The Bang for the Birr

Public Expenditures and Rural Welfare in Ethiopia

Tewodaj Mogues, Gezahegn Ayele, and Zelekawork Paulos

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Foreword

This report explores and compares the impacts of different types of public spending on rural household welfare in Ethiopia. The analysis of public financial and household-level data reveals that returns to road investments are significantly higher than returns to other spending but are much more variable across regions. This regional variability suggests that the government should carefully consider regionally differentiated investment priorities. Some evidence indicates that the returns to road spending are increasing over time, with higher returns to road investments seen in areas with better-developed road networks.

The household expenditure impacts of per capita public expenditure in agriculture are substantially smaller and do not emerge as statistically significant. A separate examination of the three stages of analysis shows that—while the contribution of a strong agricultural sector to the incomes of both farming and nonfarming rural households is strong—the link between public expenditures in agriculture and performance in agriculture is poor, resulting in nonsignificant returns to agricultural spending. This suggests that a more careful examination of the composition as well as the execution of the agricultural budget would be advisable, in order to explore how it can be made more effective. There is also some evidence that the most significant effects of agricultural expenditures on rural households are observed in the most urbanized regions, pointing to the potentially important impact of market proximity on returns to public interventions in agriculture.

Expenditures in the education sector have greater rural welfare returns than agriculture spending but on average lower returns than road spending. However, while returns to road spending seem to be concentrated in a few regions, those to education have a wider reach across many regions and the returns are less varied in magnitude across regions. Expenditures in the health sector do not have widely significant effects on rural incomes—suggesting, together with other findings in the empirical work, that nonincome measures of well-being should be considered in the analysis of future public expenditures.

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Director General, IFPRI

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Acronyms and Abbreviations

ADLI	Agricultural Development–Led Industrialization
CSA	Central Statistical Authority
ESSP	Ethiopian Strategy Support Program
GDP	gross domestic product
HICE	Household Income, Consumption and Expenditure (Survey)
IFPRI	International Food Policy Research Institute
kWh	kilowatts per hour
MOFED	Ministry of Finance and Economic Development
OLS	ordinary least squares
PTR	pupil-to-teacher ratio
RSDP	Road Sector Development Program
SNNP	Southern Nations, Nationalities, and Peoples
S-2SLS	system-two-stage-least-squares
S-3SLS	system-three-stage-least-squares
TVET	technical and vocational education and training

Summary

Over the past decade and a half, Ethiopia's approach to promoting development and improving the lives of the country's rural population has been driven by a government strategy called Agricultural Development–Led Industrialization (ADLI). This strategy's main goal is fast, broad-based development within the agricultural sector that can power economic growth. While ADLI stipulates regulatory, trade, market, and other policies as engines of agricultural growth, it relies heavily on increasing public expenditure in agriculture and infrastructure, as well as in social sectors that are perceived as contributing to agricultural productivity.

Thus Ethiopia's public expenditure policy is at the heart of the policy measures intended to translate ADLI into reality. Given budget constraints, a critical and actionable research question is what kind of relative contributions different types of public investments make to welfare. Any answer to this question will have important implications for expenditure policy, especially the portfolio composition of public resources.

This research report explores and compares the impacts of different types of public spending on rural household welfare in Ethiopia. After an introduction to the topic in Chapter 1, Chapter 2 reviews the empirical and theoretical literature. Most of the studies examining the link between public expenditure and development outcomes fall into one of two categories. Studies in the first category explore how the size of *overall* public expenditure or public investment affects growth or poverty. The second category consists of studies that correlate spending in one economic sector with outcomes in that sector or with broader measures of welfare. Both categories of study can provide useful input into policymaking decisions. However, there is a striking lack of research aimed at examining how the *composition* of public spending affects key development outcomes—a particularly policy-relevant question. In the literature that does look comparatively at public spending across sectors, the empirical methods used include marginal benefit incidence analysis, general equilibrium models, and econometric approaches, which are all discussed in Chapter 2.

Chapters 3 and 4 provide a foundation for the conceptual and empirical portion of the report by discussing Ethiopia's development strategy, key trends in development outcomes, and patterns in public expenditures. In 2002 the Ethiopian government spelled out a development strategy whose main tenets were the continuation of ADLI and expanding fiscal and administrative decentralization. The government's public expenditure priorities have been strongly shaped by these two features of the development strategy.

Chapter 5 describes the framework underlying the empirical analysis of the welfare returns to different types of public spending. It illustrates three stages of the analysis. The first highlights the role of access to public services in determining the welfare of rural households, incorporating the way in which public services and sector-specific outcomes, such as school enrollment and road density, may contribute both directly and indirectly to that welfare. The second stage shows how public services and infrastructure are in turn determined by the amount of public financial resources committed to different sectors. The final stage of the

analysis draws on the pathways captured by the prior two stages to show how public expenditure affects rural welfare.

When assessing how access to different types of public services may affect household well-being and how public expenditure may lead to public services and infrastructure, several issues affecting the transformation of public financial resources into sectoral outcomes and household welfare must be considered:

- Access to public services can have both direct and indirect effects on household welfare. Direct effects obtain, for example, in the case of direct cash or in-kind transfers through a safety-net program. But most public services predominantly improve household welfare in indirect ways, by affecting the returns to, or the productivity of, households' private assets. For example, public investment in irrigation infrastructure improves the welfare of agricultural households by increasing the contribution of their agricultural assets (such as cultivable land) to production.
- There is typically a lag between the public expenses incurred in a sector and the time when a response can be observed. The length of this lag may vary depending on the type of sector-specific service indicator. For example, substantial resource investment in road construction in a given region might be expected to affect road density within one or two years of the investment. In contrast, education spending in a given region will not lead to an improvement in the literacy rate until several years later.
- The complementarity, mutual dependence, and sometimes negative externalities between investments across different sectors will also affect assessment of the returns to public investment. For example, public investment in road infrastructure increases road density and road quality, which in turn may reduce the transport costs for agricultural inputs and outputs, thus improving productivity in the agricultural sector.
- The decision to invest public resources in a given activity will typically be influenced by the state of affairs in the target sector. As an example, if the health sector is better developed in one region compared to other regions, a strong equity focus in (central) expenditure policy would imply the tendency to spend less per capita on health in the better-off region compared to other regions. This potential reverse feedback from sectoral performance to the magnitude of public expenditures has important methodological implications for the empirical analysis.

The empirical strategy, described in Chapter 6, follows the conceptual model described in the previous chapter and undertakes a three-stage analysis to assess the contributions of different types of public services to rural welfare; the effect of public spending on these public services; and finally the returns to public expenditures in terms of rural welfare. Chapter 7 presents the following results:

1. Returns to public investments in road infrastructure are by far the highest. However, the geographic variability of welfare returns to public spending on roads is also higher than that in other sectors. This regional variability in returns to road investment suggests the need for careful region-specific investment policies in the road sector.
2. The household welfare impacts of public expenditure in agriculture are—perhaps surprisingly—smaller than the effects of road spending and do not emerge as being statistically significant.
3. Results suggest that the lack of significance derives from the poor link between public expenditures and the performance of the agricultural sector, and not from a limited role

of agriculture in promoting rural welfare. In fact the performance of the agricultural sector contributes significantly to rural consumption both when considering this role on average in Ethiopia and when assessing regionally disaggregated effects.

4. In contrast to the road infrastructure sector, returns to expenditures in education are characterized by wider reach, more homogeneity, and less intensity. Education spending has widespread effects on welfare that are positive, significant, and similar across a broad range of regions (in contrast to returns to expenditures in the road sector, which are strongly concentrated in a few regions). The magnitude of these returns is more constrained than in the road sector, but still larger and more significant than those to investments in agriculture.
5. Rural welfare returns to spending in the health sector do not emerge strongly, with significant returns in only one region and a relatively low magnitude of birr-for-birr returns. This, together with other findings in the empirical work, suggests that nonincome measures of well-being should be considered in the analysis of future public expenditures.

In conclusion, Chapter 8 points to an issue that goes beyond the scope of this report but is clearly worthy of additional study: the efficiency of public spending. The utility of public investments for household welfare and poverty reduction depends on at least two things: (1) the portfolio of the public budget and the appropriateness of the allocation of resources across sectors, and (2) the efficiency with which resources are used in any given sector or subsector. This report focuses on the former issue, provoking an inquiry into the second question. Such an inquiry is particularly important with regard to Ethiopian agricultural investments, both because agriculture strongly dominates Ethiopia's economy and because the government's development strategy emphasizes the agricultural sector. A substantial body of research suggests that a strategic focus on agriculture may be appropriate, given Ethiopia's stage of development. Therefore an investigation into the drivers of efficiency in the country's agricultural public spending may be the next important step in policy research in Ethiopia.

CHAPTER 1

Public Spending and Rural Welfare in Ethiopia

Over the past decade and a half, Ethiopia's approach to bringing about development and to improving the lives of the country's rural population has been driven by a governmental development strategy called Agricultural Development–Led Industrialization (ADLI).[1] The main goal of this strategy is to attain fast and broad-based development within the agricultural sector and to use this development to power economic growth. While ADLI stipulates regulatory, trade, market, and other policies as an engine of agricultural growth, it has also relied heavily on increasing public expenditure in agricultural and other infrastructure and social sectors that are perceived as contributing to agricultural productivity.

Thus Ethiopia's public expenditure policy is at the heart of the policy measures intended to translate ADLI into reality. Several prior studies have sought to evaluate the success or failure of ADLI by examining other governmental policies considered central to agricultural and rural development, such as the land tenure policy (for example Deininger and Jin 2006), reforms in agricultural input markets (for example Jayne et al. 2002) and agricultural output markets (for example Dercon 1995), policies regarding the agricultural extension system (for example Belay and Abebaw 2004; Benin, Ehui, and Pender 2004; Alene and Hassan 2005), food security programs (for example Farrington and Slater 2006; Gelan 2006), and rural energy policy (for example Teferra 2002; Wolde-Ghiorgis 2002).[2] However, few if any studies have explored whether the government's public budget allocations have been consistent with the stipulated development strategy or with good practices for achieving development. Even less is known regarding the extent to which the actual public investments have achieved improvements in household incomes.

Given the budget constraints faced by governments, the critical and actionable research question with regard to public expenditures is often not whether certain types of public investments contribute to welfare improvements, but rather how different types of public investments compare in terms of their relative contributions to welfare. Any answer to this question will have important implications for expenditure policy, especially in terms of the portfolio composition of public resources.

[1]This strategy is not to be confused with Irma Adelman's concept of ADLI, which stands for agricultural demand–led industrialization (Adelman 1984), although the Ethiopian government's development strategy has several features that appear to draw from Adelman's concept.

[2]These are but a few examples from this extensive body of literature, the bulk of which falls outside the scope of the present report.

This research report explores and compares the impacts of different types of public spending on rural household welfare in Ethiopia. As with the literature on public investment in other developing countries, discussed later, the few published papers on public expenditure in Ethiopia either have been based on general equilibrium models that simulate the effects of changes in overall public spending (Agenor, Bayraktar, and El Aynaoui 2004) or have concentrated on examining how public spending in one particular sector affects performance in that sector (Collier, Dercon, and Mackinnon 2002). We are not aware of any other study comparing the welfare or poverty effects of different types of public expenditure in Ethiopia.

For the purposes of this report, we use the terms *public investment* and *public expenditure* interchangeably. This distinction, while critical in other contexts, is not useful in the present work because we are interested in more than just the physical outcomes of public investment. When considering the number of school buildings, for example, one might examine only the role of capital expenditure (which is often referred to as "public investment" in other contexts) in education as it relates to the number of schools in a given region, without including recurrent expenditures for teacher salaries, supplies, and the like. However, when one is interested in a broader measure of performance in the education sector (for example, the primary enrollment ratio), then both recurrent and capital expenditures in education must be seen as forms of investment in human capital. Therefore, unless otherwise noted, we herein refer to the total (recurrent and capital) amount of public expenditure interchangeably as public expenditure or public investment.

The analysis in this report finds that, among the sectors considered, returns to public investments in road infrastructure are by far the highest. However, the geographic variability of welfare returns to public spending on roads is also higher than that in other sectors. This regional variability in returns to road investment suggests the need for careful region-specific investment policies in the road sector. Perhaps surprisingly, the household welfare impacts of public expenditure in agriculture are smaller than the effects of road spending, and in fact they do not emerge as being statistically significant. Results suggest that the lack of significance derives from the poor link between public expenditures and the performance of the agricultural sector, and not from a limited role of agriculture in promoting rural welfare. Rather the performance of the agricultural sector contributes significantly to rural consumption both when considering this role on average in Ethiopia and when assessing regionally disaggregated effects.

In contrast to the road infrastructure sector, returns to expenditures in education are characterized by wider reach, more homogeneity, and less intensity. Education spending has widespread effects on welfare in that these returns are positive, significant, and similar across a broad range of regions, in contrast to returns to expenditures in the road sector, which are strongly concentrated in a few regions. The magnitude of these returns is more constrained than in the road sector, but still larger and more significant than those to investments in agriculture. Rural welfare returns to spending in the health sector do not emerge strongly, with significant returns in only one region and a relatively low magnitude of birr-for-birr returns.

The following chapter first discusses the empirical literature on public investment and development goals in developing countries; this is followed by a discussion of the existing evidence on public investment impacts in Ethiopia. To place the empirical strategy and estimation of public expenditure effects into context, Chapter 3 begins with a brief overview of the key currents of Ethiopia's development strategy and the development outcomes seen over the past 15 years. This is juxtaposed in Chapter 4 against broad trends in public expenditure, with further detail provided for selected sectors, development strategies, expenditure trends, and performance. Chapter 5 presents the conceptual context for this report and explores some of the challenges inherent in such public expenditure analysis. Chapter 6 describes the econometric strategy based on the conceptual framework of the preceding section. A description of the data and the results of this estimation approach are given in Chapter 7, with overall conclusions presented in the last chapter.

CHAPTER 2

Empirical Approaches to Assessing the Impact of Public Spending

Most of the studies examining the link between public expenditure and development outcomes fall into one of two categories. Studies in the first category explore how the size of *overall* public expenditure or public investment affects growth or poverty. Examples include Agenor, Bayraktar, and El Aynaoui (2004) (described in more detail subsequently), who examined the impact of shifting resources from recurrent to capital expenditure in Ethiopia, and Aschauer (2000), who compared the contributions of overall stocks of public and private capital to the national income while accounting for the size, financing, and efficiency of public capital.

The second category includes studies in which the authors sought to correlate spending in one economic sector with outcomes in that sector, or with broader welfare measures (for example Collier, Dercon, and Mackinnon [2002] on the health sector in Ethiopia, and Roseboom [2002] on agricultural research). Also included in this category are studies seeking to assess the effectiveness of aid by determining the extent to which aid contributes to growth and poverty reduction by supporting increases in certain types of public investment (for example Gomanee, Girma, and Morrissey [2003] on social sector investment).

Both types of studies can provide useful input into policymaking decisions. However, there is a striking lack of research aimed at examining how the *composition* of public spending affects key development outcomes—a particularly policy-relevant question.

Usually the main public investment decision facing policymakers is how to allocate an existing pool of public resources across various sectors, rather than whether to increase or decrease the public budget. The question of allocation is typically considered annually or as part of deliberations over a country's medium-term strategy. Budget allocation is inherently a political process in developing and industrialized countries alike, and budget decisions will typically reflect a range of considerations in addition to overall economic growth or poverty reduction. There is considerable need for studies on which types of public investments contribute the most to development goals, as this information may help shape aspects of the budgeting process.

Paternostro, Rajaram, and Tiongson (2007) noted that the relative lack of research-based studies comparing the effectiveness of different types of public expenditure in contributing to poverty reduction has prompted international donors and the governments of developing countries to equate pro-poor spending with social sector investments, leading to corresponding expenditure policies. However, a number of studies (to be discussed later) have suggested that in many developing countries the greatest contributions to poverty reduction are not necessarily derived from social sector spending, but rather from investments in "hard" infrastructure such as roads, electrification, and agricultural research systems. In the absence of empirical evidence supporting development returns to public spending, considerations other than economic development may fill the vacuum created by this knowledge gap. Hence research on the relative returns to different types of public investment may contribute a great deal to improving policy decisions.

Several methods have been employed to examine the contributions to development outcomes of public spending in different sectors. Marginal benefit incidence analysis has been commonly used to assess the relative poverty orientation of various forms of investment. Ajwad and Wodon (2007) examined municipalities with different income levels in Bolivia and compared the benefit incidence of education, water, sewerage, electricity, and telephone services. However, this and several other studies employing marginal benefit incidence analysis fail to incorporate the actual expenditure outlays for these public services.

Other studies have used general equilibrium models to project public investment effects into the future; these include those by Dabla-Norris and Matovu (2002) on Ghana, Jung and Thorbecke (2003) on Tanzania and Zambia, and Lofgren and Robinson (2005) on several African countries. Several of these studies focused on the effects of education, although other types of investment were analyzed as well. Devarajan, Swaroop, and Zou (1996) used regression analysis (ordinary least squares [OLS] and fixed effects models) to compare the growth effects of public expenditures across functional and economic classifications.

Using various econometric methods, a series of papers have taken an altogether different approach to assessing the relative contribution of different types of spending to agricultural income. Rather than by sector, this literature classifies expenditure by the extent to which they provide public goods or privately incurred subsidies. Using as the central explanatory variable the share of public spending on private subsidies to total public expenditures, in cross-country panel regression in Latin America (Allcott, Lederman, and López 2006; López and Galinato 2007) and in both developed and developing countries (López and Islam 2008), these studies consistently find that reducing the share of private subsidies in expenditure would increase agricultural gross domestic product (GDP), reduce poverty, and make agricultural production more environmentally sustainable.

Another set of studies, also relying on econometric panel data but focusing their analysis at the country level, employ simultaneous equation–based models to study the effect of a range of sectoral expenditures on agricultural growth and poverty outcomes (for example Fan, Hazell, and Thorat 2000; Fan, Zhang, and Zhang 2002). These studies used aggregate province-level data on public expenditure, public capital, sectoral performance indicators, labor and wage variables, and agricultural productivity and poverty. The models incorporated the various pathways by which spending may affect poverty, and they generally showed that public spending on agricultural, health, education, and other sectors built up public capital and improved public services at the sector level. Furthermore they showed that improved public services and sector-level development increased the incomes of rural residents both by fostering agricultural productivity, which improved agricultural incomes, and by providing more nonfarm income opportunities, which increased both wages and off-farm employment. Improved agricultural productivity was also found to have a price effect, as it reduced agricultural prices relative to other prices. Both the price and the (farm and off-farm) income effects were found to contribute positively to poverty reduction.

The previous studies have yielded mixed findings on the relative contributions of public investment in different sectors, perhaps reflecting the range of methodologies employed, variation in the types of economies studied, and differences in the target sectors. Education spending was found to have the largest poverty-reducing effect in several of these studies (for example Fan, Zhang, and Zhang 2002; Fan, Zhang, and Rao 2004), especially in studies that specifically focused on the education sector (for example Jung and Thorbecke 2003; Dabla-Norris and Matovu 2002). In contrast, transportation spending was found to have limited or even negative impacts on poverty (for example Lofgren and Robinson 2005; Ajwad and Wodon 2007). Devarajan, Swaroop, and Zou (1996) found weak evidence that expenditure on certain types of education (subsidiary services such as school feeding and transportation to schools) and health (public health research) had a positive effect on growth, whereas capital-intensive spending categories such as infrastructure had a negative effect on growth. Interestingly several other studies found that road infrastructure investment was the first or second most effective category in terms of reducing poverty (Fan, Zhang, and Zhang 2000; Fan, Zhang, and Rao 2004). The results of the studies classifying expenditures in terms of public goods orientation versus private subsidy orientation—namely that subsidy-oriented spending is detrimental to agricultural income and poverty reduction—are robust to a range of specifications, estimation approaches, and time lags of variables.

This relatively large variation among the results of studies on sectoral spending suggests that the methodologies used to analyze the relative returns to public spending should be carefully considered. A thorough methodological review goes beyond the scope of this report, but we can conclude that the quality of any given analysis is likely to be enhanced when (1) the effects of different types of spending are assessed within a common empirical framework, (2) the estimation accounts for the multiple pathways by which spending may affect growth or poverty, and (3) the common simultaneity problem of a policy variable (for example public expenditure) is appropriately addressed. (See Benin et al. [2008] and Paternostro, Rajaram, and Tiongson [2007] for further discussion of methodological approaches.)

