation crops, and machinery and equipment, which were obtained from Benin and Nin-Pratt (2015, based on FAOStat). For land development, machinery, and equipment, we assumed equal weight for the cocoa and noncocoa subsectors and disaggregated the total values based on the share of cocoa area in total agricultural area, which resulted in a range of 8.4 percent in 1961 to 7.4 percent in 2012. For plantation crops, we used the share of cocoa area in total area under tree crops, which resulted in a range of 82 percent in 1961 to 50 percent in 2012. For chemical fertilizers, we first obtained the proportion of cocoa farmers who used chemical fertilizers from studies based on GLSS data or other surveys (such as Teal and Vigneri 2004; FAO 2005; Vigneri 2008; Aneani et al. 2012; Obuobisa-Darko 2015) for the relevant survey or study years. Then, we used a linear extrapolation to fill in the proportion for the other years, which resulted in a range of 1 percent in 1961 to 46 percent in 2012. These data were used to obtain the share of cocoa area that is chemically fertilized, assuming that the share of cocoa farmers using chemical fertilizers is equivalent to the share of cocoa area that is chemically fertilized. This information was then used to disaggregate the total amount of fertilizer used, based on the share of the fertilized cocoa area in the total agricultural area that is fertilized.

The level of technology (*A*) is measured using a time dummy variable representing the level at specific time periods: 1961–1974 = 0, 1975–1983 = 1, and 1984–2012 = 2. The reasoning for this is based on Benin and Nin Pratt (2016), who showed that TFP growth pattern in Ghana was stagnant, declining, and increasing, respectively, within those subperiods. For the other variables represented by $\boldsymbol{Z}^y$ in the production function, we use rainfall (R) data obtained from HarvestChoice (2015). For the instruments, represented by $\boldsymbol{Z}^G$ in equation (3b), we tried three variables:

- A dummy variable representing the type of ruling government (*GOV*: 1 = military in 1966–1969, 1972–1979, 1982–1992; 0, otherwise)
- An indication of whether budget allocations may be informed by expenditure review studies, which is measured by a dummy variable for the three years following the year (1977, 1997, 2006, and 2012) in which an agricultural public expenditure review was undertaken (*PER*)
- An indication of whether budget allocations for agriculture are fixed relative to the allocations to other sectors, which is measured by the share of agricultural expenditure in total expenditure (*SHA*)

Estimation Methods

Because the data can be aggregated for the agricultural sector as a whole and then disaggregated for the cocoa and noncocoa subsectors, we estimate two broad production functions: one for the agricultural sector as a whole (equation (6a)) and then separate ones for the cocoa and noncocoa subsectors (equation (6b)):

$$y_t = a + \delta A_t + \alpha l_t + \sum_{j=1}^{3} \beta_j k_{jt} + \tau R_t + \sum_{q=0}^{N} \gamma G_{t-q} + \pi NG_t + e_t \qquad (6a)$$

$$y_{st} = a_s + \delta_s A_t + \alpha_s l_{st} + \sum_{j=1}^{3} \beta_{js} k_{jst} + \tau_s R_t + \sum_{q=0}^{N} \gamma_s G_{st-q} + \pi_s NG_t + e_{st}. \qquad (6b)$$

As discussed in the conceptual framework, a major issue with the estimation is addressing endogeneity of G, which is addressed using IV or 2SLS. The instruments, in addition to all the other exogenous variables, are used in a first-stage estimation of G_t and G_{st} (see equation (3b)), and then the results are used in a second-stage estimation of equations (6a) and (6b), respectively. Because use of weak instruments could lead to more biased estimates and low statistical significance of the estimated parameters (Greene 1993), we try each instrument (*GOV*, *PER*, and SHA_s) individually, as well as in combinations. Then, we use several statistical tests to test for the validity of the instruments in the first-stage regression and for the exogeneity of G_t in the second-stage regressions. The tests include the Durbin score, Wooldridge score, and Wu-Hausman tests of endogeneity (Durbin 1954; Wu 1974; Hausman 1978; Wooldridge 1995); R-squared statistics from the first-stage regression to test for weak instruments (Bound, Jaeger, and Baker 1995); and the Sargan score, Wooldridge score, and Basmann tests of overidentifying restrictions (Sargan 1958; Basmann 1960; Wooldridge 1995).

In the estimation of equation (6a), we try two different treatments of agricultural expenditure—first, in aggregate for the cocoa and noncocoa sectors, $\sum_{q=0}^{N} \gamma G_{t-q}$, and then separately for the two subsectors, $\sum_{s=1}^{2} \sum_{q=0}^{N} \gamma_s G_{st-q}$. In both equations (6a) and (6b), we also consider further disaggregation of the expenditure on the cocoa subsector by expenditure on the Ghana Cocoa Board versus other industry costs.

In equation (6b), the error terms in the subsector production functions may be contemporaneously correlated. Therefore, we estimate the equations using seemingly unrelated regression (SUR) methods (Zellner 1962; Zellner and Huang 1962). We test for independence of the error terms using the Breusch-Pagan test (Breusch and Pagan 1980). This is implemented as a chi-square statistic, which, if it is statistically significant, means a rejection of the null hypothesis that the cross-equation correlation of the error terms is zero; we thus continue to use SUR. Because we do not know how to easily implement the SUR within the IV framework, the IV and SUR methods are implemented separately, with the SUR method being favored when the endogeneity of G is rejected in the IV.

In both equations (6a) and (6b), the issue of serial correlation of the error term arises because we are using time-series data. Potential serial correlation means the unobservable factors in one period may be correlated with the unobservable factors in a subsequent period (that is, e_t and e_{t-1} are correlated or that e_t and e_{t-q} are correlated in the case of autocorrelation in general). This problem leads mostly to underestimation of the standard errors and overestimation of the student t-statistics associated with the estimated parameters. We test for first-order serial correlation using Durbin's alternative test for autocorrelation (Durbin 1970) and higher-order serial correlation using the Breusch-Godfrey Lagrange multiplier (LM) test for autocorrelation (Breusch 1978; Godfrey 1978). Then, when necessary, we correct for the problem by estimating robust standard errors using the Newey-West standard errors for OLS estimation (Newey and West 1987) and adjustments for different types of misspecification for the IV and SUR estimates (Wooldridge 2013). Because the robust specifications typically tend to result in larger standard errors and lower statistical significance of the estimated parameters, which we find to be true with the estimates obtained here, we attach greater confidence to the parameter estimates that are statistically significant at the 10 percent level or lower. Nevertheless, we report the statistical significance of the estimated parameters with both regular and robust specifications of the standard errors.

All continuous variables used in the estimation were transformed by natural logarithm, so that their respective estimated coefficients are interpreted directly as elasticities. The regressions were carried out with STATA software version 14.0 (from StataCorp), using the "regress," "ivregress," "sureg," and "sem" estimation and postestimation commands. The estimated elasticities on agricultural expenditure ($\hat{\gamma}$ and $\hat{\gamma}_s$) and the annual average expenditure ($\bar{G}$ and $\bar{G}_s$), value-added per hectare ($\bar{y}$ and $\bar{y}_s$), and land area ($\bar{D}$ and $\bar{D}_s$) were used to calculate the RORs, which were done in a Microsoft Excel spreadsheet using the "IRR" command function.

