Assessing Agricultural Policy for Targeted Reforms in Sub-Saharan Africa

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Abstract:

Assessing how the policy of taxing agricultural export to boost government revenues while subsidizing food production to improve food security has affected the African agriculture is a requisite for investment and fiscal policy reforms. I estimate the substitution and endowment effects of the mix of government taxes and subsidies on the mix of agricultural commodities in selected Sub-Saharan African countries. The commodities are divided into cash commodity, importable food, and non-tradable food categories. Result show that changes in the ratio of taxes on any two commodity categories lead to commodity substitution but the cross-effects are asymmetric and counterintuitive. A higher tax on cash commodity relative to tax on importable food causes relatively more harms to the production of importable food than to the production of the cash commodity. More important, the endowment effects are found to be greater than these substitution effects, representing 60-to 70% of the policy effects on output levels. Sub-Saharan Africa 's quest to reform its agriculture sector must thus consider that the relative level of assistance matters most. The priority before assisting any targeted subsector would be to increase the amount of investment resources for the whole sector; reshuffling resources without increasing them provokes unintended consequences.

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1. Introduction

To reduce their budget and food trade deficits, many agriculture-based economies in Sub-Saharan Africa have long resorted to the twin policies of raising taxes on agricultural commodity exports and subsidizing food production to reduce food imports. For many African countries, the net impacts of these taxes and subsidies on the economy and on the agricultural sector remain unassessed. More important, reliable estimates of both the substitution and endowment effects of these government policies are missing. Having such estimates is however crucial to improve decision making at farm, sector, and national level and, especially, to formulate future investment and fiscal policy reforms. Simply put, if the substitution effects of these government policies are known to be larger (smaller) than the endowment effects, then a mix of government policies targeting assistance or investment on one crop will likely succeed (fail) to boost production incentive on that targeted crop, indicating to policy makers that direct price support is effectively superior (inferior) to lump-sum subsidies.

This paper aims to estimate the effects of the mix of production and trade policy distortions on agricultural production in selected Sub-Saharan African countries. Specifically, I estimate and compare the substitution and endowment effects of distortions among the mix of agricultural commodities to draw implications for decision making. Such an investigation is important at a time when directional policy to reform and diversify the African agriculture is one of the highest priorities.   This paper differs from past studies as it first dissociates the effects of distortions from other market price effects, and then splits the effects of distortions into substitution and endowment effects.

Many studies (e.g. Roumasset and Clarete, 1990; Anderson and Valenzuela, 2007, Anderson et al. 2012; Falkowski and Olper, 2013; Anderson, 2014) concur that policies in both domestic and international markets have distorted developing countries' agricultural production considerably. Jayne and Rashid

(2013) explain how Sub-Saharan Africa's input subsidies on food crops have had limited effects on food

production and have even created further distortions. But these conclusions often conceal how the

various policies interact and how their effects are distributed across commodities. In many Sub-Saharan

African countries in particular, cash commodities have often been taxed to boost the governments'

revenues (Anderson and Masters, 2008), and price stabilization and food aid policies have affected food

production incentives (Thiele 2004, Del Nino et al., 2007). The cross effects and the substitution and

income effects of these policies on cash and food commodities have often been overlooked.   Similarly,

it remains unclear whether lump-sum subsidies or targeted assistance could have created greater

agricultural incentive. This paper addresses these issues and discusses implications for assessing key

strategies, such as coupled and de-coupled assistance as well as crop diversification, aimed at raising

agricultural output and revenue.

2. Model

2.1 Basic framework

One common method to estimate the substitution and endowment effects of a mix of policies on mix of

commodities starts with finding the solutions of a profit maximizing sector producing M outputs

(products) with N inputs (factors) in an open economy.   The aims are to capture what variables the

change in the ratio between the output levels of two commodities depends on and specify such

functional dependence. I assume that unit prices of outputs (the *P's)* and unit prices of inputs (the *r's*)

are determined exogenously.   The technology linking the amounts of input $X_j's$ to levels of output $Y_i's$ is

given by a joint production function *F*(.), none other than the production possibility frontier (PPF) curve.

A profit-maximizing sector given the available technology solves the following:

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$$\max_{Y_i, X_j, \mu} L = \sum_{i=1}^{M} P_i Y_i - \sum_{j=2}^{N} r_j X_j - \mu.[F(Y_1,...,Y_m; X_1,...X_n)];$$

with $\sum_{i}^{M} x_{ij} = X_j;$

The standard solutions are that:

    (i) **the value of marginal product is equal to factor return**

(1) $r_j = P_i.\dfrac{dY_i}{dx_{ij}} = P_{i'}\dfrac{dY_{i'}}{dx_{i'j}}$; or $.\dfrac{dY_i}{dY_{i'}} = \dfrac{P_{i'}}{P_i}\dfrac{dx_{ij}}{dx_{i'j}}$

    (ii) **the marginal rate of substitution between any two inputs j and j' is equal to the ratio of the**

        prices of these factors

(2) $\dfrac{r_j}{r_{j'}} = -\dfrac{dX_{j'}}{dX_j}$; and more important,

    (iii) **the rate of product transformation is equal to the output price ratio**

(3) $\mu = -\dfrac{\partial F / \partial Y_i}{\partial F / \partial Y_{i'}} = -\dfrac{\partial Y_{i'}}{\partial Y_i} = \dfrac{P_i}{P_{i'}}.$

Beside these three equations, introduction of 'factor intensity' leads to the relation between factor

endowment and output (cf. the Rybczynski theorem in an open economy). This relation can be derived

from the dual cost minimization of the sector and with the assumption that the factor contents are

fixed, and factor markets clear.

(4) $\sum_{i}^{M} a_{ij}^{*}.Y_i^{*} = X_j$, for all i, and for all j,

where a_{ij} is the factor content (or factor intensity), i.e. the amount of input j needed to produce one unit of product i; Y is output and X input; the star '*' indicates the equilibrium values of the variables and parameters derived from the cost minimization.

For each input j, taking the derivative of both sides of (4) with respect to X_j and solving for dYi/dXj for all i and all j leads to a series of N equations where all the right-hand sides are functions only of the (a_{ij}). In a model with two outputs i and i' and two inputs j and j', the following conclusion can be drawn:

$$(5)\ \frac{\partial Y_i^*}{\partial X_j} > 0 \text{ and } \frac{\partial Y_{i'}^*}{\partial X_j} < 0 \text{ iff } = \left(\frac{x_{ij}^*}{x_{ij'}^*} = \frac{a_{ij}^*}{a_{ij'}^*} \right) > \left(\frac{x_{i'j}^*}{x_{i'j'}^*} = \frac{a_{i'j}^*}{a_{i'j'}^*} \right) \text{ i.e. the production of good } i \text{ is more } j\text{-}$$

intensive (or less j'-intensive) than the production of good i',

Or equivalently;

$$(5')\ \frac{\partial Y_i^*}{\partial X_{j'}} < 0 \text{ and } \frac{\partial Y_{i'}^*}{\partial X_{j'}} > 0 \text{ iff } \frac{x_{ij}^*}{x_{ij'}^*} > \frac{x_{i'j}^*}{x_{i'j'}^*}, [1]$$

meaning that when the endowment in factor j (or j') rises relative to those of the other factor, the output of the good that uses j (or j') intensively will rise while the output of the other good will decline.