In considering the contributions of investments across different sectors, there has been long-standing acknowledgment that these investments do not contribute to development and welfare exclusively and independently of each other. For example, investments in agricultural research and development that increase the availability of improved seed varieties, as well as improved extension services, can increase the returns to education investments in terms of agricultural productivity (Jamison and Lau 1982; Foster and Rosenzweig 1996). Effective investments in education, in turn, may enhance the returns to irrigation infrastructure (Van de Walle 2000). These studies, however, do not explicitly account for the (public) cost side of these investments—in fact, there is no analytical work to our knowledge which explicitly considers the interdependence of public expenditures in effecting development outcomes.[1]

As stated earlier, to date relatively few studies have provided guidance for public resource allocation across sectors, and the available work has focused on the econometric analysis of differential returns to public expenditure in terms of poverty. Even fewer such studies have been performed at the country level, especially in African countries. This constitutes an important knowledge gap for the continent, especially given the centrality of public expenditure policy in many African economies. This shortage of research likely stems at least in part from the dearth of data on regionally and sectorally disaggregated expenditures, sector-specific outcome variables, and region-specific poverty, income,

[1]One exception is Fan and Saurkar (2005), who studied the case of Uganda.

and growth indicators. Given the potentially high policy relevance of research into public investment priorities, however, such data constraints call for the adaptation of existing empirical methods to allow analysis based on the data landscape in Africa.

As with the literature on public investment in other developing countries, the few such papers on Ethiopia either are based on general equilibrium models simulating the effects of changes in overall public spending or else concentrate on how public spending in one particular sector affected performance in that sector.[2] We are not aware of any other study comparing the welfare or poverty effects of different types of public expenditure in Ethiopia.[3]

Collier, Dercon, and Mackinnon (2002) and Agenor, Bayraktar, and El Aynaoui (2004) reported two of the more careful studies on this topic in the context of Ethiopia. These two studies differed from each other in the scope of public spending examined, the type of effect explored, and the methodology employed, but both focused on the relative returns to reallocating resources from recurrent to capital expenditures. Agenor, Bayraktar, and El Aynaoui (2004) applied an aggregate one-representative-household, one-good macroeconomic model to Ethiopia, and they used it to explore the links among foreign aid, the composition of public investment, growth, and poverty. Policy experiments were conducted to assess the poverty and growth effects of changes in the composition of public spending. In this study, however, the main distinction was made between government consumption (recurrent expenditure) and public investment (capital expenditure) across the broad sectors of health, education, and infrastructure. Hence, rather than conducting a policy simulation in which the sectoral allocation was changed, the authors simulated the effects of a shift from recurrent to capital expenditure.

In contrast, Collier, Dercon, and Mackinnon (2002) focused on the health sector, exploring how different types of public spending in that sector determined the extent to which health services were used by rural residents in various areas of the country. They found that reallocation of public resources for health away from spending that sought to increase the "quantity" of health care toward spending aimed at enhancing the "quality" of health care would increase usage rates. In this sense, as in the study by Agenor, Bayraktar, and El Aynaoui (2004), the authors found that the key trade-off in public expenditure was that between recurrent and capital expenditure.

Aside from the academic literature on public investment, a range of policy and review papers have been made available through development finance organizations, most notably the World Bank through its Public Expenditure Reviews and similar reports. These show trends in public expenditure in Ethiopia, describe fiscal policy and how it affects public resource allocation, and make recommendations for public expenditure management (for example World Bank 2002, 2003, 2004, 2008).

[2]Seifu (2002) conducted a preliminary benefit incidence analysis of public spending on education and health.

[3]As previously, we herein focus specifically on studies explicitly analyzing public expenditures. Several other studies have examined the effects of public investments by determining the impact of access to public services on welfare or poverty in Ethiopia. However, only a few of these studies compared the relative contributions of different types of public services. An exception was Dercon et al. (2007), who carefully analyzed the role of access to all-weather roads and extension services in the consumption growth and poverty of rural households in Ethiopia.

CHAPTER 3

Development Strategy and Development Outcomes in Ethiopia

Development Strategy

In 2002 the Ethiopian government spelled out a four-pronged development strategy consisting of: (1) continuation of ADLI, (2) fiscal and administrative decentralization, (3) reform of the civil service and justice system, and (4) capacity building. The latter is a crosscutting element intended to enhance skills and institutions in the agricultural sector, the civil service system, and the lower tiers of government. Thus the development strategy currently in use involves both economic policies and the transformation of noneconomic institutions.

The government's public expenditure priorities have been shaped by ADLI and the trend toward increased fiscal decentralization. ADLI, which was conceived at the inception of the current government in 1993, was formulated as a long-term strategy to bring about economic growth and poverty reduction by focusing on agriculture as the engine of growth. Within this focus on the agricultural sector, the formulation of ADLI prioritized the dissemination of improved varieties and extension for improved farm practices in a first phase of development, the building of agricultural infrastructure (for example irrigation schemes) in a second phase, and a focus on nonfarm rural employment in a third phase (MOPED 1993).

The second pillar of Ethiopia's long-term development strategy, decentralization, has affected public investment by restructuring the budget process. The federal structure of the government is enshrined in the 1994 constitution, which stipulates that the regional levels of government are to hold significant autonomy in administrative, political, and fiscal affairs. Politically the constitution provides wide executive and legislative powers to each region and even ensures the individual regions' right to secession. Fiscally the power of revenue generation lies predominantly with the federal government, with financial transfers from the central administration to the various regions made formally as unrestricted block grants.

Table 3.1 shows that federal grants tend to comprise a large share of a given region's total budget, ranging from 60 to 87 percent (except for Addis Ababa, the federal transfers of which are very small in both relative and absolute value). From 1996 until recently, public expenditure decisions were made primarily at the regional level of government. As is apparent from Table 3.1, there is considerable regional variation in the size of the transfers, even once these are normalized by population size. Addis Ababa aside, the Oromia region received by far the smallest block grants, amounting to 19 birr per person, whereas transfers to Harari and Gambela were over 20 times higher, at over 400 birr per person (see Figure A.1 for the location of each region).

Table 3.1 Per capita own-source and federal transfer components of regional budgets in Ethiopia, 1997

Region	Own-source (birr)	Transfers (birr)	Total budget (birr)	Transfers as percent of budget	Population share (percent)[a]
Addis Ababa	280	12	292	4	4
Afar	57	159	216	73	2
Amhara	19	46	65	72	26
Beneshangul-Gumuz	46	308	354	87	1
Dire Dawa	57	126	183	69	1
Gambela	264	406	670	61	0
Harari	139	433	572	76	0
Oromia	17	43	60	71	35
SNNP	13	19	32	60	19
Somale	62	163	225	72	6
Tigray	24	79	103	77	6
Average	89	163	252	66	100

Source: Authors' own calculations using data from Ministry of Finance and Economic Development.
Notes: Technically Ethiopia consists of nine administrative regions and two city administrations (Addis Ababa and Dire Dawa). However, in common parlance all eleven administrative units are referred to as "regions"; this practice is adopted in the present report for convenience. SNNP—Southern Nations, Nationalities, and Peoples.
[a]Based on the 1994 Population and Housing Census; some very small figures appear as zero due to rounding.

Interestingly, when the size of the region (in terms of population) is compared with the per capita transfers received, a pattern emerges to partially illuminate how transfers are allocated across regions. An almost perfectly inverse relationship can be seen between the population size and the size of the per capita federal transfer. The larger the region, the smaller the amount of per-person budget transfer. This may be in part due to fixed costs of government administration, although the order of magnitude of difference in the per capita block grants (ranging from 19 birr per person to 400 birr per person) may not be fully explained by economies of scale of regional government administration.

In 2002, some spending responsibility was shifted to the wereda (district) level in the four major regions of Ethiopia, which taken together comprise over 85 percent of the population.[1] Mirroring the 1996 devolution of fiscal responsibility to the regions, this second round of decentralization meant that the weredas began receiving a large share of their revenue as block grants from the regions. At present nearly half of the regional budgets are transferred to the weredas of the four largest regions.

The substantial and far-reaching decentralization policy of the Ethiopian government has necessitated a shift in the priorities of public expenditure, both through the need to allocate resources for capacity building at the lower tiers of government and through differences in policy priorities at the local level. However, there is as yet little research on the extent to which actual

[1]Weredas are administrative units below zones, which in turn lie below regions. In 2004 there were 531 weredas in Ethiopia (CSA 2004), each having an average population of about 100,000. Since then the number of weredas has increased substantially as several weredas were split into two. The four major regions (excluding the city administrations of Dire Dawa and Addis Ababa) are Amhara, Oromia, Southern Nations, Nationalities, and Peoples (SNNP), and Tigray.

expenditure decisionmaking matches the fiscal autonomy formally given to the weredas. For other aspects of decentralization, some insightful research does exist. For a detailed study exploring the divergence between actual and formal political autonomy at the wereda level, for example, see Pausewang, Tronvoll, and Aalen (2002).

Growth, Welfare, and Poverty in Ethiopia

Macroeconomic performance in Ethiopia was positive during the 1990s, when macroeconomic policies sought to control the size of the government deficit, keep inflation low, and generally restore macroeconomic stability. Aside from the transition period of the early 1990s, when the inflation rate spiked to above 30 percent, inflation has remained within single digits. The budget deficit was maintained at between 2 and 10 percent of GDP and was therefore within moderate bounds, with the exception of the period of the border war with Eritrea (1998–2000), when the deficit increased to some 12–13 percent (International Monetary Fund 2002; World Bank 2005b).

During the 1990s growth performance in Ethiopia was moderate and highly volatile. The beginning of the decade was marked by instability after the overthrow of the Marxist dictatorship, which led to a transition period during which per capita GDP growth reached a low of –11 percent (World Bank 2005e). With the end of the civil war, the establishment of a provisional government, and the restoration of political stability (1992/93), GDP increased by 17 percent. While the mean of annual per capita GDP growth was 1.5 percent from 1991 to 2002, 1998 marked another reversion to negative growth. This was the first year of the Ethiopia-Eritrea war, which brought about large losses in agricultural production and the diversion of a substantial amount of expenditure to finance the war.

Despite modest but on average positive growth in Ethiopia during the 1990s, the country's per capita GDP in 2002 was only 8 percent greater than income levels 20 years earlier. This reflected the very weak overall performance of the economy during the 1980s, a decade of stagnation and even decline (average annual growth was negative from 1982 to 1992). In this sense, part of the initial growth seen after the emergence of the current government reflected a recovery from the long civil war and the damaging economic policies of the preceding government.

The moderate economic growth seen in the 1990s failed to translate into noticeable poverty reduction. Poverty rates decreased slightly from 1995 to 2000, with the poverty headcount ratio falling from 45.5 percent to 44.2 percent over this five-year period; this was driven by a modest decline in rural poverty by 2 percentage points, while urban poverty increased markedly from 33 percent to 37 percent during this period (MOFED 2002). This rural-urban differential was even more pronounced when poverty rates were measured using spatially and temporally specific poverty lines (World Bank 2005d). This difference may reflect the emphasis on the agricultural sector as the engine for development through ADLI, as well as such other factors as outmigration of rural poor to the towns and cities.

A regional disaggregation of poverty rates (Table 3.2) shows that the marginal poverty reduction over the latter half of the 1990s was derived almost exclusively from poverty reduction in the Amhara region, where the poverty rate fell by 10 percentage points.[2] For most other regions poverty either increased or declined marginally.

[2]The distinction between upper and lower poverty lines is derived from two different ways of calculating the poverty line, with the former using a "poorer" reference group for calculation of poverty compared to the latter. For more details see World Bank (2000d, 16).

Table 3.2 Geographic distribution of poverty: Headcount poverty rates across regions, 1995 and 1999

	Lower poverty line			Upper poverty line		
Region	1995	1999	Difference (percentage points)	1995	1999	Difference (percentage points)
Addis Ababa	34	41	7	50	57	7
Afar	20	43	23	26	63	37
Amhara	45	36	–9	65	55	–10
Beneshangul-Gumuz	49	54	5	72	71	–1
Dire Dawa	47	49	2	65	68	3
Gambela	35	66	31	48	79	31
Harari	25	29	4	43	47	4
Oromia	28	32	4	46	52	6
SNNP	49	48	–1	67	65	–2
Somale	8	15	7	18	33	15
Tigray	45	49	4	66	69	3

Source: World Bank (2005d).
Note: SNNP—Southern Nations, Nationalities, and Peoples.

Poverty was most prevalent in the two small western regions, Beneshangul-Gumuz and Gambela (the latter in 1999). As discussed in the previous section and subsequently, while poverty and income measures showed the two western regions to be among the worst off, they scored very high in public investments and public capital variables that reflect these investments. This likely mirrors the (regional) equity emphasis in government allocations of public resources. Somewhat surprisingly—given that it is considered one of the regions that lags furthest behind—Somale enjoyed the lowest poverty incidence by far, during both time periods and using either poverty line. Afar (in the earlier period) and Harari (in 1999) had the next lowest rates of poverty. It is also noteworthy that the two city-states, Addis Ababa and Dire Dawa, were at or below the median in terms of poverty rates by region.[3]

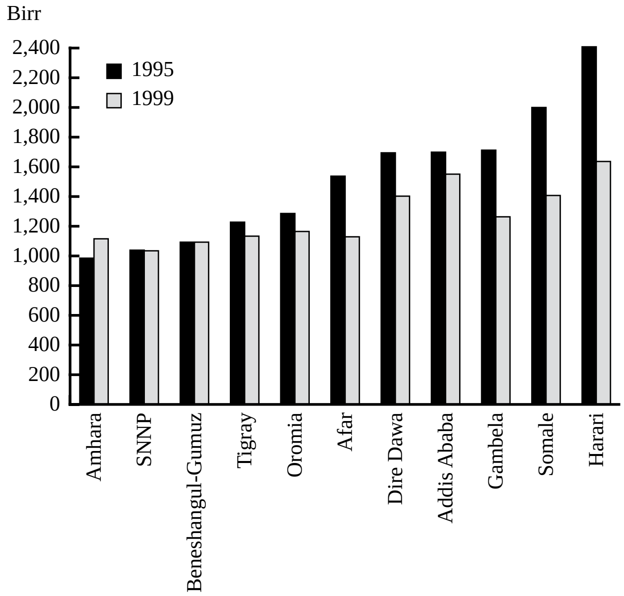
In assessing average welfare, we will concentrate on rural welfare because it is the central variable of interest in our subsequent analysis of public investment impact. While on average the percentage of people in poverty moderately declined in rural areas over the second half of the 1990s, average rural welfare actually fell, as seen in Figure 3.1 (which reflects Table A.1 in the Appendix). Overall rural household welfare declined by 2 percent, driven by welfare declines in eight out of the eleven regions. Figures 3.1a and 3.1b rank the regions by their initial (1995) average per capita household welfare, with Figure 3.1a showing an inverse relationship between initial welfare and subsequent welfare growth in Ethiopia.

Figure 3.2 represents a similarly disaggregated picture of household welfare, but it is based on a different nationwide survey and provides a further breakdown of mean

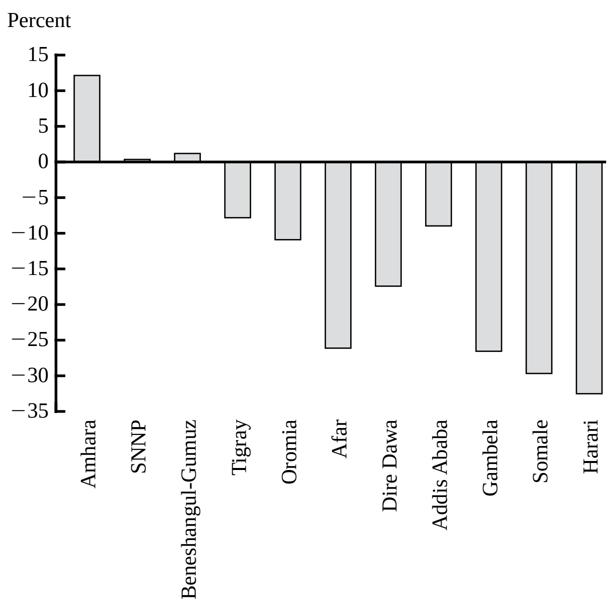
[3]The distribution of poverty rates by region drawn from World Bank (2005d), the information on region-averaged income from CSA (2001) (see Figure 3.1a), and the regional dummies in the later econometric results are all reasonably consistent with each other. However, they are consistently counterintuitive. One would expect, for example, the capital, Addis Ababa, to have close to the lowest poverty rate and average welfare, and the pastoral and remote regions of Somale and Afar to be at or below the median.

Figure 3.1 Per capita household expenditure by region

(a) Household expenditure levels, 1995 and 1999



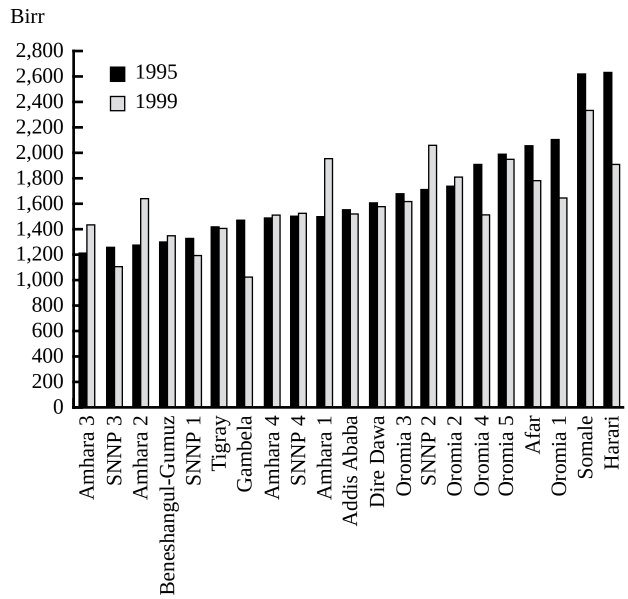
(b) Household expenditure changes, 1995–2000



Source: Central Statistical Authority (2001), based on the Household Income, Consumption and Expenditure Surveys.

Note: SNNP—Southern Nations, Nationalities, and Peoples.

Figure 3.2 Real per-adult-equivalent household expenditure



Source: World Bank (2005d), based on the Welfare Monitoring Surveys.
Note: SNNP—Southern Nations, Nationalities, and Peoples.

household expenditures in the large regions, divided by groups of zones (see Table A.2 in the Appendix for further details). The two representations of the geographic distribution of welfare found in Figures 3.1 and 3.2 are broadly consistent with each other.

Thus the geographic distribution of well-being in Ethiopia (based on both poverty and mean income estimates) indicates that in the second half of the 1990s residents of the southern region and the two western regions, Gambela and Beneshangul-Gumuz, were the least well-off. In contrast, the highest incomes and lowest poverty rates were found in the pastoral region of Somale and the small, dominantly urban eastern region of Harari. The only notable improvement in poverty incidence and average household income during this period was achieved in the Amhara region.

CHAPTER 4

Strategies, Public Spending, and Performance in Key Sectors

Multiple data sources are represented in both the descriptive and econometric analyses. The public expenditure data, drawn from the Ministry of Finance and Economic Development (MOFED), comprise annual data from fiscal years 1993/94 to 2000/01 and include federal and regional expenditures, with the later years including expenditure data from the districts and other administrative units. These data are disaggregated by functional and economic classification. Further sector-specific data, usually disaggregated by region and available for multiple years, were obtained from the respective line ministries and are primarily contained in the following descriptive sections. The latter also include agricultural variables, such as crop yield. These were obtained from multiple years of the Agricultural Sample Survey conducted by the Central Statistical Authority (CSA).

The analysis of the determinants of rural household welfare draws on an Ethiopian national household budget survey, referred to as the Household Income, Consumption and Expenditure Survey (HICE), which was conducted by the CSA in 1999/2000. Given that we focus herein on rural welfare, only the rural household observations from the HICE are used. Part of the data on household access to public services is drawn from the CSA's Welfare Monitoring Survey of the same year. The analysis also includes data on sectoral performance drawn from a World Bank database including a range of economic, agricultural, and demographic variables at the zone level.

