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Government Expenditures in Kenya, 1950–2014

Determinants and Agricultural Growth Effects

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INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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ABSTRACT

Annual data on Kenya from 1950 to 2014 are used to analyze the determinants of the level and composition of government expenditures and estimate the agricultural-output returns to the different types of government expenditures. The paper analyzes expenditures for six functions (general administration, defense, education, health, agriculture, and other economic functions—transport, communications, etc.) as well as the capital-to-recurrent expenditure ratios within each of the six functions. Simultaneous equations modeling methods are employed, and different diagnostic tests are used to check for and address issues with stationarity, causality, and autocorrelation. Different model specifications are used to assess the sensitivity of the results to using different measures and combinations of the conceptual variables that are hypothesized to affect the composition of government expenditures and agricultural production.

The results show that total government expenditures as a share of gross domestic product have declined over time. Expenditures on health, defense, agriculture, and other economic functions (transport, communications, environment, etc.) have evolved in the opposite direction from changes in total government expenditures, while expenditures on education have evolved in the same direction as changes in total government expenditures. The composition of government expenditures is influenced by various socioeconomic factors (such as national income, sources of government revenue, official development assistance, foreign exchange rate, terms of trade, real interest rate, and rural-urban population structure) and political-economy and environmental factors that were introduced as shocks (such as change in government and political party systems, policy reforms, actions by interest groups, civil unrest, and drought).

Different types of government expenditures have had differential effects on agricultural value added, with varying returns to the amounts spent. Estimated benefit-cost ratios are in the range of 33.0 to 87.1 for functional expenditures on health, 9.7 to 13.9 for capital expenditures on agriculture, 3.2 to 9.3 for functional expenditures on education, and 3.6 to 4.3 for functional expenditures on other economic functions—transport, communications, environment, etc. Functional expenditures on defense and capital expenditures on health, education, and administration, which have had moderate to large negative returns, have not been beneficial in increasing agricultural value added. Implications for raising the productivity of the government’s recurrent expenditures in the agricultural sector, as well as for capital expenditures in the nonagricultural sectors, are discussed.

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ABBREVIATIONS AND ACRONYMS

3SLS	three-stage least squares
BCR	benefit-cost ratio
COMESA	Common Market for Eastern and Southern Africa
COTU	Central Organization of Trade Unions
EAC	East African Community
GDP	gross domestic product
KNUT	Kenya National Union of Teachers
KSh	Kenyan shilling
LM	Lagrange multiplier
R&D	research and development
ReSAKSS-ECA	Regional Strategic Analysis and Knowledge Support System for Eastern and Central Africa
SEM	simultaneous equations modeling
TFP	total factor productivity

1. INTRODUCTION

Public spending is motivated by the desire to reduce economic inefficiencies caused by market failures and to reduce inequality in the distribution of goods and services caused by differences in initial allocation of resources across different groups and members of society. Different types of public expenditures have different effects in reducing economic inefficiencies and inequality, via different but interdependent pathways that materialize over time at different rates (Fan 2008). Arguably, then, the ability to make good decisions about how to prioritize and allocate public budgets depends on knowing how effective and efficient different types of expenditures are—though political, cultural, and other factors dominate budget allocation decisions in many cases (Cusack 1997; Bräuninger 2005; Mogues 2015).

Different studies have focused on different issues along the expenditure allocation–to–outcomes pathway. The bulk of the literature seems to focus on the end of the chain or the link between the composition of expenditures and growth; however, the growing body of evidence on this link is inconclusive. Several studies find a positive relationship, particularly for low levels of expenditure (for example, Ram 1986; Aschauer 1989; Grossman 1990; Devarajan, Swaroop, and Zou 1996). For those that find a negative relationship (for example, Landau 1986; Barro 1990; Levine and Renelt 1992), particularly for high levels of expenditure, inefficiencies arising from distortionary taxes are a factor. Some of studies that have tried to differentiate the effects for different expenditure functions (for example, infrastructure, health, education, agriculture, and defense) or economic uses (for example, capital versus recurrent, productive versus nonproductive) also show mixed effects. For example, papers by Easterly and Rebelo (1993) and Fan (2008), as well as reviews by Glomm and Ravikumar (1997) and Mogues, Fan, and Benin (2015), show that government expenditures on communications, transportation, education, and health have large positive impacts on growth. Others, however, such as Devarajan, Swaroop, and Zou (1996) and Gosh and Gregoriou (2008), find the opposite: that government expenditures on communications, transportation, education, and health have a negative effect on growth. Some of the more recent studies on the topic (for example, Bayraktar and Moreno-Dodson 2012) suggest that the inconclusiveness may derive from the selection of countries in the cross-country dominated analyses, as the effects of government expenditures depend on a country's growth path. Thus, the jury seems to be still out on the direction of causality between expenditure and growth—whether it is Wagnerian, where public expenditure is endogenous and an outcome of growth in income (Wagner 1883) or Keynesian, where public expenditure is exogenous and a determinant of growth in income (Keynes 1936).

The literature focusing more on the beginning of the chain, or examining the determinants of the level and composition of government expenditures, seems more theoretical, as measures of most of the conceptual variables that are hypothesized to affect expenditure allocation decisions are still in their infancy. The recent review by Mogues (2015) of the political-economy determinants of public spending allocations, for example, shows that expenditure allocations in many cases fly in the face of the evidence of their growth effects or economic returns. Incentives for and constraints on key actors (including politicians, bureaucrats, interest groups, and donors), characteristics of publicly provided goods and services, and other economywide sociopolitical factors may be more important than efficiency considerations. Considering a partisan decisionmaking process, for example, it is expected that because political parties differ in their macroeconomic and economic management policies, they will implement different interventions. Here too, the evidence is mixed. Cusack (1997), for example, lists several studies that suggest either a strong, a weak, or no causal relationship between political affiliation and public spending. Kramon and Posner (2013) argue that the evidence depends on the goods or outcomes being studied because of different preferences of different political parties for different outcomes. The researchers thus conclude that the findings of studies that focus on a single good or just a few goods among several that the government allocates may be problematic, compared to studies that either use an all-encompassing measure such as total government spending or include many of the various goods and services that are provided by the government.

Using annual data on Kenya from 1950 to 2014, this paper contributes to the two strands of literature by analyzing the determinants of the composition of government expenditures and estimating the effects of the different types of expenditures on agricultural growth. We use simultaneous equations modeling (SEM) methods; carry out different diagnostic tests to check for and address stationarity, causality, and autocorrelation; and use different model specifications to assess the sensitivity of the results to using different measures of the conceptual variables that are hypothesized to affect the composition of government expenditures and growth. By integrating the analysis of the determinants of composition of government expenditures with the estimation of the effects of spending on growth, the contribution of the paper is unique.

Briefly, we find that total government expenditures as a share of gross domestic product (GDP) have generally declined over time, and that expenditures on agriculture and other economic functions (transport, communications, etc.) tend to suffer the most as budgets become tighter. The composition of government expenditures is influenced by various socioeconomic factors (such as national income, sources of government revenue, official development assistance, foreign exchange rate, terms of trade, real interest rate, and rural-urban population structure) and political-economy and environmental factors that were introduced as shocks (such as change in government and political party systems, policy reforms, civil unrest, and drought).

As expected, different types of government expenditures have had differential effects on agricultural value added, with varying returns to the amounts spent. The largest return in terms of increasing agricultural value added has derived from functional expenditures on health (with a benefit-cost ratio [BCR] of 33.0 to 87.1), followed by capital expenditures on agriculture (BCR of 9.7 to 13.9), functional expenditures on education (BCR of 3.2 to 9.3), and functional expenditures on other economic functions—transport, communications, environment, etc. (BCR of 3.6 to 4.3). Expenditures on defense, which have a negative BCR, have not been beneficial in increasing agricultural value added. The same applies to capital expenditures on health, education, and administration, suggesting that the positive returns to functional expenditures in these sectors, especially health and education, have derived from recurrent expenditures. We discuss implications for raising the productivity of the government's recurrent expenditures in the agricultural sector, as well as for capital expenditures in the nonagricultural sectors.

The rest of the paper is organized as follows. In the next section, we present the conceptual framework, followed by estimation methods and data in section 3. The results are presented in section 4, and conclusions and implications in section 5.

2. CONCEPTUAL FRAMEWORK

Determinants of Level and Composition of Government Expenditures

Let the total amount of the government budget (G_t) and its allocation to the *m*th function (F_{mt}) and *j*th economic use within each function (E_{jmt}) at time *t* be represented by the following equations:

$$G_t = \alpha^G + \boldsymbol{Z}_t^{G\prime}\beta^G + \tau^G t + \varepsilon_t^G \tag{1a}$$

$$F_{mt} = \alpha_m^F + \boldsymbol{Z}_{mt}^{F\prime}\beta_m^F + \tau_m^F t + \varepsilon_{mt}^F \tag{1b}$$

$$E_{jmt} = \alpha_{jm}^E + \boldsymbol{Z}_{jmt}^{E\prime}\beta_{jm}^E + \tau_{jm}^E t + \varepsilon_{jmt}^E \tag{1c}$$

where ***Z*** captures the vector of factors influencing the allocations, including economic, sociopolitical, demographic, and environmental or natural factors, as well as shocks such as wars, floods, droughts, or depression.[1] By allowing ***Z*** to vary across the different decision-making processes, we capture the notion that the influential factors may not be the same for the various allocations. The main elements of ***Z*** are derived from the literature that deals with the explanation of growth in public expenditures, which may be classified into three types of analyses: those based on Wagner's law (Wagner 1883), or the law of increasing spending dependent on growth in national income; those based on the displacement hypothesis (Peacock and Wiseman 1961), which suggests that public expenditures display stepwise growth that coincides with major shocks; and those explaining the changing pattern and composition of public expenditures based on stages of development, changing growth and equity concerns, or different public choice mechanisms.

Although Wagner's law seems to have been the first model to attempt to explain growth in public expenditure, its study has persisted as the debate has evolved and focused on different things, including the definition of state activity, measures of income and expenditure, and the direction of causality (that is, Wagnerian versus Keynesian, or where public expenditure is exogenous and a determinant of growth in income). See reviews of some of the earlier studies in Singh and Sahni (1984) and Ram (1987), and more recently in Durevall and Henrekson (2010) and Magazzino, Giolli, and Mele (2015). The main arguments for the law are that public functions and private activities are substitutes, and that increased growth and development leads to demand for greater or more superior forms of public intervention. The evidence is mixed, however, and often dependent on the types of countries, the periods under investigation, and demographic factors. For example, Durevall and Henrekson (2010) find that although

[1] Equations 1a, 1b, and 1c could have been made more explicit to include, for example, G_{t-k}, F_{mt-k}, and E_{jmt-k}, respectively, to capture the notion of path dependency. For notational simplicity, these are absorbed in ***Z***.

Wagner's law does not hold in the long run, it does hold over some subperiods of the data when the dependency ratio is controlled for. In their study, Magazzino, Giolli, and Mele (2015) find that Wagner's law holds for 8 of the 27 countries analyzed. Of the remaining 21 countries, however, reverse causality is found in 4, causality in both directions in 3, and a neutral relationship or absence of causality in 12. Kuckuck (2014), using historical data from the mid-19th century on five industrialized European countries, finds that the relationship between public spending and economic growth (or Wagner's law) weakens at advanced stages of development.

Studies based on the displacement hypothesis have evolved from the work of Fabricant (1952), which examines the productivity and determinants of different types of government activities in the American economy during the first half of the 20th century, and Peacock and Wiseman (1961), investigating the impact of random factors on the growth of public expenditure in the United Kingdom. Peacock and Wiseman observed growth in expenditure as a series of plateaus separated by peaks, with the peaks coinciding with shocks. Compared to the number of studies on Wagner's law, there are fewer on the displacement hypothesis, which may be related to the need for long time-series data on expenditures and shocks at multiple intervals. The limited evidence is mixed here too; Goff (1998) and Durevall and Henrekson (2010) find support for it, whereas Diamond (1977) does not.

A major determinant studied in the literature in the third category is globalization, following either an efficiency or a compensatory theory. The former predicts that increasing trade liberalization or the openness of an economy will exert pressure on domestic governments to reduce spending, as the technology-enhancing and cost-reducing effects of globalization on the domestic economy will decrease the need for governments to produce certain public goods and services such as research and development (R&D), transportation, and information and communication technology (Garrett 2001). The compensatory theory predicts the opposite, based on the argument that government spending plays a risk-reducing role and will therefore increase to buffer the external shock or to better equip the country to compete in the open economy, via unionization, for example. Rodrik (1998) finds robust evidence for the compensation theory, which is unaffected by the inclusion of other control variables, persists for different measures of government spending drawn from all available datasets, and prevails for both low- and high-income countries. Pickup (2006), in contrast, does not find support for either the efficiency or the compensatory theory.

With respect to the stage of development as a determinant of the changing pattern and composition of public expenditures, the theoretical foundations are not firm but they seem to emanate from the notion that as a government's control of the economy changes with development, so do the size of its expenditures and the components of these expenditures. The evidence is again mixed, however. Schmedtje and Lall (1968), for example, in a study on 46 developing countries, find no significant correlation between government expenditures and level of economic development, as measured by different levels of gross national product per capita. Though Lall (1969) finds that whereas the shares of social (health and education) and infrastructure expenditures in total government expenditures increase with rising incomes, the share of agriculture expenditures declines. In a recent study on 147 countries from 1980 to 2010, Yu, Fan, and Magalhães (2015) find that the size of the government relative to the economy or spending intensity was higher in developed than in developing countries, and that while developing countries allocated more of their total expenditures to education, social protection, and defense, developed countries allocated more of their total expenditures to social protection. The shares allocated to agriculture and infrastructure were lowest in both developed and developing countries, though they were on the rise in developing countries and declining in developed countries.

The fundamental hypothesis of the political economy models of government expenditure is that political actors favor expenditures that best serve the groups they represent. See Mogues (2015) for a recent review of the literature. The partisan model, for example, suggests that left- and right-leaning parties, because they differ in their macroeconomic and economic management policies, will implement different interventions and achieve different fiscal outcomes. Here too, however, the evidence is mixed. The review by Cusack (1997), for example, lists several studies that suggest a strong, a weak, or no causal relationship. Bräuninger (2005) finds that it is the programmatic preferences of governmental actors as stated in their electoral manifestos, rather than the left- or right-wing ideology of their affiliated parties, that has a significant effect on the level and composition of expenditures. Furthermore, the level and composition of expenditures are influenced by the number of coalition parties in the government, or the dispersion of decision-making authority. Therefore, although most of the various actors (including politicians, bureaucrats, interest groups, trade unions, and donors) may be active in deciding on the functional allocation F_{mt} or economic-use allocation E_{mt}, few may be involved in deciding the total amount G_t. This is the reason for allowing ***Z*** to vary across the different decision-making processes in equations 1a, 1b, and 1c.

Growth Effects of Government Expenditures

The fundamental notion underlying the growth effect of public spending is that public capital and private capital are complements in the production process, so that an increase in public spending 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). These effects can be categorized into four pathways of impact—crowding in of private capital, technology advancing, human capital enhancing, and transaction cost reducing—which are reflected in the following sets of models linking different types of expenditures (G_t, F_{mt}, and E_{jmt}) and *n*th input (I_{nt}) and *h*th capital (C_{ht}) in equations 2a and 2b, respectively, and outputs in the *s*th agricultural and nonagricultural subsectors (Y_{st}) in equation 3:

$$I_{nt} = \alpha_n^I + \delta_n^{I,G} G_t + \delta_n^{I,F} F_{mt} + \delta_n^{I,E} E_{jmt} + \boldsymbol{X}_{nt}^{I\prime} \beta_i^I + \tau_n^I t + \varepsilon_{nt}^I \quad (2a)$$

$$C_{ht} = \alpha_h^C + \delta_h^{C,G} G_t + \delta_h^{C,F} F_{mt} + \delta_h^{C,E} E_{jmt} + \boldsymbol{X}_{ht}^{C\prime} \beta_h^C + \tau_h^C t + \varepsilon_{ht}^C \quad (2b)$$

$$Y_{st} = \alpha_s^Y + \delta_s^{Y,G} G_t + \boldsymbol{F}_{mt}' \delta_s^{Y,F} + \boldsymbol{E}_{jmt}' \delta_s^{Y,E} + \boldsymbol{I}_{nt}' \gamma_s^{Y,I} + \boldsymbol{C}_{ht}' \gamma_s^{Y,C} + \boldsymbol{W}_{st}^{Y\prime} \beta_s^Y + \tau_s^Y t + \varepsilon_{st}^Y \quad (3)$$

where ***X*** and ***W*** capture the vector of factors influencing the different inputs, capital, and outputs. As specified earlier, ***X*** may vary across the different types of inputs and capital, as may ***W*** for the different subsectors. Specifically, ***X*** includes economic factors (such as prices of inputs and outputs, interest rates, foreign exchange rates, and terms of trade), environmental or natural factors (such as weather and natural resources), and shocks (such as wars, floods, and droughts—with the latter two being more prominent in the agricultural sector). Because equation 3 is more of a technical relationship, ***W*** captures things like production organization and other processes, in addition to the environmental factors and shocks mentioned above.

The link between expenditures and growth is captured in a comprehensive manner in the model by allowing expenditures (G_t, F_{mt}, and E_{jmt}) to have direct effects as well as indirect effects via I_{it} and C_{ht} in equation 3. Furthermore, endogeneity of expenditures is implicit in the sense that Y_{st} is a potential determinant in equations 1a, 1b, and 1c via the economic factors related to output in ***Z***. The same applies to endogeneity of inputs I_{nt} and capital C_{ht}. Thus, identification of the system requires the general condition that $\boldsymbol{X} \neq \boldsymbol{Z} \neq \boldsymbol{W}$, although the variables may share some common elements.

To further explain the different pathways of impact (that is, crowding in of private capital, technology advancing, human capital enhancing, and transaction cost reducing) and our hypotheses, we focus on the literature regarding public expenditures in the agricultural sector and on developing countries, since these have not been as widely and explicitly discussed. Where necessary, we refer to some of the more general studies to support the arguments.

Regarding the crowding-in effect of public expenditure, this effect is a commonly advanced rationale used to advocate for greater public spending. For example, public investment in dams and canals for irrigation is expected to increase private investment in on-farm irrigation systems, as found by Fan, Hazell, and Thorat (2000). Malla and Gray (2005) and Görg and Strobl (2006) also find significant crowding-in effects of public R&D on private R&D, with estimated elasticities in the range of 0.10 to 0.28. Similar crowding-in arguments have been made for input subsidies (that is, subsidizing the price of the input sold in the market)—especially for chemical fertilizers and mechanical equipment. In many cases, however, such expenditures have not increased overall use of the inputs, because poor targeting of the programs has crowded out use of commercial inputs—the bulk of the subsidized inputs was provided to farmers who would have purchased them regardless (Jayne et al. 2013). We expect this pathway to be manifested directly in equation 2a, especially for the recurrent-expenditure component of E_{jmt}, and in equation 2b for the capital-expenditure component of E_{jmt}, with a positive relationship indicating crowding in and a negative relationship indicating crowding out.

Technology-advancing growth effects typically derive from yield-enhancing technologies[2] developed through public expenditures in R&D. These growth effects or pathways have been widely studied and have been documented to show large rates of return on investment (for example, Rosegrant, Kasryno, and Perez 1998; Fan, Hazell, and Thorat 2000; Fan, Zhang, and Zhang 2004; Fan, Yu, and Saurkar 2008; Thirtle, Piesse, and Lin 2003; Fan and Zhang 2008; Alene and Coulibaly 2009). The studies by Rosegrant, Kasryno, and Perez (1998) and Fan, Hazell, and Thorat (2000), for example, analyze the effects of agricultural R&D expenditures on total factor productivity (TFP), with estimated elasticities in the range of 0.05 to 0.25, while the studies by Thirtle, Piesse, and Lin (2003); Fan, Zhang, and Zhang (2004); Fan, Yu, and Saurkar (2008); and Alene and Coulibaly (2009) analyze the effects on land or labor productivity,

[2] Technologies may be biological (for example, genetically modified organisms and hybrids), chemical (for example, fertilizers and pesticides), mechanical (for example, tractors and implements), or informational (for example, husbandry practices, value chains, and early-warning systems).

with estimated elasticities in the range of 0.09 to 0.44. The growth effects of R&D investments, however, tend to materialize with a long time lag and can persist long afterward. Thirtle, Piesse, and Lin, for example, consider a 5-year lag of agricultural R&D investments, while Alene and Coulibaly consider a 16-year lag. The choice of the length of the lag seems to be influenced by the length of the time-series data used to accommodate degrees-of-freedom issues, with longer lags being used in studies that have longer time-series data. We expect this pathway to be manifested in equation 3, directly with respect to the R&D expenditures component of F_{mt} and indirectly via inputs I_{nt} and capital C_{ht}.

Transaction costs are important, as they drive whether markets are integrated, are thin, or fail (Sadoulet and de Janvry 1995). Thus, the transaction-cost-reducing growth effects are expected to derive from public expenditures on infrastructure (roads, bridges, transportation, communications, storage, energy, and so on). By facilitating the movement of goods and services, improving access to input and output markets, and reducing the costs of doing business, such expenditures are expected to contribute to reducing the cost of inputs and technologies and raising the value of outputs, thereby raising the productivity of other forms of capital in production. This is implied in, for example, the studies by Fan, Hazell, and Thorat (2000); Fan, Zhang, and Zhang (2004); Fan, Yu, and Saurkar (2008); Teurel and Kuroda (2005); Fan and Zhang (2008); and Benin et al. (2012), which find significant positive effects of public investment in road infrastructure on agricultural TFP, land productivity, or labor productivity. In their Uganda study, for example, Fan and Zhang (2008) find that the returns to spending on feeder roads were three to four times higher than the returns to spending on laterite, gravel, or tarmac roads. Therefore, we expect this pathway to be manifested in our model via especially the relationship between the dependent variables (I_{it}, C_{ht}, and Y_{st}) and the expenditure components of F_{mt} relating to transport, communications, and infrastructure.