2.2 Substitution effects along the PPF

I now use information from these five standard equations to derive how the change in the ratio of two levels of output behaves and how such a behavior is specified. The insights from these five equations dictate the search for a relation showing that the output ratio $Y_i/Y_{i'}$ between two products i and i' is at

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[1] See proof of Rybczynski's theorem in Vousden (1995) page259-60.

least a function of the undistorted output price ratio $P_i/P_{i'}$, a distortion θ on the two commodities , a

shifter C (including for instance technological shifts), input (endowment) vector **X**, and some other

exogenous factors Z linked to the supply. In other words, one can hypothesize a generic form such as

$Y_i/Y_{i'} = f(P_i/P_{i'}; \theta; C; \textbf{X}; \textbf{Z})$.

Equation (3) seems to be a good starting point to approach such generic expression, but there is only

one problem in that (3) shows the marginal rate of substitution $dY_i/dY_{i'}$, not the ratio of the two output

levels $Y_i/Y_{i'}$. An additional assumption is needed.

With the assumption of a constant elasticity of transformation between any two outputs, the marginal

rate of transformation can be written as a function of the ratio of the levels of output and a technology

parameter (see for example Powell and Gruen (1968) for detail):

$$(6) \quad \frac{\partial Y_i}{\partial Y_{i'}} = -A^{1/\tau} \cdot \left(\frac{Y_i}{Y_{i'}} \right)^{1/\tau}$$

Substituting (6) for (3) leads to:

$$(7) \frac{Y_i}{Y_{i'}} = A^{-1} \cdot \left(\frac{P_i}{P_{i'}} \right)^{-\tau}$$, which is much closer to this paper's goal than (3) was.

The parameter $\tau < 0$ is the elasticity of transformation; A is often called a 'bias' or loosely 'the PPF slope

changer' and determines the shape of the PPF. [2] In this regard A can be thought of as a function of

exogenous shocks affecting the factor-intensity ratios in the two subsectors, i.e. a change in the

marginal rate of transformation along the iso-price curve without shifting the PPF: A= A(aij/aij'; ai'j/ai'j').

But what about the shifters of the PPF? It is important to note that equation (6) is a partial derivative,

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[2] Also in Powell and Gruen (1968).

i.e. it is satisfied when the shifters (such as the level of input resource and technology) are held constant. It is therefore reasonable to rewrite (7), now an expression of the ratio of two outputs, to include these shifters. More generally, a ratio of two supply equations should include information on factor endowment (e.g. input prices and technology).[3] Equation (7) can then be rewritten as:

(8) $\quad \dfrac{Y_i}{Y_{i'}} = A^{-1}.C(c_i/c_{i'};r_j;r_{j'}).\left(\dfrac{P_i}{P_{i'}}\right)^{\tau}$

where A is the bias parameter (the PPF slope changer), and $C\,(.)$ is the host of shifters composed of changes in the levels of endowments and of technology. The level of endowments can be represented by the price of factor j relative to factor j', $r_j/r_{j'}$, while sector specific technology is represented by the ratio of sector specific technological shift ci/ci. I recall that a neutral technological change in the sector causes a parallel shift of PPF and does not affect the ratio $Y_i/Y_{i'}$.

To complete the model, the distortion has to be introduced in (8) through prices and through the level of endowment. It is assumed that the nominal price is a separable function of the undistorted price and level of assistance. There are at least two reasons why distortion can be separated from price: first, supply may not be linear in price, and second, distortion may affect expectation and incentives at level that may differ from the level that an undistorted price change would provoke. The undistorted prices $\overline{P}_i$ and $\overline{r}_j$ are linked to distorted price P_i and r_j by :

(9a) $\qquad\qquad P_i = \theta(\eta_i).\overline{P}_i.Z_i^z\,,$

where η_i is the distortion (source of substitution effect), and Θ(.) is a continuous monotonic function of the distortion, and

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[3] Equation (1) also hints that the output level ratio has to depend on input prices.

(9b) $$r_j = \theta(\lambda_j)\bar{r}_j.\rho_j,$$

where λ is the distortion on input j (the source of endowment effect) at the sector level, and ρ_j represents factors (such as exchange rates, GDP per capita) affecting the wedge between distorted and undistorted input price.

For any two outputs i and i' and two inputs j and j', substituting (8), (9a), (9b) and (9c) into (7), and recalling that according to (2) RTS equals input price ratio leads to the following expression of output ratio in logarithmic form (Production frontier and indirectly Rybczynski):

(10)

$$\ln\left(\frac{Y_i}{Y_{i'}}\right) = \alpha_a \ln A + \alpha_c \ln(c_i/c_{i'}) + +\alpha_P \ln\left(\frac{\bar{P}_i}{\bar{P}_{i'}}\right) + \alpha_\eta\{\ln\theta(\eta_i) - \ln\theta(\eta_{i'})\} + \alpha_\lambda\{\ln\theta(\lambda_j) - \ln\theta(\lambda_{j'})\} + \alpha_r \ln\bar{r}_j + \alpha_{r'}$$
$$+ \alpha_Z \ln Z_{i,i'}$$
;

A CES assumption on the undistorted factor markets implies

(11) $$\frac{\bar{X}_j}{\bar{X}_{j'}} = -B^{-1}.\left(\frac{\bar{r}_j}{\bar{r}_{j'}}\right)^{\zeta}.$$

Assuming that the price of one input is set arbitrarily to unity and substituting (11) into (10) leads to:

(12)

$$\ln\left(\frac{Y_i}{Y_{i'}}\right) = \alpha_a \ln A + \alpha_t t + \alpha_c \ln(c_i/c_{i'}) + \alpha_P \ln\left(\frac{\bar{P}_i}{\bar{P}_{i'}}\right) + \alpha_\eta\{\ln\theta(\eta_i) - \ln\theta(\eta_{i'})\} + \alpha_\lambda\{\ln\theta(\lambda_j) - \ln\theta(\lambda_{j'})\} + \alpha_x \ln$$
$$+ \alpha_\rho \ln\rho_{jj'} + \alpha_Z \ln Z_{i,i'}.$$

where *Y* is output quantity, *A* is technology bias, $\overline{P}$ undistorted price, and $\dfrac{\overline{X}_j}{\overline{X}_{j'}}$ ithe capital-to-labor

ratio. The variable ρ and Z are, from earlier definitions, hosts of control variables. For instance,

$\rho_{jj'}$ represents factors affecting the input price ratio, and hence shifting the capital-to-labor ratio.

Similarly, $Z_{i,i'}$ is a host of exogenous variables that may shift the ratio of the two undistorted prices $\dfrac{\overline{P}_i}{\overline{P}_{i'}}$.

Later in the estimation these variables $\rho_{jj'}$ and $Z_{i,i'}$ can be merged to represent the likes of exchange

rates, or GDP per capita that affect both input and output prices ratios.