Public expenditure trends since the conception of the ADLI strategy in 1993 have only partially reflected the orientation of the government's strategy toward agricultural development. Sectors seen as important to poverty reduction (such as agriculture, natural resource development, health, education, and road infrastructure) have absorbed a relatively steady share of total spending. In contrast, the proportion of expenditure on agriculture and natural resources, while high compared to that in most other African countries, has declined moderately (Table 4.1).[1]

In addition ADLI mandates greater investment in public goods that predominantly benefit households relying directly on agriculture, as well as goods aimed at transforming the agricultural sector from a subsistence sector to one that contributes to commercial activity and the country's export revenue. The government's expenditure policy in these sectors is discussed in more detail later.

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[1]The various African governments recently agreed to strive toward allocating at least 10 percent of public spending to agriculture—as called for by the Comprehensive African Agriculture Development Program of the New Partnership for Africa's Development—but only a few governments, including that of Ethiopia, have met this goal in one or more years over the past decade.

Table 4.1 Public expenditures on selected sectors, 1984–2005 (percent of total public expenditure)

	Year	Energy and mining	Agriculture and natural resources	Education	Health	Transportation and communications	Roads[a]	All six sectors
Actual expenditures	1984	6.8	15.8	9.7	3.2	2.6	2.1	40.1
	1989	4.7	12.8	9.4	3.3	1.7	1.0	32.9
	1994	3.4	13.1	13.5	5.1	2.3	9.0	46.4
	1995	4.4	12.7	15.1	5.3	2.5	7.4	47.4
	1996	8.0	13.4	14.5	5.8	4.0	8.1	53.9
	1997	3.7	11.3	14.0	5.9	1.9	8.6	45.5
	1998	3.1	11.2	11.6	4.3	2.5	7.0	39.8
	1999	1.8	8.3	9.5	3.3	1.9	6.2	31.1
	2000	2.8	9.4	13.4	4.0	2.7	8.4	40.8
	2001	0.4	12.4	16.4	4.8	3.0	10.6	47.5
Provisional expenditures[b]	2002	2.8	11.3	16.6	5.1	1.5	9.6	46.9
	2003	2.5	15.6	20.6	4.3	1.2	9.1	53.3
	2004	0.5	21.0	19.9	4.9	2.9	10.7	59.9
	2005	1.0	21.3	21.8	4.6	4.2	11.8	64.6

Source: World Bank (2004).

[a]Only capital expenditures; however, road capital expenditures tend to make up nearly all of the road expenditures that go through the public budget (see also Table 4.3).

[b]Estimates of actual expenditures in years for which the accounts were not yet closed when the data were compiled.

As shown in Table 4.2, the decentralization of public investment responsibility has progressed further in the social sectors than in infrastructure sectors, such as energy, roads, and transportation and communications. The ratio of federal-level expenditure to countrywide expenditure in the energy sector is as high as 97 percent, whereas federal expenditures in education and health account for only 25 percent and 16 percent, respectively, of total government spending in these areas.

Energy

Ethiopia suffers from a general lack of infrastructural development, particularly in the area of energy supply. This constitutes a tremendous constraint limiting the development of agriculture and rural towns. Agricultural productivity is severely inhibited by reliance on rainfed production in volatile climates, where irrigation facilities are nonexistent, due in part to the lack of a suitable power supply. In rural towns lacking electricity, residents, shops, and small-scale industries must all rely on inefficient and insufficient traditional energy technologies, limiting commercial activity, production, and rural growth.

As is the case in several other Sub-Saharan African countries, the main energy sources in rural Ethiopia are biomass resources such as fuelwood and dung. The use of electricity in Ethiopia is minuscule, with only 0.7 percent of rural households using electricity for lighting in 1995 (Wolde-Ghiorgis 2002). This level of access to electric power is actually lower than that in many other poor countries; for example, according to the World Bank (2005b) electricity consumption per capita in 2001 was 22 kWh in Ethiopia, whereas in the same year it was 456, 331, and 89 kWh for, respectively, Sub-Saharan Africa as a whole, South Asia, and the Least-Developed Coun-

Table 4.2 Composition of total expenditure by level of government, 1998

	Federal government	Regional governments	National total
Roads			
Million birr	598.7	461.1	1,059.8
Percent	56.5	43.5	100.0
Education			
Million birr	429.9	1,272.8	1,702.7
Percent	25.2	74.8	100.0
Health			
Million birr	104.5	533.8	638.4
Percent	16.4	83.6	100.0
Agriculture			
Million birr	569.6	589.7	1,159.2
Percent	49.1	50.9	100.0
Natural resources			
Million birr	122.2	366.9	489.0
Percent	25.0	75.0	100.0
Energy and mining			
Million birr	437.8	12.8	450.6
Percent	97.2	2.8	100.0
Transportation and communications			
Million birr	354.4	17.3	371.6
Percent	95.4	4.6	100.0

Source: Authors' own calculations using data from Ministry of Finance and Economic Development.

tries.[2] Other sources—including solar power and other renewables, petroleum, and natural gas—represent only a negligible share of total rural energy consumption.

Access to electric power in general, and rural electrification in particular, remain low in Ethiopia despite the fact that electricity-related expenditures have accounted for 90–95 percent of the capital budget for the energy sector over the past decade (Wolde-Ghiorgis 2002) and public expenditure on energy is comparable to that in other important sectors, such as public health. While public investment in infrastructure is an important part of the government's agriculture-led growth and poverty reduction strategy, the energy sector is not among the key priorities of this strategy. As laid out in Ethiopia's 2002 poverty reduction strategy paper (MOFED 2002), the priority sectors slated to receive escalated financing are agriculture (with an emphasis on the provision of extension services and food security), water (with a focus on rural water supply), roads (with an emphasis on construction and upgrading of trunk roads), education (primary education), and health (maternal and child health and prevention of malaria and tuberculosis).

Road Infrastructure

Figure 4.1 shows the state of road infrastructure in Sub-Saharan African countries, using the two common measures of road density: total road length normalized by population size and by land area. While road density in Africa is abysmally low, Ethiopia ranks nearly last in the region, with 521 km of roads per million people. Only

[2]United Nations classification.

Sudan has a lower population-normalized road density. When road density is measured with respect to land area, Ethiopia still ranks ninth from last (with Sudan again last) among African countries, with 36 km of roads per 1,000 km^2. This current state of road infrastructure, in fact, follows a drastic increase in public investment in roads since the mid-1990s. This resulted in an expansion of the total road network in Ethiopia by 35 percent. As of 2005 about half of Ethiopia's road network is made up of trunk and link roads administered by a federal agency, the Ethiopian Roads Authority. The remainder are the so-called rural roads, which are administered by regional agencies, the rural roads authorities.

Public investment and other policies regarding roads are laid out in the Road Sector Development Program (RSDP), developed by the Ethiopian Roads Authority in 1997. The RSDP outlines a 10-year strategy for developing road infrastructure. During the first phase, from 1997 to 2002, road-building projects were to give priority (in this order) to providing improved access to ports, as well as existing and new resource areas and food-deficit areas, and to maintaining a degree of equity between the regions in terms of transport infrastructure. Given these priorities, a relatively large share of the capital expenditures were allocated for asphalt and gravel roads. However, the 34 percent increase in unpaved roads in the latter half of the 1990s was much higher than the increase in paved roads (7 percent) over the same period (MOFED 2002).

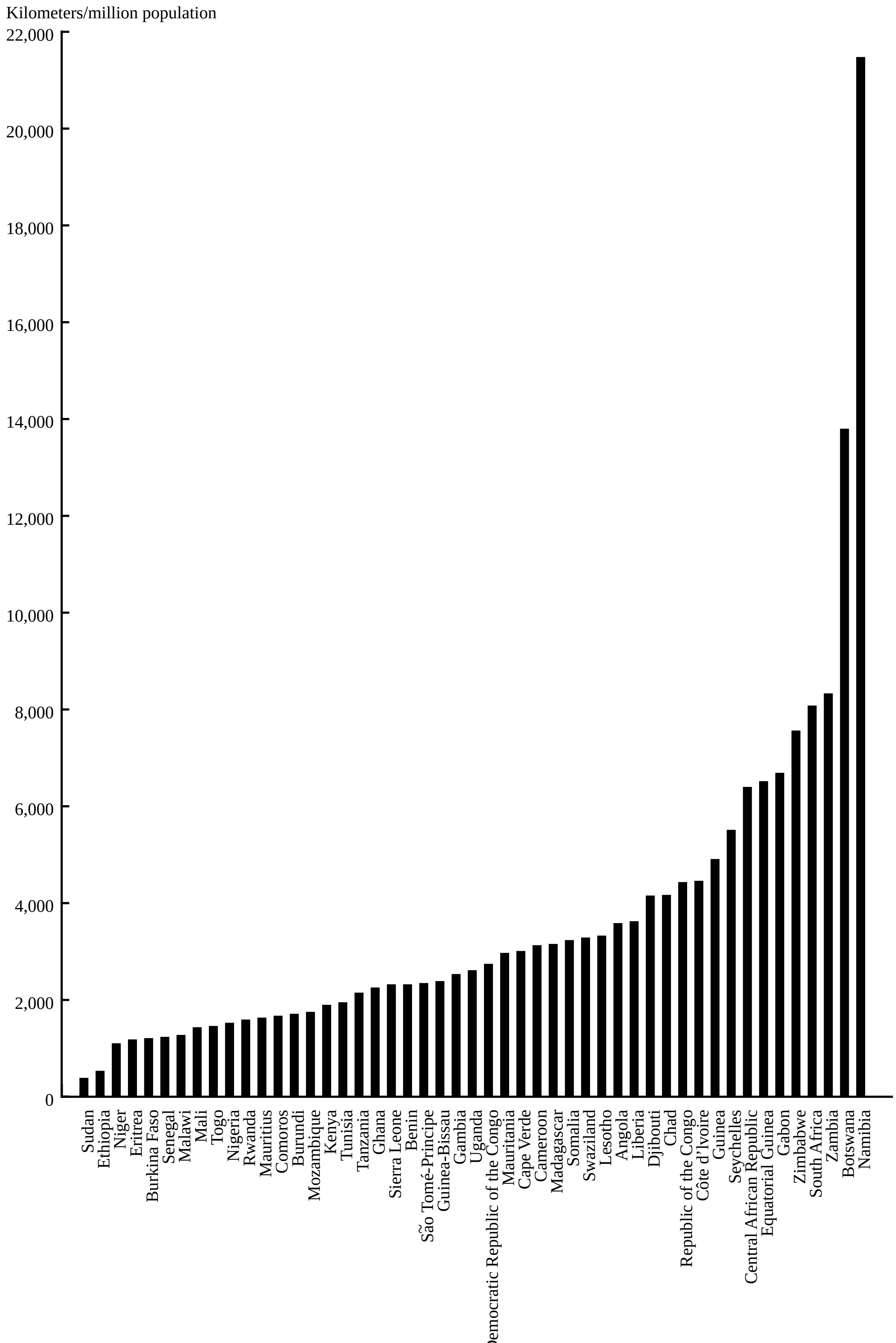
The second phase of the RSDP, from 2003 to 2007, was designed to address the low level of road connectivity among the regions. The main roads typically radiate from Addis Ababa to the various regions, but travel between regional towns is difficult. The second phase of the RSDP also emphasized the development of village rural roads, which were more likely to immediately benefit poor populations. Village-level associations were assigned the task of proposing and implementing road projects. However, institutions at all administrative levels—kebeles (peasant associations), weredas, regions, and the federal level—are expected to be involved in the various stages of rural road development.

Public investment in roads as a share of spending in the agricultural, social, and infrastructure sectors increased significantly, beginning with the change of government in 1991. As seen in Table 4.1, this share of spending in these sectors rose from 3–5 percent in the 1980s to 15–20 percent in the 1990s. Indeed the relative increase in spending on road construction is unrivaled by the increase in any of the other agricultural, social, or infrastructure sectors in Ethiopia.

Table 4.3 shows the geographic distribution of road spending. When the share of each region's (capital) expenditure, expressed relative to the total capital spending of all regions, is compared with its share of the population, it becomes evident that the capital city-state Addis Ababa and the more marginal areas of Beneshangul-Gumuz, Gambela, and (to some extent) Afar have allocated resources to roads well beyond their population shares.

Tables 4.4 and 4.5 show road density by region, with Table 4.4 showing density over time and Table 4.5 showing these data disaggregated by road type. A comparison of Tables 4.4 and 4.5 with Table 4.3 shows that in the case of the road sector, the geographic distribution of sectoral performance may be broadly aligned with the expenditure distribution. Road density, measured as kilometers of roads per 1,000 people, was consistently highest in Gambela and second highest in either Beneshangul-Gumuz or Afar, depending on the year. However, while population-based road density was highest in the marginal regions, it was lowest (or, to be precise, zero) for asphalted roads in regions such as Beneshangul-Gumuz, Gambela, and Somale. Interestingly and surprisingly, Table 4.5 shows that it was highest for Afar, possibly due to the low population density in this pastoral region. When road density was measured in

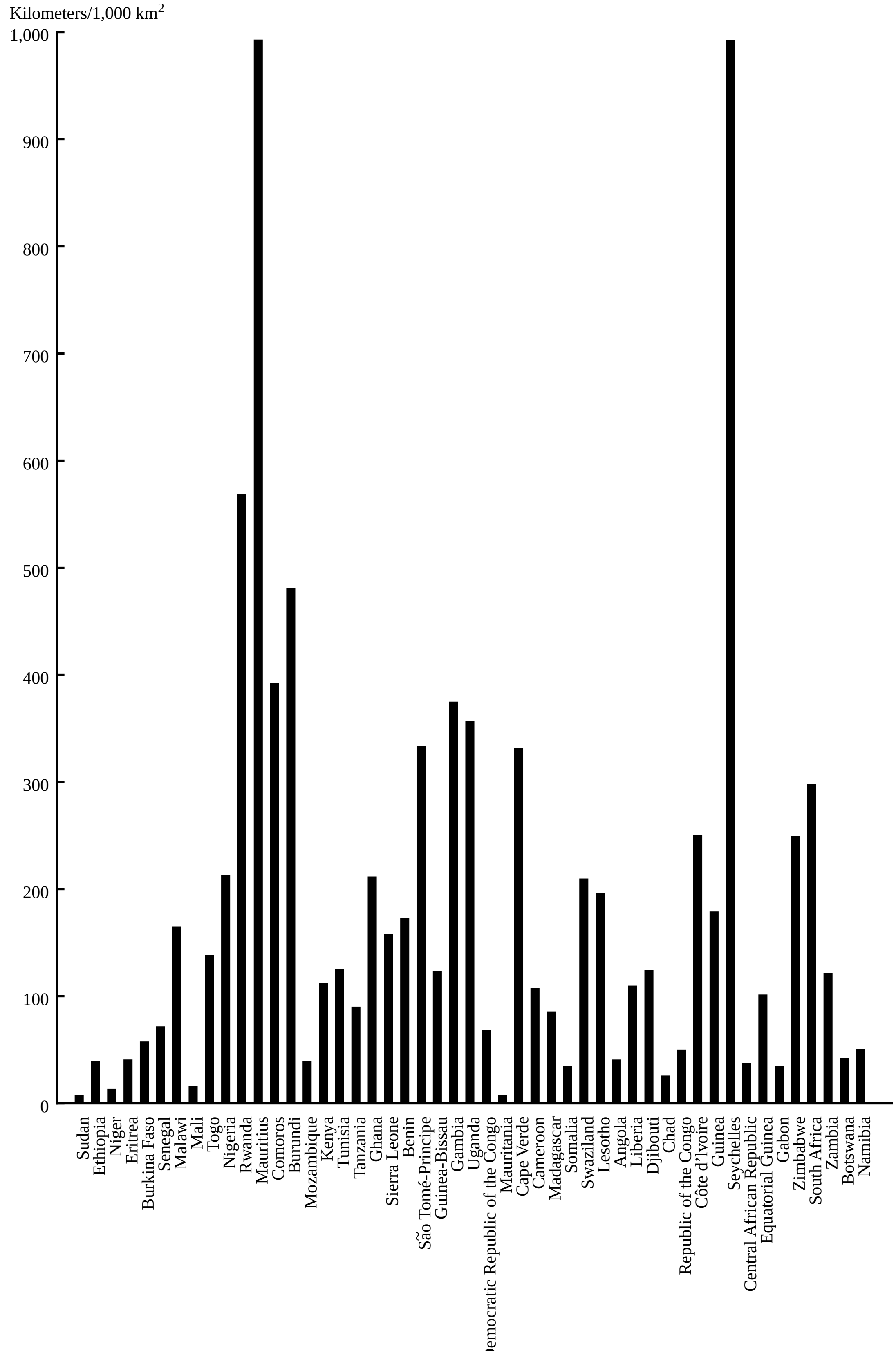
Figure 4.1 Road density in Ethiopia and Sub-Saharan African countries



Source: World Bank (2007).

Note: The most recent data available vary by country, between 1999 and 2004. The most recent data available for Ethiopia are from 2004.

Figure 4.1 Continued



Note: The most recent data available vary by country, between 1999 and 2004. The most recent data available for Ethiopia are from 2004.

Table 4.3 Capital and recurrent road infrastructure expenditures by region, 1998

	Addis Ababa	Afar	Amhara	Beneshangul-Gumuz	Gambela	Harari	Oromia	SNNP	Somale	Tigray	Regional total
Capital											
Million birr	117.9	17.7	78.3	23.5	13.8	0.0	98.5	48.4	24.0	20.6	442.8
Percent	26.6	4.0	17.7	5.3	3.1	0.0	22.2	10.9	5.4	4.7	100.0
Recurrent											
Million birr	8.4	0.0	3.9	0.2	0.0	0.0	4.7	0.0	0.0	1.1	18.3
Percent	46.0	0.0	21.1	1.2	0.0	0.0	25.9	0.0	0.0	5.8	100.0
Recurrent as percent of total	6.7	0.0	4.7	0.9	0.0	0.0	4.6	0.0	0.0	4.9	4.0
Population											
Thousands	2,570	1,243	16,748	551	216	166	23,023	12,903	3,797	3,797	65,344
Percent	3.9	1.9	25.6	0.8	0.3	0.3	35.2	19.7	5.8	5.8	100.0

Source: Authors' own calculations using data from Ministry of Finance and Economic Development. Data for Dire Dawa were not available.
Note: SNNP—Southern Nations, Nationalities, and Peoples.

Table 4.4 Density of all-weather roads, selected years

	Kilometers per 1,000 persons					Kilometers per 1,000 km^2				
Region	1995	1996	1997	2003	2004	1995	1996	1997	2003	2004
Addis Ababa	n.a.	n.a.	n.a.	0.7	0.7	n.a.	n.a.	n.a.	3,659.4	3,849.7
Afar	0.7	1.0	1.0	1.5	1.6	8.7	12.6	12.7	21.3	23.7
Amhara	0.2	0.3	0.3	0.4	0.4	20.8	32.1	32.9	46.0	48.5
Beneshangul-Gumuz	0.8	0.9	0.8	2.5	3.1	8.0	8.4	8.4	29.1	36.4
Dire Dawa	n.a.	n.a.	n.a.	0.4	0.5	n.a.	n.a.	n.a.	93.6	126.8
Gambela	1.7	4.8	4.7	5.9	6.6	12.6	36.3	36.3	52.1	60.5
Harari	n.a.	n.a.	n.a.	0.4	0.7	n.a.	n.a.	n.a.	188.8	315.7
Oromia	0.4	0.5	0.5	0.4	0.4	22.5	34.4	34.4	29.8	31.0
SNNP	0.2	0.3	0.3	0.4	0.4	19.5	25.2	26.5	43.8	46.8
Somale	0.4	0.4	0.4	0.8	0.8	3.8	4.0	4.2	10.1	10.6
Tigray	0.2	0.5	0.5	0.6	0.7	12.0	29.1	30.0	44.1	51.0
Ethiopia	0.3	0.4	0.4	0.5	0.5	14.0	21.2	21.6	30.1	32.5

Source: Central Statistical Authority (1995, 1996, 1997); Ethiopian Roads Authority.
Note: n.a.—Not available; SNNP—Southern Nations, Nationalities, and Peoples.