Before presenting the econometric results of the impact of agricultural public spending, it is useful to first look at the trends in the two main variables—agricultural public expenditure (G_s) and agricultural value-added per unit area (y_s)—to provide a brief historical context within which the two subsectors have been managed over time in Ghana.

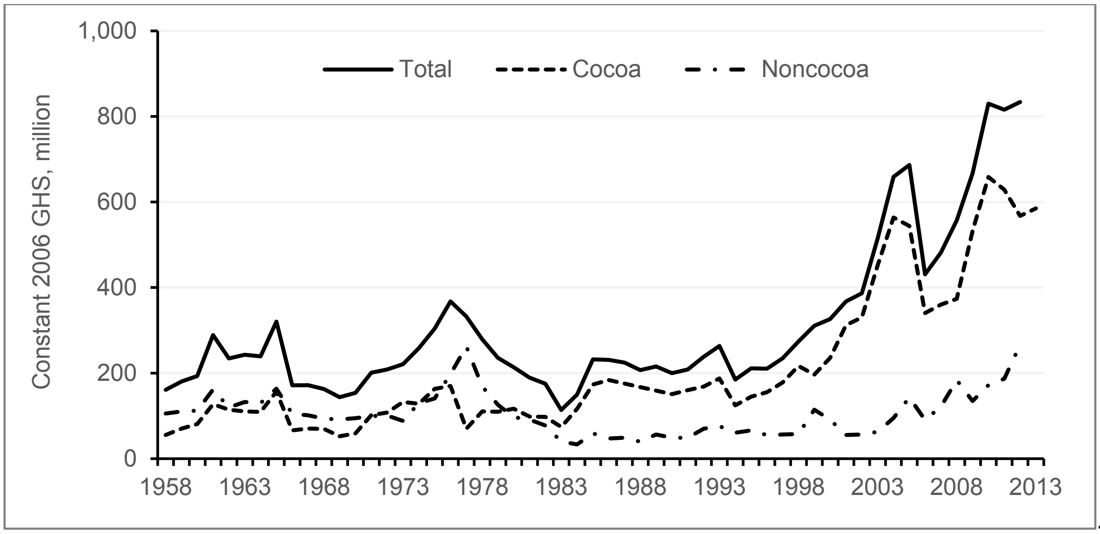
Trends in Agriculture Expenditure and Value-Added per Unit Area

Trends in agricultural public expenditure (G_s) and agricultural value-added per unit area (y_s) are shown in Figures 3.1 and 3.2, respectively. Behind the scenes is how successive governments thought about and implemented agricultural policy, as well as how public expenditures were undertaken and accounted for. Some of the major influential factors include the following:

- Until 1990, there was direct agricultural production by the government through state farms and cooperatives.
- Subsidization of farm production stopped in 1990 and returned in 2007.
- Implementation of policies and strategies was mostly through projects until the 1990s and then through programs and sectorwide approaches afterward.
- Government and public spending was decentralized, including the enactment of the Local Government Law in 1988, establishment of the District Assembly Common Fund in 1993, and implementation of direct district budgeting and execution starting in 2012.
- Agricultural public expenditure reviews were conducted in 1977, 1998, 2006, and 2012.
- The country signed the CAADP compact in 2009.

To analyze these further and to better understand the overall trends presented in Figures 3.1 and 3.2, we provide a brief historical narrative of agricultural policies, strategies, and performance under successive periods of governments, starting with the late colonial period in 1951. The subperiod trends are summarized in Table 3.2.

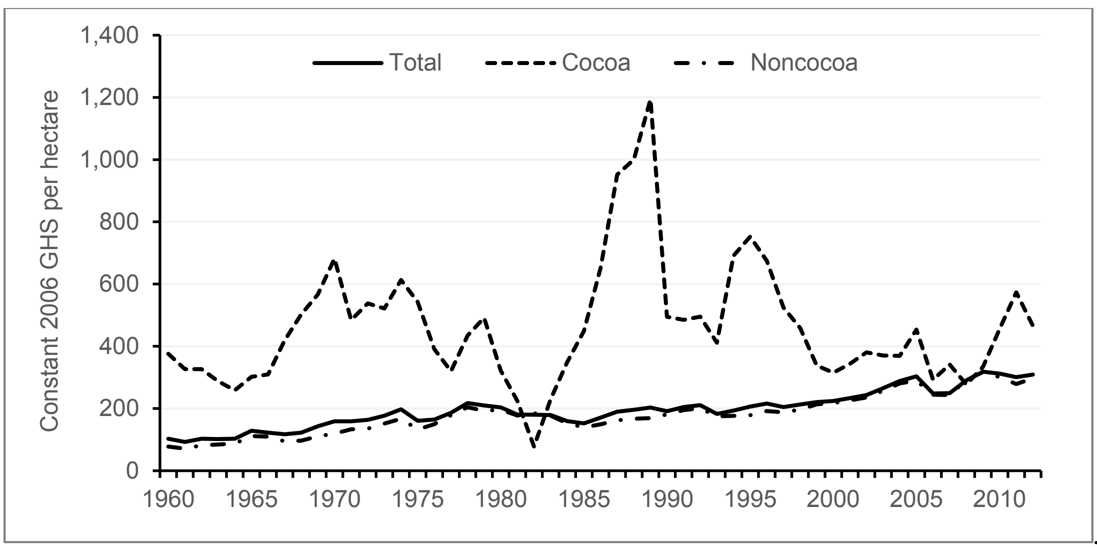
Figure 3.1 Agricultural public expenditure in Ghana by subsector, 1958–2013



Source: Author's calculation and illustration based on Stryker (1990), Quartey-Papafio (1977), World Bank (1960, 1978, 1985), Jebuni and Seini (1992), MOFEP (1995), IMF (1998, 2000, 2005, 2015), GOG (2005), Ghana Cocoa Board (2013), and IFPRI (2015a, 2015b).

Note: GHS = Ghanaian cedi.

Figure 3.2 Agricultural value-added per hectare by subsector in Ghana, 1958–2013



Source: Author's calculation and illustration based on Kapur et al. (1991), IMF (1998, 2000), GOG (2005), GSS (2010), Jedwab and Osei (2012), Coulombe and Wodon (2007), World Bank (2007, 2015), and FAO (2015).

Note: GHS = Ghanaian cedi.