Equation (12) is the pursued framework summarizing the main determinants of the ratio of the level of

output *i* to that of another output *i'*. It provides a direct assessment of the substitution effects due to

pure price incentive (the coefficient α_p) and the substitution effects resulting from the crowding out of

the policies on the two products (the coefficient α_n).[4] Equation (12) also informs how key variables

such as the capital-to-labor ratio and other control variables affect the substitution between

commodities. Moreover, technological effects may also be revealed by the coefficients α_t (α_t =0 for a

neutral technological shift) and α_c . It is also noted that the substitution effects here can be interpreted

as Marshallian parameters because they are directly derived from the profit-maximization problem. For

estimation purposes, (12) has the advantage of using variables with relatively accessible information.

2.3 Supply functions and the effect of distortions: Uses of Duality and Hicksian parameters

The basic framework described so far offers a glimpse of the relative effects of the distortion on the

direct substitution between each pair of outputs, but there is now a need to focus more on the net

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[4] These parameters of the substitution effects differ from Gordon (1989) by being directly measurable without the need of strong assumptions on functional forms.

effects of the overall distortion on each output within a sector and to provide a framework that differentiates the substitution effects from the endowment effects.

Endowment effects include policy effects on the whole sector's profit, i.e. revenue and cost. For instance, any tax or subsidy affects a sector's revenue whenever it affects output prices, or when it is a direct money transfer to or withdrawal from that sector. But more important, such a direct money transfer or withdrawal also affects the access to inputs and hence operating costs; the reason is that the change in the level of financial capital, hence the input ratio, leads to substitution between inputs that may only be possible at a new, different cost level. Moreover, there are also policies that subsidize or tax input directly, thereby distorting the operating costs directly.

The next steps aim to distinguish endowment effects from substitution effects and, more important, to specify the relation between output levels on the one hand and profitability and level of subsidy or tax on the other hand.   The Marshallian and Hicksian parameters with the Slutsky decomposition of the supply relation for each product *i* are estimated.   I employ the duality approach of Diewert (1974a), Fuss (1977) and Gordon (1989), using an indirect (dual) revenue function to derive a supply relation that includes revenues and cost elements with fixed endowment in resources. Such a duality shows that the parameters estimated from such a function are Hicksian parameters.

More formally, the indirect revenue function at price P for a given input level X is

REV(P;X) = max [P.Y(X)], and Hotelling's lemma indicates that the output maximizing revenue

is $\dfrac{\partial REV}{\partial P_i} = Y_i(\mathbf{P}, \mathbf{X}^*)$. Using these expressions, the indirect profit function can be written as:

(13) $\pi = \max_{\hat{X}} REV(P, X) - \sum_j x_j^*(P, X).r_j$,

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where the '*' on variable indicates its optimal value under profit maximization. Under constant return to scale, the total revenue function can also be written as $REV = R. Q$, where R is a price index, called 'unit-output price,' for an imaginary representative aggregate output index Q. If all nominal variables are normalized (i.e. divided) by the price index R, the optimal profit function becomes:

$$\pi^* = Q^* - \sum_j x_j^* . r_j \text{ , or}$$

$$(14)\ Q^* = \pi^* - \sum_j \frac{\partial \pi^*}{\partial r_j} . r_j \ .$$

Equation (14) states that the optimal aggregate (or representative) supply index is a function of the normalized profit (including endowment effects) and input prices.[5] Based on (14) and the earlier assumption that distortion is separable from prices, the supply function for the i-th production can generally be written as

$$(15a)\ Y_i = Y_i(\mathbf{P},(REV(\mathbf{P}, f(X^*)) - \omega(\mathbf{P}, f(X^*)))\text{, or more directly}$$

$$(15b)\quad Y_i = Y_i(\overline{\mathbf{P}}, \Theta, (REV(\overline{\mathbf{P}}, \Theta, X^*)) - \omega(\overline{\mathbf{P}}, \Theta, X^*))\text{,}$$

where Y is output, $\overline{\mathbf{P}}$ is a vector of the undistorted output price, Θ is the level of distortion (the level of assistance or protection on both output and input), $REV(.)$ is the revenue function; ω (.) is the cost equation and X^* is a vector of the optimal input levels.[6]

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[5] The arguments in the profit function include prices and quantity of inputs.

[6] Note that the revenue and cost functions are in 'reduced' forms, i.e. they are functions of output prices and input quantities. The direct revenue and direct cost functions generally depend on output level and prices.

Following Lau and Yotopoulos (1972), I now make use of (15a) and (15b) to specify the elasticities measuring the effects of prices and levels of assistance (i.e. the distortions). Taking the derivative of (15b) with respect to $\overline{P}_i$ and rearranging terms leads to supply elasticity

$$(\frac{\overline{P}_i}{Y_i})\frac{\partial Y_i}{\partial \overline{P}_i} = (\frac{\overline{P}_i}{Y_i})\frac{\partial Y_i}{\partial \overline{P}_i}\bigg|_{\overline{X}} + (\frac{\overline{P}_i}{Y_i}\frac{REV}{REV})\frac{\partial Y_i}{\partial REV}\frac{\partial REV}{\partial \overline{P}_i} - (\frac{\overline{P}_i}{Y_i}\frac{\omega}{\omega})\frac{\partial Y_i}{\partial \omega}\cdot\frac{\partial \omega}{\partial \overline{P}_i} \text{, or summarily}$$

$$\sigma_{Yi,\overline{P}i} = \sigma_{Yi,\overline{P}i}^{\overline{X}} + \overline{s}_i.\sigma_{yi,REV} - \sigma_{yi,\omega}.\sigma_{\omega,\overline{P}i} \text{ ,}$$

where $\sigma_{Yi,\overline{P}i}$, $\sigma_{yi,REV}$ and $\sigma_{yi,\omega}$ are the elasticities of output with respect to own price, revenue, input cost (or more generally production cost), respectively. The elasticity $\sigma_{Yi,\overline{P}i}^{\overline{X}}$ is the own-price elasticity when level of input (hence the endowment) is held constant; the elasticity $\sigma_{\omega,\overline{P}i}$ represents how output price changes affect input price (i.e. testing the Rybczinsky theorem). The scalar $\overline{s}_i$ i=Yi. $\overline{P}_i$ /REV is the share of the revenue from i to total revenue. It is the Slutsky equation in the sense that the own-price effects are separated into price effects and income effects.

The cross-price effect of the change of Y_i with respect to price $P_{i'}$ on output Y_i would just be

$$\sigma_{Yi,\overline{P}i'} = \sigma_{Yi,\overline{P}i'}^{s} + \overline{s}_{i'}.\sigma_{Yi,REV} - \sigma_{Yi,\omega}.\sigma_{\omega,\overline{P}i'}$$ where $\overline{s}_{i'}$ =Yi'. $\overline{P}_{i'}$ /REV and the rest of the variables are as before.

By analogy, since the index Θ is from a separable price function, its effect on output level can also be written as

$$(16) \quad \sigma_{Yi,\Theta} = \sigma_{Yi,\Theta}^{\overline{X}} + (s_{\Theta}.\sigma_{yi,REV} - \sigma_{yi,\omega}.\sigma_{\omega,\Theta}).$$

Equation (16) shows how the distortions will affect output prices. The first term on the right hand side is the Hicksian parameter capturing the effect of the distortion Θ on i-th output, holding the levels of inputs (i.e. input endowment) constant. The rest, in parenthesis, represents the net endowment effect, i.e. the difference between revenue endowment and factor endowment, of the distortion on the level of i-th output. The next step is to estimate separately these elasticities before making the comparison between the change in output with the input level held constant and the change in output due to increase or decrease in endowment.