Table 4.5 Road density by road type, 2003

	Kilometers per 1,000 persons				Kilometers per 1,000 km^2			
Region	Asphalt roads	Gravel roads	Rural roads	All roads	Asphalt roads	Gravel roads	Rural roads	All roads
Addis Ababa	0.155	0.550	0.000	0.706	804.948	2,854.424	0.000	3,659.372
Afar	0.539	0.277	0.673	1.489	7.720	3.971	9.648	21.340
Amhara	0.049	0.112	0.230	0.391	5.739	13.208	27.010	45.957
Beneshangul-Gumuz	0.000	1.302	1.243	2.540	0.000	14.910	14.238	29.148
Dire Dawa	0.075	0.244	0.078	0.395	17.650	57.528	18.446	93.624
Gambela	0.000	2.661	3.199	5.860	0.000	23.650	28.437	52.087
Harari	0.105	0.133	0.179	0.418	47.462	60.152	81.218	188.832
Oromia	0.073	0.117	0.194	0.383	5.735	9.190	15.196	30.121
SNNP	0.031	0.153	0.245	0.428	3.600	18.090	28.913	50.603
Somale	0.000	0.292	0.523	0.815	0.000	3.632	6.511	10.143
Tigray	0.060	0.313	0.249	0.622	4.253	22.222	17.672	44.146
Ethiopia	0.065	0.184	0.255	n.a.	3.977	11.288	15.661	167.408

Source: Ethiopian Roads Authority (road length); Central Statistical Authority (population data); dataset for World Bank (2005b) (land area).
Note: n.a.—Not available; SNNP—Southern Nations, Nationalities, and Peoples.

terms of area (kilometers of roads per 1,000 km^2), Addis Ababa, followed by the city-state of Harari, had the highest density.[3]

Agriculture

As discussed earlier, agriculture is at the heart of the ADLI strategy and is expected to fuel economic growth and poverty reduction. Given such a focus on the agricultural sector, one would expect to see strong resource allocation to agriculture since 1993, when ADLI was first conceived. Indeed, despite fluctuations, real agricultural expenditure has been increasing since then (Table 4.6). Through the decentralization and intensification of extension services, which is one of the key features of ADLI, expenditure on agricultural extension approximately doubled over the 1990s (although it continues to constitute a rather small share of agricultural spending).

Table 4.6 also suggests that, over time, allocations have shifted somewhat away from spending related to natural resources and the environment in favor of agriculture. With the country heavily dependent on both agriculture and its natural resource base, and given the intimate relationship between the agricultural sector and the environmental and natural resource sector, it is not immediately apparent how the government should balance its spending between these two areas. The noticeable shift of expenditures in favor of the agricultural sector appears to reflect the increasingly high priority accorded by the government to the provision of agricultural services and technology.

Regarding the administrative sources of spending in the 1990s—that is, the share of expenditures executed by subnational administrative units versus the federal government—the last row of Table 4.6 shows that regions handled the majority of expenditures in the agricultural and natural resources sector. Despite progressive decentralization in Ethiopia, this share has declined in recent years. World Bank (2008) discusses this trend in greater detail.

A regional breakdown of real per capita expenditure on agriculture over this period is presented in Table 4.7. For most of the regions, agricultural spending was less than 30 birr per capita. Some of the highest expenditures, however, took place in the relatively urbanized regions of Addis Ababa and Harari. The Gambela region spent by far the largest amount per capita in agriculture; this no doubt reflects the dramatically higher per capita public budget and federal transfers to Gambela. While the national figure for agricultural spending as a whole moderately increased during this period, high variation was seen at the regional level, meaning that no particular regional spending pattern is readily discernable.

The regional distribution of land productivity (one indicator of agricultural performance) is illustrated in Table 4.8. Thanks to its favorable agroecological conditions, Gambela had the highest yield levels by far, whereas the arid regions of Afar, Dire Dawa, Harari, and Somale had the lowest. In particular the pastoral regions of Afar and Somale rely much more heavily on livestock breeding as the main economic activity, hence these results are not unexpected.

One could naturally expect there to be a lag period between the inception of agricultural expenditures and the point at which results might be observed in terms of agricultural performance. Even given this, however, it appears that over the 1990s agricul-

[3]This is despite the fact that these road data do not capture municipal roads, but only rural and interregional roads. For example, the total road network of the SNNP region does not include the length of roads managed by the cities within SNNP. However, the very high density of interregional and other nonmunicipal roads passing through commercially important towns such as Addis Ababa and Harari contributes to these city-states' high figures for road infrastructure.

Table 4.6 Total national expenditure on agriculture and natural resources, 1993–2000 (millions, constant 1995 birr)

Expenditure category	1993	1994	1995	1996	1997	1998	1999	2000
Ministry of Agriculture	196.2	224.9	304.1	363.5	373.1	417.1	388.3	451.0
Agricultural research	78.8	61.5	15.8	31.8	74.0	98.2	105.1	170.1
Agricultural extension	10.7	9.8	18.5	16.9	23.9	26.0	22.2	19.4
Other agricultural services	306.1	223.3	311.3	296.9	181.2	553.9	417.6	303.8
Seed	—	—	0.3	0.4	0.8	2.7	1.9	3.2
Fertilizer	—	—	—	0.5	0.6	0.7	0.7	9.8
Coffee and Tea Authority	60.2	63.4	24.8	19.5	5.4	7.3	33.6	27.3
Livestock	—	—	—	—	—	1.6	1.5	2.0
Cooperatives development	—	—	—	—	—	—	—	3.4
Integrated development	—	—	—	—	—	0.6	1.4	2.2
Rural infrastructure	16.7	—	—	—	44.6	57.9	—	—
Other agricultural expenditures	—	—	—	—	—	—	—	3.2
Ministry of Water	69.4	109.4	61.5	61.3	55.5	57.6	65.5	93.9
Water supply	—	248.9	220.5	345.0	346.8	293.4	254.4	196.4
Other water expenditures	—	—	—	119.2	92.0	134.5	49.1	122.2
Environment	—	—	—	1.1	1.3	1.6	1.8	3.1
Biodiversity	—	—	—	—	1.2	1.5	1.6	4.2
Other natural resource expenditures	411.8	262.1	202.7	127.5	51.7	—	—	—
Total	1,149.9	1,203.4	1,159.4	1,383.6	1,252.2	1,654.5	1,344.6	1,415.3
Percent subnational	69.8	63.4	71.0	79.5	76.2	58.0	58.4	58.1

Source: Authors' own calculations using data from Ministry of Finance and Economic Development.
Notes: "Ministry of Agriculture" refers mostly to administrative and personnel expenditures of the ministry. There was little information in the data provided on what constituted "Other agricultural services." Refer to World Bank (2008) for a more in-depth discussion of the composition and pattern of public spending on agriculture and rural development in Ethiopia. — indicates the category was not recorded for this year.

Table 4.7 Real per capita regional expenditure on agricultural and natural resources, 1993–2000 (birr)

Region	1993	1994	1995	1996	1997	1998	1999	2000
Addis Ababa	11.76	22.43	50.25	61.91	58.72	44.64	29.66	13.31
Afar	32.29	16.57	16.09	6.47	18.27	61.27	33.63	24.29
Amhara	8.25	10.40	10.40	11.27	12.12	11.96	9.10	9.69
Beneshangul-Gumuz	18.87	23.90	19.84	11.29	14.66	43.24	56.86	36.78
Dire Dawa	14.42	18.32	17.52	14.16	15.26	14.91	8.39	7.86
Gambela	52.58	77.29	100.29	134.37	48.88	37.11	35.94	34.80
Harari	4.49	58.67	32.46	52.92	50.46	21.48	16.63	104.97
Oromia	10.30	14.76	12.79	20.28	14.93	12.08	10.77	15.50
SNNP	8.00	12.80	13.16	12.85	10.29	15.25	7.54	7.91
Somale	3.42	10.47	19.18	18.54	14.58	11.94	25.83	10.65
Tigray	17.67	19.04	13.80	34.80	26.91	17.18	12.98	12.91
Ethiopia	16.63	22.08	20.64	23.89	20.97	26.88	21.19	21.68

Source: Authors' own calculations using data from Ministry of Finance and Economic Development.
Note: SNNP—Southern Nations, Nationalities, and Peoples.

tural productivity has not responded to investments. It may therefore be necessary to empirically extend this descriptive analysis in order to examine other indicators of agricultural performance, further dissect the provision of public services within the agricultural subsectors, and monitor performance indicators within the agricultural sector over a longer period.

Education

The rural literacy rate in Ethiopia (for the population 10 years old and above) started from a very low baseline in the early 1990s and has since shown improvement both in levels and in terms of urban-rural and gender disparities. In 1999 the rural and urban literacy rates were 22 and 70.4 percent, respectively (MOFED 2002), which in turn had improved from 16 and 70 percent, respectively, only two years earlier. The gender gap in rural literacy improved somewhat during this period, with the ratio of female literacy rate to male literacy rate rising from 0.28 to 0.33. However, as of 2002, Ethiopia remained far behind other poor countries worldwide in terms of educational outcomes (Table 4.9).

Ethiopia has made some important progress when one considers the longer view and examines intermediate outcomes in the education sector. Over the past 10 or so years, educational coverage at all levels

Table 4.8 Yield of annual crops by region, 1995–2000 (quintals per hectare)

Region	1995	1996	1997	1998	1999	2000
Addis Ababa	14.9	12.0	13.0	10.0	10.3	12.6
Afar	7.9	13.2	7.3	n.a.	12.9	2.5
Amhara	9.8	10.2	8.9	9.5	9.4	9.5
Beneshangul-Gumuz	11.1	10.5	11.4	11.3	10.7	10.2
Dire Dawa	5.9	11.6	7.4	10.5	10.0	9.2
Gambela	22.6	17.4	19.3	20.5	19.3	21.5
Harari	10.4	9.7	7.4	8.5	8.8	7.5
Oromia	13.1	13.2	12.2	11.7	12.1	12.9
SNNP	13.3	13.5	12.6	10.6	10.6	11.9
Somale	7.1	7.3	9.8	5.7	4.7	7.6
Tigray	11.0	12.3	8.9	10.8	11.1	9.8
Ethiopia	11.7	11.9	10.7	10.7	10.8	11.2

Source: Calculated using data from the Central Statistical Authority’s Agricultural Sample Surveys, 1995–2000.
Note: n.a.—Not available; SNNP—Southern Nations, Nationalities, and Peoples.

Table 4.9 Literacy rate, 1990 and 2002 (percent of 15-year-olds and above)

	Male			Female			Gender gap	
	1990	2002	Increase	1990	2002	Increase	1990	2002
Ethiopia	37	49	12	20	34	14	17	15
South Asia	59	67	8	34	44	10	25	23
Sub-Saharan Africa	60	71	11	40	56	16	20	15
Low income	64	72	8	42	53	11	22	19

Source: World Bank (2005e).

has experienced a sustained increase. The greatest success was achieved at the primary level, where the gross enrollment ratio more than tripled from 20 percent in 1993 to 62 percent in 2001. Other levels also showed increases, with the enrollment ratio in secondary education increasing from 8 percent to 12 percent, and that in tertiary education increasing from 0.5 percent to 1.7 percent (World Bank 2005a; see also Table 4.10).

Unfortunately these improvements in coverage have been accompanied by a sustained deterioration in educational quality. The national average pupil-to-teacher ratio (PTR) increased steadily over the 1990s and into the new millennium (Table 4.11), with the most serious effects seen in rural areas. For example, the PTR in 1994 was 32 in rural areas and 34 in urban areas. By 2001 the PTR in rural areas had more than

Table 4.10 Primary school (grades 1–8) gross enrollment ratio, 1994–2003

Region	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Addis Ababa	84.9	82.9	80.3	82.0	84.7	91.4	118.3	128.4	135.4	142.6
Afar	8.4	8.4	8.4	8.4	7.1	9.1	11.5	12.6	13.8	14.8
Amhara	17.9	22.3	28.0	34.6	40.4	46.8	53.3	58.1	58.5	61.8
Beneshangul-Gumuz	35.4	42.8	48.6	69.9	74.9	81.8	88.5	89.1	98.4	100.5
Dire Dawa	41.0	41.6	50.7	58.9	60.0	62.4	75.7	80.2	78.6	83.2
Gambela	53.9	50.4	66.3	83.5	89.1	93.7	95.8	102.7	124.6	106.6
Harari	53.4	54.9	65.6	77.1	90.0	96.2	105.3	107.5	105.0	104.5
Oromia	21.2	26.0	30.8	39.6	45.0	51.6	57.9	62.4	66.9	72.7
SNNP	28.8	38.4	44.4	55.7	56.8	59.8	63.8	67.5	71.8	74.2
Somale	11.6	11.6	11.6	11.6	8.0	8.3	10.6	13.1	15.1	15.1
Tigray	43.7	45.0	45.1	56.1	58.4	63.5	73.9	77.6	73.7	80.6
Ethiopia	26.2	30.1	34.7	41.8	45.8	51.0	57.4	61.6	64.4	68.4

Source: Ministry of Education.
Notes: The primary gross enrollment ratio is defined as the ratio between all students enrolled in primary school and the population in the official age range for that cycle. In Ethiopia the age range for primary schooling is 7–14 years. Thus enrollment of students who are outside the official age bracket can lead to this ratio exceeding 100 percent. SNNP—Southern Nations, Nationalities, and Peoples.

Table 4.11 Primary school (grades 1–8) pupil-to-teacher ratio, selected years

Region	1992	1995	1999	2000	2001	2002	2003
Addis Ababa	49	51	46	45	38	41	39
Afar	29	23	28	29	31	29	32
Amhara	20	33	62	67	70	70	71
Beneshangul-Gumuz	18	38	50	50	52	49	51
Dire Dawa	33	38	43	44	41	40	41
Gambela	22	35	35	36	38	39	48
Harari	26	36	26	23	24	27	24
Oromia	21	32	53	60	66	68	72
SNNP	28	51	61	63	66	67	67
Somale	13	21	37	35	44	52	52
Tigray	51	47	62	67	69	59	55
Ethiopia	27	38	56	60	63	64	65

Source: Ministry of Education.
Note: SNNP—Southern Nations, Nationalities, and Peoples.

doubled to 73, whereas the urban ratio had increased to only 48. This has dramatically increased the burden on teachers in rural areas, making it more difficult to encourage graduates from cities and towns to take rural teaching positions.

In 1994 the government of Ethiopia adopted the New Education and Training Policy. This policy sought to change the existing structure of the education system, which was modeled after Western education systems and was perceived by the government as being inappropriate for the realities of Ethiopia. The new system defined primary education as grades 1–8, thus putting pressure on school capacities in the higher secondary grades (standardized testing was not administered prior to grade 8). This prompted the government to drastically increase enrollment barriers to the 11th grade, effective with the 2001/02 school year. The 1994 reform also placed new emphasis on the expansion of technical and vocational education and training (TVET) and required the use of local languages for primary instruction.

The policy focus on TVET translated into a substantial increase of public spending for this subsector relative to overall education spending. While recurrent education expenditures increased by 78 percent from 1993 to 2001, TVET expenditures increased more than 12-fold or by 1,120 percent (World Bank 2005a). Recurrent expenditures for higher education also increased disproportionately to the overall rise in spending, more than tripling during this period. While spending at the primary level constituted the largest share of education expenditure, it grew more slowly than overall expenditure, increasing by only 40 percent from 1993 to 2001. Possibly to rectify this imbalance, the government's 2002 poverty reduction strategy stated that improvement of access to primary education would be the top priority within the education sector.

Health

Although Ethiopia has shown modest and gradual improvements on a range of health indicators, these indicators remain at very low levels overall. Child mortality has improved from 269 per 1,000 live births in 1960 to 204 in 1990 to 170 in 2002. However, in order for Ethiopia to meet the Millennium Development Goals for health this figure must be halved over the next decade (World Bank 2004). Immunization rates have been subject to large swings over the past few decades, with downswings often coinciding with periods of unrest and war. As of 2002 the immunization rate was

Table 4.12 Immunization and child mortality rates for Ethiopia and selected African countries, 2002

		Immunization rate (percent 1–2 yrs)		Mortality rate (per 1,000 live births)	
	GDP per capita	Diphtheria-pertussis-tetanus	Measles	Infant	Under 5 years old
Ethiopia	124	56	52	114	171
Malawi	157	64	69	113	182
Sierra Leone	165	50	60	165	284
Tanzania	207	89	89	104	165
Chad	232	40	55	117	200
Ghana	429	80	81	60	97

Source: World Bank (2005e).

slightly above 50 percent, making it one of the lowest even among very poor countries (Table 4.12). Maternal mortality in Ethiopia is also among the worst in the world, at about 500–700 per 100,000 births (World Bank 2004). Furthermore only about a quarter of the rural population has access to any modern health services at all (Russell and Abdella 2002).

Wartime destruction was associated with the outbreak of epidemics and the lowest level of health services coverage in 30 years (Kloos 1998). Upon taking power in 1991, the transitional government set the rehabilitation of war-damaged hospitals and clinics as a major health priority. Beyond postwar priorities, the health sector under the new government formulated policies that departed markedly from those of the previous regime, most notably in emphasizing private participation and granting more authority to local governments. The 1993 Ethiopian Health Policy laid out key elements of sectoral reform, including the strengthening of primary health care, a new focus on cost recovery mechanisms, decentralization of delivery, and encouraging greater participation of the private sector and nongovernmental organizations in the provision of health care (Russell and Abdella 2002). Yet some of these principles were later compromised, as when the Ministry of Health closed private clinics in Addis Ababa in 1996 (Kloos 1998).

Access to health services, as measured by potential health service coverage (Table 4.13), did not markedly improve from 1999 to 2003 in the strict context of access to health stations and centers. In fact there was a significant decline in access to such facilities from 2002 to 2003. This, however, may simply reflect the government's overall effort to downgrade many health stations to "health posts" offering predominantly preventive services.

As illustrated by the right side of Table 4.13, access to health services from a broader array of health facilities showed more of an increase during this period. While information on the regional distribution of potential health service coverage was not available prior to 1999, the Ministry of Health (1999) reported that nationwide potential health service coverage by health stations and centers was 38 percent in 1992, 48.5 percent in 1996, and 51 percent in 1997. This suggests that coverage by health stations and centers increased rapidly in the first half of the 1990s and then stagnated and even declined slightly thereafter. Some of this decline was ameliorated by increased coverage by private clinics (World Bank 2004).

One striking aspect of the distribution of health coverage over this period is the relatively high coverage in regions often deemed marginal by various indexes of development. For example, Beneshangul-Gumuz and Gambela showed the highest coverage rates. This may reflect the strong policy focus on equalizing public services between regions. However, Table 4.14 indicates that the intensity of coverage was below average in these regions, implying that, among those populations who fell into a given coverage area, people in regions like Beneshangul-Gumuz and Gambela were still more remote from health facilities than individuals in most other regions.

Since 1997 Ethiopian health sector policy has been guided by the Health Sector Development Program.[4] This program, which was intended to steer health sector policy over the short and medium term, reaffirmed the previous focus on improving

[4]The sector development programs, which have been launched for the road, health, and education sectors and some others, have been motivated by a need to harmonize donor activities in these sectors, with the aim of using aid money more effectively. They have been designed in collaboration with and with the support of several donors. Aid agencies, especially the World Bank, have moved toward programmatic lending, placing less emphasis on project financing.