Human-capital-enhancing growth effects derive typically from public spending on education, extension, health, water, sanitation, and so forth, by making the labor force more literate and healthier and increasing human capital accumulation in production (Schultz 1982). This is particularly important for successful modern agricultural enterprises, which tend to be complex and are increasingly becoming knowledge intensive. A comprehensive review of 80 case studies on the impacts of agricultural extension by Alston et al. (2000) shows large positive economic returns to public spending on agricultural extension, with an average rate of return of 85 percent. The studies by Fan, Hazell, and Thorat (2000); Fan, Zhang, and Zhang (2004); and Fan, Yu, and Saurkar (2008) also show significant positive effects of public spending on education on agricultural TFP, land productivity, or labor productivity, with estimated elasticities in the range of 0.05 to 0.68. Like agricultural R&D investments, human capital productivity effects materialize with a lag and can persist long afterward. Fan, Yu, and Saurkar, for example, consider a seven-year lag of expenditures on agricultural extension in Uganda. As with the previous pathways, we expect this pathway to be manifested in our model via the relationships between the expenditure components of F_{mt} relating to health, education, etc., and I_{it}, C_{ht}, and Y_{st}, especially the latter.

The growth effects or pathways of other functional components of F_{mt}, such as expenditures on general administration, defense, and law and order, may be described as facilitative. For example, by protecting all forms capital from internal and external shocks or harm, such expenditures may ensure continuity of production. Similarly, by protecting property rights, they may spur innovation and the generation of new technologies that may raise productivity. Therefore, we expect such general facilitative growth effects to be manifested via the expenditure components of F_{mt} relating to administration, defense, law and order, and so forth in the above equations.

3. EMPIRICAL APPROACH

Econometric Methods and Estimation Issues

Annual data on Kenya from 1950 to 2014 are used to estimate the system of equations using simultaneous equations modeling (SEM) methods. Because there are a maximum of only 64 observations in the dataset that we could compile for this study (more on the data later) and we must control for several factors in the estimation, a fundamental objective is to include equations for the dependent variables that we have data on for all the years. This helps avoid degrees-of-freedom problems that arise from estimating several equations and having variables with a small number of observations. Data on inputs (equation 2a) and capital (equation 2b) were not available for many years, and so we estimate equations 1a, 1b, and 1c and a reduced-form version of equation 3 for the agricultural sector only.

As we are using time-series data, another issue to deal with is stationarity of especially the dependent variables, which we find to be nonstationary in their levels but stationary in their first differences (more on this later). Therefore, we estimate the first-difference equations according to the following:

$$g_t = \tau^g + \boldsymbol{z}_t^{g\prime} \beta^g + \epsilon_t^g \tag{1a$'$}$$

$$f_{mt} = \tau_m^f + \boldsymbol{z}_{mt}^{f\prime} \beta_m^f + \epsilon_{mt}^f \tag{1b$'$}$$

$$e_{jt} = \tau_j^e + \boldsymbol{z}_{jt}^{e\prime} \beta_j^e + \epsilon_{jt}^e \tag{1c$'$}$$

$$y_t = \tau^y + \delta^g g_t + \boldsymbol{f}'_{mt} \delta_m^f + \boldsymbol{e}'_{jt} \delta_j^e + \boldsymbol{x}_t^{i\prime} \gamma^i + \boldsymbol{x}_t^{c\prime} \gamma^c + \boldsymbol{w}'_t \beta^w + \epsilon_t^y \tag{3$'$}$$

where the lowercase variables represent the first difference of their uppercase counterparts (for example, $f_{mt} = F_{mt} - F_{mt-1}$ and $\boldsymbol{w}_t = \boldsymbol{W}_t - \boldsymbol{W}_{t-1}$) and $\epsilon_t = \varepsilon_t - \varepsilon_{t-1}$. The vectors of variables $\boldsymbol{x}^i$ and $\boldsymbol{x}^c$ are the instruments for inputs and capital, respectively. Also, the initial constant term α drops out and is replaced by a new one τ since $t - (t - 1) = 1$. Therefore, the sets of parameters to be estimated are τ, δ, β, and γ, which are differentiated for the various sub-equations, types of expenditures, or instruments. Specifically, β^g, β_m^f, and β_j^e are the estimators of expenditure allocation decisions with respect to total expenditures, functional expenditures, and capital expenditures within a function, respectively. Similarly, δ^g, δ_m^f, and δ_j^e are the estimators of the agricultural growth effect with respect to total expenditures, functional expenditures, and capital expenditures within a function, respectively. Then, γ^i, γ^c, and β^w are the estimators of the effect of other factors on agricultural growth.

There are two other major estimation issues to address as well. First, in applying SEM methods, the error terms ϵ_t are assumed to have a mean of zero and constant variance, and be uncorrelated with the explanatory variables and uncorrelated across equations or over time (Zellner and Theil 1962; Greene 1993). For the latter, autocorrelation, we test the null hypothesis of no autocorrelation using the Harvey Lagrange multiplier (LM) test (Harvey 1990; Judge et al. 1985), separately for each equation and then for the overall system. The second issue is identification of the system, which we use exclusion restrictions to accomplish. The rule of thumb for using exclusion restrictions is that the number of exogenous variables excluded from equation q must be at least as large as the number of endogenous variables included in equation q. In addition to the explanatory factors discussed earlier, we use the lagged value of each dependent variable as its instrument, to strengthen identification of the entire system of equations.

In general, first differencing helps address expenditure endogeneity due to omitted time-invariant factors such as agroclimatic conditions that are fixed over time (Fan, Hazell, and Thorat 2000). Also, differencing can address expenditure endogeneity due to simultaneity if expenditure decisions are driven by levels, but not changes, in the hypothesized outcome, or agricultural output in this case. The drawback of differencing, however, is that it could remove the long-term effect of expenditures whose benefits typically materialize with a lag rather than contemporaneously (Hsiao 1986).

Data, Sources, and Variables

The data were compiled primarily from several statistical abstracts dating back to the 1950s that were downloaded from the website of the Kenya National Bureau of Statistics (KNBS 2016). These were supplemented with data from other sources, including GDP deflators and population (World Bank 2016a) and rainfall (World Bank 2016b).

For total government expenditures (G_t) and their functional disaggregation (F_{mt}), we maintain the conventional classification of the functions of government (IMF 2014). For functional expenditures F_{mt}, we consider seven functions for the analysis: (1) administration; (2) defense and law and order; (3) education; (4) health; (5) agriculture; (6) transport, communications, and other economic functions; and (7) other functions. The classification by economic use E_{jt} is based on the differentiation of capital and recurrent expenditures within each of the seven functions. Following the literature, we use the ratio of total government expenditures to GDP as the measure of G_t, the share of functional expenditures in total expenditures as the measure of F_{mt}, and then the share of capital expenditures in the related functional expenditures as the measure of E_{jt}. As the functional expenditure shares add up to 1, the share of expenditures on other functions (item 7) is excluded from the analysis or is used as the referenced share. This means that there are also six capital-to-functional expenditure ratios with respect to E_{jt}. Detailed descriptions of the variables are presented in Table 3.1.[3]

Agricultural output Y_t is based on the GDP for production in the crops, livestock, forestry, and fishery subsectors. Because the effect of public expenditures is expected to materialize with time rather than contemporaneously, we use the five-year forward-moving average value in the estimation to capture the short- to medium-term effect of government expenditures.

[3] See Table A.1 in the appendix for the time-series data on government expenditures, GDP, and agricultural GDP.

Table 3.1 Detailed descriptions of variables and sources of data

Label	Description	Source
Endogenous variables		
AGRVAD	Agriculture value added, 2009 billion KSh (5-year forward-moving average)	KNBS 2016, World Bank 2016a
TOTEXP	Total government expenditures, share in GDP (G)	KNBS 2016, World Bank 2016a
	Government expenditures by function, share of total government expenditures (F_m):	KNBS 2016
FUNEXP-ADM	Administration	
FUNEXP-DEF	Defense and law and order	
FUNEXP-EDU	Education	
FUNEXP-HTH	Health	
FUNEXP-AGR	Agriculture	
FUNEXP-OEC	Transport, communication, and other economic functions	
	Government capital expenditures by function, share of total functional expenditures (E_{jm}):	KNBS 2016
CAPEXP-ADM	Administration	
CAPEXP-DEF	Defense and law and order	
CAPEXP-EDU	Education	
CAPEXP-HTH	Health	
CAPEXP-AGR	Agriculture	
CAPEXP-OEC	Transport, communication, and other economic functions	
Exogenous or predetermined continuous variables		
GDPPCAP	GDP per capita, 2009 billion KSh	KNBS 2016, World Bank 2016a
REVSOUR	Government revenue from investments, share of total revenue	KNBS 2016
FOREX	Foreign exchange rate, KSh per US$1	World Bank 2016a, Antweiler 2018
ODA	Official development assistance, share of GDP	World Bank 2016a, KNBS 1960
OPENECON	Openness of economy, ratio of value of exports to imports	KNBS 2016
RURALPOP	Rural population, percent of total population	KNBS 2016, World Bank 2016a
TOTRADE	Terms of trade, ratio of agricultural GDP deflator to total GDP deflator	World Bank 2016a
REALINTR	Real interest rate, nominal interest rate minus inflation rate	World Bank 2016a, Reinhart and Rogoff 2010
PRICE-EN	Ratio of world energy price index to non-energy price index	World Bank 2018, Radetzki 2006
PRICE-IO	Ratio of world grain price index to fertilizer price index	World Bank 2018, Radetzki 2006
WAGE	Ratio of agricultural wages to nonagricultural wages	KNBS 2016
RAINFALL	Coefficient of variation of monthly rainfall	World Bank 2016b
Exogenous or predetermined categorical variables		
RULGOVT	Ruling government: 1950, 1963, 1978, 2002, 2012	ReSAKSS-ECA 2018, BBC 2018
POLSYST	Political party system: 1950, 1969, 1982, 1992, 2005	ReSAKSS-ECA 2018, BBC 2018
NATDEV	5-year national development plan: 1950, 1966, 1970, 1974, 1979, 1984, 1989, 1994, 1997, 2002, 2007	ReSAKSS-ECA 2018, BBC 2018
RECDEV	Regional economic community development: 1950, 1967, 1977, 1981, 1999	ReSAKSS-ECA 2018, BBC 2018

AGRDEV	Agriculture-specific development plan or strategy: 1950, 1974, 1982, 1999	ReSAKSS-ECA 2018, BBC 2018
MINOFIN	Minister of finance: 1950, 1960, 1962, 1969, 1982, 1988, 1993, 1998, 2000, 2002, 2003, 2006, 2011, 2013	ReSAKSS-ECA 2018, CIA 2016
COTU	COTU secretary-general: 1966, 1969, 1975, 1979, 1981, 1986, 2001	InformationCradle 2018
KNUT	KNUT secretary-general: 1958, 1969, 2001, 2008, 2010, 2013	InformationCradle 2018
FISCALPOL	Fiscal policy (currency change or major monetary incidents): 1950, 1966, 1991	KNBS 2016
CIVUNREST	Major civil unrest incidents: 1950, 1969, 1992, 1998, 2002, 2008, 2012	ReSAKSS-ECA 2018, BBC 2018
DROUGHT	Drought incidents: 1950, 1965, 1971, 1979, 1983, 1991, 1994, 1996, 1999, 2004, 2005, 2008, 2010	Masih et al. 2014

Source: Authors.

Note: For the exogenous or predetermined variables, the lagged values are used (this includes the lagged values of the endogenous variables). The exogenous categorical variables take on the value of 1 in 1950 and subsequent years until a change in regime or an incident takes place and then the value goes up to 2, then 3, 4, etc., for the respective years indicated. COTU is the Central Organization of Trade Unions and KNUT is the Kenya National Union of Teachers. All continuous variables are transformed by natural logarithm, excluding those measured as indexes or as percentages or shares. Then the first differences of all transformed or nontransformed variables are used in the estimation.

For variables captured by ***Z***, that is, factors affecting the level and allocation of government expenditures, we follow the literature closely and use, for example, GDP per capita to test Wagner's law; different shocks such as change in government and political party systems, policy reforms, drought, and civil unrest to test the displacement hypothesis; and a measure of the openness of the economy to test the efficiency or compensatory theory of the effects of globalization. Other variables include foreign exchange rate, source of revenue, official development assistance, rural-urban population structure, terms of trade, and real interest rate. All the above variables are included in all the expenditure equations, except for terms of trade, which is included in the functional expenditure equations only, and real interest rate, which is included in the capital expenditure equations only.

The categorical explanatory variables (representing shocks such as change in government and political party systems, policy reforms, civil unrest, and drought) take on the value of 1 in 1950 and subsequent years until a change in regime or an incident takes place and then the value goes up to 2, then 3, 4, etc., for the respective years indicated.[4] Using the variable on the ruling government (RULGOVT), for example, there have been five governments: the protectorate government until 1963, when Jomo Kenyatta was elected as the first president, then Daniel Arap Moi's government in 1978, Mwai Kibaki's in 2002, and Uhuru Kenyatta's in 2012. For the political party system (POLSYST), we capture four distinct periods: the passage of Kenya's National Assembly and Presidential Elections Act creating a multiparty system in 1969, constitution of a one-party state in 1982, return to a multiparty system in 1992, and a constitutional referendum in 2005. To capture changes in the broad national development agenda, we

[4] See Table A.2 in the appendix for details on the evolution of the political system and major incidents that occurred each year at the national level and for the agricultural sector from which the various variables were created.

use the five-year national development plans (NATDEV), representing the years when the plans were developed, adopted, or published. Regional economic community development (RECDEV) captures four major points during the periods under analysis: formation of the East African Community (EAC) in 1967, dissolution of EAC in 1977, Kenya joining the Common Market for Eastern and Southern Africa (COMESA) in 1981, and reconstitution of EAC in 1999 (which Kenya joined in 2000). For agriculture-specific development or strategies (AGRDEV), we capture three major turning points, during 1973–1975, 1981–1983, and 1998–2000, though we use the midpoints of 1974, 1982, and 1999, respectively, for the analysis. The main events for 1973–1975 are the declaration of sugar as a special crop in 1973, the launch of the national soil and water conservation program in 1974, and a sessional paper to increase agriculture expenditures in 1975. For 1981–1983, the main events are a sessional paper on national food policy in 1981, the arid and semi-arid lands development policy in 1982, and approval of the national extension program in 1983. For 1998–2000, they are the collapse of the Kenya Cooperative Creameries in 1998, liberalization and restructuring of the tea industry in 1999, and launch of the National Agriculture and Livestock Extension Project in 2000. The variable capturing change in the position of the minister of finance (MINOFIN) is straightforward, with the minister changing every two to four years and the longest-serving minister being Mwai Kibaki (1969–1881), who later became president from 2002 to 2012. For fiscal policy (FISCALPOL), we capture two main events: the introduction of the Kenyan shilling (KSh) in 1966 and the introduction of tradable foreign exchange bearer certificates in 1991. The variables representing incidents of major civil unrest (CIVUNREST) and drought (DROUGHT) are straightforward, with 6 and 12 annual incidents, respectively.

Another factor affecting the level and allocation of government expenditures that we considered but found difficult to measure independent of government and political parties is interest groups, especially trade unions, which are very active in Kenya. We had wanted to use the number of strikes demanding better pay and services by different sectoral trade unions. However, we could not obtain accurate annual data on the number of strikes, as these were rampant each year. For example, there were about 100 to 230 strikes a year in the 1965–1970 periods alone (COTU 2018). The establishment of Cockar's Industrial Court in 1966 helped reduce the number of strikes in the 1970s and 1980s because Kenyan workers became willing to go through the lengthy court process rather than resort to strikes (COTU 2018). Therefore, we tried a categorical variable measuring change in the leadership of the Central Organization of Trade Unions (COTU), which is the umbrella organization of the trade unions in Kenya, and the Kenya National Union of Teachers (KNUT), which is the most active trade union in Kenya (InformationCradle 2018). For COTU, the leaders or secretaries-general were Clement Lubembe (1966–1969), Dennis Akumu (1969–1975), Juma Boy (1975–1979), Justus Mulei (1981–1986), Joseph Mugalla (1986–2001), and Francis Atwoli (2001–present). For KNUT, they were Stephen Kioni (1958–1969), Ambrose Adeya Adongo (1970–2001), Francis Ng'ang'a (2001–2008), Lawrence Majali (2008–2010), David Okuta Osiany (2010–2013), and Mudzo Nzili (2013–present).

With respect to the factors (***X*** and ***W***) affecting agricultural output, the variables included are price indexes of inputs and outputs, real interest rate, agricultural and nonagricultural wages, terms of trade, population structure, drought, civil unrest, and rainfall. Although many of these factors are outcomes of policies and institutions, we test the direct influence of the latter on output by trying some model specifications where some of the variables representing government and political systems discussed above are included in the output equation. To also evaluate potential omitted variable bias, we try some model specifications where the lagged value of output is included as an explanatory variable.

Variables for identifying the system of equations

Given the structure of the system of equations, excluding some of the variables in the expenditure equations from the output equation, as discussed above, helps identify the latter. To strengthen the exclusion restrictions, we include the lagged value of each expenditure dependent variable as part of its explanatory variables, that is, G_{t-1} is included in $\boldsymbol{Z}_t^G$, F_{mt-1} in $\boldsymbol{Z}_t^F$, and E_{jt-1} in $\boldsymbol{Z}_t^E$. This is also intuitive from a path dependency perspective, or the notion that current expenditure allocation depends on prior allocation decisions. Because including a lagged dependent variable as an explanatory variable tends to take out much of the variation and make the effect of other explanatory variables less significant, it allows us to be more confident about the effect of the variables that are statistically significant. Including lagged dependent variables as explanatory variables also helps reduce the occurrence of autocorrelation arising from model misspecification.

Other Estimation Issues

Stationarity of the time series data

As we are using time-series data and macroeconomic variables, stationarity of the series become important in order to avoid any spurious regressions. Basically, nonstationarity, or the existence of unit root(s), impacts the asymptotic properties of the estimates, as the series exhibits no mean reversion, has infinite variance, and suffers permanent effects from random shocks. We tested for stationarity of especially the dependent variables using the augmented Dickey-Fuller (Dickey and Fuller 1979) and Phillips-Perron (Phillips and Perron 1988) tests, which have the null hypothesis that the variable contains a unit root. The results show that the root is problematic with the variables in the levels, but not in first differences, with or without a time trend (detailed results are presented later). The regressors or explanatory variables can have a mix of stationary and nonstationary variables.

Multicollinearity

Undertaking sensitivity checks on the results by including and excluding different variables in the regressions leads to some cases in which there are as many as 22 regressors in an equation, especially for the output equation. Therefore, multicollinearity is a potential problem. The main variables of concern were some of the categorical variables, especially the trade union variables, where the correlation between KNUT and CIVUNREST is highly significant and the correlations between COTU and KNUT and between COTU and FISCALPOL were moderately significant. Therefore, we estimated different model specifications where COTU is excluded and then included in all the expenditure equations, in addition to using either KNUT or CIVUNREST in the expenditure equations on education. For the specific subsets of explanatory variables used in different model specifications, we tested for multicollinearity using the condition number and variance decomposition proportions (Belsley, Kuh, and Welsch 1980) among the regressors in each equation and found this to be of no concern, as the condition number was less than 30.

Cross-equation covariance

Based on the assumptions of the error term ϵ_t that contemporaneous correlation exists, we do not impose any restrictions on the cross-equation variance-covariance matrix of ϵ_t. If contemporaneous correlation does not exist, then ordinary least squares can be applied separately to each equation, and the results will be fully efficient and there is no need to use SEM in the estimation. The Breusch-Pagan LM diagonal covariance matrix test (Judge et al. 1985) is used, which has the null hypothesis that there is no contemporaneous correlation.

4. RESULTS

Descriptive Statistics of the Variables and Stationarity Tests

Summary statistics of the dependent variables

Summary statistics of all the variables are presented in Table 4.1. Agriculture value added (AGRVAD) averaged KSh 454 billion in 2009 prices from 1950 to 2014, with a minimum value of KSh 83.3 billion and a maximum value of KSh 857.7 billion. Total government expenditures as a share of GDP (TOTEXP) averaged 0.30 per year over the same period, with low and high values of 0.17 and 0.53, respectively. The six types of functional expenditures considered here represented a total average share of 0.58 of total government expenditures, with education consuming the largest share (0.16), followed by transport, communication, and other economic functions (0.15), defense and law and order (0.14), and administration (0.09). Agriculture (0.08) and health (0.05) were allocated the lowest shares. Looking at minimum and maximum values for the functional expenditures, other economic functions (transport, communication, etc.) experienced the largest variance, followed by agriculture, suggesting that government expenditures in these two sectors have been the most variable or least stable over time. With respect to capital expenditures for the six functions, transport, communication, and other economic functions were the most capital intensive (0.54) relative to the amount spent on the function, followed by agriculture (0.43), administration (0.26), health (0.17), education (0.10), and defense and law and order (0.06). The relatively lower capital-to-functional expenditure ratios in the last two sectors (that is, education and defense and law and order) likely reflect a larger workforce base or operations, given that they were among the three sectors that attracted the largest functional expenditures. The result is also consistent with the government being more sensitive to trade unions and unrest in these sectors and thus allocating more to salaries and recurrent expenditures compared to capital spending.