The steps leading to equation (16) have implied that $\sigma_{Yi,\Theta}$ and $\sigma_{Yi,\Theta}^{\overline{X}}$ should be derived from Marshallian and Hicksian supply equations respectively. Estimating the Marshallian parameters is straightforward by the use of the reduced form of (15), i.e. specifying that supply is a function of all prices, and of the index of the level of assistance Θ :[7]

$$(17)\ \ln Y_i = \beta_C \ln c_{0i} + \beta_{ii} \ln \overline{P}_i + \sum_{i' \neq i}^{M-1} \beta_{ii'}.\ln \overline{P}_{i'} + \sum_j \beta_{ijr} \ln \overline{r}_j + \beta_{i\theta} \ln \Theta,\ \text{for all } i=1, ..M,\theta.$$

The Marshallian elasticity $\sigma_{Yi,\Theta}$ specified in (16) is just the estimated coefficient $\beta_{i\theta}$ on distortion coefficient estimated from (17).

The derivation of the Hicksian parameter $\sigma_{Yi,\Theta}^{\overline{X}}$ is next. Hicksian parameters are derived from indirect profit and revenue functions in (14) and (15a). As in Gordon (1989), the notion that Q is an aggregate representative output index means that the share equation derived from such an index leads directly to the Hicksian supply parameters[8]. Customarily, the share equations can be written in generic forms as

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[7] Alternatively, it can be similarly obtained through the indirect profit function.

[8] By analogy to the analysis of share equations in a demand system, restrictions on the parameters can be imposed using property of the supply equation to estimate Hicksian elasticities (See Fuss 1974, Gordon 1989).

$$(18) \ s_i = \gamma_{0i} + \gamma_{ii} \ln \overline{P}_i + \sum_{i'}^{M-1} \gamma_{ii'} \ln \overline{P}_{i'} + \gamma_{i\theta} \ln \Theta$$

for all $i = 1, ..M, \Theta$,

where s_i is the revenue share of product i based on the undistorted price, the γ 's are parameters to be estimated and the rest of the variables are as defined before. Once the parameters of the share equations (17) and (18) are defined, these parameters can be used to calculate the Allen-Uzawa partial elasticity between output i and i' defined as

$$(19) \ e_{i'i} = REV \cdot \frac{\dfrac{\partial^2 REV}{\partial P_i . \partial P_{i'}}}{\dfrac{\partial REV}{\partial P_i} \cdot \dfrac{\partial REV}{\partial P_{i'}}} , \text{ or more explicitly}$$

$$(20) \ e_{i'i} = \frac{\gamma_{i'i} + s_i \cdot s_{i'}}{s_i \cdot s_{i'}} .$$

Finally, as shown in Berndt and Wood (1975) and in Allen (1938) , the Hicksian elasticity $\sigma_{i'i}$ is related to the Allen-Uzawa elasticity $e_{i'i}$ by the following:

$$(21) \ \sigma_{i'i} = \left| s_i . e_{i'i} \right|$$

$$(22) \ \sigma_{i'i} = \left| \frac{\gamma_{i'i}}{s_{i'}} + s_i \right| .$$

By analogy, the Hicksian elasticity of Y_i with respect to the distortion is

$$(23)\ \sigma_{Yi,\Theta}^{\bar{X}} = \left| \ \frac{\gamma_{i\theta}}{s_\theta} + s_i \ \right|,$$

where s_i is the average of the commodity i's revenue share based on the undistorted price, s_θ is the

revenue share due to the distortion; $\gamma_{i\theta}$ is the coefficient on the distortion in the share equation in (18),

i.e., it is the elasticity of share of the revenue from output i (based on the undistorted price) with

respect to the level of distortion. With estimates of parameters $\beta_{\theta i} = \sigma_{Yi,\Theta}$ from (17) and $\sigma_{Yi,\Theta}^{\bar{X}}$ from

(23) at hand, their difference $\sigma_{Yi,\Theta i} - \sigma_{Yi,\Theta}^{\bar{X}}$ can be computed to represent, according to (16), the total

endowment effect of the distortion on the i-th output.

3. **Data and Econometric Model**

   3.1 Data

To find some evidence of the effects of a mix of policies on a mix of products, the model and especially

equations (12), (17) and (18) are applied to a panel of agricultural data drawn from Anderson and

Valenzuela's (2008) international distortion database. Covering the period 1951-2005, the original

Anderson and Valenzuela database includes 75 countries but is missing observations for some years and

for some commodities. The choice of the panel data was therefore dictated by such limitations

especially on prices, volume of output and level of assistance or taxation to these crops. The panel data

I used cover the period 1961-2005 for selected commodities in eighteen developing countries in Sub-

Saharan African countries (see Table 1).

For each country, I consider an agricultural sector with only three groups of commodities (or

subsectors): exportable cash commodities (e.g. spices, tea, tobacco, cocoa, coffee, hides and skins, palm

oil); importable commodities (e.g. rice, wheat, maize); and non-tradable food (e.g. roots and tubers,

some local fruits). These classifications seem to differentiate the products by their presumed end use

(cash activities to get money vs. food to be consumed locally by households), although there is generally

no clear boundary between what are termed "cash" and "food" commodities, given that both can be

tradable commodities. In Sub-Saharan Africa, a distinction can be made also on the basis of production

(or post-harvest) technique, i.e. that the exportable cash commodities such as industrial crops like

tobacco, cotton, cocoa and coffee employ relatively more machineries (for irrigation, storage etc.) than

importable commodities like rice or maize.[9] It is therefore plausible to hypothesize that the exportable

cash commodities are generally more capital intensive than the importable commodities.   Similarly,

hypothesizing that both tradable commodities (cash and tradable food) are more capital intensive than

the non-tradable commodities (roots and tubers) seems reasonable.   In any case, the above model

allows the testing of these hypotheses.

Table 1 shows the list of these three main groups of commodities selected as cash, food, and non-traded

in each country while Table 2 summarizes the key variables. It is noted in Table 2 that the production of

importable food represents about 41%, the largest share, of the total value of production of the three

commodity categories. Table 2 also shows the discrepancies between actual (i.e distorted) and

reference (i.e undistorted) farm gate prices especially in cash commodities.

(Table 1, here)

(Table 2, here)

One of the most important variables depicting distortion in the Anderson and Valenzuela distortion

database is the Nominal Rate of Assistance (NRA). The NRA is the percentage by which domestic

producer price is above border price and is widely used as a proxy for the level of assistance. Dollar

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[9] See Robinson and Thierfelder (1996) distinguishing `non-tradable' from `non-traded' goods.

value of subsidies or taxation is a good representation of distortions, but the NRA index per crop seems more convenient when addressing cross-effects of the distortions.