Table 4.13 Potential health service coverage, selected years (percent)

	Includes health centers and health stations					Includes health centers, health stations, health posts, and private clinics		
Region	1999	2000	2001	2002	2003	2001	2002	2003
Addis Ababa	36.66	93.39	79.37	80.00	72.55	152.49	150.64	155.44
Afar	57.16	52.70	55.03	49.96	50.75	75.08	72.25	74.06
Amhara	42.37	43.50	42.55	40.21	15.85	59.72	56.85	51.76
Beneshangul-Gumuz	166.79	86.21	161.95	159.48	148.15	206.19	200.86	207.07
Dire Dawa	72.44	51.52	86.26	54.62	68.92	140.35	103.64	127.03
Gambela	229.52	87.96	238.74	166.67	136.75	299.55	274.12	226.50
Harari	137.30	114.46	145.35	134.83	129.73	197.67	205.06	200.00
Oromia	53.17	46.91	52.29	51.47	52.22	66.61	68.03	70.78
SNNP	49.58	55.06	48.30	48.66	47.18	66.69	65.47	81.08
Somale	35.96	30.55	35.27	40.98	31.76	46.05	47.98	43.81
Tigray	65.91	66.24	64.60	67.52	63.46	81.65	86.12	87.04
Ethiopia	50.71	51.24	51.80	50.97	43.63	70.74	70.22	73.16

Source: Ministry of Health.
Notes: "Potential health service coverage" is defined in the Ethiopian context as the share of the population that had access to a health facility 10 km away or less (World Bank 2005c). Values may exceed 100 percent because the coverage is considered for each health facility within 10 km to which individuals have access. SNNP—Southern Nations, Nationalities, and Peoples.

Table 4.14 Average distance to the nearest health center, 2000 (km)

	Rural		Total	
	Mean	Standard deviation	Mean	Standard deviation
Addis Ababa	6.47	5.13	2.07	3.35
Afar	18.09	23.20	9.57	18.59
Amhara	8.63	7.62	5.09	6.77
Beneshangul-Gumuz	10.56	12.21	6.58	10.51
Dire Dawa	3.99	3.57	2.52	2.86
Gambela	8.33	9.58	4.91	7.98
Harari	4.05	3.05	2.46	2.79
Oromia	8.59	7.42	5.24	6.63
SNNP	6.89	6.69	5.33	6.41
Somale	9.71	12.94	5.65	11.74
Tigray	7.88	5.89	4.65	5.15
Ethiopia	8.30	9.33	4.93	7.81

Source: Authors' own calculations based on Central Statistical Authority's Welfare Monitoring Survey, 2000.
Note: SNNP—Southern Nations, Nationalities, and Peoples.

accessibility to and quality of primary health care and on increasing the share of total government spending on health. Indeed in 2001 government expenditure on health as a share of total investments in the health sector in Ethiopia exceeded the average in South Asia and several other low-income countries. However, per-GDP government expenditure on health in Ethiopia fell below the Sub-Saharan African average, and public and private expenditure on health taken together made up a smaller share of GDP than in any of the other developing country groups (Table 4.15). This underscores

Table 4.15 Health expenditures in Ethiopia and other low-income country groups, 2001

	Expenditure as percent of GDP		Public as percent of total expenditure	Expenditure per capita ($)
	Total	Public		
Ethiopia	4	1	41	3
South Asia	5	1	22	22
Low income	4	1	26	23
Sub-Saharan Africa	6	3	41	29

Source: World Bank (2005e).

the relatively significant role that public funds play in the financing of Ethiopia's health sector. In absolute terms, spending on health per person in Ethiopia falls far short of expenditures in Africa, South Asia, and the low-income countries. Health expenditures are $3 per capita per annum in Ethiopia, which is between one-seventh and one-tenth of comparable expenditures in other low-income economies.

In the implementation of Ethiopia's decentralization policy, the devolution of resource allocation responsibility to the lower tiers of government was most extensive for the social sectors, including health. Accordingly the regions accounted for over 87 percent of government recurrent expenditure and nearly all (99 percent) of capital expenditure in 2001. With the deepening of decentralization beginning in 2002, part of the regional health budgets were passed down to the weredas. As seen in the decentralization of spending responsibility in other sectors, some problems were associated with the devolution. For example, the weredas were not fully capable of maintaining facilities, did not have adequate staffing (despite the continued deployment of health personnel from the regions), and faced challenges in coordinating with other weredas for services and drug distribution activities spanning a wider geographic space.

In the following chapters we build on this descriptive overview, expanding the inquiry to examine how public expenditure in key sectors may have differentially affected the welfare of rural households. The next chapter sets the stage by providing the conceptual context for how public spending may contribute to rural household incomes by affecting the productivity of household private assets. We also discuss the possibility of expenditure policy itself being influenced by sector-specific levels of development, and what this implies for econometric identification in the analysis.

CHAPTER 5

Conceptual Framework of Public Spending, Public Services, and Private Assets

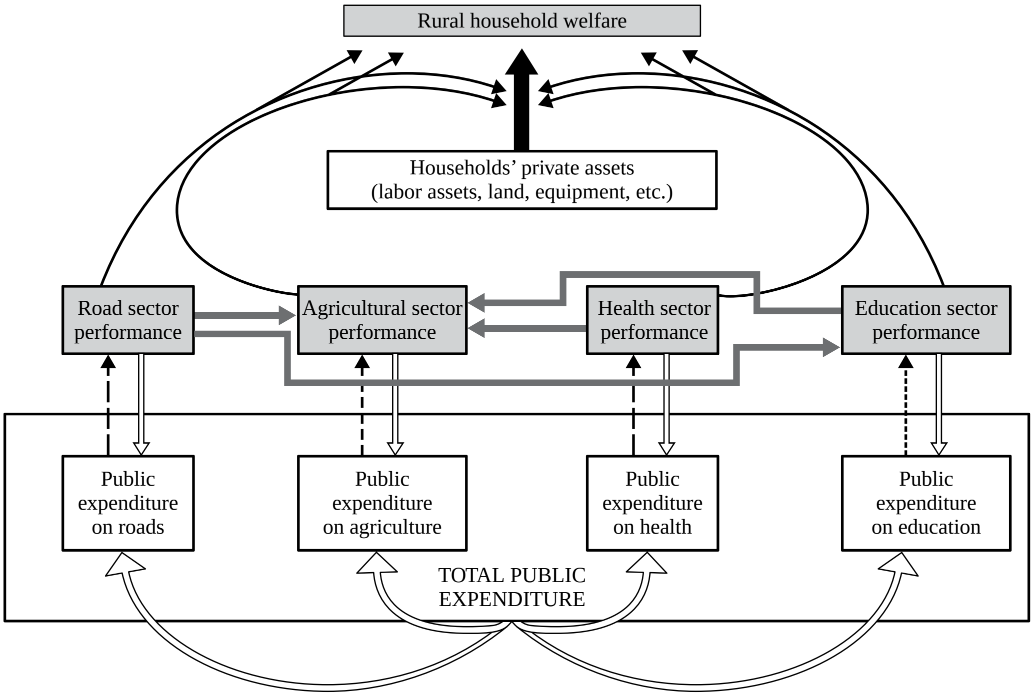
Figure 5.1 is an illustration of the framework that underlies our analysis of the effect of public expenditures on rural welfare. This analysis comprises three stages. The first is represented by the upper half of the illustration and the links shown by the solid arrows. It highlights the role of access to public services in determining the welfare of rural households, incorporating the way in which public services and sector-specific outcomes may contribute directly to that welfare; they may also contribute indirectly by increasing the productivity of households' private assets. The second stage of our analysis is summarized by the bottom half of the figure. This shows how public services and infrastructure or sector-specific performance is itself determined by the amount of public financial resources committed to the sectors (dashed arrows). The final stage of the analysis, represented by the whole figure, draws on the pathways captured by the prior two stages to show how public expenditure affects rural welfare.

When assessing how access to different types of public services may affect household well-being, and how public expenditure leads to public services and infrastructure, several issues affecting the transformation of public financial resources into sectoral outcomes and household welfare must be considered.

First, access to public services can have both direct and indirect effects on household welfare, as indicated by the thin solid arrows in Figure 5.1. The direct effects include improvements in well-being that are usually not captured by monetary measures of welfare, such as the value of household expenditure or income. Ferroni and Kanbur (1992) incorporated nonmonetary measures in designing a framework for poverty-oriented public expenditure allocation. For example, improved sanitation arising from public subsidies for the construction of household latrines directly benefits individuals through the inherent desirability of improved hygiene. But direct effects can also be realized in the conventional metric of welfare. For example, public provision of unconditional "safety net" transfers directly boosts household income.

Most public services, however, predominantly improve household welfare in indirect ways, by affecting the returns to, or the productivity of, households' private assets. For example, public investment in irrigation infrastructure improves the welfare of agricultural households by increasing the contribution of their agricultural assets (such as cultivable land) to production. Naturally the provision of public services may have both direct and indirect impacts on well-being; in the example of access to better sanitation given above, latrine subsidies offer the inherent (nonmonetary) benefits of improved hygiene, while health improvements arising from these public investments may make household members more productive. In this sense, sanitation investments indirectly affect welfare by increasing the returns to the

Figure 5.1 Framework for the effect of public expenditures on rural household welfare



household's labor assets. Similar mixed effects are typically seen in response to better access to education.

Second, there is typically a lag between the public expenses incurred in a sector and the time when a response can be observed. The length of this lag may vary depending on the type of sector-specific service indicator. For example, substantial resource investment in road construction in a given region might be expected to affect a measure of road capital—say, road density—within one or two years of the investment. In contrast, education spending in a given region will not lead to an improvement in the literacy rate until several years later, because children educated today will figure into the literacy rate only after they become adults. In Figure 5.1, differences in the length of time until sectoral outcomes may be expected are suggested by the varying thicknesses of the dashed arrows.[1] The lag period will also differ for public spending within a given sector, depending on the sectoral variable. For example, education spending is expected to affect the enrollment ratio or school density much sooner than the literacy rate.

Third, the complementarity, mutual dependence, and sometimes negative externalities (as in Ersado, Amacher, and Alwang 2004) between investments across different sectors will also affect assessment of the returns to public investment. This interaction across various forms of public expenditure may occur in multiple ways. At the level of expenditure policy or the budget process, the decision to spend more in a given sector implies a reduction in resources for another sector. However, resources allocated to one sector may also immediately benefit outcomes in other sectors. For example, public

[1]The thickness of the various arrows is not intended to suggest a specific hierarchy of sectors by lag length, but only to illustrate the fact that differences in lags exist.

investment in road infrastructure increases road density and road quality, which in turn may reduce the transport costs for agricultural inputs and outputs, thus improving productivity in the agricultural sector. As demonstrated by the shaded arrows in Figure 5.1, such interrelated effects are more appropriately analyzed by assessing (for example) the contribution of better road infrastructure to agricultural performance, rather than the effects of road sector *expenditure* on agriculture, particularly if the within-sector effects of spending are already accounted for.

Finally, the decision to invest public resources in a given activity will typically be influenced by the state of affairs in the target sector, as symbolized by the downward-pointing open arrows in the illustration. If the health sector is better developed in one region compared to other regions, spending may be affected in two ways: (1) a strong equity focus in expenditure policy would imply the tendency to spend less per capita on health in that region compared to other regions, or (2) a higher density of health facilities and medical staff in the region will generate a greater need for complementary health resources (such as medical supplies) compared to locations with fewer facilities per capita. Thus an expenditure policy based on resource needs would imply greater resource allocation to the more-developed region. (In this example, this would apply to expenditures complementary to facilities, rather than capital expenditure on the health centers themselves.)

Furthermore a sectoral expenditure policy primarily concerned with efficiency may lead to greater investments in a sector where performance indicators are already high. For example, areas with higher agricultural potential (due to agroecological conditions, existing high capital base, institutional structures, and so on) may also be areas in which public investment in modern inputs will generate higher returns in terms of agricultural productivity. Even if these areas are less poor than low-potential regions, a sectoral strategy driven by a focus on efficiency at the sector level, and spending decisions that are strongly aligned with sectoral strategies, would allocate relatively greater public resources in the agricultural sector to these better-performing areas.

Naturally the size of public expenditure in a given sector depends not only on sectoral policy, but also on the overall size of the public budget for that region (see the curved open arrows in Figure 5.1). In turn regional budgets are highly dependent on federal transfers (Table 3.1). The distribution of these transfers is not neutral with respect to a region's state of development, and this can again affect the feedback loop from development to public spending. Specifically, in the Ethiopian context, the sizes of the block grants from the federal government to the various regions are determined to some extent by the government's goal of reducing inequality across regions. Hence, as shown in Table 3.1, the per capita transfers from the federal government to Beneshangul-Gumuz, a rather underdeveloped region, constituted 87 percent of the region's total budget in 1997, whereas those to Addis Ababa constituted only 4 percent of that region's budget. The simple correlation in per capita funds between own-source regional revenues (such as regionally collected taxes) and federal grants was –0.70 during this period (Table 3.1), suggesting that the equity focus of federal fiscal policy is manifested in the transfers made. This argument, taken on its own, would suggest that less-developed regions may allocate greater per capita expenditures to various sectors, ceteris paribus.

However, other forces pull the relationship between regional sectoral development and sectoral spending in the other direction. Better-developed regions are generally better equipped to generate their own revenue through taxes, user fees, and similar levies. This source of input to the regional budget therefore tends to be higher in regions with higher sectoral performance indicators. Through this link between regional development and the region's own revenue-raising capacity, higher sectoral development tends to contribute to greater public resources, in turn leading to higher levels of public expenditure in any given sector (holding all other factors, including federal transfers, constant).

In sum, the nature of the potential reverse feedback from sector-specific performance to the size of public expenditure is complex. Without detailed knowledge of policy orientation, and without conclusive information about which—if any—of the policy factors discussed previously may dominate, the qualitative attributes of this feedback effect are a priori ambiguous and must be accounted for empirically. The next chapter presents the econometric strategy underlying the empirical analysis of the features we have just discussed conceptually.

CHAPTER 6

Empirical Strategy

The conceptual framework of the previous chapter presents the three stages of analysis for tackling the research question. The empirical approaches in each of these stages are now detailed.

In the first stage, a household consumption equation specifies the effects of access to a range of public services (*PS*), which are allowed to operate directly (superscripted d) and indirectly (superscripted ind) to potentially enhance the productivity of private assets *A*. The specification is

$$\ln(c_{ij}) = \alpha + \sum_{j=1}^{J} \phi_j^{\mathrm{d}\prime} D_{ij} PS_{ij}^{\mathrm{d}} + \sum_{j=1}^{J} \phi_j^{\mathrm{ind}\prime} D_{ij} A_{ij} PS_{ij}^{\mathrm{ind}} + \mu' X_{ij} + \varepsilon_{ij} \qquad (1)$$

The dependent variable, ln(*c*), is the natural log of per-adult-equivalent household expenditure. D_{ij} is a dummy equal to 1 if household *i* is in location *j*. The coefficients ϕ_j may vary by area. Thus this specification permits differentiation of the effects of public service access by region, agroecological zone, or other geographic unit. The public service and private asset terms are vectors, as we are assessing the impact of multiple types of public services. The different superscripts for the public services expressions, apart from indicating the direct and indirect effects they may have on welfare, also emphasize that the vector of sectoral services that would be hypothesized to have direct effects in principle need not be identical to the vector of variables with hypothesized indirect effects. *X* constitutes the vector of control variables, which include commonly used household characteristics, and μ is the corresponding coefficient vector. As usual, α is the intercept parameter and ε_{ij} the error term.

The second stage estimates the effects of public expenditure on services and infrastructure in selected sectors likely to be relevant to the poor. Some of the challenges faced when seeking to capture the impact of policy interventions, especially of expenditure policy, were discussed in Chapter 5. In addition public expenditure is a flow measure. In order to use such a measure to identify the effect on sectoral performance at some particular point in time, the approach to be utilized must account for the effect of public investments over time, especially in cases where the results may be expected to show a lag.

Several alternative approaches have been used to determine the impact of public expenditure. Here we briefly discuss each, drawing on selected previous studies to provide a context for the empirical strategy used in this report. Given the concrete interest in discussing the merits of certain methodological questions that may inform the econometric specification (for example how the flow nature of public spending is handled, and how to account for the possible time lag in results), we will focus on studies that explicitly draw on public spending data, as opposed to studies that infer public investment effects from returns to physical public capital or public services.

In the specific context of Ethiopia, Collier, Dercon, and Mackinnon (2002) used public expenditure data at the national level to compute the unit costs of increasing the quantity and quality of health care, and they then conducted simulations using these unit costs. The unit cost approach, while illustrative, fails to account for nonexpenditure factors that may affect health capital variables, as well as the potential lag between intervention and outcome. However, limitations to expenditure data may necessitate this approach, which was also used in Fan, Zhang, and Rao (2004) and Fan, Nyange, and Rao (2005).

Similar to other studies using general equilibrium models, Agenor, Bayraktar, and El Aynaoui (2004) embedded the expenditure variables in a macroeconomic general equilibrium model in which public spending affects total demand, government budget balance, and taxes, and is affected by the size of each revenue source. The general equilibrium approach has the advantage of assessing multiple pathways from spending to growth and poverty in an aggregate-macroeconomic framework. However, it is not clear whether the model, which depends on time series data, accounts for the lag with which spending can be expected to affect growth via the variables in the model.

Gomanee, Girma, and Morrissey (2003) performed quantile regressions on cross-country panel data, in which the effect of social sector expenditure on the Human Development Index was introduced contemporaneously.[1] In other words a given country's Human Development Index for period t is regressed on expenditure in period t, along with other control variables. Unlike the unit cost approach, regression estimation allows control of nonexpenditure influences on the outcome of interest. However, this strategy also fails to account for the possibility of lagged effects.

In contrast, Devarajan, Swaroop, and Zou (1996) attempted to account for the potential time interval from the onset of public resource spending until the realization of economic performance. In this strategy, using a cross-country panel, a five-year moving average of GDP growth (from time $t + 1$ to $t + 5$) is the dependent variable on which public expenditure at time t is hypothesized to have an influence, and the relationship is assessed using various reduced-form estimation methods. This structure is intended to account for investment lags, and it should mitigate potential simultaneity arising from the fact that public policy is usually driven by economic performance indicators such as growth.

An alternative approach that explicitly accounts for the flow nature of public expenditure and the potential effects of past spending on current outcomes is akin to a distributed lag model:

$$PS^{s}_{j\tilde{t}} = \lambda + \sum_{q=0}^{\tilde{t}} \beta_q I^{s}_{j,\tilde{t}-q} + \rho Z_j + u_j \qquad (2)$$

where $I^{s}_{j,\tilde{t}q}$ refers to public investment in sector s and region j undertaken at time $\tilde{t} - q$, and the tilde above the time subscript is included to indicate that equation (2) does not represent an equation with a panel structure but rather one for the determination of sectoral outcomes at a particular point in time $\tilde{t}$. β_q is the parameter associated with the investment variable; Z_j and ρ are variable and parameter vectors, respectively,

[1]The Human Development Index is published every year as part of the *Human Development Report* by the United Nations Development Programme. This index is a broader definition of well-being that goes beyond GDP and provides a composite measure of three dimensions of human development: living a long and healthy life (measured by life expectancy), being educated (measured by adult literacy and enrollment rates), and having a decent standard of living (measured by purchasing power parity income).

which capture additional control determinants of public service performance; λ is the intercept parameter; and u_j is the error term. This strategy then includes investments made in each of the $\tilde{t}$ time periods and allows differentiation of the effects of spending in each year preceding the time period during which the sector-specific outcome variable is measured.

One challenge to this approach is the potentially high temporal correlation of investments in a given sector and region. In particular, sectors having a high component of recurrent expenditure (for example health and education) tend to be relatively stable over time; thus, for example, $I^{edu}_{j,t1}$ and $I^{edu}_{j,t2}$ for two time periods t_1 and t_2 would be highly correlated, tending to wash out the significance of the investment effects. In addition there may be multiple ways to extract the parameter of interest from model (2). The question of interest here is: How much would a marginal increase in public investment in sector *s* affect performance in this sector? The implied policy change is thus not a one-time increase (for example, an increase in $I^{edu}_{j,q}$ at some point in time *q*), but rather one that is sustained through time. This issue will be explicitly addressed in the empirical framework used in this report, which is detailed further below.