Table 3.3 Agricultural expenditure and value-added per hectare by subsector in Ghana, 1958–2012

Indicator	1958–1966	1967–1971	1972–1979	1980–1981	1982–1992	1993–2000	2001–2008	2009–2012
Agriculture expenditure, growth rate (%)								
Total	3.8	2.6	3.6	–11.3	4.2	6.1	4.3	6.7
Cocoa	6.2	5.9	–3.0	–15.6	5.9	6.4	1.0	1.5
Noncocoa	2.1	–0.3	9.0	–6.1	1.1	4.9	17.8	23.7
Agriculture expenditure (% of total expenditure)								
Total	16.1	11.4	15.8	22.9	17.3	6.7	9.8	10.8
Cocoa	7.2	4.8	7.1	12.2	12.7	4.8	7.9	8.3
Noncocoa	8.8	6.6	8.7	10.7	4.7	1.9	1.9	2.5
Agriculture expenditure (% of value-added)								
Total	10.9	5.8	7.4	5.1	5.2	5.7	8.8	11.8
Cocoa	20.3	9.7	20.0	33.4	45.5	36.7	71.5	83.7
Noncocoa	8.0	4.6	4.8	2.6	1.5	1.9	1.9	3.2
Agriculture value-added per hectare, growth rate (%)								
Total	4.3	9.1	3.2	–11.5	2.4	2.6	1.8	–1.2
Cocoa	–3.4	6.2	–4.5	–30.4	15.3	–8.2	–3.0	13.1
Noncocoa	7.4	9.3	5.2	–9.6	1.7	3.3	2.2	–2.7

Source: Author's calculation and illustration based on Stryker (1990), Quartey-Papafio (1977), World Bank (1960, 1978, 1985), Jebuni and Seini (1992), MOFEP (1995), IMF (1998, 2000, 2005, 2015), GOG (2005), Ghana Cocoa Board (2013), and IFPRI (2015a, 2015b) for expenditure data, and Kapur et al. (1991), IMF (1998, 2000), GOG (2005), GSS (2010), Jedwab and Osei (2012), Coulombe and Wodon (2007), World Bank (2007, 2015), and FAO (2015) for valued-added data.

1951 to 1966

During the colonial and pre-independence years (1900–1950), production of crops for export was the government's main focus; therefore, agriculture expenditure was targeted at cocoa, oil palm, rubber, and tobacco, in particular. Production of food crops was not a priority, and some of the foreign exchange earnings from the exports was used to import food (mainly rice, wheat, and canned fish) for mostly urban consumers (Dappah 1995). The agricultural policies in 1951–1966, under the Convention People's Party government led by Dr. Kwame Nkrumah, was dictated by the overall economic development agenda of rapid industrialization, which was primarily financed by taxing agriculture. An Agricultural Development Corporation (ADC) was established to promote the production of export crops (mainly cocoa) for foreign exchange earnings and production of industrial crops (mainly rubber, sugar cane, oil palm, and cotton) to feed the ambitious local factories that were being set up. As such, the bulk of agriculture expenditure was allocated to ADC and spent on input subsidies (imports of fertilizers, other chemicals, tractors, and implements) and on distribution and marketing of produce. Following the ADC's forced closure in 1962, due to its accumulated large debts and unsuccessful large-scale production and marketing activities, state farms and cooperatives were established to take over ADC's projects and the ministry's stations. Price controls, input and credit subsidies, and obligatory credit allocations continued to be used to support the heavy state involvement in agricultural production, distribution, and marketing (Stryker 1990; Dappah 1995). At the time of Nkrumah government's overthrow in 1966, there were 105 state farms (42 of them were inherited from ADC) cultivating about 22,396 hectares, with 62 percent under permanent crops (mainly rubber, oil palm, sugar cane, cotton, coconut, banana, and kola nut) and the remaining 38 percent under food crops (mainly maize and rice) (Austin and Luckham 1975). As Table 3.2 shows, agriculture expenditure in 1958–1966 grew at an annual average rate of 3.8 percent, with expenditures on cocoa growing faster (6.2 percent) than combined expenditures on the noncocoa subsector (2.1 percent). Although the amount spent as a share of total expenditure was slightly lower for cocoa (7.2 percent) than for noncocoa (8.8 percent), the amount spent as a share of the respective subsector's agricultural value-added was much higher for cocoa (20.3 percent) than for noncocoa (8.0 percent). Growth in the land productivity for the agricultural sector as a whole averaged 4.3 percent year, which was driven by growth in the noncocoa subsector (7.4 percent), as compared with the declining growth in the cocoa subsector (–3.4 percent)

1966 to 1972

This era was governed by the National Liberation Council military government under Lieutenant General Joseph Arthur Ankrah and Lieutenant General Akwasi Afrifa (1966–1969), followed by the second republic under Doctor Kofi Busia and the Progress Party (1969–1972). The main strategy of the National Liberation Council government that had significant bearing on the level of agriculture expenditure and how it was allocated was in trying to ward off the domestic crisis (mainly, high food prices and low producer prices) and to pay off the large debts amassed by the previous government (Austin and Luckham 1975). Doing so involved stimulating more agricultural primary exports (cocoa and timber) and cutting back on direct state involvement in agricultural production. For example, between the 1966 coup d'état and May 1968, the producer price of cocoa was doubled, no new state farms were established, and some state farms and factories were closed or sold off. This trend continued into the Busia-led government. Although there was marked structural change in the rest of the economy (especially nationalism and promotion or takeover of businesses by Ghanaians), agricultural policy and finance mostly continued as before—that is, promote production of cocoa for export, promote industrial crops to feed factories, import and subsidize fertilizer and capital for production of these crops, and import food to feed the urban consumers.

The biased support to large-scale farms or farmers is reflected in the lending practices to the sector by banks that were obligated to provide agricultural loans. The banks typically gave loans to those farms operating 20–1,000 acres of farmland and producing industrial crops or engaged in agro-industry (Austin and Luckham 1975). As Table 3.2 shows, agriculture expenditure during this era grew at an average rate of 2.6 percent per year, with expenditures on cocoa growing much faster (5.9 percent) than combined expenditures on the noncocoa subsector (–0.3 percent). Here, too, although the amount spent as a share of total expenditure was slightly lower for cocoa (4.8 percent) than for noncocoa (6.6 percent), the amount spent as a share of the respective subsector's agricultural value-added was more than twice as high for cocoa (9.7 percent) as it was for noncocoa (4.6 percent). Growth in land productivity for the agricultural sector as a whole averaged 9.1 percent per year, which was dominated by growth in the noncocoa subsector (9.3 percent), as compared with growth in the cocoa subsector (6.2 percent).

1972 to 1979

Promotion of private large-scale agricultural production was enhanced following the second coup d'état and rule of the country by the National Redemption Council military government under General Ignatius Acheampong (1972–1975) and the Supreme Military Council government under Lieutenant General Frederick Akuffo (1975–1979). It was during this era that the first agricultural-specific initiatives were launched—Operation Feed Yourself, which aimed to help reduce food imports, and Operation Feed Your Industries, which aimed to continue providing raw materials to feed local factories. During these years, fertilizer subsidies were substantial, and bank loans to large-scale operators increased rapidly (Quartey-Papafio 1977). Although small-scale farmers were not directly supported under these policies and interventions, they seem to have had easy access to fertilizer and seed, which contributed favorably to their well-being (Wiemers 2015). In general, the economic development agenda of rapid import-substitution industrialization continued.

As Table 3.2 shows, agriculture expenditure in 1972–1979 grew at an average rate of 3.6 percent year, with expenditures on cocoa experiencing a declining growth rate (–3.0 percent) and combined expenditures on the noncocoa subsector rising rapidly (9.0 percent). Still, the amount spent as a share of the respective subsector's agricultural value-added was much higher for cocoa (20 percent) than for noncocoa (4.8 percent). Growth in land productivity for the entire agricultural sector averaged 3.2 percent per year, which was again driven by growth in the noncocoa subsector (5.2 percent), as compared with the declining growth in the cocoa subsector (–4.5 percent).