For the eighteen Sub-Saharan African countries in the model, NRA data show that the agricultural production has been heavily dis-protected in the last 50 years: NRA estimates vary between –47% and 7%, but the average NRA by commodity group is between –15% and–8% in Sub-Saharan Africa between 1960 and 2005. Figure 1 contains smoothed average of NRA indexes and shows that although all three major commodity categories had been taxed, the levels of taxation neatly differ among these categories. The most taxed were the exportable (cash) commodities whose actual average prices dipped down 15 to 37% below undistorted prices. While importable food was on average moderately taxed between 8 and 15%, the non-tradable food commodities were the least taxed (about 5%).   Figure 1 also shows that for the cash and importable food commodities, taxations were highest in the aftermath of the oil shock in early 1970's (as governments perhaps needed more cash) but reduced quite steadily afterwards.

(Figure 1, here)

3.2 Econometric application

To obtain an econometric model that fits the selected panel data at hand, I add in the sets of equations (12), (17) and (18) the subscripts k=1,.., 18 for each country and t= 1961-2005 for time in each variable. I also add error terms to acknowledge the errors committed when measuring and computing actual levels of production, especially at the country level. To (12) and (17) I also add an interaction term between technology and distortions to capture any technological effect of the distortion on the output ratio. Econometrically, these equations are detailed as follows.

Output ratio equations

(24)

$$\ln\left(\frac{Y_i}{Y_{i'}}\right)_{kt} = \alpha_0 + \alpha_t t + \alpha_c \ln(c_i / c_{i'})_{kt} + \alpha_P \ln\left(\frac{\overline{P}_i}{\overline{P}_{i'}}\right)_{kt} + \alpha_\eta \{\ln \theta(\eta_i) - \ln \theta(\eta i')\}_{kt} + \alpha_\lambda \{\ln \theta(\lambda_j) - \ln \theta(\lambda_{j'})\}_{kt}$$

$$+ \alpha_x \ln\left(\frac{\overline{X}_j}{\overline{X}_{j'}}\right)_{kt} + \alpha_{\text{int}i} \left[\{\ln \theta(\eta i) - \ln \theta(\eta i')\} * \ln(c_i / c_{i'})\right]_{kt} + \varepsilon_{i/i'kt}$$

for $i, i' = 1, 2, 3$, where $i \neq i'$

Supply equations

(25)
$$\ln(Y_i)_{kt} = \beta_{ci} \ln c_{0it} + \beta_i \ln(\overline{P}_i)_{kt} + \sum_{i'}^{M-1} \beta_{i'}.\ln(\overline{P}_{i'})_{kt} + \sum_j \beta_{rji} \ln(\overline{r}_j)_{kt} ;$$
$$+ \beta_{\theta i} \ln(\Theta)_{kt} + \beta_{\text{int}i} \left[\ln c_{0i} * \ln(\Theta)_{kt}\right] + \varepsilon_{y_i kt}$$

for $i, i' = 1, 2, 3$.

Revenue share equations

(26) $$(s_i)_{kt} = \gamma_{i0} + \gamma_{ii} \ln(\overline{P}_i)_{kt} + \sum_{i'}^{M-1} \gamma_{ii'}.\ln(\overline{P}_{i'})_{kt} + \gamma_{i\theta} \ln(\Theta)_{kt} + \varepsilon_{s_i kt}$$

for $i, i' = 1, 2, 3, \Theta$; and with the restrictions that $\sum_i \gamma_{i0} = 1$, $\sum_i \gamma_{ii'} = 0$ and $\gamma_{i'i} = \gamma_{ii'}$.

with $\sum_i Y_i(\overline{P}_i - P_i) \geq 0$, $s_i = \frac{Y_i P_i}{\sum_i Y_i \overline{P}_i}$, $s_\theta = \frac{\sum_i Y_i(\overline{P}_i - P_i)}{\sum_i Y_i \overline{P}_i}$.

The main variables employed are described as follows:

Y: Volume of production (tons);

c: technological shift indicator, here share of fertilizer use per hectare;

λ: nominal rate of assistance for capital input at the overall sector (agriculture) level;

ŋ: nominal rate of assistance on output by product;

$\overline{P}$: undistorted output price (i.e. farm gate reference price);

P: distorted output price (i.e actual farmgate price);

X: amount of input, capital proxied as fertilizer uses, labor as agricultural workforce in thousands;

$\left(\dfrac{\overline{X}_j}{\overline{Xj'}} \right)$: the capital-to-labor ratio, proxied as actual fertilizer use per agricultural worker;

ρ : host of exogenous factors affecting the capital-to-labor ratio (exchange rate, GDP per capita);

$\overline{r}$: undistorted price of input (capital: interest rate or price of fertilizer; labor: wage);

Θ : overall distortion index (which can be positive or negative), generally in USD or in index or

difference between distorted and undistorted price;

Θ : a function of distortion index, used interchangeably with Θ ;

REV: Crop Revenues;

s: revenue share.

The subscripts are: *i, i'* indicate outputs; *j* and *j'* represent inputs; *t i*s time (year); and *k* is country.   Also,

$\alpha s, \beta s, \gamma s$ are the parameters to be estimated. The ε s represent the error terms.

3.3 Specification tests

I performed preliminary specification tests for equations (24), (25) and (26) to address the main

challenges in panel data analyses: choosing the types of estimators (fixed vs. random) and, just as

important, detecting and correcting for the problems of endogeneity and heteroscedasticity (due to the

different magnitudes of the volumes of commodity production across countries) as well as correlation

among residuals within and across entities. For both (24) and (25), suspected endogeneity problem

arises because the price variables are correlated with supply (output) measurement errors. I included

two time-variant demand shifters, namely, countries' GDP per capita income, and non-food price index

as instruments for the model. These two instruments are assumed to affect output prices without

directly crop production. I started with the Breusch-Pagan Lagrangean Multiplier test to check if cross-

sectional effects are indeed present in the data (in the opposite case OLS will be BLUE). For (24) and the

supply models, the values of the chi-square (with p-value =0.020) statistics indicated a rejection of the

null hypothesis and confirmation that cross-sectional effects are indeed present and that OLS estimates

are not to be used as they are not consistent and are inefficient estimators of the model and data at

hand.

Next, because of the endogeneity and heteroskedasticity problems and to address whether the fixed or

the random effects model fits the data well, I used robust Hausman type test using STATA's xtivreg and

xtoverid (Baum et al. 2007; Schaffer and Stillman 2010). The test results rejected the random effect

specification and indicated that both (24) and (25) are better specified as fixed effects.[10] Finally, I note

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[10] Obviously, inclusion of these instruments makes the model over-identified and to check both the quality of the

instruments (whether they are truly uncorrelated with error terms and strongly correlated with the endogenous

variables) and improvement in the estimates and standard errors, I employ the Sargan-Hansen test (Sargan 1958;

Hansen 1982).

that because the variables representing the levels of protection take negative values (i.e. the dis-protection), I used the levels and not the logs of these proxies; their coefficients are therefore interpreted as semi-elasticities.

4. Results and Interpretation

4.1 The substitution effects and cross-effects

The results of the estimation are summarized in the tables 3, 4, 5 and 6. First, the results of the estimation of (24) in Table 3 show the positive and statistically significant coefficients on the variable 'capital-to-labor ratio', supporting the hypothesis that the most capital-intensive products are exportable cash crops (such as cotton, cocoa and vanilla) whereas the least capital-intensive are the non-tradable commodities such as cassava or yam.