In a simultaneous equations model, Fan, Hazell, and Thorat (2000) and Fan, Zhang, and Zhang (2002) used a specification in the expenditure equations that allowed for lagged effects. On the issue of accounting for lags, these two studies differed methodologically from Devarajan, Swaroop, and Zou (1996) in two important ways. First, Devarajan, Swaroop, and Zou implicitly sought to capture lagged effects by assessing the impact of current expenditure on subsequent (average annual) growth over five years. This strategy does not permit parameterization of the individual effects of spending at different time intervals (for example the effect of current spending versus the effect of spending *t* years ago). Second, in Fan, Hazell, and Thorat (2000) and Fan, Zhang, and Zhang (2002) the lag length is not assumed to be fixed across all types of spending, but instead the appropriate lag structure is determined empirically using the adjusted-R^2 criterion. The potential collinearity among the lagged expenditures is addressed by constraining the parameters into a polynomial distributed lag structure (Davidson and MacKinnon 1993).

The approach we employ here uses as its point of departure the standard capital formation equation:

$$K^s_{jt} = K^s_{j,t-1}(1-\delta) + I^s_{jt} \tag{3}$$

with initial capital modeled as

$$K^s_{j0} = I^s_{j0}/(r+\delta) \tag{4}$$

where δ is the rate of depreciation and *r* is the rate of interest. Expanding the equation to express capital as a function only of investment, and reintroducing the notation for time $\tilde{t}$ as above, gives

$$K^s_{j\tilde{t}} = \sum_{q=1}^{\tilde{t}} I^s_{jq}(1-\delta)^{\tilde{t}-q} + I^s_{j0}\frac{(1-\delta)^{\tilde{t}}}{(\delta+r)} \tag{5}$$

Applying this capital formation equation to the public investment context, K^s_{jt} can be interpreted as “accumulated public investment.” Thus our approach assesses the effect of accumulated public investment in sector *s* and location *j*—as opposed to individual time periods’ public expenditures, as in equation (2)—on sectoral outcomes in *s* and *j:*

$$PS^s_{j\tilde{t}} = \lambda^s + \beta^s K^s_{j\tilde{t}} + \rho^s Z_j + u_j \tag{6}$$

The marginal impact of interest is β^s. Unlike the prior approaches used in Fan, Hazell, and Thorat (2000) and Fan, Zhang, and Zhang (2002), estimating the impact of accumulated public investment on public services using our strategy does not generate distinct estimates for expenditure effects in different years. However, one can derive time-differentiated effects from the estimated coefficients and parameters. For example, a one-unit increase in $K^s_{j\tilde{t}}$ corresponds to a $[1/(1 - d)^q]$-unit increase in investment in sector s and location j at time $\tilde{t} - q$. Therefore the implied impact of an increase in public spending at time $\tilde{t} - q$ is $\beta^s/(1 - \delta)^q$ (which, for example, would equal β^s for contemporaneous investment).

The conceptual framework in Chapter 5 considered the possible reverse feedback from the performance of a sector on public spending in that sector and discussed the complexity involved in hypothesizing the direction and nature of this potential reverse causation. For the empirical analysis, to the extent that there is potential simultaneity in estimating the impact of sector-specific public investment on sectoral performance variables, the direction of the potential ensuing bias cannot be conclusively determined. However, the possible downward bias in the estimate of the effect of spending on sectoral outcomes arising from equity-oriented policies is likely to be limited given that (1) federal transfers represent a large proportion of many regional budgets, and these transfers tend to be higher when the region's own revenue-raising capacity is lower; (2) the overall size of the budget seems to be a significant factor in the size of sectoral investment; and most importantly (3) regional sectoral investment decisions are made regionally, not centrally. Therefore the impact of the variation in a region's total public budget may wash out the possibility that higher development in one sector could result in lower resource commitment to that sector.

Nevertheless we cannot be certain that the various possible divergent effects of sectoral development on spending will cancel each other out. Thus, in order to acknowledge the role of the overall regional budget envelope in determining the size of sectoral spending, we instrument the accumulated public investment variable with the size of expenditure on public administration for each region. This expenditure item is not associated with the capital, recurrent spending, or overhead of any particular sector. Rather it includes spending on the regional council, the regional finance bureau, the regional court system, and other expenditure items that are not expected to directly affect performance measures in the sectors of interest, but that are expected to be correlated with the amount of spending in those sectors.

The S equations (equal to the number of sectors analyzed) are appropriately estimated within a systems framework. First, it is likely that shocks that affect the general local economy in location j and also affect the random variations in performance or services in sector s may also affect unaccounted-for variation in the services of another sector s'. This creates correlation of the error terms across equations. Second, we want to allow for cross-sectoral synergies, that is, the possibility that outcomes in one sector may affect those in another. Thus the latter are estimated as a system in order to capture the efficiency gains of system estimation in the context of cross-equation error correlation. These instruments were collectively employed in a system-three-stage-least-squares (S-3SLS) framework, and the results were compared against alternative system estimations.

It is also a plausible hypothesis that there are not only cross-sectoral but also spatial spillovers in public investments. Investments in one region may come to benefit neighboring regions. This would recommend also introducing a spatial correlation into the analysis, especially with regard to public investments in road infrastructure. The structure of Ethiopia's regions, however, imposes a serious constraint in explicitly accounting for possible spatial correlation. As the map in Figure A.1 in the Appendix shows, the regions are highly heterogeneous in size, and some have been gerrymandered to result in very noncompact boundary structure. These characteristics, together with the small number of regions, make it difficult to obtain sufficient variation in any "neighborhood" variable that would be used for spatial estimation.

In the third stage of analysis, we use the results of the first two stages to compare the effects of an increase in per capita public expenditure in various sectors on household well-being, as measured by household consumption. These effects are differentiated by region.

First, from equation (1), we derive the effect of access to sectoral services on welfare as

$$\phi_j^* \equiv \partial \ln(c_{ij})/\partial PS_{ij}^{\mathrm{d}} = \phi_j^{\mathrm{ind}} \bar{A}_j \qquad (7)$$

for the public services for which only indirect effects are assessed, where $\bar{A}$ is the mean of the measure of private assets, and

$$\phi_j^* \equiv \partial \ln(c_{ij})/\partial PS_{ij}^{\mathrm{ind}} = \phi_j^{\mathrm{ind}} \bar{A}_j + \phi_j^{\mathrm{d}}, \qquad (8)$$

where both direct and indirect effects are captured. Then using the results from the first two stages gives us

$$\eta_j^s \equiv \partial \ln(c_{ij})/\partial K_{jt}^s = \phi_j^{s*} \times \beta^s, \qquad (9)$$

that is, the effect of interest for sector s and region j.

The standard errors of the welfare effect of spending are obtained using the delta method (Oehlert 1992). We let $h(\hat{\gamma})$ be an m-dimensional (linear or nonlinear) function of the parameter estimator vector $\hat{\gamma}$, that is, $h(\hat{\gamma}) = [h_1(\hat{\gamma}), \ldots, h_M(\hat{\gamma})]$, with the $1 \times K$ parameter vector $\hat{\gamma}$ consisting of estimators from the first- and second-stage regressions, that is, $\hat{\gamma} = [\hat{\beta}'\hat{\phi}']'$. The variance-covariance matrix of this function of parameters can be estimated using the delta method:

$$\widehat{\mathrm{var}}_\Delta(h(\hat{\gamma})) = H \times \widehat{\mathrm{var}}(\hat{\gamma}) \times H, \qquad (10)$$

with the subscript Δ referring to the delta method approach. H is an $M \times K$ matrix defined as

$$H_{mk} = \left. \frac{\partial h_m(\hat{\gamma})}{\partial \hat{\gamma}_k} \right|_{\gamma = \hat{\gamma}} ; k = 1, \ldots, K; m = 1, \ldots, M \qquad (11)$$

and $\widehat{\mathrm{var}}(\hat{\gamma})$ is a simultaneous robust covariance matrix on the estimator vector (which, as mentioned previously, is composed of parameters from the two different models).

In the case of our model, the function $h(\hat{\gamma})$ takes on the simple nonlinear form of equation (9), $h_m(\hat{\gamma}) = \hat{\phi}_m \hat{\beta}_m$, and $M = K/2$, which is also the number of parameters from each regression involved in a nonlinear function. Hence we can simplify the expression for the standard errors of the multiplicative function to

$$\begin{aligned} \widehat{\mathrm{var}}_\Delta(h(\hat{\gamma})) &= \sqrt{diag[\widehat{\mathrm{var}}_{\Delta m}(h(\hat{\gamma}))]} \\ &= \sqrt{\widehat{\mathrm{var}}(\hat{\phi}_m)\hat{\beta}_m^2 + \widehat{\mathrm{var}}(\hat{\beta}_m)\hat{\phi}_m^2}. \end{aligned} \qquad (12)$$

The following chapter presents and discusses the results from the first-, second-, and third-stage analysis and examines the robustness of the results by varying the specifications, parameter assumptions, and estimation approaches.

CHAPTER 7

Estimation

First-Stage Analysis: Public Services, Private Assets, and Rural Welfare

Table 7.1 provides descriptive statistics on the variables included in the first-stage regression (also see the tables in Chapter 4), and Tables 7.2–7.8 give the estimation results from the first stage. Indicators of performance (access to services) are included for the four sectors considered important for welfare enhancement in rural areas, namely agriculture, road infrastructure, education, and health.

Table 7.2 presents the "short" model, in which the sector performance variables are introduced in terms of their direct and indirect effects, and their impact is not geographically differentiated, although region effects are included. Access to education (proxied by the primary school enrollment rate) and access to health care (measured by the distance to the nearest health facility) are interacted with the household's labor assets, given that better access to educational and health services is expected to increase labor productivity. This model is also based on the hypothesis that higher average performance in agriculture and better access to roads will improve the contribution of farmers' agricultural assets to their welfare. The variables indicating access to services and performance in four sectors are introduced as zonal-average variables, both to mitigate likely simultaneity when including household-specific variables on access to services in these sectors and also to enable, in the second-stage analysis, an examination of the link between public investments and these sector performance variables.

The multistage nature of the empirical approach, and the concomitant choice of variables to proxy sectoral outcomes, implies an assumption for the education sector case worth making explicit. Using school enrollment rate as a proxy for access to education services within a locality assumes that there is relatively limited mobility of rural households over time, so that the average school access of a given individual's current zonal residence is the relevant locality for this measure. This assumption is arguably not very stringent, given low levels of rural mobility (referring here to permanent resettlements rather than seasonal migration, which is common), and given the relatively large size of the geographic unit over which we average the sector variables.[1] We thus propose that the "temporal distance" between an education sector measure such as enrollment rate and the labor productivity of adult households can be bridged with a relatively plausible assumption of low household mobility in Ethiopia's rural areas, while this measure is suitable for linking public expenditures to educational outcomes.

[1]In Ethiopia the zone is the second subnational administrative unit, below the region. The country has approximately 60 zones.

Table 7.1 Descriptive statistics for Ethiopia's rural population

Variable	Mean[a]	Standard deviation[a]
Log of per-adult-equivalent household expenditure	7.23	0.48
Households with male head (share)	0.77	0.42
Age of head	43.66	14.97
Household size in adult-equivalents	3.43	1.35
Number of female workers[b]	1.13	0.70
Number of male workers[b]	1.03	0.80
Labor assets (number of working-age household members)[b]	2.57	1.40
Years household has lived in current house	9.00	10.10
Education of household head	1.37	0.97
Occupation solely in agriculture (share)	0.79	0.41
Agricultural assets index[c]	3.79	1.79

Source: Authors' own calculations based on the Welfare Monitoring and Household Income, Consumption and Expenditure Surveys, 2000.
[a]Means and standard deviations pertain to rural households only.
[b]"Working age" is defined as 14–50 years old.
[c]The agricultural assets index includes the number of livestock weighted by tropical livestock units, as well as ownership of land, plough(s), sickle(s), sprayer(s), tractor(s), yoke(s), and other agricultural capital equipment.

On the other hand, a broader educational outcome measure, such as the literacy rate, poses a challenge in linking public investments in education to the education sector outcome measure, which cannot be bridged without very long region-disaggregated time series data on education public expenditures. Such data are unavailable in Ethiopia, as in many developing countries.[2]

With regard to the indirect effects, we would ideally capture the effect of access to services and infrastructure on the returns to the full set of rural household-related productive private assets. However, the survey data included only information on agricultural assets, consumer durables, and "hybrid" assets having both functions. Therefore our analysis traces the indirect effects for farming households and more general effects for rural households in which farming does not constitute the dominant economic activity.

The results show that, after region effects are controlled for, rural households in areas with better road infrastructure, education access, and agricultural productivity have higher consumption levels. Both the direct effects and the indirect effects, via the impact of public services on private productive assets, are significant in nearly all cases.

Tables 7.3 and 7.4 consider alternative sectoral effects to those above. Table 7.3 includes only average effects of indicators of services and performance in the four sectors of interest, and Table 7.4 includes both direct and indirect effects—in the manner discussed previously—for all sectors. The results across all three specifications point to a limited impact of health sector services and infrastructure when the indirect effect is not considered, that is, when the way that better access to health care makes household labor assets more productive is not explicitly accounted for. Access to roads appears to contribute to rural welfare improvements, whether this influence is hypothesized to manifest itself directly or through increasing the productivity of agricultural

[2]A few studies, for countries in which such time series data exist (for example China and India), have used literacy rate as the education sector outcome measure; these include Fan, Hazell, and Thorat (2000).

Table 7.2 Indirect and direct countrywide rural welfare effects of public services and infrastructure access

Dependent variable: *ln*(household consumption per adult-equivalent)

Sector effects	
Agriculture: indirect effects	0.00011
Yield × agricultural asset index (if farming household)	(0.00010)
Agriculture: direct effects	0.01498***
Yield (if nonfarming household)	(0.00582)
Road infrastructure: indirect effects	0.00185**
Road density × agricultural asset index (if farming household)	(0.00078)
Road infrastructure: direct effects	0.01475*
Road density (if nonfarming household)	(0.00880)
Education: indirect effects	0.06208***
Enrollment rate × labor assets	(0.01389)
Health: indirect effects	–0.00110***
Distance to health facilities × labor assets	(0.00042)
Region effects	
Afar	–0.27311***
	(0.09123)
Amhara	–0.33167***
	(0.03729)
Beneshangul-Gumuz	–0.46090***
	(0.05251)
Gambela	–0.63596***
	(0.07987)
Oromia	–0.24290***
	(0.03538)
SNNP	–0.44841***
	(0.03575)
Somale	0.05327
	(0.06148)
Tigray	–0.25212***
	(0.04797)
Constant	7.42702***
	(0.07904)

Household characteristics	
Head is male	–0.00962
	(0.01615)
Age of head	–0.00178
	(0.00231)
Age of head squared	0.00002
	(0.00002)
Household size (adult-equivalents)	–0.09741***
	(0.00888)
Number of years lived here	0.00068
	(0.00079)
Number of female workers	–0.01240
	(0.01151)
Number of male workers	–0.00480
	(0.01108)
Education of head	0.11569***
	(0.00755)
Engaged in agriculture	0.24345***
	(0.06662)
Number of observations	7,871
Number of clusters	674
F-statistic (23,673)	42.05***
R^2	0.19

Notes: Ordinary least squares estimation with robust standard errors; errors corrected for enumeration area cluster effects. Standard errors in parentheses. Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. Variables used for access to services and performance in four sectors—agriculture: crop yield (average physical yield of all annual crops, in quintals per hectare); road infrastructure: road density (kilometers of roads per 1,000 persons); education: primary enrollment rate – gross enrollment rate in primary school (grades 1–8); health: access to health facilities – distance to nearest health facility (in kilometers). Road infrastructure, education, health, and agriculture variables are measured as zonal averages. SNNP—Southern Nations, Nationalities, and Peoples.

Table 7.3 Average countrywide rural welfare effects of public services and infrastructure access

Dependent variable: ln(household consumption per adult-equivalent)

Sector effects	
Agriculture: average effects	0.020177***
	(0.00502)
Road infrastructure: average effects	0.066524**
	(0.03318)
Education: average effects	0.395526***
	(0.07484)
Health: average effects	–0.001990
	(0.00148)
Region effects	
Afar	–0.243317***
	(0.08066)
Amhara	–0.261932***
	(0.04303)
Beneshangul-Gumuz	–0.655155***
	(0.09435)
Gambela	–1.594032***
	(0.39920)
Oromia	–0.247577***
	(0.04153)
SNNP	–0.461964***
	(0.04160)
Somale	0.220302***
	(0.07434)
Tigray	–0.260067***
	(0.04857)
Constant	7.057753***
	(0.09503)

Household characteristics	
Head is male	–0.002535
	(0.01546)
Age of head	–0.000617
	(0.00228)
Age of head squared	0.000004
	(0.00002)
Household size (adult-equivalents)	–0.080022***
	(0.00730)
Number of years lived here	0.001366*
	(0.00072)
Number of female workers[a]	0.007249
	(0.00923)
Number of male workers[a]	0.015767*
	(0.00895)
Education of head	0.111982***
	(0.00751)
Engaged in agriculture	0.067010***
	(0.01620)
Number of observations	7,871
Number of clusters	674
F-statistic (21,673)	43.77***
R^2	0.20

Notes: Ordinary least squares estimation with robust standard errors; errors corrected for enumeration area cluster effects. Standard errors in parentheses. Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. Variables used for access to services and performance in four sectors—agriculture: crop yield (average physical yield of all annual crops, in quintals per hectare); road infrastructure: road density (kilometers of roads per 1,000 persons); education: primary enrollment rate – gross enrollment rate in primary school (grades 1–8); health: access to health facilities – distance to nearest health facility (in kilometers). Road infrastructure, education, health, and agriculture variables are measured as zonal averages. SNNP—Southern Nations, Nationalities, and Peoples.

[a]"Working age" is defined as 14–50 years old.

assets. On the other hand, the contribution to rural welfare of performance in the agricultural sector appears to be more strongly captured directly. The contribution of access to education services to welfare is positive and significant when either only average direct effects or only indirect effects are considered.

The region effects include all regions but the three city-states Addis Ababa, Dire Dawa, and Harari, which are predominantly urban. Predictably, living in virtually any of the predominantly rural regions is associated with lower welfare compared to residence in the rural areas within one of the three city-states. Not surprisingly, given the sub-

Table 7.4 Direct and indirect region-specific effects of access to services in all four sectors

Dependent variable: ln(household consumption per adult-equivalent)

Sector effects	
Agriculture: indirect effects	0.0000996
	(0.00010)
Agriculture: direct effects	0.0139738**
	(0.00548)
Road infrastructure: indirect effects	0.0019293**
	(0.00079)
Road infrastructure: direct effects	0.0154903*
	(0.00827)
Education: indirect effects	0.0043818
	(0.01218)
Education: direct effects	0.4129054***
	(0.07986)
Health: indirect effects	–0.0013818***
	(0.00038)
Health: direct effects	0.0014434
	(0.00186)

Region effects	
Afar	–0.1034807
	(0.10040)
Amhara	–0.2450146***
	(0.04324)
Beneshangul-Gumuz	–0.5030774***
	(0.05397)
Gambela	–0.7593951***
	(0.08056)
Oromia	–0.184924***
	(0.03852)
SNNP	–0.3963259***
	(0.03626)
Somale	0.2382982***
	(0.07670)
Tigray	–0.2207021***
	(0.04765)
Constant	7.070113***
	(0.10325)

Household characteristics	
Head is male	–0.0125085
	(0.01606)
Age of head	–0.000506
	(0.00231)
Age of head squared	4.00×10^{-6}
	(0.00002)
Household size (adult-equivalent)	–0.0795711***
	(0.00857)
Number of years lived here	0.0009514
	(0.00076)
Number of female workers[a]	0.0148335
	(0.01103)
Number of male workers[a]	0.0234985**
	(0.01080)
Education of head	0.1131162***
	(0.00762)
Engaged in agriculture	0.2263183***
	(0.06303)

Number of observations	7,871
Number of clusters	674
F-statistic (25,673)	38.59***
R^2	0.19

Notes: Ordinary least squares estimation with robust standard errors; errors corrected for enumeration area cluster effects. Standard errors in parentheses. Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. Variables used for access to services and performance in four sectors—agriculture: crop yield (average physical yield of all annual crops, in quintals per hectare); road infrastructure: road density (kilometers of roads per 1,000 persons); education: primary enrollment rate – gross enrollment rate in primary school (grades 1–8); health: access to health facilities – distance to nearest health facility (in kilometers). Road infrastructure, education, health, and agriculture variables are measured as zonal averages. SNNP—Southern Nations, Nationalities, and Peoples.