To further clarify the trends in government expenditures, Table 4.2 shows the correlation coefficients for the different variables, first among total and functional expenditures and then among total and capital expenditures. With respect to total and functional expenditures, the results show a moderately and statistically significant positive correlation between total and education expenditures, whereas the correlations between total expenditures and the other functional expenditures are negative, with agriculture having the largest negative correlation coefficient. The correlation between total and administrative expenditures, although positive, is not statistically significant. The share of agriculture expenditures is negatively correlated with administration and education expenditures and positively correlated with expenditures for all other functions. Together, these results suggest that expenditures on education tend to suffer the most as budgets become tighter. When the government faces greater budget constraints, as typically happens following droughts, epidemics, and other crises, it tends to allocate relatively more to the non-education sectors that better deal with the crises such as health for epidemics, agriculture for droughts, and defense for civil unrest. When the budget is relatively less constrained and total government expenditures are on the rise, other sectors tend to be ignored relative to education. This may be due to the effectiveness of the KNUT, which is the only trade union that manages to pull off national strikes that last for several weeks—with major national strikes occurring in 1962, 1965, 1966, 1969, 1997, and 2013. For example, in the national strike in 1997, the union demanded a 300 percent salary increment for teachers, which has become the basis for ongoing negotiations with the government (InformationCradle 2018). The estimated correlation coefficients with respect to the capital expenditure shares are mostly positive, except for education, whose capital-to-functional expenditure share is negatively correlated with the capital-to-functional expenditure shares in the other sectors, as well as with total expenditures. This is consistent with the previous results that relate to the government being more sensitive to trade unions and unrest in these sectors and thus allocating more to salaries and recurrent expenditure compared to capital spending.

Table 4.1 Summary statistics of variables, 1950–2014

Variable	Mean	Standard Error	Minimum	Maximum
Endogenous				
AGRVAD	454.022	26.527	83.303	857.742
TOTEXP	0.296	0.010	0.170	0.533
FUNEXP-ADM	0.092	0.004	0.030	0.180
FUNEXP-DEF	0.138	0.004	0.070	0.202
FUNEXP-EDU	0.164	0.005	0.089	0.223
FUNEXP-HTH	0.053	0.001	0.026	0.072
FUNEXP-AGR	0.083	0.007	0.023	0.214
FUNEXP-OEC	0.151	0.008	0.055	0.252
CAPEXP-ADM	0.258	0.022	0.004	0.599
CAPEXP-DEF	0.063	0.005	0.004	0.139
CAPEXP-EDU	0.096	0.004	0.015	0.361
CAPEXP-HTH	0.175	0.011	0.045	0.431
CAPEXP-AGR	0.431	0.015	0.184	0.673
CAPEXP-OEC	0.544	0.017	0.236	0.892
Exogenous				
GDPPCAP	54.919	1.538	18.130	88.198
REVSOUR	0.186	0.011	-0.033	0.355
FOREX	32.039	4.182	7.016	98.178
ODA	5.548	0.470	1.106	16.155
OPENECON	0.516	0.008	0.387	0.748
RURALPOP	84.494	0.669	73.945	92.638
TOTRADE	0.950	0.013	0.775	1.496
REALINTR	3.152	0.628	-12.315	13.012
PRICE-EN	0.509	0.049	0.086	1.253
PRICE-IO	1.535	0.069	0.505	3.004
WAGE	0.315	0.009	0.205	0.418
RAINFALL	71.831	1.948	44.349	104.445
RULGOVT	0.060	0.029	1	5
POLSYST	0.060	0.029	1	5
NATDEV	0.149	0.044	1	11
RECDEV	0.060	0.029	1	5

AGRDEV	0.045	0.025	1	4
COTU	0.104	0.038	1	7
KNUT	0.089	0.035	1	6
MINOFIN	0.239	0.052	1	13
FISCALPOL	0.030	0.021	1	3
CIVUNREST	0.090	0.035	1	7
DROUGHT	0.194	0.049	1	13

Source: Authors' model results.

Note: See Table 3.1 for detailed descriptions of variables. For the categorical exogenous variables, the mean values are the number of years during the period 1950–2014 (as a proportion of the total number of years) in which there was a change in the regime or an incident.

Table 4.2 Correlation coefficients for government total, functional, and capital expenditures, 1950-2014

Variable	TOTEXP	FUNEXP-ADM	FUNEXP-DEF	FUNEXP-EDU	FUNEXP-HTH	FUNEXP-AGR	FUNEXP-OEC
TOTEXP	1.00 n.a.						
FUNEXP-ADM	0.16	1.00 n.a.					
FUNEXP-DEF	-0.48 ***	-0.02	1.00 n.a.				
FUNEXP-EDU	0.42 ***	0.58 ***	-0.10	1.00 n.a.			
FUNEXP-HTH	-0.41 ***	-0.14	0.48 ***	0.14	1.00 n.a.		
FUNEXP-AGR	-0.65 ***	-0.43 ***	0.47 ***	-0.59 ***	0.42 ***	1.00 n.a.	
FUNEXP-OEC	-0.39 ***	-0.32 **	0.48 ***	-0.06	0.71 ***	0.37 ***	1.00 n.a.

Variable	TOTEXP	CAPEXP-ADM	CAPEXP-DEF	CAPEXP-EDU	CAPEXP-HTH	CAPEXP-AGR	CAPEXP-OEC
TOTEXP	1.00 n.a.						
CAPEXP-ADM	0.78 ***	1.00 n.a.					
CAPEXP-DEF	0.08	0.19	1.00 n.a.				
CAPEXP-EDU	-0.52 ***	-0.49 ***	0.09	1.00 n.a.			
CAPEXP-HTH	0.48 ***	0.42 ***	0.02	-0.17	1.00 n.a.		
CAPEXP-AGR	0.32 ***	0.31 **	0.25 **	-0.15	0.51 ***	1.00 n.a.	
CAPEXP-OEC	0.41 ***	0.45 ***	0.27 **	-0.42 ***	0.50 ***	0.48 ***	1.00 n.a.

Source: Authors' model results.

Note: See Table 3.1 for detailed descriptions of variables. n.a. = not applicable. *, **, and *** mean the test is statistically significant at the 10, 5, and 1 percent level, respectively.

Summary statistics of the exogenous variables

Summary statistics of the exogenous variables are also presented in Table 4.1. GDP per capita (GDPCAP) averaged KSh 55 billion in 2009 prices from 1950 to 2014, with a minimum value of KSh 18.1 billion and a maximum value of KSh 88.2 billion, which translates into an annual average growth rate of about 6.3 percent. Government revenue from investments (REVSOUR) averaged 19 percent, and official development assistance (ODA) as a share of GDP averaged 5.5 percent, with a minimum value of 1 percent and maximum of 16 percent. The foreign exchange rate (FOREX) has increased by more than 10 times, averaging KSh 32 / US$1, with a minimum of KSh 7 / US$1 and maximum of KSh 98 / US$1. The openness of the economy (OPENECON), measured by the ratio of the value of exports to imports, averaged 0.5, with a minimum of 0.4 and a maximum of 0.7, indicating that Kenya imported more than it exported annually over the period under analysis. For the terms of trade (TOTRADE), the average value of 0.95 indicates that the agricultural sector is slightly favored compared to the total economy, with the favoring most pronounced at the minimum value of 0.8 during the late 1960s and early 1970s, and then shifting in favor of the nonagricultural sector at the maximum value of 1.5 in recent years. The real interest rate (REALINTR) averaged 3.1, indicating that the nominal interest rate was higher than the inflation rate on average, with a minimum value of -12 (that is, when the nominal interest rate was lower than the inflation rate) and a maximum value of 13. Regarding the price indexes for the world, on average, the index for energy commodities was about one-half that of non-energy commodities (PRICE-EN), while the index for grain was 1.5 times that of fertilizer (PRICE-IO). The fact that the respective minimum value is less than 1 and the maximum value is greater than 1 suggests that there have been swings in the two indexes favoring first the item in the denominator (when the value is less than 1) and then the item in the numerator (when the value is greater than 1). With regard to labor wages (WAGE), agricultural workers' wages were 30 percent of the wages obtained by nonagricultural workers on average, and the ratio ranged between 20 and 40 percent. Rural population as a percentage of total population (RURALPOP) averaged 84 percent, with the share declining gradually over time from a high of 93 percent in the 1950s to a low of 74 percent in recent years. The average coefficient of variation of monthly rainfall (RAINFALL) was 72 percent, with a minimum value of 44 percent and maximum value of 104 percent. The highest variations occurred in 1981, 1997, and 2001, and the lowest variations occurred in 2005, 2010, and 2014.

For the categorical exogenous variables, mostly capturing the shocks, the mean value is the proportion of the total number of years from 1950 to 2014 in which a change in the regime or an incident occurred. The variables capturing overall national development (NATDEV), minister of finance (MINOFIN), and incidents of drought (DROUGHT) experienced the most changes or incidents.

Stationarity test results for the dependent variables

Details of the stationarity test results for the dependent variables shown in Table 4.3 suggest that unit root is a problem with the level measures but not the first differences. The exceptions are the share of administration expenditures in total expenditures (FUNEXP-ADM) and the share of capital expenditures for education (CAPEXP-EDU), whose level measure is also stationary. Therefore, the first-difference measures of the variables were used in the estimation to avoid spurious regressions, which are possible when using the level measures of the variables.

Table 4.3 Stationarity test results for level and first difference of dependent variables, 1950–2014

Variable	Unit root test	Level		First difference	
		Test statistic	*p*-value	Test statistic	*p*-value
AGRVAD	ADF	1.74	1.000	-9.63 ***	0.000
	PP	0.21	0.996	-9.58 ***	0.000
TOTEXP	ADF	-3.16 *	0.093	-10.59 ***	0.000
	PP	-2.87	0.174	-12.31 ***	0.000
FUNEXP-ADM	ADF	-4.78 ***	0.000	-12.99 ***	0.000
	PP	-4.89 ***	0.000	-14.02 ***	0.000
FUNEXP-DEF	ADF	-3.05	0.118	-9.33 ***	0.000
	PP	-3.02	0.127	-9.40 ***	0.000
FUNEXP-EDU	ADF	-2.67	0.250	-8.41 ***	0.000
	PP	-2.82	0.189	-8.42 ***	0.000
FUNEXP-HTH	ADF	-2.88	0.170	-7.55 ***	0.000
	PP	-2.94	0.148	-7.52 ***	0.000

FUNEXP-AGR	ADF	-2.44		0.359	-7.42	***	0.000
	PP	-2.60		0.279	-7.41	***	0.000
FUNEXP-OEC	ADF	-2.07		0.563	-8.26	***	0.000
	PP	-2.10		0.549	-8.28	***	0.000
CAPEXP-ADM	ADF	-2.84		0.181	-9.54	***	0.000
	PP	-2.73		0.225	-9.99	***	0.000
CAPEXP-DEF	ADF	-2.63		0.267	-7.83	***	0.000
	PP	-2.73		0.223	-7.83	***	0.000
CAPEXP-EDU	ADF	-4.19	***	0.005	-7.25	***	0.000
	PP	-4.53	***	0.001	-7.27	***	0.000
CAPEXP-HTH	ADF	-2.16		0.513	-7.10	***	0.000
	PP	-2.26		0.458	-7.05	***	0.000
CAPEXP-AGR	ADF	-3.13	*	0.100	-10.07	***	0.000
	PP	-3.10		0.107	-10.36	***	0.000
CAPEXP-OEC	ADF	-2.61		0.277	-8.86	***	0.000
	PP	-2.59		0.300	-8.97	***	0.000

Source: Authors' model results.

Note: See Table 3.1 for detailed descriptions of variables. ADF = augmented Dickey-Fuller. PP = Phillips-Perron. *, **, and *** mean the test is statistically significant at the 10, 5, and 1 percent level, respectively.

Determinants of Government Expenditure Allocation

Detailed results for the entire system of equations using three-stage least squares (3SLS) estimation are presented in Table 4.4. The results are compared with those from six other model specifications, whose details are presented in Tables A.3 to A.8 in the appendix. These specifications include one in which the lag of functional expenditure ($FUNEXP_m$) is included in the capital expenditure equation (results are in Table A.3) and four others in which some of the exogenous variables are excluded from the agricultural output equation: the lag of agricultural output—AGRVAD (Table A.4); real interest rate—REALINTR, terms of trade—TOTRADE, and rural population—RURALPOP (Table A.5); and prices and wages (PRICE-EN, PRICE-IO, and WAGE), either together on their own (Table A.6) or in addition to REALINTR, TOTRADE, and RURALPOP (Table A.7). Results of the model specification in which COTU is included in all the expenditure equations and KNUT is used instead of CIVUNREST in the expenditure equations on education are reported in Table A.8.

In general, the last two specifications, in which prices and wages (PRICE-EN, PRICE-IO, and WAGE) are excluded for the output equation, either together on their own or in addition to REALINTR, TOTRADE, and RURALPOP, perform poorly with respect to autocorrelation. Several of the individual equations as well as the overall system fail the Harvey LM test (Harvey 1990; Judge et al. 1985).

Thus, the presentation focuses on the results from the base model (Table 4.4) and the first three alternative model specifications (Tables A.3, A.4, and A.5), which have strong overall model results. Use of the system of equations is supported, first, by rejection of the Breusch-Pagan LM diagonal covariance matrix test, which the null hypothesis is that there is no contemporaneous correlation across the equations (Judge et al. 1985). Second, the *F*-tests for the individual equations and the system are statistically significant at the 1 percent level. Also, the *R*-squared for the individual equations (except for the output equation) is within the range of 0.3 and 0.6, but it is greater than 0.8 for the entire system, considering the two different measures of the *R*-squared.

For the agricultural output equation, the *R*-squared is negative. This is due to the way in which the 3SLS estimation deals with the regressors that are specified as instruments. As our goal is to estimate the parameters of a structural model, the actual values, not the instruments for the endogenous right-hand-side variables, are used to determine the *R*-squared. Basically, the model residuals are computed over a different set of regressors from those used to fit the model, and so the 3SLS estimates are no longer nested within a constant-only model of the dependent variable, and the residual sum of squares is no longer required to be smaller than the total sum of squares (Zellner and Theil 1962; Greene 1993).

Determinants of government total expenditures

The results shown in Table 4.4 (column under TOTEXP) support the Wagnerian hypothesis, or the law of increasing spending dependent on growth of national income, as indicated by the positive and statistically significant effect of the lag of GDP per capita (GDPPCAP) on total government expenditures as a share of GDP. Other variables with a positive and statistically significant effect on total government expenditures are the foreign exchange rate (FOREX), official development assistance (ODA), urbanization (negative of RURALPOP), civil unrest (CIVUNREST), and drought. Variables with a negative and statistically significant effect are those associated with changes in agricultural development strategy (AGRDEV), political system (POLSYST), regional economic community development (RECDEV), and rainfall. As several of these variables are measured as shocks, the results provide greater support for the displacement hypothesis of total government expenditure, but in a mixed manner, as some of the relevant variables have a positive effect (CIVUNREST and DROUGHT) and others have a negative effect (POLSYST, REGDEV, and AGRDEV). Neither the efficiency nor the compensatory theory of the effects of globalization is supported by the results, as the variable representing the openness of the economy (OPENECON) is not statistically significant. The results also show that total government expenditures as a share of GDP have declined over time, which is indicated by the negative and statistically significant effect of the lag of the variable.

These results hold under most of the other model specifications. The main exceptions are the results for a couple of the variables in the model specifications when prices and wages (PRICE-EN, PRICE-IO, and WAGE) are dropped from the output equation, either together on their own (Table A.6) or in addition to other variables (real interest rate—REALINTR, terms of trade—TOTRADE, and rural population—RURALPOP) (Table A.7). Then, the effect of the openness of the economy (OPENECON) became significantly positive, while the negative effect of regional economic community development (RECDEV) was lost. However, the overall model results for these two specifications are poor, especially with respect to autocorrelation.

Determinants of government functional expenditures

The results for the determinants of expenditure allocation to the six functions of government—administration (FUNEXP-ADM), defense and law and order (FUNEXP-DEF), education (FUNEXP-EDU), health (FUNEXP-HTH), agriculture (FUNEXP-AGR), and other economic functions (FUNEXP-OEC)—are shown in Table 4.4 under the columns labeled accordingly. In general, the different functions are associated positively or negatively with different sets of variables. For the variables that have a statistically significant effect on multiple functions, their effect (positive or negative) is consistent across the functions. The only variable that has mixed effects (that is, has a significantly positive association with one function and a significantly negative association with another function) is the one capturing the source of government revenue (REVSOUR). In this case, source of government revenue has a positive effect on defense and law and order, education, and health, but a negative effect on agriculture, though the effect on agriculture is weak. Therefore, we can conclude that the direction of effect of any variable is consistent across the different expenditure functions that it influences.

Table 4.4 Three-stage least squares estimation results, 1950–2014

Variable	AGRVAD	TOTEXP	FUNEXP-ADM	FUNEXP-DEF	FUNEXP-EDU	FUNEXP-HTH	FUNEXP-AGR
TOTEXP	0.752 ***						
FUNEXP-ADM	0.143						
FUNEXP-DEF	-2.104 ***						
FUNEXP-EDU	1.042 ***						
FUNEXP-HTH	0.191						
FUNEXP-AGR	-0.479						
FUNEXP-OEC	0.496 **						
CAPEXP-ADM	-0.180 **						
CAPEXP-DEF	-0.268						
CAPEXP-EDU	-0.605 ***						
CAPEXP-HTH	-0.457 ***						
CAPEXP-AGR	0.306 ***						
CAPEXP-OEC	-0.031						
Lg TOTEXP		-2.611 ***	1.213 **	-0.068	1.870 ***	-0.031	-0.397
Lg $FUNEXP_m$			-4.675 ***	-3.310 ***	-2.850 ***	-1.911 ***	-1.035 **
Lg $CAPEXP_j$							
Lg GDPPCAP		0.171 **	-0.126 **	-0.048	-0.072 **	-0.014	-0.097 ***
Lg REVSOUR		-0.012	0.020	0.055 **	0.050 *	0.019 **	-0.047 *
Lg FOREX		0.256 ***	-0.168 ***	-0.101 **	-0.190 ***	-0.020	-0.031
Lg ODA		0.009 ***	-0.002	0.001	-0.004 **	-0.001 **	-0.001
Lg OPENECON		0.098	0.030	-0.005	0.022	0.014	0.016
Lg RURALPOP	0.005	-0.038 **	0.006	0.007	0.008	-0.001	0.005
Lg TOTRADE	-0.101		0.029	0.071	0.079 **	0.002	-0.019
Lg REALINTR	-0.002 *						
RULGOVT		0.017	-0.008	0.009	-0.007	-0.001	0.012
POLSYST		-0.064 ***	0.009	0.024 ***	0.017 **	0.009 ***	0.005
NATDEV		0.002	0.003	0.005	0.002	0.003	-0.011 **
REGDEV		-0.031 **	0.003	0.014 *	0.003	-0.002	0.002
AGRDEV		-0.043 **	0.017	0.008	0.032 ***	0.004	0.007
MINOFIN			-0.006	0.001	0.006	0.003	-0.004
FISCALPOL			-0.041 **	0.003	-0.039 ***	-0.002	-0.021 *
CIVUNREST	-0.006	0.065 ***	-0.006	-0.029 ***	-0.025 ***	-0.010 ***	-0.002
DROUGHT	-0.014	0.020 *	-0.001	-0.001	-0.008	-0.002	-0.001
RAINFALL	0.053 *	-0.039 **	0.007	0.009	0.011	0.005 *	0.022 ***
Lg PRICE-EN	0.057 ***						
Lg PRICE-IO	0.023						
Lg WAGE	0.562 ***						
Lg AGRVAD	0.015						
Intercept	0.066	0.054 ***	0.020	0.052 ***	0.005	0.012 **	0.027 *
R-squared	-9.755	0.500	0.317	0.308	0.553	0.457	0.379
F-test	600.640 ***	65.130 ***	52.940 ***	49.030 ***	93.820 ***	56.320 ***	41.210 ***
Rho	0.032	0.027	0.030	0.062 *	0.003	0.001	0.000
Overall model results:	Berndt *R*-squared = 0.999; McElroy *R*-squared = 0.864; *F*-statistic = 18,690.16 (0.000)***; rho = 15.93 (0.318); BP = 317.76 (0.000)***						

Source: Authors' model estimation results.

Note: See Table 3.1 for detailed descriptions of variables. Lg means lag value. For rho, the test is autocorrelation using the Harvey Lagrange multiplier (LM) test with the null hypothesis that rho is zero (Harvey 1990; Judge et al. 1985). BP = Breusch-Pagan LM diagonal covariance matrix test with the null hypothesis that there is no contemporaneous correlation (Judge et al. 1985). For overall model results, the figure in parentheses is the *p*-value. *, **, and *** refer to statistical significance at the 10, 5, and 1 percent level of significance, respectively. Blank cell means not applicable.