(Table 3, here)

Second, concerning the exchange rate effects on the output ratios, the negative sign on the exchange rate coefficient for both equations for cash vs. importable crops and cash vs. non-tradable is somewhat counterintuitive. It indicates, for instance, that devaluation of currency reduces the output ratio, i.e. the production of either importable or non-tradable commodities has increased at faster rates than that of cash commodities. Contrarily to the expectation that devaluation of currencies would boost export and stimulate production of cash commodities in these African countries, the evidence from the analysis suggests that currency depreciation has not favored the production of cash crops relative to either type of food crop. One possible explanation is that the currency depreciation increases the cost of importing some essential inputs and therefore reduces the expansion of cash-commodity production. Another explanation is that because devaluation has made food import more expensive, the agricultural sectors in these countries may have turned their focus to producing more of local and non-tradable crops such

as roots and tubers. Finally, the effect of exchange rates on the ratio of cash production over either importable or non-tradable commodities is negative, because the former includes perennial crops (tree crops, tea or coffee) which, as Table 4 later indicates, have low supply elasticity in comparison with the mostly annual or seasonal food grains (rice and maize).

Additional findings indicated in Table 3 concern the substitution effects and the cross-effects, particularly the ways the ratio of the levels of undistorted output prices and the differences in the level of taxation between two commodities affect the output ratio. First, the positive coefficient on the ratio of the two undistorted prices means that an increase in price incentive would increase output which is, as expected, a movement along a concave PPF. Specifically, the positive sign of the coefficient on the ratio of the undistorted (reference) price of the cash commodity to either the importable or non-tradable commodities therefore indicates that these commodities may substitute for one another when the agricultural sector wants to maximize total profit for given endowment and price levels. An increase in price of a cash commodity relative to an importable commodity would induce farmers and attract resources toward the production of more cash commodities and less importable or non-tradable food. It is noted that such substitution is weak between the importable and non-tradable food.

More important, the statistically significant negative sign of the coefficient on the distortion differential across the three columns in Table 3 indicates that a higher increase in taxation of cash commodities relative to an increase in taxation of importable food has caused more harms to the production of importable food than to the production of cash commodities. Both productions of cash and importable food commodities have declined due to the relatively high taxation on cash commodities, but, counterintuitively, the output decline has been more severe for the importable food commodities. That any tax hike on one commodity affects other commodities is unsurprising. Why such cross effects are asymmetric and counterintuitive is puzzling.

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One explanation for why the production of importable food is punished more severely than cash commodities as the dis-protection gap between the two rises is that the importable food is more price elastic than cash commodities. This is evidenced in table 4, which indicates that although the estimates of own-supply elasticity are low for both, the supply of importable food is twice as price elastic (with respect to both prices and taxes) as that of the cash commodity. Another possible explanation can be found in how the production responds to access to capital input and factor inputs in general. If taxation increases faster for cash crops than for importable food, then, as a result, agricultural export revenue, an important source of foreign currencies to purchase imported essential inputs, will also decline faster. Results in Table 4 seem to undermine this second explanation by showing that the importable food production depends less on imported inputs such as fertilizer (i.e. it is relatively less-capital intensive) compared to cash crops. However, that a decline in revenue from cash commodities, an important source of agricultural revenue, would also mean a loss in the ability to invest in technology or to hire inputs, including labor is highly plausible. Such loss would proportionately affect the relatively labor-intensive commodities including importable food and non-tradable food. Summarily, the cross-effect result supports the argument that detaching the efforts to improve food security from the efforts to reduce taxation on cash crops is counterproductive.

Similar results apply for the cross-effects between importable and non-tradable food. The effect of the difference in the level of distortion indicates that a high rate of taxation of importable food inflicts a larger output decrease in the non-tradable than in the importable food. This correlation suggests that even if production of non-tradable commodities is generally not subjected to either per unit or ad valorem tax, it has suffered a great deal when importable food crops are under taxation. The positive consequence is that removing taxation on importable food crops may not only increase their production

but will also induce an increase in the production of non-tradable crop which are the main staples in rural areas.

4.2. The endowment vs. substitution effects

As shown in equation (16), the distortion effects are split into substitution and endowment effects to provide greater insights into policy implications. This approach requires that the Marshallian parameters be estimated from (25) and Hicksian parameters indirectly from (26). The results on Marshallian parameters are summarized in Table 4 with the particular focus on the semi-elasticity coefficients on the effect of the distortions. Table 4 shows that each USD 100 million of tax is associated with a 1.4% decline of the production of cash commodities and a 2% decline in the production of importable food. The average estimation of the 'dis-protection' for the selected countries has been about 270 million USD per year, which puts the decrease in cash and importable food production correlated with the distortion at about 3.8 % and 5.4 %. These Marshallian estimates of 0.038 and 0.054 show that on average the effects of distortions on the level of production seem not dramatically high, but given the low-price elasticity of production for these commodities the effects are nevertheless non-negligible.

(Table 4, here)

Next, the Hicksian parameters have to be derived from the estimation of the share equations (26). These shares are estimated simultaneously as a system of panel data and also that only the results for the shares of cash and importable commodities are reported in Table 5. The share equation for non-tradable commodities has been dropped in the estimation to avoid a singularity problem; the

parameters of the non-tradable commodities can in any case be obtained through adding-up and symmetry conditions. Overall, the signs on the price coefficients, positive for own price and negative for cross prices, are as expected.

(Table 5, here)

The coefficients on the distortion, are -0.006 and -0.002 for the share equations of the cash and food commodity respectively. Using the mean values of taxation of 2.7 hundred million USD, the corresponding Hicksian elasticities based on Fuss (1977) and Gordon (1984) method for the cash and food commodity are 0.012 and 0.023. Based on equation (16), the difference between the Marshallian and Hicksian elasticities represents the net endowment effects of the distortion. Thus, these figures imply that the net endowment effects in terms of elasticities are about 0.038-0.012=0.026 for the cash commodity and 0.054-0.023=0.031 for the importable food. In other words, the endowment effects of the distortion on the output levels of cash and importable food crops are respectively about 70% and 60% of the total effects. These figures mean that the taxation of the agricultural sector in Sub-Saharan African countries in the last 5 decades had substantially reduced resource endowment (mainly capital) and reduced the growth of agricultural production. The dis-protection had not only rekindled the output composition; more important, it stripped the sector the means, and especially, the capital (equipment, fertilizer, etc.) required to sustain an increase in overall production.

This large endowment effect also implies that at least for the agricultural sector examined in this study, there is no evidence of strong positive effects of taxation on the levels of work efforts and production, as some authors[11] argue. But even if taxation had increased the levels of work efforts and production,

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[11] see Karlsson, 2004.

such an increase would be suppressed by a fall in production due to the decline in both the capital-to-labor ratio and the level of capital available to the sector.

5 Conclusion and Implications

Many cash-strapped and food insecure countries used or continue to tax their agricultural export to increase government revenue and subsidize food production to quell hunger. This paper generally shows that for the agricultural sector these policies have generally been counterproductive. I estimate the substitution and endowment effects of a mix of policies on a mix of commodities to analyze a dataset of government taxation and subsidies in selected Sub-Saharan African countries. To capture the cross-effects, i.e. what the distortions on one commodity do to other commodities, I divide the commodities into three groups on the basis of their factor content, factor intensity, and end use; the groups are cash commodity, importable food and non-tradable food. Similarly, to examine the distributional effects of the distortions, I split the effects of distortions into substitution and endowment effects and estimate Marshallian and Hicksian elasticities to derive the substitution and endowment effects of the policies.