1979 to 1981

Following another coup d'état in June 1979 came the brief military government of the Armed Forces Revolutionary Council, led by Flight Lieutenant Jerry John Rawlings from June to September 1979, and then the third republic, led by the government of the People's National Party under Doctor Hilla Limann from September 1979 to December 1981. Dr. Limann's government launched a two-year program, Action Programme for Agricultural Production, 1980–1981 (Andah 1980). As Table 3.2 shows, although there was negative growth in most indicators during this relatively short period, likely reflecting the widely acclaimed economic mismanagement of the government prior to the coup d'état, this period recorded the highest annual average share of total expenditures allocated to agriculture (22.9 percent) compared with all other periods. The amount spent as a share of the respective subsector's agricultural value-added continued to be much higher for cocoa (33.4 percent) than for noncocoa (2.6 percent).

1982 to 2000

Jerry Rawlings came back to power, first through another coup d'état under the government of the Provisional National Defence Council from the eve of 1982 until 1993, and then through the ballot box, ushering in the fourth republic under the National Democratic Congress government until January 2001. This roughly 20-year period is known for the Structural Adjustment Program, which is locally called the Economic Recovery Program. In addition, numerous agricultural sector–specific plans, strategies, projects, or programs were launched. As expected with the structural adjustment, there was substantial cutback in government spending in general, and agricultural input subsidies were stopped in 1990. Overall agriculture expenditure grew at an average rate of 4.2 percent in 1982–1992 and 6.1 percent in 1993–2000, with expenditures on the cocoa subsector growing faster than combined expenditures on the noncocoa subsector. As Table 3.2 shows, the share of agriculture expenditure in total expenditure declined substantially from 17.0 percent in 1982–1992 to 6.7 percent in 1993–2000. The amount spent as a share of total expenditure or as the share of the respective subsector's agricultural value-added was much higher for the cocoa subsector than for the noncocoa subsector.

With the launch of the Local Government Law, the decentralization policy, and institution of the District Assembly Common Fund, direct spending and accounting of expenditures at lower levels increased, likely increasing the targeting of expenditures for agricultural and rural development (Mogues and Benin 2012). Comparative growth in land productivity was mixed, however; whereas it was higher in the cocoa subsector (15.3 percent per year) than in the noncocoa subsector (1.7 percent per year) in 1982–1992, it was lower for the cocoa subsector (–8.2 percent per year) than for the noncocoa subsector (3.3 percent percent) in 1993–2000.

2001 to 2008

With the National Patriotic Party, led by John Agyekum Kufuor, coming into power in January 2001, there was a shift from project-based agricultural development to program-based and sectorwide approaches. Some of the most influential approaches on the sector were the Presidential Special Initiatives, the Agricultural Services Subsector Investment Program, and the Food and Agricultural Sector Development Policy, among others. It was during this era that CAADP, the Africa-wide, agriculture-led development initiative, was launched in the continent, though Ghana did not officially complete and sign its national compact until 2009. The CAADP raised the profile of agricultural expenditures and influenced the definition and accounting of agriculture expenditure (the debate of which continues today).

In 2007, the government announced that it would reintroduce agricultural input subsidies (fertilizer, block farms, mechanization, and buffer stock) and then went on to spend an average of GHS 7.9 million each year in 2007 and 2008 to implement it (Benin et al. 2013). Direct spending at subnational levels continued. As Table 3.2 shows, at the national level, agriculture expenditure during this era grew at an average rate of 4.3 percent per year, with growth in expenditure on the cocoa subsector being almost stagnant (1.0 percent) compared with growth in expenditure on the noncocoa subsector (17.8 percent).

The amount spent as a share of total expenditure or as a share of the respective subsector's agricultural value-added continued to be much higher for cocoa than for noncocoa. For example, the share of expenditure on cocoa as a share of the subsector's agricultural value-added was 71.5 percent, compared with only 1.9 percent for the noncocoa subsector. Growth in land productivity for the entire agricultural sector averaged 1.8 percent per year, which again was dominated by growth in the noncocoa subsector (2.2 percent), compared with growth in the cocoa subsector (–3.0 percent).

2009 to 2013

Since January 2009, the National Democratic Congress has been the ruling government in Ghana—first under Professor John Evans Atta Mills (2009–2012) and then John Dramani Mahama (2012–present). Some of the key policies, programs, and projects undertaken include the Ghana Commercial Agriculture Project and the Soil, Land, and Water Management Project. Direct spending at subnational levels continued. In 2012, the composite budgeting system was introduced for all 216 metropolitan, municipal, and district assemblies[3] to effect fiscal decentralization of the 1988 Local Government Law, in which all decentralized functions of government are directly managed by the assemblies at the respective levels of government. Agricultural input subsidies also remained strong. The overall trends in agriculture expenditure at the national level are similar to trends seen in the preceding periods analyzed. For example, agriculture expenditure during this era grew at an average rate of 4.7 percent per year, with expenditure on cocoa barely growing (1.5 percent), as compared with combined expenditure on the noncocoa subsector (23.7 percent). The share of expenditure on cocoa as a share of the subsector's agricultural value-added was 83.7 percent per year, compared with only 3.2 percent per year for the noncocoa subsector. Growth in land productivity for the entire agricultural sector was –1.2 percent, with growth in the cocoa subsector (13.1 percent) outperforming growth in the noncocoa subsector (–2.7 percent).

Summary: Overall Trends from 1958 to 2013

To summarize, overall agricultural policy and expenditure have favored the cocoa subsector. Between 1958 and 2013, the periods over which the data used here are available, agricultural expenditure on the cocoa subsector grew at an average rate of 3.7 percent per year, compared with –0.4 percent for the noncocoa subsector. The share of expenditures on the cocoa subsector as a share of the subsector's agricultural value-added was 40 percent per year, compared to only 3.2 percent per year for the noncocoa subsector. The annual average growth rate in land productivity for the entire agricultural sector averaged 1.9 percent per year, driven by growth in the noncocoa subsector (2.3 percent), as compared with growth in the cocoa subsector (0.2 percent).

[3] These include 6 metropolitan assemblies, 49 municipal assemblies, and 161 district assemblies.

4. RESULTS AND DISCUSSION

Descriptive Statistics of Variables Used in the Regressions

Table 4.1 presents descriptive statistics of the specific variables used in the econometric analysis from 1970 to 2012. Annual average agricultural value-added per hectare (land productivity) was GHS 215 for the entire agricultural sector, with the average for the cocoa subsector (GHS 483) being more than double the average for the noncocoa subsector (GHS 200).[4] Annual average agricultural public expenditure was GHS 187 million for the entire agricultural sector when only expenditure on the Ghana Cocoa Board for the cocoa subsector is counted, and GHS 335 million when expenditure on the Ghana Cocoa Board and other industry costs for the cocoa subsector are counted. These amounts represent 9 percent and 13 percent, respectively, of the total government expenditure. The annual average amount spent on the cocoa subsector (GHS 87 million) is less than the amount spent on the noncocoa subsector (GHS 100 million) when only expenditure on the Ghana Cocoa Board for the cocoa subsector is counted, but more than double (GHS 235 million) when expenditure on the Ghana Cocoa Board and other industry costs for the cocoa subsector are counted. As such, counting the expenditure on the cocoa subsector puts the performance of the Ghanaian government's expenditure on agriculture above the 10 percent Maputo Declaration target. Otherwise, it would be 5 percent or less (Benin 2014).