Table 4.4, continued: Three-stage least squares estimation results, 1950–2014

Variable	FUNEXP-OEC	CAPEXP-ADM	CAPEXP-DEF	CAPEXP-EDU	CAPEXP-HTH	CAPEXP-AGR	CAPEXP-OEC
TOTEXP							
FUNEXP-ADM							
FUNEXP-DEF							
FUNEXP-EDU							
FUNEXP-HTH							
FUNEXP-AGR							
FUNEXP-OEC							
CAPEXP-ADM							
CAPEXP-DEF							
CAPEXP-EDU							
CAPEXP-HTH							
CAPEXP-AGR							
CAPEXP-OEC							
Lg TOTEXP	-0.408	7.153 ***	0.172	0.025	-1.334	-0.099	-0.150
Lg FUNEXP$_m$	-2.352 ***						
Lg CAPEXP$_j$		-4.005 ***	-2.184 ***	-2.518 ***	-1.979 **	-4.302 ***	-3.886 ***
Lg GDPPCAP	-0.079	-0.108	0.019	0.073	0.082	0.123	-0.120
Lg REVSOUR	-0.009	-0.138	-0.112 ***	0.060 *	0.019	0.098	-0.026
Lg FOREX	-0.090	-0.140	-0.065 *	-0.045	0.156	0.144	-0.016
Lg ODA	0.004	0.015 *	-0.001	0.000	0.000	0.001	0.024 ***
Lg OPENECON	0.058	-0.057	-0.011	0.158 ***	0.057	0.131	0.017
Lg RURALPOP	-0.010	-0.066 *	-0.003	0.002	-0.052 **	-0.069 *	-0.135 ***
Lg TOTRADE	0.118 *						
Lg REALINTR		-0.002	0.000	-0.001	0.000	0.001	0.001
RULGOVT	-0.022	-0.054	-0.001	-0.007	-0.074 ***	-0.004	0.011
POLSYST	0.005	-0.072 *	0.000	-0.005	-0.039 *	-0.008	-0.014
NATDEV	0.013	-0.012	-0.006	0.002	0.024	-0.044	-0.040
REGDEV	0.012	-0.057	-0.003	-0.005	0.009	0.036	-0.055
AGRDEV	0.003	0.018	-0.010	-0.011	-0.046 *	-0.035	-0.075 *
MINOFIN	-0.006	-0.062 ***	-0.010 *	0.005	0.021	0.021	-0.084 ***
FISCALPOL	0.014	-0.089	-0.016	-0.005	-0.047	0.044	0.031
CIVUNREST	-0.015	0.058	-0.005	0.010	0.024	-0.078 *	-0.027
DROUGHT	-0.007	-0.061 **	-0.005	0.000	0.007	0.005	0.018
RAINFALL	-0.001	0.037	-0.014	-0.007	-0.002	0.036	-0.042
Lg PRICE-EN							
Lg PRICE-IO							
Lg WAGE							
Lg AGRVAD							
Intercept	0.050 ***	-0.070	0.017 *	0.019	0.053 **	0.171 ***	0.222 ***
R-squared	0.367	0.446	0.478	0.406	0.328	0.297	0.539
F-test	54.290 ***	67.760 ***	71.180 ***	61.500 ***	33.200 **	40.870 ***	75.020 ***
Rho	0.004	0.013	0.041	0.001	0.045 *	0.006	0.001
Overall model results:	Berndt *R*-squared = 0.999; McElroy *R*-squared = 0.864; *F*-statistic = 18,690.16 (0.000)***; rho = 15.93 (0.318); BP = 317.76 (0.000)***						

Source: Authors' model estimation results.

Note: See Table 3.1 for detailed descriptions of variables. Lg means lag value. For rho, the test is autocorrelation using the Harvey Lagrange multiplier (LM) test with the null hypothesis that rho is zero (Harvey 1990; Judge et al. 1985). BP = Breusch-Pagan LM diagonal covariance matrix test with the null hypothesis that there is no contemporaneous correlation (Judge et al. 1985). For overall model results, the figure in parentheses is the *p*-value. *, **, and *** refer to statistical significance at the 10, 5, and 1 percent level of significance, respectively. Blank cell means not applicable.

The variables that have a positive and statistically significant effect on any expenditure function are total expenditures (TOTEXP) on administration and education; terms of trade (TOTRADE) on education and other economic functions; political system (POLSYST) on defense, education, and health; agricultural development strategy (AGRDEV) on education; and rainfall on agriculture and health. The variables that have a negative and statistically significant effect on any expenditure function are foreign exchange rate (FOREX) on administration, defense, and education; GDP per capita (GDPPCAP) on administration, education, and agriculture; official development assistance (ODA) on education and health; national development strategy (NATDEV) on agriculture; fiscal policy (FISCALPOL) on administration, education, and agriculture; and civil unrest (CIVUNREST) on defense, education, and health. The results also show that the share of total expenditures on all the six functions considered has generally declined over time, which is indicated by the negative and statistically significant effect of the lag of the respective functional expenditure variable ($FUNEXP_m$).

Because the lag of total expenditures (TOTEXP) is included in the functional expenditure equations, the above results reflect the direct effects of the variables on the functional expenditures, given their effect via total expenditures. For example, GDP per capita has a significant positive effect on total expenditures, which has a significant positive effect on administration and education expenditures. However, GDP per capita has a significant negative effect on administration and education expenditures. The same pattern applies to foreign exchange rate (with respect to administration and education expenditures), official development assistance (with respect to education expenditures), and civil unrest (with respect to education expenditures). Variables with a pattern in the opposite direction are political system and agricultural development strategy, both of which have a significant negative effect on total expenditures but a significant positive effect on education expenditures. There are no variables that have the same statistically significant sign on total expenditures and any functional expenditure category. This means that the net effect of any variable on a functional expenditure category is lower in absolute terms than its direct effect, that is, after taking out its effect on total expenditures.

There is a decreasing trend in all functional as well as total expenditure variables as revealed by the statistically significant negative effects of the lag of those variables ($FUNEXP_m$ and TOTEXP). The positive sign and large size of the effects of total expenditures on education and administration expenditures confirm that the variations in expenditures for these two functional areas are mostly explained by the variations in total expenditures. In contrast, the variations in agriculture and all other functional expenditures are not associated with changes in total expenditures. The estimated coefficients have a negative sign, which is consistent with the sign of correlation coefficients presented earlier (see Table 4.2), but they are not statistically significant. Education expenditures are significantly affected by the largest number of variables, accounting for about one-third of all the statistically significant effects, which is consistent with the earlier suggestion that expenditure allocation to the education sector is the most sensitive. Education is followed by health, defense, and agriculture, which together account for another third of all the statistically significant effects—whether positive or negative. Expenditure allocations to other economic functions were significantly affected by the least number of variables.

The above results on the determinants of functional expenditures hold under most of the other model specifications. Here too, the main changes are in the model specifications when prices and wages

(PRICE-EN, PRICE-IO, and WAGE) are dropped from the output equation, either together on their own (Table A.6) or in addition to other variables (real interest rate—REALINTR, terms of trade—TOTRADE, and rural population—RURALPOP) (Table A.7). For example, some of the variables that had statistically weak effects lost their statistical significance, while a couple of others that were not statistically significant became weakly significant. When COTU is included in all the expenditure equations and KNUT is used in place of CIVUNREST in the equations on education, the effect of FISCALPOL remains unchanged, KNUT has the same effect as CIVUNREST, and COTU has a positive significant effect on defense and education (see Table A.8).

Determinants of government capital expenditures

The results for the determinants of the capital expenditure share within each of the six functions of government—administration (CAPEXP-ADM), defense and law and order (CAPEXP-DEF), education (CAPEXP-EDU), health (CAPEXP-HTH), agriculture (CAPEXP-AGR), and other economic functions (CAPEXP-OEC)—are shown in Table 4.4 under the columns labeled accordingly. Here, most of the variables with a statistically significant coefficient have a negative sign, except for total expenditures, official development assistance, and the openness of the economy, which have a positive effect on some of the capital expenditure shares, including administration, education, and other economic functions. Like the results for the determinants of functional expenditures, the source of government revenue (REVSOUR) has mixed effects on two of the capital expenditure shares—positive on defense and law and order and negative on education, though the effect with respect to education is weak.

The variables that have a negative and statistically significant effect on any capital expenditure shares are rural population share (RURALPOP) on the capital expenditure shares for administration, health, agriculture, and other economic functions; change in ruling government (RULGOVT) on the capital expenditure share for health; change in political system (POLSYST) on the capital expenditure shares for administration and health; change in agricultural development strategy (AGRDEV) on the capital expenditure shares for health and other economic functions; change in minister of finance (MNOFIN) on the capital expenditure shares for administration, health, agriculture, and other economic functions; incidents of civil unrest (CIVUNREST) on the capital expenditure share for agriculture; and incidents of drought (DROUGHT) on the capital expenditure share for administration. The results also show that the capital expenditure shares for all six functions considered have generally declined over time, which is indicated by the negative and statistically significant effect of the lag of the respective capital expenditure share variable ($CAPEXP_j$).

Here too, because the lag of total expenditures (TOTEXP) is included in the capital expenditure share equations, the above results reflect the direct effects of the variables on the capital expenditure shares, given their effect via total expenditures.[5] However, as the lag of total expenditures is statistically significant in the capital expenditure equation for administration (CAPEXP-ADM) only, the variables that are most likely to have a net effect that is significantly different from the direct effect are those that

[5] In the model specification that includes the lag of the functional expenditure variable ($FUNEXP_m$) in the respective capital expenditure equation (see Table A.3), the results also reflect the direct effects of the variables on the capital expenditure shares, given their effect via the functional expenditures.

significantly affect both total expenditures and capital expenditures for administration. These are official development assistance, rural population share, and political system.

The capital expenditure shares that are significantly affected by the largest number of variables are those for administration, health, and other economic functions. With regard to the capital expenditure share in the health sector, however, all the variables that significantly affect it have a negative influence. This is the same for the capital expenditure share in the agricultural sector, though the effect of the variables is weak. Thus, capital investment in the health sector seems to have been the most sensitive over time with an inverse relationship with the variables, especially with respect to change in ruling government—although urbanization (negative measure of RURALPOP) has increased capital investment in the health sector.

Like the results for the determinants of functional expenditures, the results here hold under most of the model specifications, with similar changes under two of the specifications that also have poor overall model results with respect to autocorrelation: when prices and wages (PRICE-EN, PRICE-IO, and WAGE) are dropped from the output equation, either together on their own (Table A.6) or in addition to other variables (real interest rate—REALINTR, terms of trade—TOTRADE, and rural population—RURALPOP) (Table A.7). When COTU is included in all the expenditure equations and KNUT is used in place of CIVUNREST in the equations on education, the effect of FISCALPOL remains unchanged, KNUT has the same effect as CIVUNREST, and COTU has a positive significant effect on education and agriculture (see Table A.8).

Agricultural Growth Effect of Government Expenditures

Estimated elasticities of agricultural output with respect to government expenditures

Detailed results on the effects of different types of government expenditures on agricultural output (AGRVAD) are shown in Table 4.4 under the column labeled accordingly. The results are summarized in Table 4.5 and compared with those from the other model specifications that include the lag of the respective functional expenditure ($FUNEXP_m$) in the capital expenditure equations or exclude some of the exogenous variables from the agricultural output equation. As the results indicate, the model specifications in which prices and wages (PRICE-EN, PRICE-IO, and WAGE) are excluded, either together on their own (model V) or in addition to other variables (real interest rate—REALINTR, terms of trade—TOTRADE, and rural population—RURALPOP) (model VI), do not perform well with respect to autocorrelation, either in the output equation or for the overall system of equations (see test results in the last two rows of Table 4.5). The other model specifications (models II, III, IV, and VII) give results that are similar to those of the base model (model I) specification. The main notable differences are associated with the magnitudes of the effects of some of the expenditures in the model specification in which COTU is included in all the expenditure equations and KNUT is used in place of CIVUNREST in the equations on education (see model IV). Here, the effect is much smaller for government total expenditures and functional expenditures on education, but larger for functional expenditures on health. The following presentation of the results is thus focused on the base model (model I in Table 4.5) and these other four model specifications (models II, III, IV, and VII in Table 4.5).

Table 4.5 Summary of three-stage least squares estimation results, effect of government expenditures on agricultural value added, 1950–2014

Variable	Base model (I)	Capital expenditure equations: Including lag of functional expenditures ($FUNEXP_m$) (II)	Specification of agricultural output equation:				Expenditure equations: including COTU and using KNUT for CIVUNREST (VII)
			Excluding lag of agricultural value added (III)	Excluding interest rate, terms of trade, and population (IV)	Excluding prices and wages (V)	Excluding prices, wages, interest rate, terms of trade, and population (VI)	
TOTEXP	0.752 ***	0.948 ***	0.810 ***	0.776 ***	0.248	0.263	0.453 ***
FUNEXP-ADM	0.143	-0.020	0.098	0.135	-0.650 ***	-0.591 ***	-0.005
FUNEXP-DEF	-2.104 ***	-1.994 ***	-2.234 ***	-2.404 ***	-1.179 ***	-1.391 ***	-2.154 ***
FUNEXP-EDU	1.042 ***	1.347 ***	0.796 ***	1.017 ***	0.903 ***	0.862 ***	0.465 **
FUNEXP-HTH	0.191	1.567 **	1.535 *	0.529	-0.061	0.824	4.052 ***
FUNEXP-AGR	-0.479	-0.787	-0.487	-0.671 *	0.203	0.001	-0.676 *
FUNEXP-OEC	0.496 **	0.532 *	0.580 ***	0.485 **	0.159	0.199	0.213
CAPEXP-ADM	-0.180 **	-0.135	-0.180 **	-0.167 **	-0.086	-0.119	-0.154 **
CAPEXP-DEF	-0.268	-0.197	-0.280	-0.274	-0.790 ***	-0.899 ***	-0.591 **
CAPEXP-EDU	-0.605 ***	-0.574 ***	-0.631 **	-0.603 ***	0.012	-0.028	-0.605 ***
CAPEXP-HTH	-0.457 ***	-0.473 ***	-0.506 ***	-0.457 ***	-0.111	-0.171 *	-0.527 ***
CAPEXP-AGR	0.306 ***	0.324 ***	0.328 ***	0.424 ***	0.272 ***	0.522 ***	0.438 ***
CAPEXP-OEC	-0.031	-0.036	-0.026	-0.026	0.019	0.023	0.075
CIVUNREST	-0.006	-0.004	-0.002	-0.011	-0.006	0.007	0.030
DROUGHT	-0.014	-0.010	-0.008	-0.014	0.002	0.002	-0.007
RAINFALL	0.053 *	0.048	0.053	0.051	0.003	-0.008	0.025
Lg PRICE-EN	0.057 ***	0.058 ***	0.055 ***	0.057 ***			0.032 **
Lg PRICE-IO	0.023	0.023	0.025	0.024 *			0.023 **
Lg WAGE	0.562 ***	0.568 ***	0.544 ***	0.559 ***			0.554 ***
Lg RURALPOP	0.005	0.009	-0.011		-0.021		-0.012
Lg TOTRADE	-0.101	-0.143	-0.085		-0.001		0.042
Lg REALINTR	-0.002 *	-0.001 *	-0.002 *		-0.000		-0.001
Lg AGRVAD	0.015	0.016		0.013	-0.012	-0.013	-0.003
Intercept	0.066	0.070	-0.007	0.054	-0.062	-0.063	-0.023
R-squared	-9.755	-11.099	-11.236	-11.935	-5.139	-10.814	-10.814
F-test	600.640 ***	693.360	628.460 ***	746.280 ***	304.020 ***	562.460 ***	573.903 ***
Rho	1.922	0.793	1.805	1.602	4.454 **	5.626 **	2.147
Rho (system)	15.926	15.616	16.633	15.646	22.102 *	24.780 **	17.559

Source: Authors' model estimation results.

Note: See Table 3.1 for detailed descriptions of variables. Lg means lag value. For detailed results on the complete system of equations, see Table 4.4 for the full model, Table A.3 for model II, Table A.4 for model III, Table A.5 for model IV, Table A.6 for model V, Table A.7 for model VI, and Table A.8 for model VII. For rho, the test is autocorrelation using the Harvey Lagrange multiplier test with the null hypothesis that rho is zero (Harvey 1990; Judge et al. 1985). *, **, and *** refer to statistical significance at the 10, 5, and 1 percent level of significance, respectively. Blank cell means not applicable.

In general, the results show that different types of government expenditures have differential effects on agricultural output, some being significantly positive (total expenditures, functional expenditures on education and other economic functions, and capital expenditures on agriculture) or negative (functional expenditures on defense and capital expenditures on administration, education, and health), while others are weakly significant (functional expenditures on health and agriculture) or not significant at all (functional expenditures on administration and capital expenditures on defense and other economic functions). These results indicate that not all types of government expenditures have benefitted or contributed to growth in the agricultural sector.

Overall, an increase in total government expenditures, measured as a share of GDP, has an estimated elasticity in the range of 0.45 to 0.95, meaning that a 1 percent increase in total expenditures as a share of GDP is associated with an increase in agricultural value added of 0.45 to 0.95 percent. For the other types of expenditures with a positive effect on agricultural value added, the estimated elasticities are 0.46 to 1.35 for functional expenditures on education, 1.54 to 4.05 for functional expenditures on health, 0.48 to 0.58 for other economic functions, and 0.31 to 0.44 for capital expenditures on agriculture. The finding of a positive effect with respect to education is consistent with the results of other studies (for example, Fan, Hazell, and Thorat 2000; Fan, Zhang, and Zhang 2004; and Fan, Yu, and Saurkar 2008), following the argument that education increases human capital accumulation in various production activities (Schultz 1982). The same human capital argument holds for health, although the results obtained here are relatively weak, as the estimated elasticities are statistically significant at the 5 or 10 percent level in two of the model specifications only. Capital expenditures on agriculture in the Kenya data include investments in tree, crop, plant, and animal resources yielding repeat products. Thus, the finding is consistent with the literature and supports the case for continued government investment in agricultural R&D. As expenditures on other economic functions include spending on transport, communications, etc., the results obtained here are consistent with those of other studies (for example, Fan, Hazell, and Thorat 2000; Fan, Zhang, and Zhang 2004; Fan, Yu, and Saurkar 2008; Teurel and Kuroda 2005; Fan and Zhang 2008; and Benin et al. 2012) that find significant positive effects of public spending on road infrastructure on agricultural TFP, land productivity, or labor productivity.

For the types of government expenditures with a negative effect, the estimated elasticities are -1.99 to -2.40 for functional expenditures on defense, -0.13 to -0.18 for capital expenditures on administration, -0.57 to -0.63 for capital expenditures on education, and -0.46 to -0.53 for capital expenditures on health. The strongly negative effect of capital expenditures on education and health is surprising, although it may reflect the rural-urban bias of investment in such capital, given that functional expenditures on both education and health have positive effects on agricultural output. These results are also consistent with the findings of Devarajan, Swaroop, and Zou (1996) on overall economic growth, and they argue that current expenditures, by being squeezed by capital expenditures, turn out to be more productive at the margin. In general, the mixed effects found here are consistent with the results of other studies that have used the same approach to distinguish the effects of different expenditure functions (for example, infrastructure, health, education, agriculture, defense) or economic uses (for example, capital versus current, productive versus nonproductive).

Considering the linkages among the different types of expenditures, total government expenditures can change without causing a change in the functional expenditure shares, when expenditures on all functions change in equal proportion. Therefore, the effect of change in total government expenditures can be evaluated separately. The same applies to a change in a functional expenditure share without a change in the related capital expenditure share. Also, the capital expenditure share can change without a change in the related functional expenditure share. However, a change in any functional expenditure share, with or without a change in total government expenditures, will necessarily imply a change in one more of the other functional expenditure shares.

With respect to the other variables, those with strong influence across the different model specifications are prices and wages, specifically ratio of world energy price index to non-energy price index (PRICE-EN), with an estimated elasticity of 0.06, and ratio of agricultural wages to nonagricultural wages (WAGE), with an estimated elasticity of 0.56. The real interest rate (REALINTR) has a weak effect, though it is consistent across the different model specifications.

Returns to government expenditures (marginal benefit-cost ratios)

Because the different types of expenditures are measured as shares of different things (for example, GDP for total expenditures, total expenditures for functional expenditures, and functional expenditures for capital expenditures), it is useful to calculate and compare the returns to the different types of expenditures. This is done at the margin of the mean values of the expenditures over the period of the data, which is from 1950 to 2014. The results are shown in Table 4.6 using benefit-cost ratios (BCRs) corresponding to the range of values of the estimated elasticities presented in the preceding section.

Focusing on the results related to the elasticities that are statistically significant, the agricultural value-added returns to total government expenditures are about 1, within a range of 0.5 to 1.1. This means that each shilling that has been spent by the Kenyan government from 1950 to 2014 has yielded a return of 50 cents to 1 shilling of agricultural value added, on average. Of the different types of government expenditures, the largest return in agricultural value added has derived from functional expenditures on health (BCR of 33.0 to 87.1), followed by capital expenditures on agriculture (BCR of 9.7 to 13.9), functional expenditures on education (BCR of 3.2 to 9.3), and functional expenditures on other economic functions—transport, communications, etc. (BCR of 3.6 to 4.3). These are comparable (though on the higher side) to existing estimates of BCRs in other countries in Africa and Asia (see Table A.9 for a review of several studies). For example, the BCR of 33.0 to 87.1 for health is much higher than the ratios estimated for other countries: 0.8 in India (Fan, Hazell, and Thorat 2000) and 0.9 in Uganda (Fan and Zhang 2008). For agriculture expenditures, the estimates are comparable to the estimates for agriculture R&D in other countries, for example, 6.7 in China (Fan, Zhang, and Zhang 2004), 12.4 in Uganda (Fan and Zhang 2008) and Tanzania (Fan, Nyange, and Rao 2012), and 13.4 in India (Fan, Hazell, and Thorat 2000). For education, the BCR of 5.5 to 9.3 is higher than in other countries, for example, 1.4 in India (Fan, Hazell, and Thorat 2000) and 2.7 in Uganda (Fan and Zhang 2008). The BCR of 3.6 to 4.3 estimated for other economic functions—transport, communications, environment, etc.—is within the range of other estimates for roads, for example, 0.9 in Thailand (Fan, Jitsuchon, and Methakunnavut 2004) and 7.2 in Uganda (Fan and Zhang 2008).