Results show that when the ratio of taxation between two commodities varies, substitution through cross-effects occurs, but the cross-effects are asymmetric and counterintuitive: a higher increase in taxation on cash commodities relative to an increase in taxation of importable food caused relatively more harm to the production of importable food than to the production of cash commodities. An explanation from the estimation is that the food commodities are more price- and distortion-elastic, but it is plausible also that when cash-commodity production is taxed, the agricultural sector's earning declines rapidly and as a result, the ability to buy key inputs including hired labor for the relatively labor-intensive importable food falters. The implication is that in a mixed output system, the full and net

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effect of assistance or taxation on each commodity growth may go against the intended goal of the policy. What matters is not just the nominal, absolute level of assistance or taxation per se; of a much greater importance is its level in comparison with what is applied to other commodities. For instance, an increased assistance to food crop production relative to other crops in order to promote food security may create unwanted surplus in the other crops while keeping the assisted food crop at lower growth path. Conversely, as the results show, in the midst of an already tough food-insecurity struggle, taxing cash crops proves to be a bad idea.

The other main set of findings comes from the decomposition of the output effect of distortions into substitution and endowment effects. The decomposition reveals that endowment effects far surpass the substitution effects and represent about two thirds of the total effects. That is, as the taxation increases, the massive decline in the availability of resources, especially capital, holds back production. The large size of the net endowment effects relative to the size of the substitution effects has three far-reaching implications for how policies aimed at reversing the taxation on agriculture and guiding investment reforms in many developing countries may work. First, direct support such as lump-sum or 'decoupled' subsidies may have more direct positive effects on agricultural production than the 'coupled' subsidy or target price does; this is consistent with findings from O'Donoghue and Whitaker (2010). [12] Second, when across-the-board assistance increases, whatever negative effects the change in input ratio or moral hazard may inflict on the profit and on the level of output, the net endowment effect of subsidies on output level would be positive. This is because the negative effects would likely be more than offset by the effects of the increased availability of capital relative to labor (i.e. in making

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[12] Key and Roberts (2009) found that an increase in payments may shift work efforts from non-farm activities to farm activities. Weber and Key (2012) concluded that decoupled payment had little effect on US program crop production and harvested acreage but admitted that such conclusion may not apply because the use of the extra income may be specific to market conditions.

capital relatively cheap compared to labor) and the direct increase in amount of capital through money transfer.

Third, any attempt to encourage diversification by introducing new cash crops or to promote food security by assisting food crop production will be unsuccessful without new investments and, especially, without a reduction, or ideally, a removal of direct and indirect taxes on agriculture. Shuffling resources around by literally 'undressing' maize to 'dress' cotton is not sensible because the cross-effects may provoke unintended consequences because crop responses to incentive or taxation differ considerably. The priority before targeting any sub-sector for assistance would be to increase the amount of and access to resources, hence adding investment and capital to the whole agricultural sector. Practically, reducing the government taxes on cash or export commodities can help reduce food insecurity, and lump-sum subsidies are definitely more preferable than direct price supports.

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Tables and Figures

Table 1. The Main Commodities by Country

Country	Cash (exportable) commodity	Importable food commodity	Non-tradable food commodity
Benin	**Cotton**	**Maize,** Rice,	**Cassava,** Yam
Burkina Fasso	**Cotton**	**Millet**	Cassava, **Sorghum**
Cameroun	Cocoa, **Coffee,** Cotton	**Maize**	**Cassava**
Côte d'Ivoire	**Cocoa ,** Coffee, Cotton	**Rice,**	**Cassava**
Ethiopia	**Coffee**	**Maize**	**Teff**
Ghana	**Cocoa**	Maize, Rice	**Cassava**
Kenya	**Tea**	**Wheat**	**Maize**
Madagascar	**Vanilla**	**Rice**	**Cassava**
Mali	**Cotton**	**Millet**	**Cassava,** Sorghum
Mozambique	Cotton, **Tobacco**	**Groundnut**	**Cassava**
Nigeria	Cocoa, **Cotton**	Maize, **Rice**	Cassava, **Millet**
Senegal	**Cotton,** Groundnut	**Rice**	**Millet**
Sudan	**Cotton,** Sheep meat	**Wheat**	**Millet**
Tanzania	**Cotton,** Tea	**Maize**	**Millet**
Togo	**Cotton,**	**Millet**	**Cassava,** Sorghum, Yam,
Uganda	Coffee**, Cotton**	**Maize,** Rice	Cassava**, Sweet potatoes**
Zambia	**Cotton,** Tobacco	**Maize,** Rice, Sorghum	**Millet**
Zimbabwe	**Cotton,** Groundnut**,** Tobacco	**Maize,** , Soybean	**Sorghum,** Sunflower

Note: In bold are the commodities employed in the estimation, as they have the most available information in each country.

Table 2. Descriptive Statistics of Key Variables

Commodity	Variable	Unit	Mean	Median	Std Dev
Cash (export)					
	Production	T	176688.4	113900.0	216648.7
	Reference farm gate price	USD/T	1000.4	619.8	1235.4
	Actual Farm gate price	USD/T	860.5	334.1	3311.8
	Value share		0.239	0.158	0.231
	NRA on output		-0.386	-0.403	0.311
	(Nb. Of observations=1173)				
Importable food					
	Production	T	768993.2	402216.5	976569.6
	Reference farm gate price	USD/T	191.9	158.5	196.0
	Actual Farm gate price	USD/T	154.2	153.8	79.9
	Value share		0.408	0.360	0.272
	NRA on output		-0.035	0.000	0.538
	(Nb. Of observations=985)				
Non Tradable food					
	Production	T	2569083.7	926000.0	5208050.5
	Reference farm gate price	USD/T	114.4	98.2	74.6
	Actual farm gate price	USD/T	90.5	80.6	51.2
	Value share		0.343	0.344	0.290
	NRA on output		-0.057	0.000	0.227
	(Nb. Of observations=969)				
All agriculture					
	Fertlizer use per ha	100g/ha	122.9	71.4	145.7
	Fertilizer use/ag. lab.force	T/active ag. pop	0.0062	0.0043	0.0069
	Real Interest rate	%	5.432	7.337	14.102
	Gross subsidy equivalent	100 million USD	-2.695	-0.461	4.271
	(Nb. Of observations=3127)				

Source: Author's computation from Anderson and Valenzuela database

Table 3. Substitution Effects between Crops under Distortion (One Way Fixed-Effects Estimation)

Dependent variable: Output ratio (LogY1/LogY2)	Cash (1) vs. importable food(2)	Cash (1) vs. non-tradable food(2)	Importable food(1)vs. non-tradable food(2)
Independent variables:			
Year	0.010*** (0.020)	0.097*** (0.022)	-0.021** (0.011)
Price ratio: Log(P1/P2)	0.355*** (0.028)	0.371 *** (0.021)	0.02 (0.05)
Difference in rate of assistance: NRA(1)-NRA(2) on output	-0.349** (0.113)	-0.157 (0.150)	-0.202** (0.082)
Difference in rate of assistance in input	-30.468* (15.340)	-29.244* (17.490)	3.219 (8.924)
Fertilizer use per econ. active agric. population: (Log(K/L)	0.082* (0.060)	0.136* (0.071)	0.252*** (0.036)
Exchange rate: Log(ER)	-0.158 *** (0.033)	-0.169*** (0.037)	0.052** (0.019)
LogGDP deflator	-1.648*** (0.400)	-1.470*** (0.461)	0.380* (0.168)
R-Sq	0.81	0.85	0.94
TxN=44x12			

Note: Figures in parentheses below the coefficients are standard deviations. The superscripts ***, **, and * are level of significance at 0.01, 0.05 and 0.1 respectively.