Table 4.1 Summary statistics of variables by subsector, 1970–2012 annual average

Variable	Total		Cocoa		Noncocoa	
	Mean	Standard error	Mean	Standard error	Mean	Standard error
Agricultural value-added, GHS/ha (*y*)	214.70	7.25	482.87	32.10	200.11	7.93
Nonagricultural expenditure, mil. GHS (*NG*)	2789.19	304.52	2,789.19	304.52	2,789.19	304.52
Agricultural expenditure 1, mil. GHS (*G1*)[a]	187.04	11.30	86.84	5.14	100.20	8.71
Agricultural expenditure 2, mil. GHS (*G2*)[b]	335.01	29.83	234.80	25.38	100.20	8.71
Labor, number per hectare (*l*)	0.18	0.01	0.66	0.04	0.16	0.01
Crop capital, GHS/ha ($k1_c$)	219.52	8.19	1,485.71	29.21	144.40	6.51
Livestock capital, GHS/ha ($k1_l$)	176.80	6.46	NA	NA	176.80	6.46
Fertilizer, kg/ha (*k2*)	1.20	0.16	0.29	0.07	1.26	0.017
Animal feed, kg/ha (*k3*)	74.31	5.26	NA	NA	74.31	5.26
Rainfall, mm (*R*)	96.13	1.57	96.13	1.57	96.13	1.57
Technology (*A*), cf.: 1970–1974 = 0						
1975–1983 = 1	0.21	0.06	0.21	0.06	0.21	0.06
1984–2012 = 1	0.67	0.07	0.67	0.07	0.67	0.07
Instruments (Z^G)						
Type of government (*GOV*)	0.44	0.08	0.44	0.08	0.44	0.08
Years following expenditure review (*PER*)	0.21	0.06	0.21	0.06	0.21	0.06
Share of agricultural expenditure 1 (*SHA1*)[a]	0.09	0.01	0.04	0.00	0.05	0.01
Share of agricultural expenditure 2 (*SHA2*)[b]	0.13	0.01	0.08	0.01	0.05	0.01

Source: Author's calculation based on various data sources (see Table 3.1 for details).
Notes: [a] Using expenditure on Ghana Cocoa Board only. [b] Using expenditure on Ghana Cocoa Board and other industry activities. GHS (Ghanaian cedi) is in 2006 constant prices. cf. = compared with. NA = not applicable.

Regarding the other variables, labor and crop capital per hectare were higher for the cocoa subsector, whereas fertilizer was higher for the noncocoa subsector. Livestock capital and animal feed per hectare are only applicable to the noncocoa subsector. The level of technology, rainfall, and instruments are the same for both subsectors, as they are measured for the sector or country as a whole only.

[4] GHS (Ghanaian cedi) is in 2006 constant prices.

Estimated Elasticity of Land Productivity with Respect to Agricultural Public Spending

The regression results are presented in Tables 4.2 to 4.4. First, we look at the results related to addressing the potential endogeneity of agricultural public expenditure (*G*), which are presented in Table 4.2.

Table 4.2 First-stage results of instrumental-variables regression of total agricultural spending in Ghana, 1970–2012

Variable	Model 1			Model 2		
Lag of agricultural expenditure (*G*)						
G_{t-1}	0.09			0.06		
G_{t-2}	0.03			0.02		
G_{t-3}	–0.01			0.01		
Nonagricultural expenditure (*NG*)	0.90	***	r	0.92	***	r
Labor (*l*)	–1.03	**	r	–0.79	**	r
Crop capital ($k1_c$)	0.19			0.32		
Livestock capital ($k1_l$)	0.45			0.23		
Fertilizer (*k2*)	0.00			–0.02		
Animal feed (*k3*)	0.39	**	r	0.41	***	r
Rainfall (*R*)	–0.20			–0.18		r
Technology (*A*), cf.: 1970–1974 = 0						
1975–1983 = 1	–0.03			–0.04		
1984–2012 = 1	0.12			0.05		
Instruments (Z^G)						
Type of government (*GOV*)	NA			0.08	**	r
Share of expenditure (*SHA1*)	9.37	***	r	9.41	***	r
Intercept	–8.99	***	r	–8.27	***	r
Overall model statistics						
R-squared	0.99			0.99		
F-statistic	196.72	***	r	204.31	***	r
IV tests:						
G_t is exogenous:						
Durbin score χ^2 statistic	0.02			0.42		
Wu-Hausman *F*-statistic	0.02			0.28		
Instrument is weak (*F*-statistic)	96.31	***	r	55.97	***	r
Instruments are overidentified:						
Sargan score χ^2 statistic	NA			3.29	*	
Basmann χ^2 statistic	NA			2.32		

Source: Author's representation based on model results.

Notes: cf. = compared with. NA = not applicable. All continuous variables are transformed by natural logarithm. IV tests: G_t is exogenous = test that agricultural expenditure can be treated as exogenous; instrument is weak = test that the first-stage reduced-form equation is weakly identified; and instruments are overidentified = test that rank of matrix of first-stage reduced-form coefficients is overidentified. *, **, and *** represent statistical significance at the 0.1, 0.5, and 0.01 probability level, respectively. r represents statistical significance at the 0.1 or higher probability level for robust standard errors. For robust estimation, the IV test of exogeneity and overidentification is based on the Wooldridge score.

Instruments and First-Stage Instrumental Variable Regression Results

All three potential instruments (*GOV*, *PER*, and *SHA*) were tried in the estimation, individually and in different combinations; but only *SHA* by itself and *SHA* in combination with *GOV* worked well in terms of meeting the two IV requirements of being correlated with expenditure (*G*) and orthogonal to the error term (e_t^y). The IV tests shown in Table 4.2 confirm that the instruments are not weak and that the first-stage equation is adequately identified, though it is weakly overidentified, according to the Sargan score, when *SHA* and *GOV* are used in combination. Because only one instrument is sufficient, the test of overidentifying restrictions was implemented as a bonus. The test of exogeneity of expenditure is not rejected, implying that agricultural expenditure (*G*) is in fact exogenous in the model specification adopted in this paper. Together, these findings indicate that the impact of agricultural public spending can be consistently estimated with the OLS model and that estimation by IV may not bring any improvements (more on this later). The periods under military government rule (*GOV*) and larger expenditure shares (*SHA*) are associated with higher agricultural expenditures. Other variables with statistically significant coefficients are nonagricultural expenditure, labor, and animal feed. The results are consistent with different specifications of the standard errors.[5]

Elasticity of Land Productivity with Respect to Agricultural Public Expenditure

Results of the second-stage IV regression, as well as for the OLS and SUR specifications, are presented in Tables 4.3 to 4.5. They are presented separately for the effect of total agricultural expenditure on total land productivity (Table 4.3), followed by the effect of sectorial agricultural expenditure on total land productivity (Table 4.4), and then the effect of sectorial agricultural expenditure on sectorial land productivity (Table 4.5). In each table, the results are presented for different specifications of the standard errors.