Table 4.6 Agricultural value-added returns to different types of government expenditures in Kenya, 1950–2014

Expenditure type	Estimated elasticity				Expenditure at the mean			Value of change in agricultural value added		Benefit-cost ratio	
	Minimum		Maximum		Share	Value (2009 billion KSh)	1% of value (2009 billion KSh)	Minimum (2009 billion KSh)	Maximum (2009 billion KSh)	Minimum	Maximum
Total (share in GDP)	0.453	***	0.948	***	0.296	401.543	4.015	2.057	4.304	0.5	1.1
Function (share in total)											
Administration	-0.005		-0.020		0.092	36.764	0.368	-0.024	-0.091	-0.1	-0.2
Defense	-1.994	***	-2.154	***	0.138	55.407	0.554	-9.053	-10.915	-16.3	-19.7
Education	0.465	***	1.347	***	0.164	65.978	0.660	2.111	6.116	3.2	9.3
Health	1.535	*	4.052	**	0.053	21.126	0.211	6.969	18.398	33.0	87.1
Agriculture	-0.479		-0.676	*	0.083	33.283	0.333	-2.175	-3.068	-6.5	-9.2
Other economic	0.485	**	0.580	***	0.151	60.725	0.607	2.202	2.633	3.6	4.3
Capital (share in function)											
Administration	-0.135	**	-0.180	**	0.258	9.490	0.095	-0.613	-0.817	-6.5	-8.6
Defense	-0.197		-0.591	**	0.063	3.507	0.035	-0.894	-2.684	-25.5	-76.5
Education	-0.574	***	-0.631	**	0.096	6.301	0.063	-2.606	-2.865	-41.4	-45.5
Health	-0.457	***	-0.527	***	0.175	3.700	0.037	-2.075	-2.394	-56.1	-64.7
Agriculture	0.306	***	0.438	***	0.431	14.347	0.143	1.389	1.988	9.7	13.9
Other economic	-0.026		0.058		0.544	33.048	0.330	-0.118	0.261	-0.4	0.8

Source: Authors' calculations based on model estimation results.

Note: See Table 3.1 for detailed descriptions of variables. See Table 4.5 for estimated elasticities. *, **, and *** refer to statistical significance at the 10, 5, and 1 percent level of significance, respectively.

Functional expenditures on defense have not been beneficial to agricultural value added, with an estimated BCR of -16.3 to -19.7. The same applies to capital expenditures on defense (BCR of -55.5 to -76.5), health (BCR of -56.1 to -64.7), education (BCR of -41.4 to -45.5), and administration (BCR of -6.5 to -8.6), suggesting that the positive returns to functional expenditures in these sectors, especially health and education, have derived from recurrent expenditures. Thus, in general, recurrent expenditures by the government of Kenya in the nonagricultural sector from 1950 to 2014 have been more productive for the agricultural sector than capital expenditures have.

5. CONCLUSIONS AND IMPLICATIONS

This paper used annual data on Kenya from 1950 to 2014 to analyze the determinants of the composition of government expenditures and then estimate the agricultural-output returns to the different types of government expenditures. The paper analyzed expenditures for six functions (general administration, defense, education, health, agriculture, and other economic functions—transport, communications, environment, etc.) as well as the capital-to-functional expenditure ratio within each of those functions. Simultaneous equations modeling (SEM) methods were employed for the estimation, and different diagnostic tests were used to check for and address stationarity, causality, and autocorrelation. Different model specifications were used to assess the sensitivity of the results to the use of different measures of the conceptual variables that are hypothesized to affect the composition of government expenditures and agricultural production.

An analysis of the trends shows that total government expenditures as a share of GDP have declined over time, and that while expenditures on education tend to evolve in the same direction as changes in total government expenditures, expenditures on the other functions (defense, health, agriculture, and other economic) tend to evolve in the opposite direction from changes in total government expenditures. Regarding the determinants of spending, the results show that the composition of government expenditures is influenced by various socioeconomic factors (such as national income, sources of government revenue, official development assistance, foreign exchange rate, terms of trade, real interest rate, and rural-urban population structure) and political-economy and environmental factors that were introduced as shocks (such as change in government and political party systems, policy reforms, actions by interest groups, civil unrest, and drought). Although the different types of expenditures were influenced by different sets of the factors considered, any factor that had a statistically significant effect on more than one type of expenditure had a consistently positive or negative effect across the different types of expenditures that it influenced.

We find that different types of government expenditures have had differential effects on agricultural value added, with varying returns to the amounts spent. Focusing on the statistically significant results, the agricultural value-added returns to total government expenditures are about 1, meaning that each shilling spent by the Kenyan government from 1950 to 2014 has yielded an equal return of 1 shilling of agricultural value added. For different types of government expenditures, the largest return in agricultural value added has derived from functional expenditures on health (BCR of 33.0 to 87.1), followed by capital expenditures on agriculture (BCR of 9.7 to 13.9), functional expenditures on education (BCR of 3.2 to 9.3), and functional expenditures on other economic functions—transport, communications, environment, etc. (BCR of 3.6 to 4.3). These are comparable (though on the higher side) to existing estimates of BCRs in other countries in Africa and Asia. Expenditures on defense, which have a negative BCR, have not been beneficial in increasing agricultural value added. The same applies to capital expenditures on health, education, and administration, suggesting that the positive returns to functional expenditures in these sectors, especially health and education, have derived from recurrent expenditures.

The major implications of the findings derive from two questions: (1) how to raise the productivity of government expenditures in the agricultural sector, given that the recurrent expenditures in the sector had no statistically significant effect on agricultural value added, and (2) how to raise the productivity of capital expenditures on health and education, which, in addition to recurrent expenditures, are important for increasing human capital accumulation in production activities by making the labor force healthier and more literate.

With respect to government expenditures in the agricultural sector, capital expenditures include investments in tree, crop, plant, and animal resources yielding repeat products. Thus, the positive returns to capital expenditures in the sector support the case for continued government investment in agricultural R&D, though information on specific investment in agricultural R&D was not available. With respect to recurrent expenditures in the sector, an important consideration is the balance between payment of staff salaries and expenses for operational items such as fuel and transportation for the staff to be able to carry out their functions effectively. As the data compiled do not have such a breakdown of the recurrent expenditures, additional data and research are needed to identify the specific causes in this case. In general, to ascertain the quality of the agricultural expenditures and the relative returns, disaggregation of the agriculture expenditure data into other categories will be required, including by subfunction (for example, R&D, extension, irrigation, subsidies, pest control, etc.), subsector (crops, livestock, forestry, fishing), and target population (types of farmers, geographic location, etc.).

In considering how to raise the agricultural productivity of capital expenditures on especially health and education, it may be that capitalization in these sectors is concentrated in urban areas or outside the major agricultural production areas, and thus does not benefit those engaged in agricultural production, which tends to be concentrated in rural areas. The negative relationship between the variable representing rural population (RURALPOP) and total expenditures and most of the capital expenditures supports this idea. Therefore, it appears that capital expenditures are not only squeezing out recurrent expenditures but also displacing them from the higher agricultural-productive environments. Improving the balance of such capital expenditures between urban and rural areas (or agricultural and nonagricultural production areas) will be important, considering that the capital requirements may be different in the various areas. Here too, further research is needed to substantiate this hypothesis, as the data compiled for the study are not spatially disaggregated to allow such an analysis.

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APPENDIX

Table A.1 Total and agricultural GDP and government expenditures in Kenya, 1950–2014

Year	GDP (2009 billion KSh)		TOTEXP (2009 billion KSh)	Share of functional expenditures in total expenditures ($FUNEXP_m$)						Share of capital expenditures in functional expenditures ($CAPEXP_j$)					
	Total	Agriculture		ADM	DEF	EDU	HTH	AGR	OEC	ADM	DEF	EDU	HTH	AGR	OEC
1950	120.173	57.667													
1951	149.008	75.077	25.390	0.076	0.118	0.108	0.062	0.133	0.245	0.026	0.054	0.355	0.117	0.328	0.236
1952	154.408	70.475	29.835	0.070	0.119	0.132	0.063	0.120	0.213	0.004	0.047	0.361	0.135	0.371	0.263
1953	190.559	94.675	33.180	0.069	0.126	0.115	0.063	0.107	0.205	0.004	0.057	0.296	0.136	0.357	0.321
1954	226.457	118.621	44.007	0.030	0.110	0.093	0.050	0.087	0.150	0.110	0.070	0.204	0.122	0.373	0.290
1955	258.576	121.608	56.361	0.040	0.118	0.093	0.044	0.083	0.145	0.045	0.092	0.157	0.115	0.248	0.462
1956	275.214	133.065	57.926	0.044	0.135	0.102	0.043	0.090	0.142	0.095	0.123	0.199	0.088	0.337	0.359
1957	292.031	132.325	56.029	0.078	0.171	0.116	0.047	0.119	0.129	0.033	0.115	0.149	0.129	0.499	0.395
1958	294.114	134.429	53.643	0.093	0.181	0.133	0.055	0.101	0.141	0.021	0.070	0.116	0.127	0.309	0.327
1959	302.518	135.831	55.455	0.101	0.177	0.137	0.050	0.123	0.167	0.039	0.044	0.085	0.059	0.375	0.453
1960	316.516	137.798	55.606	0.105	0.177	0.152	0.054	0.116	0.130	0.052	0.057	0.115	0.109	0.406	0.290
1961	290.238	132.051	56.188	0.090	0.181	0.159	0.067	0.140	0.194	0.061	0.046	0.094	0.070	0.421	0.243
1962	315.226	156.026	57.754	0.086	0.165	0.158	0.065	0.149	0.175	0.067	0.044	0.086	0.061	0.487	0.331
1963	342.029	160.627	64.888	0.085	0.145	0.138	0.059	0.201	0.123	0.066	0.039	0.084	0.052	0.398	0.518
1964	359.466	173.590	74.561	0.078	0.137	0.108	0.045	0.214	0.108	0.067	0.030	0.084	0.048	0.373	0.588
1965	365.924	158.656	78.817	0.086	0.159	0.097	0.045	0.200	0.111	0.056	0.024	0.088	0.045	0.389	0.728
1966	418.674	194.229	85.160	0.076	0.166	0.089	0.048	0.164	0.134	0.050	0.034	0.099	0.046	0.463	0.584
1967	435.357	197.051	91.064	0.077	0.178	0.093	0.048	0.150	0.155	0.036	0.036	0.096	0.055	0.515	0.470
1968	467.302	207.590	99.777	0.067	0.183	0.104	0.054	0.147	0.180	0.095	0.059	0.135	0.170	0.412	0.460
1969	503.479	225.657	110.962	0.065	0.159	0.113	0.056	0.149	0.192	0.101	0.060	0.157	0.221	0.374	0.525
1970	475.666	207.968	111.333	0.070	0.145	0.144	0.065	0.110	0.211	0.112	0.066	0.101	0.233	0.371	0.598
1971	575.588	243.102	158.327	0.057	0.127	0.176	0.064	0.090	0.250	0.125	0.092	0.077	0.260	0.388	0.714
1972	657.057	242.550	180.102	0.063	0.146	0.187	0.068	0.099	0.229	0.113	0.131	0.073	0.213	0.418	0.677
1973	670.029	234.163	182.333	0.065	0.138	0.200	0.063	0.089	0.252	0.215	0.130	0.077	0.171	0.375	0.708
1974	732.387	267.499	179.553	0.060	0.141	0.200	0.063	0.101	0.238	0.142	0.091	0.070	0.161	0.440	0.710
1975	737.310	286.867	210.366	0.072	0.134	0.212	0.069	0.113	0.235	0.260	0.089	0.083	0.185	0.600	0.647
1976	749.775	291.206	218.878	0.122	0.121	0.194	0.065	0.113	0.220	0.545	0.071	0.046	0.196	0.512	0.690
1977	823.320	319.238	205.630	0.088	0.163	0.197	0.072	0.105	0.211	0.382	0.049	0.057	0.281	0.557	0.668
1978	870.645	332.960	287.417	0.090	0.193	0.160	0.062	0.093	0.231	0.402	0.076	0.057	0.209	0.595	0.705
1979	911.152	332.794	321.488	0.082	0.202	0.156	0.062	0.093	0.242	0.303	0.081	0.070	0.180	0.612	0.704

1980	939.096	336.501	328.668	0.102	0.194	0.175	0.069	0.086	0.192	0.436	0.078	0.106	0.201	0.593	0.618
1981	980.366	357.273	364.230	0.127	0.155	0.189	0.054	0.109	0.195	0.527	0.113	0.099	0.216	0.544	0.605
1982	1046.552	399.380	381.653	0.075	0.172	0.176	0.063	0.092	0.185	0.362	0.086	0.086	0.159	0.563	0.598
1983	1056.177	401.908	362.045	0.073	0.150	0.173	0.059	0.089	0.141	0.252	0.077	0.069	0.111	0.446	0.545
1984	1010.244	387.672	342.840	0.068	0.163	0.177	0.059	0.075	0.168	0.286	0.041	0.075	0.151	0.307	0.488
1985	1064.212	403.556	387.711	0.084	0.119	0.171	0.054	0.093	0.165	0.322	0.107	0.056	0.125	0.305	0.644
1986	1136.933	421.955	381.646	0.063	0.128	0.202	0.057	0.091	0.122	0.329	0.121	0.048	0.150	0.530	0.496
1987	1255.897	440.495	458.726	0.095	0.127	0.192	0.053	0.114	0.108	0.566	0.139	0.064	0.134	0.434	0.487
1988	1353.593	495.325	459.272	0.072	0.165	0.208	0.054	0.067	0.114	0.400	0.105	0.056	0.118	0.468	0.570
1989	1405.751	490.625	604.097	0.067	0.109	0.158	0.044	0.027	0.133	0.429	0.119	0.050	0.155	0.409	0.715
1990	1440.861	485.463	553.277	0.090	0.134	0.176	0.045	0.052	0.155	0.599	0.096	0.074	0.173	0.431	0.732
1991	1480.860	488.873	622.664	0.079	0.118	0.169	0.042	0.048	0.117	0.515	0.120	0.098	0.229	0.535	0.714
1992	1465.701	471.354	559.785	0.075	0.099	0.166	0.044	0.049	0.083	0.454	0.096	0.082	0.198	0.522	0.587
1993	1450.629	455.532	620.191	0.071	0.083	0.141	0.038	0.055	0.068	0.438	0.088	0.083	0.245	0.608	0.572
1994	1477.194	468.803	787.192	0.057	0.070	0.119	0.036	0.051	0.055	0.458	0.035	0.061	0.299	0.653	0.511
1995	1546.997	491.500	650.653	0.118	0.084	0.171	0.042	0.045	0.091	0.504	0.027	0.062	0.259	0.510	0.502
1996	1765.539	509.812	616.096	0.097	0.094	0.173	0.050	0.042	0.109	0.309	0.032	0.060	0.184	0.441	0.563
1997	1889.673	485.680	553.326	0.129	0.109	0.182	0.058	0.038	0.106	0.365	0.029	0.050	0.248	0.368	0.463
1998	1965.811	507.772	887.494	0.076	0.070	0.147	0.041	0.025	0.057	0.257	0.023	0.039	0.296	0.337	0.371
1999	2021.153	576.596	656.095	0.111	0.092	0.195	0.043	0.039	0.073	0.188	0.017	0.038	0.248	0.486	0.322
2000	2033.275	569.069	576.232	0.123	0.104	0.211	0.041	0.036	0.089	0.326	0.009	0.015	0.197	0.311	0.316
2001	2109.717	626.885	673.354	0.160	0.116	0.186	0.044	0.031	0.119	0.285	0.010	0.016	0.087	0.273	0.512
2002	2121.670	604.967	773.252	0.114	0.115	0.179	0.049	0.028	0.092	0.222	0.016	0.053	0.080	0.190	0.394
2003	2183.888	619.564	727.412	0.145	0.128	0.215	0.045	0.033	0.085	0.241	0.004	0.077	0.080	0.184	0.343
2004	2295.356	630.504	822.080	0.119	0.128	0.208	0.041	0.032	0.104	0.318	0.015	0.090	0.113	0.317	0.579
2005	2430.937	674.049	791.009	0.154	0.135	0.223	0.043	0.027	0.067	0.258	0.029	0.056	0.097	0.250	0.478
2006	2588.279	685.710	729.284	0.125	0.151	0.222	0.053	0.023	0.091	0.350	0.045	0.071	0.152	0.311	0.533
2007	2765.595	720.612	793.343	0.144	0.132	0.215	0.054	0.028	0.113	0.515	0.055	0.080	0.227	0.364	0.597
2008	2772.019	684.702	891.016	0.180	0.132	0.190	0.046	0.031	0.119	0.558	0.048	0.087	0.220	0.315	0.624
2009	2863.688	668.969	841.899	0.108	0.147	0.208	0.046	0.034	0.155	0.408	0.048	0.084	0.169	0.464	0.673
2010	3104.303	736.270	937.720	0.133	0.144	0.202	0.047	0.041	0.153	0.362	0.066	0.107	0.238	0.379	0.665
2011	3294.026	753.595	1,025.301	0.127	0.135	0.199	0.050	0.043	0.167	0.309	0.055	0.095	0.356	0.555	0.723
2012	3444.162	776.703	996.668	0.109	0.149	0.202	0.060	0.028	0.171	0.298	0.056	0.113	0.375	0.487	0.721
2013	3647.085	819.026	1,157.117	0.135	0.141	0.177	0.058	0.034	0.174	0.201	0.054	0.082	0.312	0.497	0.756
2014	3842.032	854.599	1,322.241	0.096	0.144	0.165	0.040	0.027	0.135	0.218	0.028	0.082	0.361	0.657	0.806

Source: Authors' compilation based on KNBS (2016) and World Bank (2016a).

Note: ADM = administration; DEF = defense; EDU = education; HTH = health; AGR = agriculture; OEC = other economic functions.

Table A.2 Evolution of political system and major policies and incidents in Kenya, 1950–2014

Table A.2a Ruling government or president and ministers of finance and agriculture, 1950–2014

Year	Government/president	Minister of finance	Minister of agriculture
1950	Protectorate governor 1	Ernest Albert Vasey	Ferdinand Cavendish-Bentinck
1951	Protectorate governor 1	Ernest Albert Vasey	Ferdinand Cavendish-Bentinck
1952	Protectorate governor 1	Ernest Albert Vasey	Ferdinand Cavendish-Bentinck
1953	Protectorate governor 2	Ernest Albert Vasey	Ferdinand Cavendish-Bentinck
1954	Protectorate governor 2	Ernest Albert Vasey	Ferdinand Cavendish-Bentinck
1955	Protectorate governor 2	Ernest Albert Vasey	Ferdinand Cavendish-Bentinck
1956	Protectorate governor 2	Ernest Albert Vasey	Michael Blundell
1957	Protectorate governor 2	Ernest Albert Vasey	Michael Blundell
1958	Protectorate governor 2	Ernest Albert Vasey	Michael Blundell
1959	Protectorate governor 2	Ernest Albert Vasey	Bruce Mackenzie
1960	Protectorate governor 3	J. H. Butter	Bruce Mackenzie
1961	Protectorate governor 3	K. W. S. Mack Enzie	Michael Blundell
1962	Protectorate governor 3	James Gichuru	Wilfrid Havelock
1963	Jomo Kenyatta	James Gichuru	Bruce Mackenzie
1964	Jomo Kenyatta	James Gichuru	Bruce Mackenzie
1965	Jomo Kenyatta	James Gichuru	Bruce Mackenzie
1966	Jomo Kenyatta	James Gichuru	Bruce Mackenzie
1967	Jomo Kenyatta	James Gichuru	Bruce Mackenzie
1968	Jomo Kenyatta	James Gichuru	Bruce Mackenzie
1969	Jomo Kenyatta	Mwai Kibaki	Bruce Mackenzie
1970	Jomo Kenyatta	Mwai Kibaki	Bruce Mackenzie
1971	Jomo Kenyatta	Mwai Kibaki	Jeremiah J. M. Nyagah
1972	Jomo Kenyatta	Mwai Kibaki	Jeremiah J. M. Nyagah
1973	Jomo Kenyatta	Mwai Kibaki	Jeremiah J. M. Nyagah
1974	Jomo Kenyatta	Mwai Kibaki	Jeremiah J. M. Nyagah
1975	Jomo Kenyatta	Mwai Kibaki	Jeremiah J. M. Nyagah
1976	Jomo Kenyatta	Mwai Kibaki	Jeremiah J. M. Nyagah
1977	Jomo Kenyatta	Mwai Kibaki	Jeremiah J. M. Nyagah
1978	Daniel T. Arap Moi	Mwai Kibaki	Jeremiah J. M. Nyagah
1979	Daniel T. Arap Moi	Mwai Kibaki	Jeremiah J. M. Nyagah
1980	Daniel T. Arap Moi	Mwai Kibaki	Gilbert Kabere M'mbijiwe
1981	Daniel T. Arap Moi	Mwai Kibaki	Gilbert Kabere M'mbijiwe
1982	Daniel T. Arap Moi	Arthur Magugu	Munyua Waiyaki
1983	Daniel T. Arap Moi	Arthur Magugu	Munyua Waiyaki
1984	Daniel T. Arap Moi	Arthur Magugu	William Odongo Omamo
1985	Daniel T. Arap Moi	Arthur Magugu	William Odongo Omamo
1986	Daniel T. Arap Moi	Arthur Magugu	William Odongo Omamo
1987	Daniel T. Arap Moi	Arthur Magugu	Elijah Mwangale
1988	Daniel T. Arap Moi	George Saitoti	Elijah Mwangale
1989	Daniel T. Arap Moi	George Saitoti	Elijah Mwangale
1990	Daniel T. Arap Moi	George Saitoti	Elijah Mwangale
1991	Daniel T. Arap Moi	George Saitoti	Elijah Mwangale
1992	Daniel T. Arap Moi	George Saitoti	Elijah Mwangale
1993	Daniel T. Arap Moi	Musalia Mudavadi	Simeon Nyachae
1994	Daniel T. Arap Moi	Musalia Mudavadi	Simeon Nyachae
1995	Daniel T. Arap Moi	Musalia Mudavadi	Simeon Nyachae
1996	Daniel T. Arap Moi	Musalia Mudavadi	Simeon Nyachae
1997	Daniel T. Arap Moi	Musalia Mudavadi	Darius Msagha Mbela

1998	Daniel T. Arap Moi	Simeon Nyachae	Musalia Mudavadi
1999	Daniel T. Arap Moi	Francis Masakhalia	Christopher Mogere Obure
2000	Daniel T. Arap Moi	Chrysanthus Okeme	Christopher Mogere Obure
2001	Daniel T. Arap Moi	Chrysanthus Okeme	Christopher Mogere Obure
2002	Mwai Kibaki	Christopher Mogere Obure	Bonaya Godana
2003	Mwai Kibaki	David Mwiraria	Kipruto Arap Kirwa
2004	Mwai Kibaki	David Mwiraria	Kipruto Arap Kirwa
2005	Mwai Kibaki	David Mwiraria	Kipruto Arap Kirwa
2006	Mwai Kibaki	Amos Kimunya	Kipruto Arap Kirwa
2007	Mwai Kibaki	Amos Kimunya	Kipruto Arap Kirwa
2008	Mwai Kibaki	Amos Kimunya	William Samoei Ruto
2009	Mwai Kibaki	Uhuru Kenyatta	William Samoei Ruto
2010	Mwai Kibaki	Uhuru Kenyatta	William Samoei Ruto
2011	Mwai Kibaki	Njeru Githae	Sally Jepngetich Kosgei
2012	Mwai Kibaki	Njeru Githae	Sally Jepngetich Kosgei
2013	Uhuru Kenyatta	Henry Rotich	Felix Koskei
2014	Uhuru Kenyatta	Henry Rotich	Felix Koskei

Source: Authors' compilation based on ReSAKSS-ECA (2018) and BBC (2018).