**Table 4. Supply Function (Marshallian) Parameter (Hausman-Taylor estimates)**

Dependent variable: Log of Output (LogY)	Exportable cash commodity	Importable food commodity	Non-tradable food commodity
Independent variables: in Log form			
Undistorted Price of Cash	**0.155 ***	-0.165 ***	-0.161**
	(0.088)	(0.052)	(0.082)
Undistorted Price of Importable	-0.078	**0.281 ***	-0.136
	(0.095)	**(0.056)**	(0.089)
Undistorted Price of Non-tradable	-0.196**	-0.054	**0.017**
	(0.083)	(0.049)	**(0.078)**
Assistance (distortion)#	0.0141 ***	0.0200 ***	0.021
	0.0039	0.0082	(0.013)
Wage (Labor productivity)	-0.324	0.534***	0.659**
	(0.283)	(0.168)	(0.264)
Fertilizer Use per ha	0.285***	0.023	0.012
	(0.058)	(0.034)	(0.054)
Interest rate	0.275***	-0.083	0.318***
	(0.092)	(0.054)	(0.857)
R-Square	0.91	0.95	0.97
TxN=34x13			

Note: Figures in parentheses below the coefficients are standard deviations. The superscripts ***, **, and * are levels of significance at 0.01, 0.05 and 0.1 respectively. # The assistance is measurement unit is 100 million USD. Assistance may have negative value so in the estimation the level, not the log-level is introduced. For example, the interpretation of the value in the first column goes as follows: Every additional 100 million USD taxation (subsidy) would decrease (increase) output of cash crop by about 1.41%. Using mean value of - 2.7 hundred million USD, this is equivalent of saying that for cash commodity, 1% decrease in dollar amount of support would reduce cash crop production by 0.04%. (Note by comparison that one percent decrease of undistorted price (quoted in dollar) will lower production by 0.15%).

Table 5. Revenue Share Parameters

Dependent variable: Revenue Share	Exportable cash commodity	Importable food commodity	Non-tradable food commodity
Independent variables: (log form)			
Intercept	0.185 *** (0.041)	0.291*** (0.036)	0.137** (0.060)
Undistorted Price of exportable cash commodity	**0.139*** (0.012)**		
Undistorted Price of Importable	-0103*** (0.012)	**0.187*** (0.012)**	
Undistorted Price of Non-tradable	-0.030*** (0.009)	-0.082*** (0.009)	**0.127* (0.056)**
Assistance (distortion)	-0.006** (0.00134)	-0.002 * (0.00159)	-0.015 (0.020)
TxN=34x13			

Note: Figures in parentheses below the coefficients are standard deviations. The superscript ***, **, and * are level of significance at 0.01, 0.05 and 0.1 respectively. The coefficients have been transformed from semi-elasticity to elasticity using mean level of assistance.
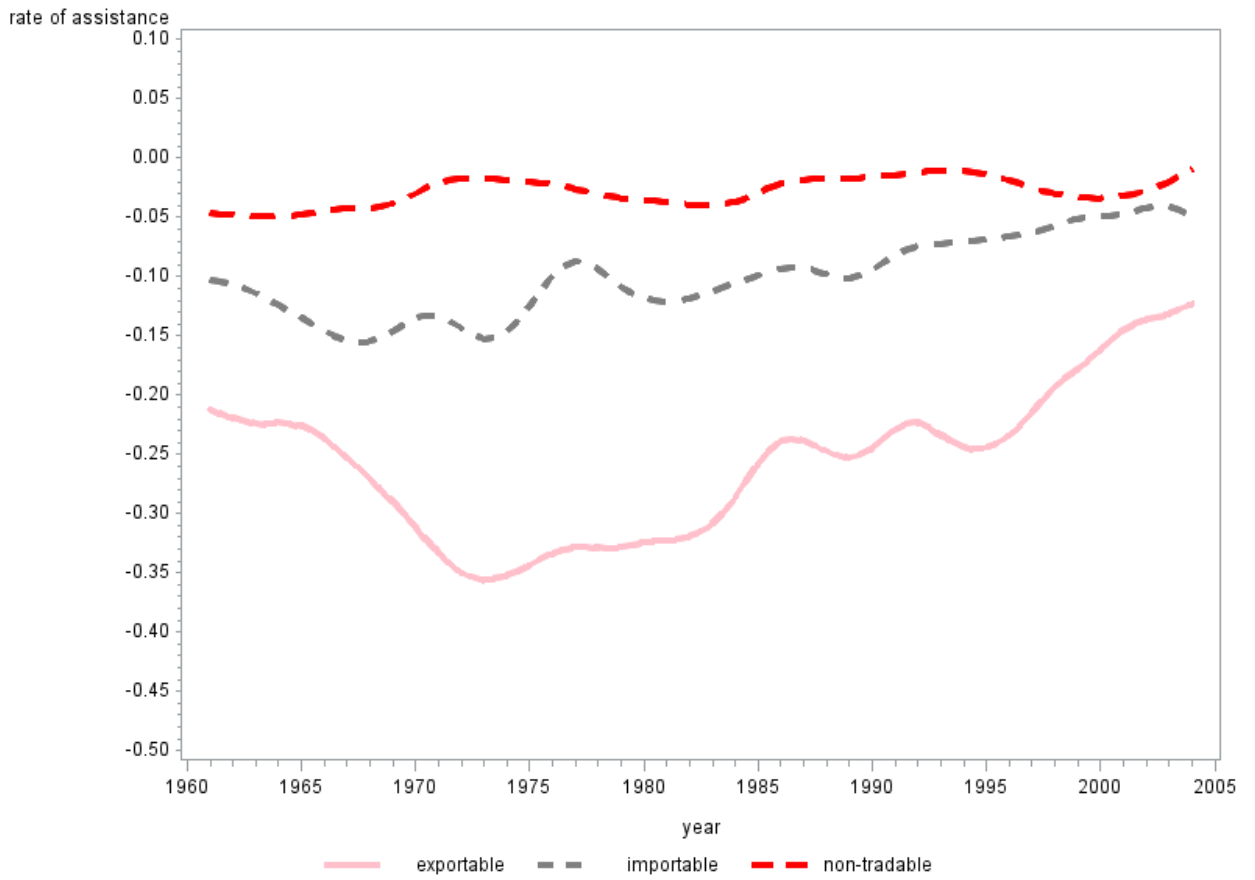
Source: Author`s computation using Anderson and Valenzuela (2008)

Figure 1. Average nominal rate of assistance for main commodity categories in Sub-Saharan Africa