Table 4.3 Regression estimates of impact of total agricultural expenditure on total agricultural value-added per hectare in Ghana, 1970–2012

Variable	IV						OLS			
	Instrument = *SHA*			Instruments = *SHA*, *GOV*						
Agricultural expenditure										
G_t	0.21	**	r	0.24	***	r	0.21	**	r	n
$G_{t–1}$	0.07			0.04			0.06			
$G_{t–2}$	0.05			0.06			0.06			
$G_{t–3}$	0.10		r	0.10		r	0.10			
Total elasticity[‡]	0.42	***	r	0.44	***	r	0.43	***	r	n
Nonagricultural expenditure (*NG*)	–0.07	*	r	–0.08	*	r	–0.08			n
Labor (*l*)	1.53	***	r	1.62	***	r	1.55	***	r	n
Crop capital ($k1_c$)	–0.54	**	r	–0.60	**	r	–0.55	*		n
Livestock capital ($k1_l$)	–0.67	**	r	–0.72	**	r	–0.68	*	r	n
Fertilizer (*k2*)	–0.01			–0.01			–0.01			
Animal feed (*k3*)	–0.09			–0.09			–0.09			
Rainfall (*R*)	0.05			0.03			0.04			
Technology (*A*), cf.: 1970–1974 = 0										
1975–1983 = 1	–0.24	***	r	–0.26	***	r	–0.25	**	r	n
1984–2012 = 1	–0.36	***	r	–0.37	***	r	–0.36	***	r	n
Intercept	13.01	***	r	13.74	***	r	13.16	***	r	n
Overall model statistics										
R-squared	0.93			0.93			0.93			
Wald- or *F*-statistic	556.08	***	r	556.90	***	r	28.96	***	r	n
Tests of serial correlation										
Durbin alternative *F*-statistic	NA			NA			0.90			
Breusch-Godfrey *F*-statistic	NA			NA			1.35			

Source: Author's representation based on model results.
Notes: cf. = compared with. NA = not applicable. All continuous variables are transformed by natural logarithm. [‡] Total elasticity is obtained by summing elasticities with respect to G_t, $G_{t–1}$, $G_{t–2}$, and $G_{t–3}$. *, **, and *** represent statistical significance at the 0.1, 0.5, and 0.01 probability level, respectively. [r] represents statistical significance at the 0.1 or higher probability level for robust standard errors. [n] represents statistical significance at the 0.1 or higher probability level for Newey-West standard errors.

[5] The results are also consistent with those of the model that includes the lag of agricultural value-added per hectare ($y_{t–1}$) as an explanatory variable.

Effect of Total Agricultural Expenditure on Total Land Productivity

Because exogeneity of agricultural expenditure (*G*) is not rejected, the results in Table 4.3 confirm that estimation by IV does not bring any improvements over estimation by OLS. The magnitudes and statistical significance of the estimates are very similar across the two IV model specifications and the OLS model. Furthermore, the statistical significance of the estimates is consistent across the different specifications of the standard errors. As the Durbin alternative and Breusch-Godfrey test results show, serial correlation is not a problem, which means the robust and Newey-West standard errors are not necessary, though we still maintain to report them. Based on the OLS results, the elasticity of total land productivity with respect to total agricultural expenditure is estimated at 0.43, which means that a 1 percent increase in total agricultural expenditure is associated with a 0.43 percent increase in total agricultural value-added per hectare or total land productivity. This is higher than the estimated elasticity of 0.22 to 0.35 in the Benin et al. (2012) study for Ghana, which is based on analysis of subnational data. It is also higher compared with the 0.08 elasticity estimated in the cross-country study of Fan, Yu, and Saurkar (2008) for total agricultural expenditure in Africa, though it is closer to the 0.36–0.38 estimated in the cross-country studies of Alene and Coulibaly (2009) and Thirtle, Piesse, and Lin (2003) for agricultural research expenditure in Africa.

Regarding the effect of other variables, the most influential ones are labor and technology. A 1.00 percent increase in labor per hectare is associated with a 1.55 percent increase in total land productivity, reflecting the dominance of labor in agricultural production in Ghana. Compared to the pre-1975 periods, land productivity was lower in the subperiods of 1975–1983 and 1984–2012. Crop and livestock capital are also statistically significant but weakly negative, possibly due to co-linearity with labor, which has a very large estimated coefficient.[6]

Effect of Sectorial Agricultural Expenditure on Total Land Productivity

Table 4.4 shows detailed results for estimating the separate effect of spending on the cocoa and noncocoa subsectors on total land productivity. In the first set of results (Model 1), expenditure on the cocoa subsector is aggregated for expenditure on the Ghana Cocoa Board and other industry costs. In the second set of results (Model 2), expenditure on the cocoa subsector is disaggregated by expenditure on the Ghana Cocoa Board and other industry costs. In Model 1, the estimated elasticities of total land productivity with respect to sectorial expenditure are 0.13 for noncocoa expenditure and 0.31 for total cocoa expenditure. In Model 2, the estimated elasticities are 0.14 for expenditure on noncocoa, 0.17 for expenditure on the Ghana Cocoa Board, and 0.26 for expenditure on other cocoa industry costs. These results suggest that elasticity with respect to expenditure on the core public functions in the cocoa subsector (represented by the Ghana Cocoa Board) and the noncocoa subsector are similar—that is, 0.17 for the Ghana Cocoa Board compared to 0.14 for the noncocoa subsector. The main difference between the two subsectors derives from the other cocoa industry costs, whose counterpart data for the noncocoa subsector were not available for the analysis. The pattern of the magnitudes and the statistical significance of the estimates with respect to the other variables, as discussed earlier, still hold. These patterns include consistency across the different specifications of the standard errors; serial correlation not being a problem; and the influential factors of labor per hectare, technology, and crop and livestock capital.

[6] Because we are more interested in the impact of agricultural expenditure, we do not focus on the estimates associated with the other variables. The *R*-squared values are in excess of 0.9, and many of the variables are statistically significant, even if some of them have unexpected signs. Nevertheless, we tried another model specification that includes the lag of agricultural value-added per hectare (y_{t-1}) as an explanatory variable. The results were similar, with the estimated coefficient on y_{t-1} not being statistically significant. The elasticity of total land productivity with respect to total agricultural expenditure was estimated at 0.38 in that model specification.