[a]"Working age" is defined as 14–50 years old.

stantial interregional economic differences in Ethiopia, the region effects are strong in explaining rural welfare. Their magnitudes also follow quite closely the information on regional poverty in Table 3.2: Rural residents of Beneshangul-Gumuz and Gambela, the two poorest regions, also have the lowest expenditure levels. In contrast Somale, which has the lowest poverty rate, is associated with the highest levels of household expenditure (however, the Somale effect is not statistically significant).

As is commonly found, here too larger households are associated with lower welfare, even when accounting for economies of scale, as does the measure of household size. Equally commonly, households with more highly educated heads enjoy greater material welfare. Occupation plays an interesting role for welfare: within rural areas, it is those households predominantly engaged in farming that fare better, compared to those who reside in the rural areas and yet are engaged in other economic activities. This may point to the lack of vibrant nonfarm opportunities in rural Ethiopia.

A common thread across the estimations so far is that the region effects play an important role in explaining rural incomes. This is intuitive in light of the very strong regional variations in welfare in Ethiopia. But the strongly significant estimates of the region effects in Tables 7.2–7.4 also raise the question of whether our central results are sensitive to dominant observations associated with any given region. Expressed differently, it may be not only that region effects are important as parameter shifters but also that the role of sectoral performance for rural incomes may be to a great extent driven by one region, so that if we were to exclude all observations of one influential region from the analysis, our results on the impact of sectoral variables on incomes would change in a meaningful way.

Table 7.5 indicates the extent of robustness of the results of the short model to the exclusion of observations associated with any single region. The first column reproduces Table 7.2, and the subsequent columns estimate the same model after excluding all observations associated with one region. The flagged coefficients indicate nontrivial changes from the base model: either there was a change in the direction of influence—a significant coefficient changed signs—or a change in significance—a significant coefficient became nonsignificant or vice versa. In the short model, conclusions on access to roads are the least robust to variations in the observation set. The significance of the average (across all regions) effect of access to roads on rural incomes becomes nonsignificant when any one of six regions is excluded from the dataset. Exclusion of the Afar region has the most influential effect, not only on coefficient significance but also on coefficient magnitude and type of effect (both direct and indirect effects become small and insignificant). As will be seen later in the region-differentiated analysis, Afar is also one of the regions in which returns to road expenditure are large and significant.

Using the formulation in Table 7.2 as the main specification of the impact of access to public services and infrastructure in the four sectors, we expand this specification to capture how the role of access to services for household welfare may be regionally differentiated (Table 7.6). Results of this main specification will, analogous to the short models discussed previously, also be compared against a case in which regionally differentiated effects are only assessed in the average, that is, they are not parsed into direct and indirect effects. This is presented in Table 7.7.

The results of the regionally differentiated first-stage estimation are presented in three columns in Table 7.6 to allow for compact presentation, but they refer to a single regression. The same goes for Table 7.7. These results serve primarily as an input to the third-stage analysis and are therefore mainly interpreted as part of our discussion of that stage. However, a few interesting observations can already be made at this stage.

Table 7.5 Robustness of short first-stage model to exclusion of observations

Dependent variable: ln(household consumption per adult-equivalent)

Excluded observations	**None**	**Afar**	**Amhara**	**Beneshangul-Gumuz**	**Gambela**	**Oromia**	**Somale**	**SNNP**	**Tigray**
Sector effects									
Agriculture: indirect effects	0.00011	0.0004	0.00009	0.0001	0.00005	0.00017	0.00011	0.00001	0.00009
	(0.00010)	(0.0003)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Agriculture: direct effects	0.01498***	0.01442**	0.01998***	0.0154***	0.01918***	0.01482**	0.0149**	0.00508	0.01547***
	(0.00582)	(0.0064)	(0.0061)	(0.0059)	(0.0058)	(0.0072)	(0.0061)	(0.0062)	(0.0058)
Road infrastructure: indirect effects	0.00185**	0.00016+	0.00177**	0.00152**	0.00444***	0.0017**	0.00183**	0.00257**	0.0018**
	(0.00078)	(0.0007)	(0.0007)	(0.0007)	(0.0017)	(0.0008)	(0.0008)	(0.001)	(0.0008)
Road infrastructure: direct effects	0.01475*	0.00263+	0.01035+	0.00974+	0.10565***	0.01225+	0.01421+	0.02478***	0.01389+
	(0.00880)	(0.0085)	(0.0086)	(0.0088)	(0.0238)	(0.0096)	(0.0088)	(0.0091)	(0.0088)
Education: indirect effects	0.06208***	0.05959***	0.06402***	0.06174***	0.07902***	0.069***	0.06103***	0.0345**	0.06252***
	(0.01389)	(0.0152)	(0.0147)	(0.016)	(0.0142)	(0.0149)	(0.0143)	(0.0135)	(0.0141)
Health: indirect effects	–0.00110***	0.00034	–0.00123***	–0.00116**	–0.00102***	–0.00141***	–0.00113***	–0.00122***	–0.00114***
	(0.00042)	(0.0004)	(0.0004)	(0.0005)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Household characteristics									
Head is male	–0.00962	0.00244	–0.02266	–0.0069	–0.00984	–0.019	–0.01402	0.00948	–0.01115
	(0.01615)	(0.0157)	(0.0178)	(0.0169)	(0.0162)	(0.0187)	(0.0164)	(0.0185)	(0.0174)
Age of head	–0.00178	–0.00007	–0.00488+*	–0.00089	–0.00197	–0.00337	–0.00139	–0.0007	–0.00171
	(0.00231)	(0.0022)	(0.0025)	(0.0024)	(0.0023)	(0.0028)	(0.0024)	(0.0026)	(0.0024)
Age of head squared	0.00002	0.000004	0.000051+**	0.000009	0.000022	0.000039	0.000016	0.000003	0.000018
	(0.00002)	(0.00002)	(0.00003)	(0.00002)	(0.00002)	(0.00003)	(0.00002)	(0.00003)	(0.00002)

Household size (adult-equivalents)	–0.09741***	–0.10845***	–0.10342***	–0.09881***	–0.10123***	–0.10022***	–0.09235***	–0.08824***	–0.09416***
	(0.00888)	(0.0094)	(0.0097)	(0.0093)	(0.0088)	(0.0102)	(0.0092)	(0.0099)	(0.0091)
Number of years lived here	0.00068	0.00098	0.00063	0.00073	0.00081	0.00036	0.00048	0.00207***	–0.00034
	(0.00079)	(0.0008)	(0.0009)	(0.0008)	(0.0008)	(0.0009)	(0.0008)	(0.0008)	(0.0009)
Number of female workers	–0.01240	–0.02307+**	–0.00834	–0.01302	–0.01964+*	–0.00726	–0.01529	0.00124	–0.01386
	(0.01151)	(0.0117)	(0.0123)	(0.0125)	(0.0115)	(0.013)	(0.0119)	(0.013)	(0.0117)
Number of male workers	–0.00480	–0.00868	–0.00758	0.00001	–0.01065	–0.01598	–0.00844	0.0183	–0.00524
	(0.01108)	(0.0117)	(0.0124)	(0.0116)	(0.0112)	(0.012)	(0.0114)	(0.0121)	(0.0115)
Education of head	0.11569***	0.11812***	0.10799***	0.11226***	0.11641***	0.1294***	0.11534***	0.10612***	0.11594***
	(0.00755)	(0.0075)	(0.0069)	(0.008)	(0.0079)	(0.0088)	(0.0077)	(0.0099)	(0.0076)
Engaged in agriculture	0.24345***	0.2105***	0.30169***	0.24924***	0.34022***	0.23751***	0.2459***	0.13738**	0.24974***
	(0.06662)	(0.0735)	(0.0725)	(0.0677)	(0.0694)	(0.0765)	(0.0703)	(0.0678)	(0.0676)
Constant	7.42702***	7.43444***	7.47963***	7.40969***	7.32395***	7.45402***	7.41377***	7.49243***	7.42158***
	(0.07904)	(0.0842)	(0.0859)	(0.0805)	(0.0805)	(0.091)	(0.0816)	(0.0835)	(0.0807)
Region effects included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	7,871	7,514	6,184	7,370	7,661	6,105	7,616	6,032	7,321
Number of clusters	674	641	530	631	656	523	652	518	627
F-statistic	42.05***	43.73***	42.73***	42.81***	42.19***	37.34***	40.79	29.11***	42.16***
R^2	0.19	0.20	0.21	0.19	0.20	0.21	0.17	0.17	0.19

Notes: Ordinary least squares estimation with robust standard errors; errors corrected for enumeration area cluster effects. Standard errors in parentheses. Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. Variables used for access to services and performance in four sectors—agriculture: crop yield (average physical yield of all annual crops, in quintals per hectare); road infrastructure: road density (kilometers of roads per 1,000 persons); education: primary enrollment rate – gross enrollment rate in primary school (grades 1–8); health: access to health facilities – distance to nearest health facility (in kilometers). Road infrastructure, education, health, and agriculture variables are measured as zonal averages. SNNP—Southern Nations, Nationalities, and Peoples.

+ denotes nontrivial changes from the base model.

Table 7.6 Regionally differentiated role of public services, including indirect effects

Dependent variable: ***ln*****(household consumption per adult-equivalent)**

Agriculture: indirect effects		Agriculture: direct effects		Education: indirect effects	
Afar	–0.00003	Afar	0.00783	Afar	0.31086***
	(0.00010)		(0.00812)		(0.11652)
Amhara	0.00031	Amhara	0.01625	Amhara	0.03506
	(0.00058)		(0.01030)		(0.02993)
Beneshangul-Gumuz	0.00221	Beneshangul-Gumuz	0.08059	Beneshangul-Gumuz	0.00277
	(0.00461)		(0.05298)		(0.02121)
Dire Dawa	0.00248***	Dire Dawa	0.05737***	Dire Dawa	0.08737***
	(0.00068)		(0.01307)		(0.03332)
Gambela	0.00296	Gambela	–0.02054	Gambela	–0.04585***
	(0.00376)		(0.01342)		(0.01745)
Harari	0.00348**	Harari	0.07924***	Harari	0.11012***
	(0.00169)		(0.01486)		(0.03033)
Oromia	0.00010	Oromia	0.03677***	Oromia	0.09600***
	(0.00028)		(0.00907)		(0.02480)
SNNP	0.00206***	SNNP	0.04052***	SNNP	–0.00531
	(0.00031)		(0.00844)		(0.02026)
Somale	–0.00290	Somale	0.07058*	Somale	0.37151***
	(0.00232)		(0.03789)		(0.10178)
Tigray	0.00164*	Tigray	0.04288***	Tigray	0.02296
	(0.00091)		(0.01540)		(0.02585)

Road infrastructure: indirect effects		Road infrastructure: direct effects		Health: indirect effects	
Afar	0.00455	Afar	0.23865***	Afar	–0.00188***
	(0.00199)		(0.04507)		(0.00046)
Amhara	0.03657***	Amhara	0.62967***	Amhara	–0.00082
	(0.01131)		(0.15859)		(0.00097)
Beneshangul-Gumuz	–0.00058	Beneshangul-Gumuz	–0.11568	Beneshangul-Gumuz	–0.00050
	(0.01841)		(0.20512)		(0.00070)
Dire Dawa	—	Dire Dawa	—	Dire Dawa	0.00473
					(0.00323)
Gambela	–0.00289	Gambela	0.08073***	Gambela	0.00312**
	(0.00512)		(0.02285)		(0.00148)
Harari	—	Harari	—	Harari	0.00383
					(0.00616)
Oromia	0.00557	Oromia	–0.03154	Oromia	0.00073
	(0.00807)		(0.13473)		(0.00090)
SNNP	–0.01289***	SNNP	0.00873	SNNP	–0.00072
	(0.00288)		(0.04944)		(0.00094)
Somale	0.04170	Somale	0.12667	Somale	0.00166
	(0.02551)		(0.25337)		(0.00138)
Tigray	0.01137	Tigray	0.20069	Tigray	–0.00083
	(0.01271)		(0.17318)		(0.00171)

Table 7.6 Continued

Household characteristics			
Head is male	–0.01072	Number of female workers[a]	–0.01119
	(0.01526)		(0.01199)
Age of head	–0.00165	Number of male workers[a]	–0.00402
	(0.00222)		(0.01135)
Age of head squared	0.00002	Education of head	0.11385***
	(0.00002)		(0.00799)
Household size (adult-equivalents)	–0.10350***	Engaged in agriculture	0.47809***
	(0.00911)		(0.11134)
Number of years lived here	0.00055	Constant	6.83598***
	(0.00073)		(0.11391)
Number of observations	7,871		
Number of clusters	674		
F-statistic (65,673)	22.38***		
R^2	0.22		

Notes: Ordinary least squares estimation with robust standard errors; errors corrected for enumeration area cluster effects. Standard errors in parentheses. Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. Variables used for access to services and performance in four sectors—agriculture: crop yield (average physical yield of all annual crops, in quintals per hectare); road infrastructure: road density (kilometers of roads per 1,000 persons); education: primary enrollment rate – gross enrollment rate in primary school (grades 1–8); health: access to health facilities – distance to nearest health facility (in kilometers). Road infrastructure, education, health, and agriculture variables are measured as zonal averages. — indicates that an estimate of the coefficient could not be derived due to collinearity. SNNP—Southern Nations, Nationalities, and Peoples.

[a]"Working age" is defined as 14–50 years old.

A strong interregional variation is seen in the effects of road access. This effect is strong and significant in two neighboring regions (Afar and Amhara) in both specifications of Table 7.6 and Table 7.7. These regions are agroecologically quite different, with Afar being a predominantly pastoral region and Amhara consisting of mostly sedentary and partly agropastoral households. The impact of road density is also positive and significant in Gambela in the main regression (Table 7.6). As noted earlier (Tables 4.4 and 4.5), Afar and Gambela have relatively high road densities, even though they are often referred to as backward regions. Amhara's road density is medium to high compared to that in other regions.

On the other hand, zonal-average road density has a significant and the lowest effect on the contribution of rural households' agricultural assets to their income. This suggests an interesting analogue between the results for this region and those for the regions described previously, which were found to have high welfare returns to access to roads. As shown in Table 4.4, SNNP had the poorest access to roads in all the years for which data are available. This, combined with the generally positive relationship between levels of and returns to road density that was identified when results for the other regions were examined, suggests that access to all-weather roads may yield increasing returns in terms of gains to the productivity of private household assets.

The specification also allows examination of whether household consumption increases when average agricultural performance is high. This effect may be realized directly and, among those whose main livelihood is farming, indirectly by generating higher returns to their agricultural assets. Unlike the case of road infrastructure, the effects across regions are less varied

Table 7.7 Regionally differentiated role of public services: Average effects

Dependent variable: *ln*(household consumption per adult-equivalent)

	Agriculture	Road infrastructure
Afar	0.0054391	0.2607905***
	(0.0077)	(0.0601)
Amhara	–0.0002382	0.3603393***
	(0.0078)	(0.1127)
Beneshangul-Gumuz	0.0062872	–0.0963467
	(0.0630)	(0.1281)
Dire Dawa	0.0633594***	—
	(0.0119)	
Gambela	0.0032982	0.0112717
	(0.0098)	(0.0173)
Harari	0.0959408***	—
	(0.0151)	
Oromia	0.041531***	–0.1518498
	(0.0084)	(0.0935)
SNNP	0.0002103	–0.1416144***
	(0.0111)	(0.0318)
Somale	0.1015087**	–0.1914414
	(0.0399)	(0.2816)
Tigray	0.0074507	0.028333
	(0.0190)	(0.1324)

	Education	Health
Afar	–0.0664204	–0.005013**
	(0.3864)	(0.0024)
Amhara	0.3940577***	0.0000393
	(0.1240)	(0.0027)
Beneshangul-Gumuz	0.5334578	–0.0019261
	(0.5360)	(0.0029)
Dire Dawa	—	0.0144647
		(0.0109)
Gambela	—	0.0103805**
		(0.0043)
Harari	—	0.0041237
		(0.0172)
Oromia	–0.0332036	0.0032383
	(0.1389)	(0.0029)
SNNP	0.5611143***	0.0017681
	(0.1941)	(0.0027)
Somale	—	0.0049176
		(0.0041)
Tigray	0.4757105*	0.0042002
	(0.2434)	(0.0047)

Household characteristics	
Head is male	–0.0068495
	(0.0147)
Age of head	–0.0021106
	(0.0022)
Age of head squared	0.0000186
	(0.0000)
Household size (adult-equivalents)	–0.0756176***
	(0.0072)
Number of years lived here	0.0012415*
	(0.0007)
Number of female workers[a]	0.0011269
	(0.0087)
Number of male workers[a]	0.014365*
	(0.0086)
Education of head	0.1141624***
	(0.0074)
Engaged in agriculture	0.0720433***
	(0.0153)
Constant	6.875859***
	(0.1133)
Number of observations	7,871
Number of clusters	674
F-statistic (43,673)	27.96***
R^2	0.24

Notes: Ordinary least squares estimation with robust standard errors; errors corrected for enumeration area cluster effects. Standard errors in parentheses. Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. Variables used for access to services and performance in four sectors—agriculture: crop yield (average physical yield of all annual crops, in quintals per hectare); road infrastructure: road density (kilometers of roads per 1,000 persons); education: primary enrollment rate – gross enrollment rate in primary school (grades 1–8); health: access to health facilities – distance to nearest health facility (in kilometers). Road infrastructure, education, health, and agriculture variables are measured as zonal averages. — indicates that an estimate of the coefficient could not be derived due to collinearity. SNNP—Southern Nations, Nationalities, and Peoples.

[a]"Working age" is defined as 14–50 years old.

and are significant for a greater number of regions. Zonal-average agricultural performance shows the strongest effects on households—and the welfare returns to their productive assets—in Dire Dawa and Harari. Given that the cities of Dire Dawa and Harer respectively dominate these two regions, this may suggest that the proximity of rural households to major markets considerably increases the income returns from stronger agricultural performance.

Interestingly access to education shows the highest returns to labor assets in the Afar and Somale regions, which also have the lowest enrollment ratios (Table 4.10). Returns to education investment are lowest in Gambela, which has among the highest enrollment. In contrast to the apparently positive relationship between levels and impact seen in the road infrastructure sector, it appears here that access to education leverages household labor assets to a greater degree in regions where the levels of access are lowest, and vice versa.

While Tables 7.2–7.4 showed that reducing the distance to health facilities had a significant positive average effect on rural welfare, specifically through making labor more productive, we see in Tables 7.6 and 7.7 that this effect is weak and largely insignificant when disaggregating the effect by region. Only in Afar is a reduction of distance to health facilities associated with greater rural consumption, and the effect is negative in Gambela.

The fact that the coefficients for the SNNP and Gambela regions related to road access and access to social services, respectively, are not only low but negative serves in a sense as a reminder that this is only a partial analysis of the benefits that may derive from public services. While road infrastructure, for example, may serve rural and urban residents alike, we are only considering the effects on rural households' incomes. Furthermore the intended goals of and the actual gains from the provision of these services may be primarily in the form of other outcomes, for example improving equitable access to services, addressing extreme poverty, and ensuring social stability. This report, however, focuses only on rural household incomes (proxied by household expenditure). If the improvement of sectoral performance to meet one set of goals comes at the expense of other goals, then such partial analysis will not be able to uncover the full social benefits of service provision, and—as may be the case in this study—may only highlight negative effects, if any.

In the estimation, the inclusion of zonal-average sector indicators as potential determinants of household welfare—in order to mitigate the simultaneity that is nearly sure to arise if one were to instead include household-level access to services—means that, on the downside, one may not be able to capture the heterogeneous provision of, and access to, services within the geographic area. For example, if zones in SNNP with better road networks also happen to be concentrated more in urban areas within the zone than in poor-network zones, then a partial focus on the effect of road density on rural welfare may present the type of result we found previously.

We cannot say conclusively whether these dynamics are in play in the case of SNNP, especially given that the nonfarm economy in that region is still heavily underdeveloped. This may suggest the need for additional work, including explicit modeling of additional mechanisms (other than returns to agricultural assets) by which road infrastructure may affect household income and consideration of the range of potential outcomes (beyond rural income) that may obtain from improvements in sector-specific performance indicators.