Table A.2b Major policies and events at the national level and in the agricultural or rural sector, 1950–2014

Year	National level	Agricultural or rural sector
1950	Mau is declared an illegal society	Tea Act (Cap. 343) is passed
1951	African elected members of government demand more African representation	*Agrarian Policy for Dealing with Population Increase, Land Tenure and Fragmentation in Kenya* report is produced
1952	Mau rebellion takes place	Kikuyu squatters and laborers are expelled from European farms
1953	The largest single massacre of the Mau uprising takes place in Lari (Lari Massacre), and the Kapenguria trial begins	Swynnerton Plan is approved
1954	National development program, 1954–1957, is created	Swynnerton Plan is implemented in April
1955	East African Royal Commission Report is published	Policy of mass land consolidation is introduced
1956	Freedom fighter Dedan Kimathi is shot, wounded, and captured	Land consolidation progresses
1957	First direct elections for Africans to the Legislative Council take place	Coffee Board restrictions, preventing Africans from growing coffee within five miles of European estates, are lifted
1958	Constitutional conference and release of Mzee Jomo Kenyatta are demanded by Kenyan citizens	Kenya Dairy Board is established
1959	Jomo Kenyatta is released from jail	Swynnerton Plan is retired at end of year
1960	Kenya constitutional conference starts at Lancaster House in London	Tea Act is revised
1961	House arrest ends for Jomo Kenyatta and he becomes leader of the Kenya African National Union (KANU) political party	Machakos Sisal Marketing Board is established
1962	KANU-KADU (Kenya African Democratic Union) coalition government is formed	Special Crops Development Authority is founded
1963	Independence: Kenya achieves internal self-governance	Gazette Notice Number 4982/63 creates Sugar Advisory Board
1964	Republic of Kenya is formed	World Bank–Commonwealth Development Corporation (CDC) Supervision Agreement is signed
1965	Sessional paper No. 10, about the theory of democratic African socialism and its practical application to planning in Kenya, is released	Kenya National Artificial Insemination Service (KNAIS) and Animal Diseases Act are passed
1966	National development plan is revised and Kenyan shilling is launched	Irrigation Act is passed, and National Irrigation Board is established
1967	East African Community (EAC) is first established	Horticultural Crop Development Authority (HCDA) is established
1968	Kitili Maluki Mwendwa, solicitor-general of Kenya since 1964, is sworn in as first African chief justice of the Republic of Kenya	Animal Diseases Rules are passed
1969	Kenya's National Assembly and Presidential Elections Act is passed	Agricultural Finance Corporation is established
1970	2nd National Development Plan, 1970–1974, is created	Agricultural credit is expanded
1971	Special Rural Development Program is created	Seeds and Plant Varieties Act (Cap. 326) is passed
1972	Territorial Waters Act is passed	Fisheries Act is passed
1973	Kenya takes its seat on the United Nations Security Council for the first time	Ministry of Agriculture declares sugar a ''special crop''

1974	Jomo Kenyatta is re-elected as president and 3rd National Development Plan, 1974–1978, is created	Kenyan National Soil and Water Conservation Program is launched
1975	Continental Shelf Act is passed	Sessional paper No. 4, on raising expenditures on agriculture, is released
1976	Fourth session of United Nations Conference on Trade and Development is held in Nairobi	Code of hygienic practices for fresh meat takes effect
1977	EAC is dissolved and parliament passes the Kenya Constitution (Amendment) Bill that would enable Kenya to establish a Court of Appeal	Fertilizers and Animal Foodstuffs Act (Cap. 345) is passed
1978	Kenyatta era ends	Government establishes Nzoia Sugar Factory
1979	Planning for Progress: 4th National Development Plan, 1979–1983, is created	Government establishes National Cereals and Produce Board (NCPB)
1980	Structural adjustment program is implemented	Livestock development policy is introduced
1981	Kenya joins COMESA	Sessional paper No. 4, on national food policy, is released
1982	Constitution of one-party state is drawn up	Arid and semi-arid lands development policy is introduced
1983	District Focus for Rural Development (DFRD) strategy is created	National Extension Program (NEP) (I and II) is approved
1984	5th National Development Plan, 1984–1988, is created	Dairy Board Act (Cap. 336) is revised
1985	UN Third World Conference on Women is held in Nairobi	Pest Control Products Act is passed
1986	Sessional paper No. 1, on economic management for renewed growth, is released	Agriculture Act (Cap. 318) is passed
1987	President Moi is re-elected president and the District Development Fund (DDF) is established	Cereal Sector Reform Program is launched
1988	Local Authorities (Validation) Act, Local Authorities Services Charge Act, and Foreign Investments Protection (Amendment) Act are passed	Land Control Act (No. 13) is passed
1989	6th National Development Plan, 1989–1993, is created	Markets are liberalized and price controls for animal feeds are removed
1990	Export processing zones (EPZs) are introduced	Kenya Veterinary Vaccines Production Institute (KEVEVAPI) is established via Legal Notice No. 223 of June 4, 1990
1991	Government introduces tradable foreign exchange bearer certificates, known as Forex Cs	Fertilizer importation and distribution is liberalized, and Seeds and Plant Varieties Act (Cap. 326) is passed
1992	Kenya implements constitutional return to multiparty state	Milk marketing is liberalized following recommendations in Dairy Master Plan (1991)
1993	7th National Development Plan is created	Government eliminates movement and price controls on maize trading
1994	8th National Development Plan, 1994–1996, is created	Sessional paper No. 2, on national food policy, is released
1995	Social Dimensions of Development Program (SDDP) is launched	Kenya ratifies World Trade Organization (WTO) Agreement on the application of sanitary and phytosanitary measures
1996	Sessional paper No. 2, on industrial transformation to the year 2020, is released	Arid Lands Resource Management Project (ALRMP) is introduced
1997	Anti-corruption authority and 8th National Development Plan are created	Lake Victoria Environmental Management Project (LVEMP) is launched
1998	El Niño brings torrential rains	Kenya Cooperative Creameries (KCC) collapse

1999	Treaty to reestablish EAC is signed, and national population census is carried out	Sessional paper No. 2, on liberalization and restructuring of the tea industry, is released
2000	Kenya joins EAC and drafts Poverty Reduction Strategy Paper (PRSP) with International Monetary Fund (IMF)	National Agriculture and Livestock Extension Project (NALEP) is launched
2001	PRSP is published	Oil Seed Crops Development Policy is introduced
2002	9th National Development Plan is created	District-Focus Rural Development Strategy (KRDS), 2002–2017, is launched
2003	Economic Recovery Strategy (ERS), 2003–2007, is launched	Horticultural Development Program (HDP) is introduced
2004	Investment Promotion Act is passed	Strategy for Revitalizing Agriculture (SRA), 2004–2014, is developed
2005	Constitutional referendum is held	Millennium villages project and National Agriculture Sector Extension Policy are launched
2006	Drought is declared a national disaster	Agricultural Sector Coordination Unit (ASCU) is established
2007	Kenya Vision 2030 is launched	National Accelerated Agricultural Inputs Access Project (NAAIAP) is launched
2008	Ethnic violence is triggered by a disputed presidential election	Cooperative law / SACCOs Act is passed and National Livestock Policy is introduced
2009	National population census is carried out	Eastern Africa Agricultural Productivity Project (EAAPP) is launched
2010	Kenya Economic Stimulus Program is launched, and new constitution of Kenya is promulgated	Comprehensive Africa Agriculture Development Program (CAADP) compact is signed, and Agricultural Sector Development Strategy (ASDS), 2010–2020, is launched
2011	Political Parties Act is passed	Environment and Land Court Act is passed
2012	Public Finance Management Act is passed	National Food Security and Nutrition Policy (NFSNP) is launched
2013	Devolved system of government takes effect after March 2013 general elections	Agriculture, Fisheries and Food Authority (AFFA) Act, Crops Act, Pyrethrum Act, and Kenya Agricultural and Livestock Research Organization (KALRO) Act are passed
2014	Kenya rebases gross domestic product (GDP), making the economy 25% larger, and becomes a middle-income country and the ninth-largest economy in Africa	Kenya Census of Agriculture is piloted in six counties

Source: Authors' compilation based on ReSAKSS-ECA (2018) and BBC (2018).

Table A.3 Three-stage least squares results, including lag of functional expenditure (FUNEXP$_m$) in the capital expenditure equations, 1950–2014

Variable	AGRVAD	TOTEXP	FUNEXP-ADM	FUNEXP-DEF	FUNEXP-EDU	FUNEXP-HTH	FUNEXP-AGR
TOTEXP	0.948 ***						
FUNEXP-ADM	-0.020						
FUNEXP-DEF	-1.994 ***						
FUNEXP-EDU	1.347 ***						
FUNEXP-HTH	1.566 **						
FUNEXP-AGR	-0.787						
FUNEXP-OEC	0.532 *						
CAPEXP-ADM	-0.135						
CAPEXP-DEF	-0.197						
CAPEXP-EDU	-0.574 ***						
CAPEXP-HTH	-0.473 ***						
CAPEXP-AGR	0.324 ***						
CAPEXP-OEC	-0.036						
Lg TOTEXP		-2.629 ***	1.163 **	-0.095	1.841 ***	-0.031	-0.392
Lg FUNEXP$_m$			-4.106 ***	-3.425 ***	-2.651 ***	-2.085 ***	-0.961 *
Lg CAPEXP$_j$							
Lg GDPPCAP		0.162 **	-0.120 **	-0.038	-0.067 *	-0.012	-0.096 ***
Lg REVSOUR		-0.024	0.022	0.060 **	0.050 *	0.020 **	-0.046 *
Lg FOREX		0.261 ***	-0.169 ***	-0.097 **	-0.184 ***	-0.019	-0.036
Lg ODA		0.009 ***	-0.002	0.001	-0.004 ***	-0.001 **	-0.001
Lg OPENECON		0.089	0.036	-0.005	0.017	0.012	0.026
Lg RURALPOP	0.009	-0.037 **	0.007	0.006	0.009	-0.001	0.005
Lg TOTRADE	-0.143		0.035	0.064	0.075 **	0.000	-0.018
Lg REALINTR	-0.001 *						
RULGOVT		0.018	-0.011	0.010	-0.006	0.000	0.010
POLSYST		-0.065 ***	0.010	0.023 **	0.017 **	0.009 ***	0.005
NATDEV		0.001	0.006	0.004	0.001	0.002	-0.010 *
REGDEV		-0.029 *	0.002	0.012	0.003	-0.002	0.001
AGRDEV		-0.043 **	0.018	0.007	0.031 ***	0.004	0.007
MINOFIN			-0.005	0.002	0.005	0.002	-0.002
FISCALPOL			-0.042 **	0.004	-0.037 ***	-0.002	-0.022 *
CIVUNREST	-0.004	0.066 ***	-0.008	-0.030 ***	-0.024 ***	-0.010 ***	-0.003
DROUGHT	-0.010	0.020 *	-0.001	-0.001	-0.008	-0.002	0.000
RAINFALL	0.049	-0.037 **	0.006	0.009	0.011	0.005 *	0.021 ***
Lg PRICE-EN	0.058 ***						
Lg PRICE-IO	0.023						
Lg WAGE	0.568 ***						
Lg AGRVAD	0.016						
Intercept	0.070	0.054 ***	0.016	0.054 ***	0.003	0.013 **	0.025 *
R-squared	-11.099	0.499	0.310	0.324	0.549	0.466	0.363
F-test	693.360 ***	63.740 ***	41.140 ***	48.370 ***	86.180 ***	55.790 ***	39.780 ***
Rho	0.013	0.030	0.058 *	0.056 *	0.002	0.004	0.000
Overall model results:	Berndt *R*-squared = 0.999; McElroy *R*-squared = 0.876; *F*-statistic = 20,094.72 (0.000)***; rho = 15.62 (0.337); BP = 312.86 (0.000)***						

Source: Authors' model estimation results.

Note: See Table 3.1 for detailed descriptions of variables. Lg means lag value. For rho, the test is autocorrelation using the Harvey Lagrange multiplier (LM) test with the null hypothesis that rho is zero (Harvey 1990; Judge et al. 1985). BP = Breusch-Pagan LM diagonal covariance matrix test with the null hypothesis that there is no contemporaneous correlation (Judge et al. 1985). For overall model results, the figure in parentheses is the *p*-value. *, **, and *** refer to statistical significance at the 10, 5, and 1 percent level of significance, respectively. Blank cell means not applicable.

Table A.3, continued: Three-stage least squares results, including lag of functional expenditure ($FUNEXP_m$) in the capital expenditure equations, 1950–2014

Variable	FUNEXP-OEC	CAPEXP-ADM	CAPEXP-DEF	CAPEXP-EDU	CAPEXP-HTH	CAPEXP-AGR	CAPEXP-OEC
TOTEXP							
FUNEXP-ADM							
FUNEXP-DEF							
FUNEXP-EDU							
FUNEXP-HTH							
FUNEXP-AGR							
FUNEXP-OEC							
CAPEXP-ADM							
CAPEXP-DEF							
CAPEXP-EDU							
CAPEXP-HTH							
CAPEXP-AGR							
CAPEXP-OEC							
Lg TOTEXP	-0.388	8.172 ***	0.264	0.441	-1.657 *	-0.578	-0.279
Lg $FUNEXP_m$	-2.325 ***	4.435	0.467	-1.954 ***	-8.628	-1.066	-0.427
Lg $CAPEXP_j$		-4.855 ***	-2.237 ***	-2.801 ***	-1.781 **	-3.991 ***	-3.860 ***
Lg GDPPCAP	-0.073	-0.062	0.033	0.086 *	0.066	0.092	-0.146
Lg REVSOUR	-0.009	-0.138	-0.115 ***	0.080 **	0.037	0.088	-0.026
Lg FOREX	-0.084	-0.082	-0.054	-0.069	0.133	0.147	-0.029
Lg ODA	0.004	0.017 **	-0.001	0.000	0.000	0.001	0.024 ***
Lg OPENECON	0.052	-0.076	-0.015	0.171 ***	0.039	0.109	0.020
Lg RURALPOP	-0.011	-0.068 *	-0.003	-0.003	-0.057 **	-0.068	-0.135 ***
Lg TOTRADE	0.110 *						
Lg REALINTR		-0.002	0.000	-0.001 **	0.000	0.001	0.001
RULGOVT	-0.020	-0.059	0.000	-0.004	-0.067 ***	-0.001	0.009
POLSYST	0.004	-0.074 *	-0.002	-0.005	-0.039	-0.006	-0.010
NATDEV	0.011	-0.013	-0.008	0.001	0.024	-0.048 *	-0.039
REGDEV	0.011	-0.056	-0.004	-0.012	0.013	0.042	-0.051
AGRDEV	0.002	0.011	-0.011	-0.006	-0.040	-0.036	-0.071 *
MINOFIN	-0.007	-0.072 ***	-0.010 *	0.006	0.017	0.016	-0.087 ***
FISCALPOL	0.015	-0.083	-0.014	-0.011	-0.052	0.048	0.025
CIVUNREST	-0.014	0.059	-0.004	0.009	0.019	-0.079 *	-0.028
DROUGHT	-0.007	-0.063 **	-0.005	0.000	0.002	0.004	0.017
RAINFALL	0.000	0.028	-0.013	-0.009	-0.006	0.036	-0.043
Lg PRICE-EN							
Lg PRICE-IO							
Lg WAGE							
Lg AGRVAD							
Intercept	0.049 ***	-0.119 **	0.008	0.041 **	0.107 **	0.183 **	0.233 ***
R-squared	0.367	0.436	0.492	0.462	0.314	0.287	0.540
F-test	45.270 ***	74.980 ***	74.850 ***	73.750 ***	34.410 **	37.240 **	75.140 ***
Rho	0.003	0.007	0.040	0.002	0.044	0.001	0.000
Overall model results:	Berndt *R*-squared = 0.999; McElroy *R*-squared = 0.876; *F*-statistic = 20,094.72 (0.000)***; rho = 15.62 (0.337); BP = 312.86 (0.000)***						

Source: Authors' model estimation results.
Note: See Table 3.1 for detailed descriptions of variables. Lg means lag value. For rho, the test is autocorrelation using the Harvey Lagrange multiplier (LM) test with the null hypothesis that rho is zero (Harvey 1990; Judge et al. 1985). BP = Breusch-Pagan LM diagonal covariance matrix test with the null hypothesis that there is no contemporaneous correlation (Judge et al. 1985). For overall model results, the figure in parentheses is the *p*-value. *, **, and *** refer to statistical significance at the 10, 5, and 1 percent level of significance, respectively. Blank cell means not applicable.

Table A.4 Three-stage least squares results, excluding lag of output (AGRVAD) from the output equation, 1950–2014

Variable	AGRVAD	TOTEXP	FUNEXP-ADM	FUNEXP-DEF	FUNEXP-EDU	FUNEXP-HTH	FUNEXP-AGR
TOTEXP	0.810 ***						
FUNEXP-ADM	0.098						
FUNEXP-DEF	-2.234 ***						
FUNEXP-EDU	0.796 ***						
FUNEXP-HTH	1.535 *						
FUNEXP-AGR	-0.487						
FUNEXP-OEC	0.580 ***						
CAPEXP-ADM	-0.180 **						
CAPEXP-DEF	-0.280						
CAPEXP-EDU	-0.631 **						
CAPEXP-HTH	-0.506 ***						
CAPEXP-AGR	0.328 ***						
CAPEXP-OEC	-0.026						
Lg TOTEXP		-2.309 ***	1.023 **	-0.257	1.807 ***	-0.049	-0.516
Lg FUNEXP$_m$			-4.717 ***	-3.407 ***	-2.748 ***	-2.006 ***	-1.071 **
Lg CAPEXP$_j$							
Lg GDPPCAP		0.174 **	-0.129 **	-0.048	-0.073 **	-0.013	-0.096 ***
Lg REVSOUR		-0.015	0.022	0.057 **	0.049 *	0.020 **	-0.047 *
Lg FOREX		0.249 ***	-0.163 ***	-0.094 **	-0.189 ***	-0.019	-0.025
Lg ODA		0.009 ***	-0.002	0.001	-0.004 **	-0.001 **	-0.001
Lg OPENECON		0.090	0.037	-0.003	0.024	0.013	0.019
Lg RURALPOP	-0.011	-0.035 **	0.004	0.005	0.009	-0.001	0.004
Lg TOTRADE	-0.085		0.029	0.068	0.078 **	0.001	-0.022
Lg REALINTR	-0.002 *						
RULGOVT		0.017	-0.008	0.010	-0.008	-0.001	0.012
POLSYST		-0.066 ***	0.010	0.025 ***	0.018 **	0.009 ***	0.005
NATDEV		0.002	0.004	0.004	0.003	0.002	-0.012 **
REGDEV		-0.029 *	0.002	0.013	0.003	-0.002	0.001
AGRDEV		-0.041 **	0.016	0.007	0.032 ***	0.004	0.006
MINOFIN			-0.005	0.001	0.006	0.003	-0.004
FISCALPOL			-0.039 **	0.005	-0.039 ***	-0.002	-0.019
CIVUNREST	-0.002	0.066 ***	-0.006	-0.030 ***	-0.025 ***	-0.010 ***	-0.003
DROUGHT	-0.008	0.019 *	0.000	0.000	-0.008	-0.002	-0.001
RAINFALL	0.053	-0.039 **	0.007	0.010	0.011	0.005 *	0.022 ***
Lg PRICE-EN	0.055 ***						
Lg PRICE-IO	0.025						
Lg WAGE	0.544 ***						
Lg AGRVAD							
Intercept	-0.007	0.046 ***	0.025 *	0.059 ***	0.005	0.013 **	0.030 **
R-squared	-11.236	0.495	0.307	0.307	0.551	0.462	0.377
F-test	628.460 ***	59.870 ***	52.900 ***	50.370 ***	89.650 ***	56.580 ***	40.430 ***
Rho	0.030	0.036	0.031	0.064 **	0.004	0.002	0.000
Overall model results:	Berndt *R*-squared = 0.999; McElroy *R*-squared = 0.874; *F*-statistic = 18,072.01 (0.000)***; rho = 16.63 (0.276); BP = 320.98 (0.000)***						

Source: Authors' model estimation results.