Table 4.4 Regression estimates of the impact of sectorial agricultural expenditure on total agricultural value-added per hectare in Ghana, 1970–2012

Variable	Model 1				Model 2			
Noncocoa expenditure								
G_t	0.04				0.04			
G_{t-1}	0.04				0.06			
G_{t-2}	0.02				0.02			
G_{t-3}	0.02				0.03			
Total elasticity‡	0.13		r		0.14		r	
Cocoa expenditure—total								
G_t	0.16	**	r	n	NE			
G_{t-1}	0.01				NE			
G_{t-2}	0.04				NE			
G_{t-3}	0.10		r	n	NE			
Total elasticity‡	0.31	***	r	n	NE			
Cocoa expenditure—Ghana Cocoa Board								
G_t	NE				0.14	*		
G_{t-1}	NE				–0.02			
G_{t-2}	NE				0.02			
G_{t-3}	NE				0.03			
Total elasticity‡	NE				0.17	*	r	n
Cocoa expenditure—other industry costs								
G_t	NE				0.10			
G_{t-1}	NE				0.02			
G_{t-2}	NE				0.03			
G_{t-3}	NE				0.11		r	n
Total elasticity‡	NE				0.26	*		
Nonagricultural expenditure (*NG*)	–0.06				–0.10			
Labor (*l*)	1.33	**	r	n	1.63	**	r	n
Crop capital ($k1_c$)	–0.33				–0.61			
Livestock capital ($k1_l$)	–0.73			n	–1.18	*	r	n
Fertilizer (*k2*)	–0.02				–0.03			
Animal feed (*k3*)	–0.08				0.06			
Rainfall (*R*)	0.03				0.01			
Technology (*A*), cf.: 1970–1974 = 0								
1975–1983 = 1	–0.21	*	r	n	–0.27	*	r	n
1984–2012 = 1	–0.33	**	r	n	–0.47	**	r	n
Intercept	11.94	**	r	n	15.91	**	r	n
Overall model statistics								
R-squared	0.92				0.92			
F-statistic	16.39	***	r	n	10.03	***	r	n
Tests of serial correlation								
Durbin alternative *F*-statistic	1.14				1.05			
Breusch-Godfrey *F*-statistic	1.96				2.34			

Source: Author's representation based on model results. See Table 3.1 for detail description of variables.
Notes: cf. = compared with. NE = not estimated. All continuous variables are transformed by natural logarithm. ‡ Total elasticity is obtained by summing elasticities with respect to G_t, G_{t-1}, G_{t-2}, and G_{t-3}. *, **, and *** represent statistical significance at the 0.1, 0.5, and 0.01 probability level, respectively. ^{r} represents statistical significance at the 0.1 or higher probability level for robust standard errors. ^{n} represents statistical significance at the 0.1 or higher probability level for Newey-West standard errors.

Effect of Sectorial Agricultural Expenditure on Sectorial Land Productivity

Table 4.5 shows detailed results for estimating the separate effect of cocoa and noncocoa subsector spending on land productivity in the cocoa and noncocoa subsectors, respectively. In the first set of results (Model 1), expenditure on the cocoa subsector is aggregated for expenditure on the Ghana Cocoa Board and other industry costs. In the second set of results (Model 2), expenditure on the cocoa subsector is disaggregated by expenditure on the Ghana Cocoa Board and other industry costs. In Model 1, the elasticity of land productivity in the noncocoa subsector with respect to expenditure in the noncocoa subsector is estimated at 0.13, whereas the elasticity of land productivity in the cocoa subsector with respect to total expenditure in the cocoa subsector is estimated at 0.71. In Model 2, the elasticity of land productivity in the noncocoa subsector with respect to expenditure in the noncocoa subsector remains the same, at 0.13. However, the elasticity of land productivity in the cocoa subsector with respect to expenditure on the Ghana Cocoa Board is 0.19 and is not statistically significant, whereas elasticity with respect to expenditure on other cocoa industry costs is 0.53. Thus, the difference between the two subsectors deriving from expenditure on other industry costs in the cocoa subsector is enhanced in the fully sectorial-disaggregated analysis.

Table 4.5 Seemingly unrelated regression estimates of the impact of sectorial agricultural expenditure on sectorial agricultural value-added per hectare in Ghana, 1970–2012

	Model 1		Model 2	
Variable	Noncocoa	Cocoa—total	Noncocoa	Cocoa—disaggregated[c]
Expenditure				
G_t	0.12 ** r	–0.16	0.15 *** r	–0.08
G_{t-1}	0.02	0.44 * r	–0.01	0.45 ** r
G_{t-2}	0.02	0.12	0.02	–0.26 *
G_{t-3}	–0.03	0.32	–0.03	0.09
Total elasticity‡	0.13 ** r	0.71 ** r	0.13 ** r	0.19
Expenditure				
G_t	NA	NA	NA	–0.20
G_{t-1}	NA	NA	NA	0.12
G_{t-2}	NA	NA	NA	0.24
G_{t-3}	NA	NA	NA	0.37 ** r
Total elasticity‡	NA	NA	NA	0.53 * r
Nonagricultural expenditure (*NG*)	–0.15 *** r	0.11	–0.25 *** r	0.19
Labor (*l*)	2.16 *** r	0.14	1.97 *** r	0.43
Crop capital ($k1_c$)	0.05	–0.58	0.30	–0.71
Livestock capital ($k1_l$)	–0.84 ** r	NA	–1.11 *** r	NA
Fertilizer (*k2*)	0.01	–0.45 *** r	–0.04	–0.52 *** r
Animal feed (*k3*)	–0.07	NA	0.29 r	NA
Rainfall (*R*)	0.13	0.80 * r	0.06	1.24 ** r
Technology (*A*), cf.: 1970–1974 = 0				
1975–1983 = 1	–0.15 *	0.07	–0.22 ** r	0.35
1984–2012 = 1	–0.35 *** r	0.51	–0.52 *** r	0.42
Intercept	14.02 *** r	0.83	13.53 ***	–0.45
Overall model statistics				
R-squared	0.92	0.57	0.91	0.60
F-statistic	488.09 ***	55.60 ***	414.71 ***	67.85 ***
Breusch–Pagan test of independence	1.03		7.62 ***	

Source: Author's representation based on model results. See Table 3.1 for detail description of variables.

Notes: cf. = compared with. NA = not applicable. All continuous variables are transformed by natural logarithm. ‡ Total elasticity is obtained by summing elasticities with respect to G_t, G_{t-1}, G_{t-2}, and G_{t-3}. *, **, and *** represent statistical significance at the 0.1, 0.5, and 0.01 probability level, respectively. [c] the first set of expenditure elasticities is for expenditure on the Ghana Cocoa Board, and the second set is for expenditure on other industry costs. [r] represents statistical significance at the 0.1 or higher probability level for robust standard errors.

Results associated with the other variables also show significant differences in the factors that influence land productivity in the two subsectors. First, none of the factors were statistically significant in both equations—that is, the noncocoa and cocoa subsectors. With respect to the noncocoa subsector, the statistically significant factors include nonagricultural expenditure (with a negative effect), labor (positive), livestock capital (negative), and technology in the post-1974 subperiods (negative). With respect to the cocoa subsector, only fertilizer (negative) and rainfall (positive) were statistically significant. Because the R-squared values are much lower in the regressions for the cocoa subsector (0.6) compared with those for the noncocoa subsector (0.9), it is likely that the effect of expenditure in the cocoa subsector on land productivity in the subsector may be overestimated to the extent that potential omitted variables are positively correlated with the subsector's expenditure. This could also be due to how the data on total labor, capital, and fertilizer were disaggregated for the cocoa and noncocoa subsectors in the absence of the actual data for the respective subsectors (see the discussion in Section 3).