Note: See Table 3.1 for detailed descriptions of variables. Lg means lag value. For rho, the test is autocorrelation using the Harvey Lagrange multiplier (LM) test with the null hypothesis that rho is zero (Harvey 1990; Judge et al. 1985). BP = Breusch-Pagan LM diagonal covariance matrix test with the null hypothesis that there is no contemporaneous correlation (Judge et al. 1985). For overall model results, the figure in parentheses is the *p*-value. *, **, and *** refer to statistical significance at the 10, 5, and 1 percent level of significance, respectively. Blank cell means not applicable.

Table A.4, continued: Three-stage least squares results, excluding lag of output (AGRVAD) from the output equation, 1950–2014

Variable	FUNEXP-OEC	CAPEXP-ADM	CAPEXP-DEF	CAPEXP-EDU	CAPEXP-HTH	CAPEXP-AGR	CAPEXP-OEC
TOTEXP							
FUNEXP-ADM							
FUNEXP-DEF							
FUNEXP-EDU							
FUNEXP-HTH							
FUNEXP-AGR							
FUNEXP-OEC							
CAPEXP-ADM							
CAPEXP-DEF							
CAPEXP-EDU							
CAPEXP-HTH							
CAPEXP-AGR							
CAPEXP-OEC							
Lg TOTEXP	-0.389	7.104 ***	0.235	-0.137	-1.490	0.537	0.090
Lg FUNEXP$_m$	-2.359 ***						
Lg CAPEXP$_j$		-4.198 ***	-2.193 ***	-2.445 ***	-2.015 ***	-4.374 ***	-3.900 ***
Lg GDPPCAP	-0.076	-0.104	0.019	0.072	0.082	0.132	-0.117
Lg REVSOUR	-0.008	-0.130	-0.112 ***	0.061 *	0.020	0.096	-0.026
Lg FOREX	-0.089	-0.120	-0.067 *	-0.038	0.163 *	0.131	-0.023
Lg ODA	0.004	0.016 *	0.000	0.000	0.000	0.001	0.024 ***
Lg OPENECON	0.055	-0.050	-0.013	0.160 ***	0.063	0.105	0.007
Lg RURALPOP	-0.010	-0.071 *	-0.002	0.000	-0.054 **	-0.065	-0.133 ***
Lg TOTRADE	0.117 *						
Lg REALINTR		-0.002	0.000	-0.001	0.000	0.001	0.001
RULGOVT	-0.020	-0.053	-0.001	-0.006	-0.074 ***	-0.002	0.011
POLSYST	0.005	-0.072 *	0.000	-0.004	-0.038	-0.012	-0.016
NATDEV	0.013	-0.013	-0.006	0.002	0.024	-0.047 *	-0.042 *
REGDEV	0.011	-0.058	-0.002	-0.006	0.009	0.039	-0.054
AGRDEV	0.003	0.014	-0.009	-0.012	-0.047 *	-0.032	-0.073 *
MINOFIN	-0.006	-0.062 ***	-0.010 *	0.005	0.021	0.020	-0.085 ***
FISCALPOL	0.013	-0.079	-0.017	-0.003	-0.044	0.040	0.028
CIVUNREST	-0.015	0.059	-0.005	0.010	0.024	-0.077 *	-0.026
DROUGHT	-0.007	-0.059 **	-0.005	0.001	0.008	0.003	0.017
RAINFALL	-0.001	0.036	-0.014	-0.007	-0.002	0.035	-0.042
Lg PRICE-EN							
Lg PRICE-IO							
Lg WAGE							
Lg AGRVAD							
Intercept	0.050 ***	-0.066	0.015	0.022	0.057 **	0.158 ***	0.217 ***
R-squared	0.367	0.443	0.477	0.403	0.327	0.288	0.538
F-test	52.680 ***	69.130 ***	71.490 ***	59.770 ***	34.100 **	43.180 ***	74.890 ***
Rho	0.003	0.009	0.039	0.001	0.050 *	0.007	0.001
Overall model results:	Berndt *R*-squared = 0.999; McElroy *R*-squared = 0.874; *F*-statistic = 18,072.01 (0.000)***; rho = 16.63 (0.276); BP = 320.98 (0.000)***						

Source: Authors' model estimation results.

Note: See Table 3.1 for detailed descriptions of variables. Lg means lag value. For rho, the test is autocorrelation using the Harvey Lagrange multiplier (LM) test with the null hypothesis that rho is zero (Harvey 1990; Judge et al. 1985). BP = Breusch-Pagan LM diagonal covariance matrix test with the null hypothesis that there is no contemporaneous correlation (Judge et al. 1985). For overall model results, the figure in parentheses is the *p*-value. *, **, and *** refer to statistical significance at the 10, 5, and 1 percent level of significance, respectively. Blank cell means not applicable.

Table A.5 Three-stage least squares results, excluding terms of trade (TOTRADE), real interest rate (REALINTR), and rural population (RURALPOP) from the output equation, 1950–2014

Variable	AGRVAD	TOTEXP	FUNEXP-ADM	FUNEXP-DEF	FUNEXP-EDU	FUNEXP-HTH	FUNEXP-AGR
TOTEXP	0.776 ***						
FUNEXP-ADM	0.135						
FUNEXP-DEF	-2.404 ***						
FUNEXP-EDU	1.017 ***						
FUNEXP-HTH	0.530						
FUNEXP-AGR	-0.671 *						
FUNEXP-OEC	0.485 **						
CAPEXP-ADM	-0.167 **						
CAPEXP-DEF	-0.274						
CAPEXP-EDU	-0.603 ***						
CAPEXP-HTH	-0.457 ***						
CAPEXP-AGR	0.424 ***						
CAPEXP-OEC	-0.026						
Lg TOTEXP		-2.507 ***	1.122 **	-0.038	1.823 ***	-0.035	-0.337
Lg FUNEXP*m*			-4.657 ***	-2.981 ***	-2.773 ***	-1.903 ***	-0.916 *
Lg CAPEXP*j*							
Lg GDPPCAP		0.144 **	-0.110 **	-0.027	-0.069 *	-0.012	-0.089 **
Lg REVSOUR		-0.009	0.017	0.055 **	0.048 *	0.019 **	-0.047 *
Lg FOREX		0.235 ***	-0.153 ***	-0.091 **	-0.185 ***	-0.019	-0.031
Lg ODA		0.009 ***	-0.002	0.001	-0.004 **	-0.001 **	-0.001
Lg OPENECON		0.088	0.037	-0.002	0.025	0.014	0.016
Lg RURALPOP		-0.033 **	0.002	0.005	0.008	-0.001	0.005
Lg TOTRADE			0.025	0.088 **	0.073 **	0.003	-0.008
Lg REALINTR							
RULGOVT		0.019	-0.009	0.009	-0.008	-0.001	0.012
POLSYST		-0.060 ***	0.006	0.021 **	0.017 **	0.009 ***	0.003
NATDEV		0.005	0.002	0.003	0.002	0.003	-0.012 **
REGDEV		-0.028 *	0.001	0.011	0.003	-0.002	0.001
AGRDEV		-0.037 **	0.014	0.005	0.031 ***	0.004	0.006
MINOFIN			-0.005	0.002	0.006	0.003 *	-0.003
FISCALPOL			-0.040 **	0.004	-0.039 ***	-0.002	-0.021 *
CIVUNREST	-0.011	0.064 ***	-0.006	-0.029 ***	-0.024 ***	-0.010 ***	-0.002
DROUGHT	-0.014	0.019 *	-0.001	0.000	-0.008	-0.002	-0.001
RAINFALL	0.051	-0.039 **	0.008	0.010	0.011	0.005 *	0.022 ***
Lg PRICE-EN	0.057 ***						
Lg PRICE-IO	0.024 *						
Lg WAGE	0.559 ***						
Lg AGRVAD	0.013						
Intercept	0.054	0.052 ***	0.021	0.046 ***	0.005	0.012 **	0.024 *
R-squared	-11.935	0.505	0.322	0.324	0.552	0.458	0.384
F-test	746.280 ***	64.050 ***	50.600 ***	51.500 ***	91.150 ***	55.730 ***	39.030 ***
Rho	0.027	0.034	0.034	0.064 *	0.003	0.001	0.000
Overall model results:	Berndt *R*-squared = 0.999; McElroy *R*-squared = 0.884; *F*-statistic = 17,750.43 (0.000)***; rho = 15.65 (0.335); BP = 309.23 (0.000)***						

Source: Authors' model estimation results.

Note: See Table 3.1 for detailed descriptions of variables. Lg means lag value. For rho, the test is autocorrelation using the Harvey Lagrange multiplier (LM) test with the null hypothesis that rho is zero (Harvey 1990; Judge et al. 1985). BP = Breusch-Pagan LM diagonal covariance matrix test with the null hypothesis that there is no contemporaneous correlation (Judge et al. 1985). For overall model results, the figure in parentheses is the *p*-value. *, **, and *** refer to statistical significance at the 10, 5, and 1 percent level of significance, respectively. Blank cell means not applicable.

Table A.5, continued: Three-stage least squares results, excluding terms of trade (TOTRADE), real interest rate (REALINTR), and rural population (RURALPOP) from the output equation, 1950–2014

Variable	FUNEXP-OEC	CAPEXP-ADM	CAPEXP-DEF	CAPEXP-EDU	CAPEXP-HTH	CAPEXP-AGR	CAPEXP-OEC
TOTEXP							
FUNEXP-ADM							
FUNEXP-DEF							
FUNEXP-EDU							
FUNEXP-HTH							
FUNEXP-AGR							
FUNEXP-OEC							
CAPEXP-ADM							
CAPEXP-DEF							
CAPEXP-EDU							
CAPEXP-HTH							
CAPEXP-AGR							
CAPEXP-OEC							
Lg TOTEXP	-0.433	7.200 ***	0.210	-0.064	-1.386	0.387	-0.029
Lg $FUNEXP_m$	-2.378 ***						
Lg $CAPEXP_j$		-4.145 ***	-2.240 ***	-2.604 ***	-1.994 **	-3.294 ***	-4.032 ***
Lg GDPPCAP	-0.078	-0.100	0.013	0.084	0.081	0.198	-0.129
Lg REVSOUR	-0.010	-0.132	-0.110 ***	0.061 *	0.022	0.089	-0.025
Lg FOREX	-0.088	-0.121	-0.069 *	-0.036	0.161 *	0.099	-0.024
Lg ODA	0.004 *	0.015 *	0.000	0.000	0.000	-0.001	0.024 ***
Lg OPENECON	0.061	-0.055	-0.015	0.160 ***	0.054	0.099	0.009
Lg RURALPOP	-0.011	-0.072 *	-0.002	0.000	-0.054 **	-0.056	-0.136 ***
Lg TOTRADE	0.114 *						
Lg REALINTR		-0.001	0.000	0.000	0.000	-0.002	0.001
RULGOVT	-0.022	-0.054	-0.001	-0.007	-0.073 ***	0.008	0.011
POLSYST	0.005	-0.074 *	0.001	-0.006	-0.039	-0.019	-0.011
NATDEV	0.013	-0.015	-0.006	0.000	0.022	-0.050 *	-0.039
REGDEV	0.011	-0.058	-0.002	-0.006	0.009	0.021	-0.053
AGRDEV	0.002	0.014	-0.008	-0.013	-0.046 *	-0.042	-0.072 *
MINOFIN	-0.006	-0.061 **	-0.010 *	0.005	0.021	0.027	-0.087 ***
FISCALPOL	0.013	-0.085	-0.016	-0.005	-0.046	0.041	0.032
CIVUNREST	-0.014	0.055	-0.005	0.009	0.021	-0.065	-0.026
DROUGHT	-0.007	-0.061 **	-0.005	0.000	0.007	0.010	0.018
RAINFALL	-0.001	0.036	-0.014	-0.007	-0.002	0.047	-0.041
Lg PRICE-EN							
Lg PRICE-IO							
Lg WAGE							
Lg AGRVAD							
Intercept	0.051 ***	-0.069	0.016 *	0.022	0.055 **	0.117 **	0.227 ***
R-squared	0.367	0.449	0.477	0.420	0.321	0.273	0.541
F-test	55.000 ***	67.610 ***	71.480 ***	61.920 ***	31.790 **	35.740 **	77.740 ***
Rho	0.004	0.008	0.043	0.001	0.044	0.000	0.000
Overall model results:	Berndt *R*-squared = 0.999; McElroy *R*-squared = 0.884; *F*-statistic = 17,750.43 (0.000)***; rho = 15.65 (0.335); BP = 309.23 (0.000)***						

Source: Authors' model estimation results.

Note: See Table 3.1 for detailed descriptions of variables. Lg means lag value. For rho, the test is autocorrelation using the Harvey Lagrange multiplier (LM) test with the null hypothesis that rho is zero (Harvey 1990; Judge et al. 1985). BP = Breusch-Pagan LM diagonal covariance matrix test with the null hypothesis that there is no contemporaneous correlation (Judge et al. 1985). For overall model results, the figure in parentheses is the *p*-value. *, **, and *** refer to statistical significance at the 10, 5, and 1 percent level of significance, respectively. Blank cell means not applicable.

Table A.6 Three-stage least squares results, excluding prices and wages (PRICE-EN, PRICE-IO, WAGE) from the output equation, 1950–2014

Variable	AGRVAD	TOTEXP	FUNEXP-ADM	FUNEXP-DEF	FUNEXP-EDU	FUNEXP-HTH	FUNEXP-AGR
TOTEXP	0.248						
FUNEXP-ADM	-0.650 ***						
FUNEXP-DEF	-1.179 ***						
FUNEXP-EDU	0.903 ***						
FUNEXP-HTH	-0.061						
FUNEXP-AGR	0.203						
FUNEXP-OEC	0.159						
CAPEXP-ADM	-0.086						
CAPEXP-DEF	-0.790 ***						
CAPEXP-EDU	0.012						
CAPEXP-HTH	-0.111						
CAPEXP-AGR	0.273 ***						
CAPEXP-OEC	0.019						
Lg TOTEXP		-2.702 ***	0.905 *	-0.044	1.922 ***	-0.030	-0.452
Lg FUNEXP$_m$			-4.219 ***	-3.084 ***	-2.971 ***	-1.731 ***	-1.183 **
Lg CAPEXP$_j$							
Lg GDPPCAP		0.145 *	-0.145 ***	-0.027	-0.073 **	-0.013	-0.082 **
Lg REVSOUR		-0.040	0.055	0.071 **	0.054 **	0.022 **	-0.042 *
Lg FOREX		0.244 ***	-0.165 ***	-0.085 *	-0.195 ***	-0.019	-0.017
Lg ODA		0.011 ***	-0.003	0.000	-0.004 **	-0.002 ***	-0.001
Lg OPENECON		0.131 *	0.051	-0.019	0.020	0.013	0.004
Lg RURALPOP	-0.021	-0.035 **	0.005	0.005	0.008	-0.001	0.003
Lg TOTRADE	-0.001		0.041	0.067	0.082 **	0.002	-0.028
Lg REALINTR	0.000						
RULGOVT		0.004	-0.010	0.016	-0.006	-0.001	0.017 *
POLSYST		-0.058 ***	0.008	0.019 *	0.017 **	0.009 ***	0.002
NATDEV		0.014	0.001	-0.002	0.002	0.002	-0.016 ***
REGDEV		-0.027	0.005	0.011	0.003	-0.002	0.001
AGRDEV		-0.040 **	0.013	0.005	0.033 ***	0.004	0.005
MINOFIN			0.002	0.003	0.006	0.003 *	-0.004
FISCALPOL			-0.042 ***	0.006	-0.041 ***	-0.002	-0.017
CIVUNREST	-0.006	0.068 ***	-0.011	-0.031 ***	-0.025 ***	-0.010 ***	-0.003
DROUGHT	0.002	0.020 *	0.000	-0.001	-0.008	-0.002	-0.001
RAINFALL	0.003	-0.040 **	0.005	0.010	0.011	0.005 *	0.022 ***
Lg PRICE-EN							
Lg PRICE-IO							
Lg WAGE							
Lg AGRVAD	-0.012						
Intercept	-0.062	0.056 ***	0.024 *	0.048 ***	0.006	0.011 **	0.029 *
R-squared	-5.139	0.528	0.266	0.358	0.555	0.461	0.397
F-test	304.020 ***	66.170 ***	48.220 ***	48.020 ***	97.620 ***	55.830 ***	41.480 ***
Rho	0.074 **	0.032	0.087 **	0.064 *	0.002	0.001	0.001
Overall model results:	Berndt *R*-squared = 0.999; McElroy *R*-squared = 0.711; *F*-statistic = 9,266.54 (0.000)***; rho = 22.10 (0.076)*; BP = 302.97 (0.000)***						

Source: Authors' model estimation results.

Note: See Table 3.1 for detailed descriptions of variables. Lg means lag value. For rho, the test is autocorrelation using the Harvey Lagrange multiplier (LM) test with the null hypothesis that rho is zero (Harvey 1990; Judge et al. 1985). BP = Breusch-Pagan LM diagonal covariance matrix test with the null hypothesis that there is no contemporaneous correlation (Judge et al. 1985). For overall model results, the figure in parentheses is the *p*-value. *, **, and *** refer to statistical significance at the 10, 5, and 1 percent level of significance, respectively. Blank cell means not applicable.

Table A.6, continued: Three-stage least squares results, excluding prices and wages (PRICE-EN, PRICE-IO, WAGE) from the output equation, 1950–2014

Variable	FUNEXP-OEC	CAPEXP-ADM	CAPEXP-DEF	CAPEXP-EDU	CAPEXP-HTH	CAPEXP-AGR	CAPEXP-OEC
TOTEXP							
FUNEXP-ADM							
FUNEXP-DEF							
FUNEXP-EDU							
FUNEXP-HTH							
FUNEXP-AGR							
FUNEXP-OEC							
CAPEXP-ADM							
CAPEXP-DEF							
CAPEXP-EDU							
CAPEXP-HTH							
CAPEXP-AGR							
CAPEXP-OEC							
Lg TOTEXP	-0.397	6.245 ***	0.171	0.115	-1.295	0.808	-0.063
Lg FUNEXP$_m$	-2.195 ***						
Lg CAPEXP$_j$		-3.811 ***	-2.371 ***	-2.516 ***	-1.859 **	-3.521 ***	-3.907 ***
Lg GDPPCAP	-0.089	-0.113	0.011	0.103 *	0.115	0.191	-0.129
Lg REVSOUR	-0.003	-0.079	-0.115 ***	0.070 *	0.025	-0.024	-0.048
Lg FOREX	-0.096	-0.115	-0.068 *	-0.030	0.173 *	0.090	-0.028
Lg ODA	0.004	0.013	0.000	-0.001	-0.001	0.003	0.025 ***
Lg OPENECON	0.064	-0.012	-0.004	0.131 ***	0.034	0.073	0.024
Lg RURALPOP	-0.009	-0.071 *	-0.002	0.000	-0.053 **	-0.056	-0.133 ***
Lg TOTRADE	0.127 **						
Lg REALINTR		-0.002 *	0.000	-0.001 *	0.000	0.000	0.001
RULGOVT	-0.023 *	-0.056	-0.005	0.003	-0.065 ***	-0.005	0.005
POLSYST	0.005	-0.079 *	0.002	-0.010	-0.044 *	-0.006	-0.011
NATDEV	0.014	-0.019	-0.004	-0.006	0.017	-0.034	-0.034
REGDEV	0.012	-0.056	-0.002	-0.008	0.005	0.022	-0.054
AGRDEV	0.002	0.005	-0.009	-0.013	-0.050 *	-0.023	-0.071 *
MINOFIN	-0.004	-0.043 *	-0.010 *	0.004	0.022	0.000	-0.088 ***
FISCALPOL	0.013	-0.082	-0.017	0.000	-0.040	0.035	0.027
CIVUNREST	-0.015	0.049	-0.005	0.009	0.024	-0.061	-0.024
DROUGHT	-0.007	-0.057 **	-0.005	0.000	0.007	0.002	0.017
RAINFALL	-0.001	0.038	-0.015	-0.005	0.000	0.044	-0.042
Lg PRICE-EN							
Lg PRICE-IO							
Lg WAGE							
Lg AGRVAD							
Intercept	0.047 ***	-0.053	0.018 *	0.016	0.049 **	0.118 **	0.222 ***
R-squared	0.368	0.428	0.477	0.435	0.337	0.260	0.541
F-test	53.300 ***	61.130 ***	74.750 ***	58.670 ***	29.310 *	27.470 *	75.920 ***
Rho	0.007	0.022	0.038	0.000	0.040	0.001	0.001
Overall model results:	Berndt *R*-squared = 0.999; McElroy *R*-squared = 0.884; *F*-statistic = 17,750.43 (0.000)***; rho = 15.65 (0.335); BP = 309.23 (0.000)***						

Source: Authors' model estimation results.