Rates of Return to Agricultural Public Spending

Based on the estimated elasticities from the different models and the annual average expenditure and value-added for the agricultural sector and the two subsectors, the rate of return was calculated over a three-year period. The results are presented in Table 4.6. The returns to total agricultural expenditure are estimated at 141 percent for the aggregate model. When expenditures on the cocoa and noncocoa subsectors are disaggregated, while still taking into consideration their effect on total agricultural land productivity, the returns are estimated at 145 percent when total expenditure on cocoa is considered and 190 percent when expenditure on cocoa is disaggregated for the Ghana Cocoa Board and other industry costs. With a completely disaggregated sectorial analysis, the returns to expenditure in the noncocoa sector are estimated at 124 percent, irrespective of how the expenditure on the cocoa subsector is treated. The returns to expenditure in the cocoa subsector are estimated at 28 percent when total expenditure on cocoa is considered; this breaks down to 11 percent for expenditure on the Ghana Cocoa Board only and 39 percent for expenditure on other cocoa industry costs only.

Table 4.6 Rates of return to agricultural public spending in Ghana, 1970–2012

Variable	Elasticity	Annual average				ROR (%)
		Expenditure (million GHS)	Value-added per ha (GHS)	Area (million ha)	Expenditure (% of value-added)	
Aggregated analysis						
Total agriculture	0.43	335.01	214.70	21.15	7.38	141
Partial sectorial analysis						
Model 1						
Total agriculture	—	335.01	214.70	21.15	7.38	145
Noncocoa	0.13	100.20	—	—	—	—
Cocoa	0.31	234.80	—	—	—	—
Model 2						
Total agriculture	—	335.01	214.70	21.15	7.38	190
Noncocoa	0.14	100.20	—	—	—	—
Ghana Cocoa Board	0.17	86.84	—	—	—	—
Other cocoa industry	0.26	147.97	—	—	—	—
Full sectorial analysis						
Model 1						
Noncocoa	0.13	100.20	200.11	19.93	2.51	124
Cocoa	0.71	234.80	482.87	1.22	39.75	28
Model 2						
Noncocoa	0.13	100.20	200.11	19.93	2.51	124
Ghana Cocoa Board	0.19	86.84	482.87	1.22	55.71	11
Other cocoa industry	0.53	147.97	482.87	1.22	34.03	39

Source: Author's calculation based on model results.
Notes: GHS = Ghanaian cedi in 2006 constant prices. — = not applicable or not estimated.

These findings show that results of the aggregate analysis mask the large differences that exist between the different subsectors; these differences are driven by both the relative elasticities and the relative expenditure–to–value-added ratios in the different subsectors. As such, it is not surprising that the returns to spending in the noncocoa subsector far outweigh the returns to spending in the cocoa subsector. Although the estimated elasticities are higher in the cocoa subsector than in the noncocoa subsector, Table 4.6 shows that the expenditure–to–value-added ratio in the cocoa subsector is about 16 times higher than in the noncocoa subsector. The annual average expenditure as a share of value-added in the cocoa subsector is 40 percent, compared with only 2.5 percent in the noncocoa subsector. The difference is even much higher when only the Ghana Cocoa Board is considered, with the share at 55.7 percent.

5. CONCLUSIONS AND IMPLICATIONS

African leaders have committed to spending 10 percent of the total government expenditure on the agricultural sector after an agreement popularly known as the Maputo Declaration. Yet African leaders have also signed various charters that demand similar or larger shares of public expenditures, which makes it is difficult to see how they can make significant shifts in expenditures across different sectors to meet the Maputo Declaration target. Thus, it has become even more pertinent to find ways to improve the productivity of the resources that have been committed to the sector. As such, knowing the returns to different types of spending in the sector is fundamental to answering questions on, for example, how much to spend on food crops versus export crops, which continues to be debated without solid empirical evidence.

This paper contributes to closing the knowledge gap by using data on Ghana from 1970 to 2012 to estimate the returns to public expenditure on different agricultural subsectors—specifically, cocoa versus noncocoa. First, production functions for the sector as a whole and separately for the two subsectors were estimated to obtain elasticities of land productivity with respect to total and sectorial agricultural expenditure. Different regression methods and related diagnostic tests are used to address potential endogeneity of agricultural expenditure, cross-subsector dependence of the error terms, and within-subsector serial correlation of the error terms. The estimated elasticities are then used to estimate the ROR to total and subsectorial expenditures.

The elasticity of land productivity with respect to total agricultural expenditure is estimated at 0.43, which means that a 1 percent increase in total agricultural expenditure is associated with a 0.43 percent increase in total land productivity or total agricultural value-added per hectare. When expenditures on the cocoa and noncocoa subsectors are disaggregated, while still taking into consideration their effect on total agricultural land productivity, the estimated elasticities are 0.13 for expenditure on noncocoa and 0.17–0.31 for expenditure cocoa, with the elasticity being lower for expenditure on the Ghana Cocoa Board compared with expenditure on other cocoa industry costs. For the fully disaggregated analysis, the elasticity of land productivity with respect to expenditure in the noncocoa subsector is estimated at 0.13, whereas the elasticity of land productivity with respect to expenditure in the cocoa subsector is estimated at 0.71, which breaks down to 0.19 for expenditure on the Ghana Cocoa Board and 0.53 for expenditure on other cocoa industry costs.

The returns to total agricultural expenditure are estimated at 141–190 percent for the aggregate analysis, depending on how the expenditures in the different subsectors are treated, while still taking into consideration their effect on total agricultural land productivity. With a completely disaggregated sectorial analysis, the returns to expenditure in the noncocoa subsector are estimated at 124 percent. The returns to expenditure in the cocoa subsector are estimated at 28 percent when total expenditure on cocoa is considered; this breaks down to 11 percent for expenditure on the Ghana Cocoa Board only and 39 percent for expenditure on other cocoa industry costs only.

Results of the aggregate analysis mask the large differences between the two subsectors, which are driven by both the relative elasticity and the relative expenditure–to–value-added ratio in the different subsectors. Although the estimated elasticities are up to 5 times higher in the cocoa subsector than in the noncocoa subsector, the expenditure–to–value-added ratio in the cocoa subsector is about 16–22 times higher than in the noncocoa subsector. As such, the relative higher returns to expenditure in the noncocoa subsector are not surprising. Together, these findings indicate that overall productivity of and returns to total agricultural expenditure can be improved by reallocating some of the expenditure resources intended for the cocoa sector to the noncocoa subsector. Although it may be difficult to reallocate existing resources that have already been committed, it seems prudent to consider this in future budget allocations or when additional resources for the sector become available.

A couple of limitations may require further study. The first is related to the data on labor, capital, and fertilizer use in the cocoa and noncocoa subsectors. Actual time-series data for the respective subsectors were not available for each year of the data analyzed in the paper. Thus, information from various GLSS and other studies that were undertaken for specific years were used to disaggregate the data on total labor, capital, and fertilizer use for those years and to extrapolate the data for the other years. Obtaining actual time-series data on these factors for the two subsectors in order to reestimate the models may alter the results. The second area for improvement is related to the quality of expenditure and the time-lag effect of spending. Because the effect of different types of public spending take different times to materialize, it may prove worthy to obtain data on the quality of expenditures in the different subsectors, which can then be used to extend the disaggregated time-series further or to model different time lags of effect in the different subsectors.

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