Note: See Table 3.1 for detailed descriptions of variables. Lg means lag value. For rho, the test is autocorrelation using the Harvey Lagrange multiplier (LM) test with the null hypothesis that rho is zero (Harvey 1990; Judge et al. 1985). BP = Breusch-Pagan LM diagonal covariance matrix test with the null hypothesis that there is no contemporaneous correlation (Judge et al. 1985). For overall model results, the figure in parentheses is the *p*-value. *, **, and *** refer to statistical significance at the 10, 5, and 1 percent level of significance, respectively. Blank cell means not applicable.

Table A.7 Three-stage least squares results, excluding prices and wages (PRICE-EN, PRICE-IO, WAGE) and other variables (TOTRADE, REALINTR, RURALPOP) from the output equation, 1950–2014

Variable	AGRVAD	TOTEXP	FUNEXP-ADM	FUNEXP-DEF	FUNEXP-EDU	FUNEXP-HTH	FUNEXP-AGR
TOTEXP	0.263						
FUNEXP-ADM	-0.591 ***						
FUNEXP-DEF	-1.391 ***						
FUNEXP-EDU	0.862 ***						
FUNEXP-HTH	0.824						
FUNEXP-AGR	0.001						
FUNEXP-OEC	0.199						
CAPEXP-ADM	-0.119						
CAPEXP-DEF	-0.899 ***						
CAPEXP-EDU	-0.028						
CAPEXP-HTH	-0.171 *						
CAPEXP-AGR	0.522 ***						
CAPEXP-OEC	0.023						
Lg TOTEXP		-2.748 ***	0.981 **	0.024	1.904 ***	-0.023	-0.415
Lg $FUNEXP_m$			-4.122 ***	-2.968 ***	-2.900 ***	-1.894 ***	-1.128 **
Lg $CAPEXP_j$							
Lg GDPPCAP		0.136 *	-0.126 ***	-0.017	-0.071 *	-0.011	-0.082 **
Lg REVSOUR		-0.039	0.055	0.068 **	0.053 **	0.021 **	-0.042
Lg FOREX		0.245 ***	-0.168 ***	-0.083 *	-0.193 ***	-0.019	-0.020
Lg ODA		0.011 ***	-0.003	0.000	-0.004 ***	-0.002 ***	-0.001
Lg OPENECON		0.131 *	0.056	-0.022	0.020	0.012	0.004
Lg RURALPOP		-0.037 **	0.009	0.006	0.009	-0.001	0.004
Lg TOTRADE			0.044	0.067 *	0.080 **	0.002	-0.025
Lg REALINTR							
RULGOVT		0.004	-0.011	0.017	-0.006	0.000	0.017 *
POLSYST		-0.058 ***	0.009	0.019 *	0.017 **	0.009 ***	0.002
NATDEV		0.014	0.001	-0.003	0.002	0.002	-0.016 ***
REGDEV		-0.026	0.004	0.010	0.003	-0.002	0.000
AGRDEV		-0.039 *	0.011	0.005	0.032 ***	0.004	0.005
MINOFIN			0.003	0.002	0.006	0.003 *	-0.004
FISCALPOL			-0.039 ***	0.007	-0.040 ***	-0.002	-0.017
CIVUNREST	0.007	0.068 ***	-0.012	-0.031 ***	-0.025 ***	-0.010 ***	-0.003
DROUGHT	0.002	0.020 *	0.001	-0.001	-0.008	-0.002	-0.001
RAINFALL	-0.008	-0.040 **	0.006	0.011	0.011	0.005 *	0.022 ***
Lg PRICE-EN							
Lg PRICE-IO							
Lg WAGE							
Lg AGRVAD	-0.013						
Intercept	-0.063	0.057 ***	0.022	0.045 ***	0.005	0.011 **	0.028 *
R-squared	-10.814	0.529	0.269	0.364	0.555	0.466	0.398
F-test	562.460 ***	97.130 ***	45.750 ***	47.190 ***	95.030 ***	55.590 ***	40.900 ***
Rho	0.094 **	0.032	0.094 **	0.066 **	0.002	0.003	0.000
Overall model results:	Berndt *R*-squared = 0.999; McElroy *R*-squared = 0.785; *F*-statistic = 8,834.57 (0.000)***; rho = 24.78 (0.037)**; BP = 305.09 (0.000)***						

Source: Authors' model estimation results.

Note: See Table 3.1 for detailed descriptions of variables. Lg means lag value. For rho, the test is autocorrelation using the Harvey Lagrange multiplier (LM) test with the null hypothesis that rho is zero (Harvey 1990; Judge et al. 1985). BP = Breusch-Pagan LM diagonal covariance matrix test with the null hypothesis that there is no contemporaneous correlation (Judge et al. 1985). For overall model results, the figure in parentheses is the *p*-value. *, **, and *** refer to statistical significance at the 10, 5, and 1 percent level of significance, respectively. Blank cell means not applicable.

Table A.7, continued: Three-stage least squares results, excluding prices and wages (PRICE-EN, PRICE-IO, WAGE) and other variables (TOTRADE, REALINTR, RURALPOP) from the output equation, 1950–2014

Variable	FUNEXP-OEC	CAPEXP-ADM	CAPEXP-DEF	CAPEXP-EDU	CAPEXP-HTH	CAPEXP-AGR	CAPEXP-OEC
TOTEXP							
FUNEXP-ADM							
FUNEXP-DEF							
FUNEXP-EDU							
FUNEXP-HTH							
FUNEXP-AGR							
FUNEXP-OEC							
CAPEXP-ADM							
CAPEXP-DEF							
CAPEXP-EDU							
CAPEXP-HTH							
CAPEXP-AGR							
CAPEXP-OEC							
Lg TOTEXP	-0.386	6.208 ***	0.168	0.110	-1.303	0.931	-0.030
Lg $FUNEXP_m$	-2.236 ***						
Lg $CAPEXP_j$		-3.728 ***	-2.277 ***	-2.509 ***	-1.816 **	-2.229 ***	-3.968 ***
Lg GDPPCAP	-0.084	-0.077	0.012	0.102 *	0.117	0.199	-0.129
Lg REVSOUR	-0.004	-0.079	-0.117 ***	0.071 *	0.025	-0.071	-0.054
Lg FOREX	-0.095	-0.119	-0.067 *	-0.031	0.174 *	0.052	-0.022
Lg ODA	0.004	0.012	0.000	-0.001	-0.001	0.002	0.025 ***
Lg OPENECON	0.063	0.006	-0.006	0.133 ***	0.035	0.014	0.011
Lg RURALPOP	-0.009	-0.063 *	-0.002	0.001	-0.053 **	-0.064 **	-0.138 ***
Lg TOTRADE	0.125 **						
Lg REALINTR		-0.002 *	0.000	-0.001 *	0.000	0.000	0.001
RULGOVT	-0.022	-0.059	-0.004	0.002	-0.065 ***	0.005	0.007
POLSYST	0.005	-0.077 *	0.002	-0.009	-0.044 *	-0.020	-0.012
NATDEV	0.014	-0.020	-0.004	-0.006	0.017	-0.035 *	-0.035
REGDEV	0.012	-0.060	-0.002	-0.008	0.005	0.009	-0.054
AGRDEV	0.002	0.002	-0.009	-0.013	-0.050 *	-0.022	-0.070 *
MINOFIN	-0.004	-0.040 *	-0.010 *	0.005	0.022	-0.004	-0.090 ***
FISCALPOL	0.013	-0.078	-0.017	0.000	-0.040	0.015	0.027
CIVUNREST	-0.015	0.048	-0.004	0.009	0.024	-0.051	-0.023
DROUGHT	-0.007	-0.055 **	-0.005	0.000	0.008	0.001	0.017
RAINFALL	-0.022	0.039	-0.014	-0.006	0.001	0.052	-0.042
Lg PRICE-EN							
Lg PRICE-IO							
Lg WAGE							
Lg AGRVAD							
Intercept	0.048 ***	-0.053	0.017 *	0.016	0.049 **	0.062	0.223 ***
R-squared	0.368	0.425	0.481	0.435	0.337	0.187	0.540
F-test	53.240 ***	58.580 ***	74.110 ***	58.310 ***	29.000 *	17.860	77.660 ***
Rho	0.006	0.023	0.037	0.000	0.038	0.018	0.001
Overall model results:	Berndt *R*-squared = 0.999; McElroy *R*-squared = 0.785; *F*-statistic = 8,834.57 (0.000)***; rho = 24.78 (0.037)**; BP = 305.09 (0.000)***						

Source: Authors' model estimation results.

Note: See Table 3.1 for detailed descriptions of variables. Lg means lag value. For rho, the test is autocorrelation using the Harvey Lagrange multiplier (LM) test with the null hypothesis that rho is zero (Harvey 1990; Judge et al. 1985). BP = Breusch-Pagan LM diagonal covariance matrix test with the null hypothesis that there is no contemporaneous correlation (Judge et al. 1985). For overall model results, the figure in parentheses is the *p*-value. *, **, and *** refer to statistical significance at the 10, 5, and 1 percent level of significance, respectively. Blank cell means not applicable.

Table A.8 Three-stage least squares estimation results, including COTU in all expenditure equations and using KNUT for CIVUNREST in the equations on education, 1950–2014

Variable	AGRVAD	TOTEXP	FUNEXP-ADM	FUNEXP-DEF	FUNEXP-EDU	FUNEXP-HTH	FUNEXP-AGR
TOTEXP	0.453 ***						
FUNEXP-ADM	-0.005						
FUNEXP-DEF	-2.154 ***						
FUNEXP-EDU	0.465 **						
FUNEXP-HTH	4.052 ***						
FUNEXP-AGR	-0.676 *						
FUNEXP-OEC	0.213						
CAPEXP-ADM	-0.154 **						
CAPEXP-DEF	-0.591 **						
CAPEXP-EDU	-0.605 ***						
CAPEXP-HTH	-0.527 ***						
CAPEXP-AGR	0.438 ***						
CAPEXP-OEC	0.058						
Lg TOTEXP		-2.515 ***	1.122 **	-0.059	1.730 ***	-0.027	-0.576
Lg FUNEXP$_m$			-4.570 ***	-3.579 ***	-2.561 ***	-1.921 ***	-1.341 ***
Lg CAPEXP$_j$							
Lg GDPPCAP		0.146 *	-0.130 **	-0.041	-0.082 **	-0.009	-0.094 ***
Lg REVSOUR		-0.022	0.045	0.077 ***	0.061 **	0.019 **	-0.032
Lg FOREX		0.229 ***	-0.166 ***	-0.095 **	-0.182 ***	-0.015	-0.023
Lg ODA		0.010 ***	-0.003	0.000	-0.004 **	-0.001 **	-0.001
Lg OPENECON		0.115	0.031	-0.025	0.010	0.010	0.014
Lg RURALPOP	-0.012	-0.035 **	0.008	0.009	0.014	-0.001	0.005
Lg TOTRADE	0.042		0.054	0.087 **	0.116 ***	-0.001	-0.017
Lg REALINTR	-0.001						
RULGOVT		0.016	-0.008	0.015	-0.013	-0.001	0.015 *
POLSYST		-0.056 ***	0.013	0.023 **	0.009	0.007 **	0.008
NATDEV		0.010	0.003	0.000	0.000	0.001	-0.013 **
REGDEV		-0.026	-0.001	0.009	0.002	-0.002	0.000
AGRDEV		-0.040 **	0.014	0.003	0.026 **	0.004	0.004
MINOFIN			-0.003	0.002	0.004	0.002	-0.002
FISCALPOL			-0.040 **	0.001	-0.042 ***	-0.002	-0.019
COTU			0.010	0.014 **	0.015 **	0.001	0.006
KNUT					-0.019 ***		
CIVUNREST	0.031	0.045 ***	-0.006	-0.029 ***		-0.007 ***	-0.009
DROUGHT	-0.007	0.020 *	0.000	0.000	-0.004	-0.002	0.000
RAINFALL	0.025	-0.041 **	0.006	0.009	0.008	0.005 *	0.021 ***
Lg PRICE-EN	0.032 **						
Lg PRICE-IO	0.023 *						
Lg WAGE	0.554 ***						
Lg AGRVAD	-0.003						
Intercept	-0.023	0.053 ***	0.020	0.055 ***	0.004	0.011 **	0.033 **
R-squared	-10.814	0.506	0.292	0.330	0.427	0.449	0.375
F-test	573.903 ***	61.320 ***	53.720 ***	57.890 ***	94.080 ***	48.330 ***	42.570 ***
Rho	0.036	0.036	0.041	0.055 *	0.000	0.005	0.002
Overall model results:	Berndt *R*-squared = 0.999; McElroy *R*-squared = 0.891; *F*-statistic = 28,103.31 (0.000)***; rho = 17.56 (0.223); BP = 340.91 (0.000)***						

Source: Authors' model estimation results.

Note: See Table 3.1 for detailed descriptions of variables. Lg means lag value. For rho, the test is autocorrelation using the Harvey Lagrange multiplier (LM) test with the null hypothesis that rho is zero (Harvey 1990; Judge et al. 1985). BP = Breusch-Pagan LM diagonal covariance matrix test with the null hypothesis that there is no contemporaneous correlation (Judge et al. 1985). For overall model results, the figure in parentheses is the *p*-value. *, **, and *** refer to statistical significance at the 10, 5, and 1 percent level of significance, respectively. Blank cell means not applicable.

Table A.8, continued: Three-stage least squares estimation results, including COTU in all expenditure equations and using KNUT for CIVUNREST in the equations on education, 1950–2014

Variable	FUNEXP-OEC	CAPEXP-ADM	CAPEXP-DEF	CAPEXP-EDU	CAPEXP-HTH	CAPEXP-AGR	CAPEXP-OEC
TOTEXP							
FUNEXP-ADM							
FUNEXP-DEF							
FUNEXP-EDU							
FUNEXP-HTH							
FUNEXP-AGR							
FUNEXP-OEC							
CAPEXP-ADM							
CAPEXP-DEF							
CAPEXP-EDU							
CAPEXP-HTH							
CAPEXP-AGR							
CAPEXP-OEC							
Lg TOTEXP	-0.264	6.822 ***	0.228	0.134	-1.353	1.001	0.115
Lg FUNEXP$_m$	-2.134 ***						
Lg CAPEXP$_j$		-4.054 ***	-2.325 ***	-2.414 ***	-2.422 ***	-3.518 ***	-3.608 ***
Lg GDPPCAP	-0.078	-0.105	0.019	0.097 *	0.092	0.224	-0.120
Lg REVSOUR	-0.009	-0.078	-0.113 ***	0.079 **	0.027	0.054	-0.049
Lg FOREX	-0.086	-0.120	-0.062	-0.030	0.166 *	0.113	-0.045
Lg ODA	0.004 *	0.014 *	0.000	-0.001	-0.001	0.001	0.024 ***
Lg OPENECON	0.046	-0.029	-0.012	0.147 ***	0.067	0.053	-0.002
Lg RURALPOP	-0.006	-0.069 *	-0.001	0.002	-0.058 ***	-0.052	-0.126 ***
Lg TOTRADE	0.134 **						
Lg REALINTR		-0.002	0.000	-0.001 **	0.000	-0.001	0.001
RULGOVT	-0.022	-0.052	-0.002	0.002	-0.075 ***	0.021	0.018
POLSYST	-0.002	-0.052	-0.002	-0.005	-0.034	-0.046	-0.020
NATDEV	0.012	-0.013	-0.006	-0.001	0.022	-0.052 **	-0.040
REGDEV	0.011	-0.066 *	-0.003	-0.011	0.009	0.022	-0.052
AGRDEV	0.000	0.009	-0.011	-0.017	-0.044 *	-0.059	-0.070
MINOFIN	-0.006	-0.055 **	-0.011 *	0.009	0.021	0.027	-0.083 ***
FISCALPOL	0.012	-0.077	-0.017	-0.004	-0.037	0.003	0.020
COTU	0.010	0.015	0.006	0.015 *	-0.010	0.056 *	-0.006
KNUT				0.013			
CIVUNREST	-0.004	0.036	-0.003		0.023	-0.092 **	-0.034
DROUGHT	-0.006	-0.059 **	-0.005	0.001	0.006	0.015	0.017
RAINFALL	-0.001	0.035	-0.015 *	-0.006	-0.001	0.038	-0.042
Lg PRICE-EN							
Lg PRICE-IO							
Lg WAGE							
Lg AGRVAD							
Intercept	0.042 **	-0.063	0.016	0.011	0.060 **	0.106 **	0.204 ***
R-squared	0.359	0.434	0.494	0.415	0.334	0.319	0.531
F-test	49.260 ***	64.680 ***	76.010 ***	72.640 ***	36.160 **	4.880 ***	73.140 ***
Rho	0.004	0.020	0.031	0.001	0.058 *	0.000	0.002
Overall model results:	Berndt *R*-squared = 0.999; McElroy *R*-squared = 0.891; *F*-statistic = 28,103.31 (0.000)***; rho = 17.56 (0.223); BP = 340.91 (0.000)***						

Source: Authors' model estimation results.

Note: See Table 3.1 for detailed descriptions of variables. Lg means lag value. For rho, the test is autocorrelation using the Harvey Lagrange multiplier (LM) test with the null hypothesis that rho is zero (Harvey 1990; Judge et al. 1985). BP = Breusch-Pagan LM diagonal covariance matrix test with the null hypothesis that there is no contemporaneous correlation (Judge et al. 1985). For overall model results, the figure in parentheses is the *p*-value. *, **, and *** refer to statistical significance at the 10, 5, and 1 percent level of significance, respectively. Blank cell means not applicable.

Table A.9 Estimated benefit-cost ratios and rates of return for different types of public investment in Africa and Asia

Type of investment	Study or source	Outcome variable and measure	BCR or ROR	Region or country
Agricultural research and extension				
Research and development	Fan, Hazell, and Thorat 2000	Agricultural total factor productivity	BCR = 13.4	India
Research	Evenson 2001	Agricultural total factor productivity	ROR = 43%	Africa
Research and development	Thirtle, Piesse, and Lin 2003	Agricultural value added per hectare	ROR = 22%	Sub-Saharan Africa
Research and development	Thirtle, Piesse, and Lin 2003	Agricultural value added per hectare	ROR = 31%	Asia
Research and development	Fan, Jitsuchon, and Methakunnavut 2004	Agricultural value added per worker	BCR = 12.6	Thailand
Research and development	Fan, Zhang, and Zhang 2004	Agricultural value added	BCR = 6.7	China
Research and extension	Fan and Zhang 2008	Household agricultural output per capita	BCR = 12.4	Uganda
National/CGIAR research	Alene and Coulibaly 2009	Agricultural value added per hectare	ROR = 55%	Sub-Saharan Africa
National/CGIAR maize research	Alene and Coulibaly 2009	Agricultural value added	ROR = 43%	West/Central Africa
Research	Fan, Nyange, and Rao 2012	Total household income	BCR = 12.5	Tanzania
National research	Fuglie and Rada 2013	Agricultural total factor productivity	ROR = 24% to 29%	Sub-Saharan Africa
CGIAR research	Fuglie and Rada 2013	Agricultural total factor productivity	ROR = 55%	Sub-Saharan Africa
Extension	Evenson 2001	Agricultural total factor productivity	Mean ROR = 30%	Africa
Extension	Benin et al. 2011	Household revenue per capita	ROR = 8% to 49%	Uganda
Irrigation				
Irrigation	Fan, Hazell, and Thorat 2000	Agricultural total factor productivity	BCR = 1.4	India
Irrigation	Fan, Jitsuchon, and Methakunnavut 2004	Agricultural value added per worker	BCR = 0.7	Thailand
Irrigation	Fan, Zhang, and Zhang 2004	Agricultural value added	BCR = 1.4	China
Roads				
Feeder roads	Fan and Zhang 2008	Household agricultural output per capita	BCR = 7.2	Uganda
Roads	Fan, Hazell, and Thorat 2000	Agricultural total factor productivity	BCR = 5.3	India
Roads	Fan, Jitsuchon, and Methakunnavut 2004	Agricultural value added per worker	BCR = 0.9	Thailand
Roads	Fan, Zhang, and Zhang 2004	Agricultural value added	BCR = 1.7	China
Social sector				
Education	Fan, Hazell, and Thorat 2000	Agricultural total factor productivity	BCR = 1.4	India
Education	Fan, Jitsuchon, and Methakunnavut 2004	Agricultural value added per worker	BCR = 2.1	Thailand
Education	Fan, Zhang, and Zhang 2004	Agricultural value added	BCR = 2.2	China
Education	Fan and Zhang 2008	Household agricultural output per capita	BCR = 2.7	Uganda
Health	Fan, Hazell, and Thorat 2000	Agricultural total factor productivity	BCR = 0.8	India
Health	Fan and Zhang 2008	Household agricultural output per capita	BCR = 0.9	Uganda
Electricity and other				
Power/electrification	Fan, Hazell, and Thorat 2000	Agricultural total factor productivity	BCR = 0.3	India
Power/electrification	Fan, Jitsuchon, and Methakunnavut 2004	Agricultural value added per worker	BCR = 4.9	Thailand
Power/electrification	Fan, Zhang, and Zhang 2004	Agricultural value added	BCR = 0.8	China
Soil and water conservation	Fan, Hazell, and Thorat 2000	Agricultural total factor productivity	BCR = 1.0	India
Antipoverty program	Fan, Hazell, and Thorat 2000	Agricultural total factor productivity	BCR = 1.1	India
Telephone	Fan, Zhang, and Zhang 2004	Agricultural value added	BCR = 1.6	China

Source: Authors' compilation based on cited sources.

Note: BCR = benefit-cost ratio; ROR = rate of return.

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