Finally, Table 7.8 presents a robustness analysis on the primary long model (Table 7.6) analogous to the one discussed with respect to the short model (Table 7.5). Here again we subject the model to data sensitivity analysis by estimating the model after exclusion of all observations associated with one region at a time. Unlike

Table 7.8 Robustness of primary first-stage model to exclusion of observations

Excluded observations	None	Afar	Amhara	Beneshangul-Gumuz	Dire Dawa	Gambela	Harari	Oromia	SNNP	Somale	Tigray
Agriculture: indirect effects											
Afar	–0.0000299	—	–0.0000545	–0.0000433	–0.0000232	–0.0000275	–0.0000204	0.0000146	–0.0000809	–0.0000179	–0.0000264
Amhara	0.000311	0.000379	—	0.000223	0.0003656	0.0003267	0.0003795	0.0006119	0.0000216	0.0003971	0.0003058
Beneshangul-Gumuz	0.0022125	0.0022295	0.001285	—	0.0025018	0.0022954	0.0025245	0.0033459	0.0011854	0.002564	0.0022802
Dire Dawa	0.0024799***	0.0024891***	0.0023021***	0.0024029***	—	0.0024962***	0.0025455***	0.0026897***	0.0022797***	0.0025528***	0.002485***
Gambela	0.0029576	0.0028776	0.0025237	0.0027371	0.0031325	—	0.0031183	0.0034247	0.0027225	0.0031054	0.0029062
Harari	0.0034789**	0.003489**	0.0032166**	0.0033617**	0.0035693**	0.0034976**	—	0.0038093**	0.0031723**	0.0035835**	0.0034824**
Oromia	0.0001025	0.0000965	0.0001188	0.0001072	0.0000988	0.0001026	0.0000965	—	0.0001157	0.0000982	0.0001053
SNNP	0.0020613***	0.0020618***	0.0019316***	0.0020177***	0.0021048***	0.0020681***	0.0021051***	0.002176***	—	0.0021043***	0.0020886***
Somale	–0.0028985	–0.0030259	–0.0028135	–0.0028398	–0.0029095	–0.0029104	–0.002923	–0.0031448	–0.0025245	—	–0.0028816
Tigray	0.0016399*	0.0016847*	0.0014028	0.001533*	0.0017111*	0.0016602*	0.0017172*	0.0019743**	0.0012658+	0.0017456*	—
Agriculture: direct effects											
Afar	0.0078255	—	0.0110153	0.0066725	0.007805	0.0078849	0.0080869	0.0087928	0.0050652	0.0080678	0.0086282
Amhara	0.016251	0.0116073	—	0.0149796	0.0163485	0.0162908	0.0164266	0.01702	0.0139144	0.016519	0.0171101*
Beneshangul-Gumuz	0.0805927	0.0706257	0.0895578*	—	0.0817426	0.0806698	0.0812551	0.0789423	0.0780958	0.0817376	0.0807677
Dire Dawa	0.0573682***	0.0498077***	0.064378***	0.0559225***	—	0.0573563***	0.0571707***	0.0563834***	0.055924***	0.0572462***	0.058425***
Gambela	–0.020538	–0.0220228+*	–0.0205252	–0.0212117	–0.0200064	—	–0.0201637	–0.020123	–0.0212617	–0.0200157	–0.0203199
Harari	0.0792364***	0.0705573***	0.0866773***	0.077632***	0.078988***	0.0792132***	—	0.078199***	0.0779076***	0.079012***	0.0805289***
Oromia	0.0367678***	0.0314319***	0.0418812***	0.0357577***	0.0365598***	0.036782***	0.0365667***	—	0.0355132***	0.0366574***	0.0375959***
SNNP	0.0405188***	0.0354187***	0.0449179***	0.0397212***	0.0403207***	0.040493***	0.0404678***	0.0396876***	—	0.0403719***	0.0414594***
Somale	0.0705771*	0.0510453	0.0901316**	0.0694281*	0.0684289*	0.0702682*	0.0683248*	0.0604202	0.0791286*	—	0.0731651*
Tigray	0.0428847***	0.0363937**	0.0477338***	0.0416083***	0.0428567***	0.0429584***	0.0429573***	0.04274**	0.0394679**	0.0432826***	—
Road infrastructure: indirect effects											
Afar	0.0045465**	—	0.0044637**	0.004572**	0.0045424**	0.0045424**	0.0045326**	0.004511**	0.0046375**	0.0045469**	0.0044805**
Amhara	0.03657***	0.0362494***	—	0.0354573***	0.0376011***	0.0368603***	0.0376635***	0.0399935***	0.0326377***	0.0378095***	0.0377507***
Beneshangul-Gumuz	–0.0005838	–0.0005169	0.0024839	—	–0.0015407	–0.0008732	–0.0016054	–0.0042265	0.002685	–0.0017264	–0.0008875
Gambela	–0.0028907	–0.0027779	–0.0023442	–0.002605	–0.0031159	—	–0.003095	–0.0034883	–0.0026316	–0.0030696	–0.0028071
Oromia	0.0055688	0.0061059	0.0035611	0.004804	0.0061855	0.0056142	0.0063411	—	0.0034641	0.006302	0.0053793
SNNP	–0.0128933***	–0.0125874***	–0.0132268***	–0.0130282***	–0.0128845***	–0.0128807***	–0.0127828***	–0.0121613***	—	–0.012742***	–0.0129224***
Somale	0.0416998	0.0432361+*	0.0396473	0.0405723	0.0421519	0.0419246	0.0423337	0.0457921+*	0.0362873	—	0.041598
Tigray	0.01137	0.0110155	0.0112848	0.0117725	0.0112844	0.0112906	0.0113327	0.0106425	0.0118627	0.0112095	—
Road infrastructure: direct effects											
Afar	0.2386494***	—	0.2455631***	0.2407673***	0.2371855***	0.2382446***	0.2361852***	0.2289865***	0.2487328***	0.2367153***	0.2373335***
Amhara	0.6296651***	0.5682091***	—	0.6173477***	0.6318635***	0.6305711***	0.6301527***	0.6248275***	0.6142512***	0.632415***	0.6475656***
Beneshangul-Gumuz	–0.1156769	–0.1031897	–0.1258595	—	–0.119999	–0.1163567	–0.1185773	–0.1143753	–0.1106478	–0.1199135	–0.1132156
Gambela	0.08073***	0.0768604***	0.0870944***	0.0807033***	0.0795908***	—	0.0799191***	0.078946***	0.0809298***	0.0796737***	0.0809784***
Oromia	–0.0315447	–0.0350526	–0.0400762	–0.0304128	–0.0310652	–0.0330009	–0.0297428	—	–0.0217385	–0.0319541	–0.0312042
SNNP	0.0087309	–0.0082213	0.0223397	0.0034129	0.0096122	0.0088909	0.0096048	0.0114693	—	0.0109031	0.01143
Somale	0.1266697	0.2296414	0.0182931	0.1188796	0.145176	0.1297506	0.146347	0.2187677	0.0236514	—	0.1124718
Tigray	0.2006891	0.1917287	0.1976427	0.1980037	0.2021291	0.2004837	0.201953	0.2085734	0.1988772	0.20098	—

Health: indirect effects											
Afar	–0.0018754***	—	–0.0019488***	–0.0019302***	–0.0018642***	–0.0018704***	–0.0018627***	–0.0016545***	–0.0021277***	–0.0018201***	–0.0019264***
Amhara	–0.0008163	–0.0007319	—	–0.0008553	–0.0008151	–0.0008143	–0.0008021	–0.0006521	–0.0010643	–0.0007709	–0.0008354
Beneshangul-Gumuz	–0.0005042	–0.0005137	–0.0005457	—	–0.0004954	–0.000501	–0.000497	–0.0004321	–0.0005554	–0.0004948	–0.0004904
Dire Dawa	0.0047267	0.0047378	0.0046318	0.0046841	—	0.0047393	0.0047531	0.0047837	0.0048323	0.0047152	0.0046674
Gambela	0.0031209**	0.0031416**	0.0030131**	0.0030973**	0.0031343**	—	0.0031411**	0.0031535**	0.0031313**	0.0031413**	0.0031115**
Harari	0.0038347	0.0037692	0.0034925	0.0037272	0.0039356	0.0038665	—	0.0042154	0.0034532	0.003966	0.0039113
Oromia	0.0007276	0.0007792	0.0006835	0.0007049	0.0007285	0.0007325	0.0007353	—	0.0006408	0.0007442	0.0007099
SNNP	–0.0007168	–0.0006142	–0.0008944	–0.0008085	–0.0006842	–0.0006986	–0.0006634	–0.0003756	—	–0.000618	–0.0007097
Somale	0.0016628	0.0017411	0.0015517	0.0016681	0.0016473	0.0016585	0.0016826	0.0017752	0.0015336	—	0.0016749
Tigray	–0.0008304	–0.0007339	–0.0007298	–0.0008385	–0.0008692	–0.0008285	–0.0008598	–0.0007619	–0.0009456	–0.0008288	—
Education: indirect effects											
Afar	0.3108573***	—	0.286381**	0.2846627**	0.3177285***	0.3137521***	0.3229755***	0.4011183***	0.199569*	0.3342972***	0.3022268***
Amhara	0.035062	0.0480608	—	0.0283422	0.0360499	0.0355905	0.0373825	0.0610655+*	0.0022091	0.0416112	0.0301893
Beneshangul-Gumuz	0.0027651	0.0115439	–0.003276	—	0.0038195	0.0031573	0.0046163	0.0194199	–0.0181584	0.0073895	–0.0000896
Dire Dawa	0.0873717***	0.1014876***	0.0769926**	0.0800905**	—	0.0880441***	0.0905852***	0.1181355***	0.0482655+	0.0951995***	0.0842961**
Gambela	–0.0458486***	–0.0386617**	–0.0514859***	–0.0500643***	–0.0443188**	—	–0.044146**	–0.0307424*	–0.0657679***	–0.041205**	–0.0474434***
Harari	0.1101222***	0.1198099***	0.1042206***	0.1056719***	0.1107873***	0.1105749***	—	0.1284035***	0.0859142***	0.1150693***	0.1077654***
Oromia	0.0960016***	0.1096625***	0.083407***	0.0874425***	0.0986368***	0.0968126***	0.1002396***	—	0.0560411**	0.1046775***	0.0924788***
SNNP	–0.0053067	0.0070247	–0.0132564	–0.0120405	–0.0036479	–0.004769	–0.0026372	0.0206057	—	0.0017925	–0.0091462
Somale	0.3715089***	0.4174995***	0.3296004***	0.3419433***	0.3802432***	0.3749431***	0.386356***	0.4839415***	0.2340307**	—	0.358915***
Tigray	0.0229616	0.0344079	0.0121165	0.0169875	0.0245225	0.0236241	0.0260112	0.0480437+*	–0.0105306	0.0298293	—
Household characteristics											
Male head	–0.0107223	–0.0009711	–0.0125801	–0.0083602	–0.0140057	–0.0113669	–0.0176587	–0.0222415	0.0081963	–0.015421	–0.0096087
Age of head	–0.0016528	–0.0006217	–0.003903	–0.0007617	–0.0019507	–0.0019617	–0.001563	–0.0024277	–0.0004914	–0.0016059	–0.001702
Age of head squared	0.0000171	7.75×10^{-6}	0.0000392	7.06×10^{-6}	0.0000197	0.0000206	0.0000182	0.0000284	-1.61×10^{-7}	0.0000175	0.0000164
Household size	–0.1035003***	–0.1117144***	–0.1068088***	–0.10412***	–0.0998719***	–0.1018156***	–0.104723***	–0.1128117***	–0.0950972***	–0.1006275***	–0.0989163***
Years lived here	0.0005496	0.0007411	0.0009466	0.0004647	0.0004975	0.0005274	0.0004841	0.0002982	0.0019753+***	0.0002773	–0.0004847
Number of women	–0.011189	–0.0197701	–0.0066346	–0.0123011	–0.0103787	–0.0125228	–0.0082043	–0.006716	–0.0036276	–0.0161498	–0.0126296
Number of men	–0.0040244	–0.0063973	–0.0035431	0.0015513	–0.007353	–0.0048496	–0.0014804	–0.0177572	0.0136812	–0.010088	–0.0029374
Education of head	0.1138522***	0.1161434***	0.1028169***	0.1119486***	0.1129253***	0.1153338***	0.1160214***	0.1265308***	0.1083719***	0.114088***	0.1137221***
Work in agriculture	0.4780927***	0.4013179***	0.5675471***	0.4708721***	0.4696071***	0.4765477***	0.4735336***	0.4567751***	0.4711916***	0.4705353***	0.4851941***
Constant	6.835979***	6.889722***	6.85771***	6.845901***	6.836326***	6.835808***	6.823063***	6.828793***	6.838449***	6.82655***	6.829132***
Number of observations	7871	7514	6184	7370	7516	7661	7520	6105	6032	7616	7321
Number of clusters	674	641	530	631	644	656	644	523	518	652	627
F-statistic	22.38***	22.86***	22.79***	23.33***	22.76***	23.02***	22.07***	21.9***	18.73***	21.52***	22.94***
R^2	0.2192	0.2138	0.2419	0.2200	0.2117	0.2167	0.2027	0.2502	0.2018	0.2145	0.2238

Notes: Ordinary least squares estimation. Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. Variables used for access to services and performance in four sectors—agriculture: crop yield (average physical yield of all annual crops, in quintals per hectare); road infrastructure: road density (kilometers of roads per 1,000 persons); education: primary enrollment rate – gross enrollment rate in primary school (grades 1–8); health: access to health facilities – distance to nearest health facility (in kilometers). Road infrastructure, education, health, and agriculture variables are measured as zonal averages. — indicates not applicable. SNNP—Southern Nations, Nationalities, and Peoples. + denotes nontrivial changes from the base model.

in the short models, where region effects were introduced as parameter shifters of the sectoral effects, the long models already account for the region-differentiated role of sectoral performance and services on rural welfare.

Here the described data sensitivity analysis may be expected to reveal somewhat less strong changes of the parameters of interest to the exclusion of observations of regions. However, the basis for the core (third-stage) results is the long model, and it is of interest to examine the extent to which the core findings are robust to variations in the observations along a dimension (regional) to which results may plausibly be sensitive.

As Table 7.8 shows, the exclusion regressions here—as in the robustness checks for the short model—do not result in any change in the sign of those coefficients that are significant in both the base and the exclusion model. However, as before, there are some changes in the significance of coefficients. Specifically all such substantive changes result from three exclusions: removing observations of Afar, Oromia, or SNNP. The nontrivially changing coefficients are interspersed across sectors, though coefficients for the education sector experience the most such changes. The changes resulting from the removal of Afar or Oromia from the dataset are all in the direction of making the changed coefficients significant (without altering their sign), whereas the removal of SNNP makes some coefficients nonsignificant compared with the analysis on all observations.

Removing Afar makes significant the direct effects in agriculture for Gambela and the indirect effects of access to roads in Somale. The latter change is also effected by the removal of the Oromia observations, and this exclusion also makes the education effects of two regions (Amhara and Tigray) newly significant, resulting in a greater spread of education effects across regions where this spread was already large in the base model. Exclusion of observations for SNNP renders the indirect agriculture effects and the education effects insignificant. The section “Third Stage Analysis: Linking Household Welfare to Public Spending” will discuss the implications of this sensitivity analysis on the final, third-stage findings, as the findings of central interest are the birr-for-birr welfare returns to public spending across various sectors. As will be seen then, this robustness analysis, passing through the third-stage estimation, leaves intact only some of the sensitivities observed in this first-stage analysis, specifically the changes found in the education sector in the exclusion of Afar and Oromia.

In summary the absence of any qualitative changes (in terms of changes in the direction of effects) in the results of all exclusion regressions, both for the primary long model and for the previously discussed short model, suggests that on an important dimension the results are not overly driven by any one (statistically) dominant region. At the same time, the presence of a few changes in significance is likely to derive at least in part from a sample size effect, with a reduction in sample size increasing the standard errors. However—and especially since not all changes observed are in the direction of loss of significance, but some also reflect a gain of significance—it is likely that the changes observed may also be a result of some correlation between regions, such that exclusion of one region influences the reliability of estimates of the sector effects of another region. We will later evaluate the returns to public spending in the four sectors, which are based on these results and on those of the second-stage analysis. The latter is discussed next.

Second-Stage Analysis: Public Services and Public Spending

Tables 7.9–7.12 show the estimations of the second-stage analysis, in which we assess the impact of different types of public

Table 7.9 Public spending and sectoral outcomes: Specification with cross-sector complementarities

		System-ordinary-least-squares	S-2SLS	S-3SLS
Agriculture	K^{AGR}	0.0067963	0.0052505	0.0056631
		(0.0049)	(0.0051)	(0.0047)
	rain	0.000987	0.001002	4.27×10^{-4}
		(0.0011)	(0.0011)	(0.0010)
	land/household	–1.790331	–1.839903	–1.44268
		(1.1948)	(1.1971)	(1.0825)
	althi	0.4653955	0.4119225	0.2517467
		(0.8660)	(0.8682)	(0.7859)
	dist.road	–0.257024**	–0.261464**	–0.240359**
		(0.1037)	(0.1038)	(0.0944)
	malaria.vuln.	–1.643644	–1.537951	–1.459696
		(1.4750)	(1.4795)	(1.3416)
	Constant	13.08183***	13.30639***	13.46706***
		(2.0958)	(2.1069)	(1.9121)
	PI effect (%Δ)	*0.061*	*0.047*	*0.051*
Road infrastructure	K^{ROD}	0.0191324***	0.0200249***	0.0198547***
		(0.0016)	(0.0017)	(0.0016)
	sh.urban	1.01081	0.8020279	0.9380496
		(0.9449)	(0.9588)	(0.9140)
	pop.dens.	–0.00111	–0.000885	–0.000882
		(0.0011)	(0.0011)	(0.0010)
	Constant	–0.019083	–0.063643	–0.075217
		(0.2151)	(0.2180)	(0.2076)
	PI effect (%Δ)	*1.665*	*1.743*	*1.728*
Education	K^{EDU}	0.0013633***	0.0013711***	0.0013385***
		(0.0002)	(0.0002)	(0.0002)
	sh.urban	–0.38861*	–0.393432*	–0.33706
		(0.2095)	(0.2217)	(0.2100)
	dist95	–0.032***	–0.031987***	–0.034743***
		(0.0100)	(0.0100)	(0.0094)
	Constant	0.5131153***	0.5122048***	0.5204103***
		(0.0554)	(0.0571)	(0.0543)
	PI effect (%Δ)	*0.229*	*0.230*	*0.225*
Health	K^{HLT}	–0.004582	–0.008419*	–0.008445*
		(0.0045)	(0.0050)	(0.0048)
	sh.urban	–7.672327**	–5.901605*	–6.314749*
		(3.3637)	(3.5075)	(3.3472)
	malaria.vuln.	1.535785	1.64796	1.850204
		(1.2237)	(1.2351)	(1.1793)
	Constant	7.339445***	7.360492***	7.291173***
		(0.8340)	(0.8410)	(0.8036)
	PI effect (%Δ)	*–0.065*	*–0.119*	*–0.119*

	R^2 (percent)	F-statistic	R^2 (percent)	F-statistic	R^2 (percent)	χ^2
Equation						
Agriculture	25.5	2.28**	25.3	2.13*	24.5	12.9**
Road infrastructure	82.7	68.45***	82.6	66.08***	82.6	215.95***
Education	58.6	20.28***	58.6	17.4***	58.5	60.4***
Health	25.7	4.96***	24.5	5.50***	24.4	19.4***
Hausman test				$\chi^2(12) = 3.57$; *p*-value = .9975		

Notes: Standard errors in parentheses. $N = 53$. Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. althi—midlands/highlands dummy; dist95—zonal-average distance in kilometers to the nearest school; dist.road—average distance in kilometers to the nearest all-weather road; land/household—average household land size in hectares; malaria.vuln.—share of population that is vulnerable to malaria; pop.dens.—population density (persons per square kilometer); rain—mean rainfall in millimeters; sh.urban—share of population that is urban.

Table 7.10 Public spending and sectoral outcomes: Specification including agricultural inputs as a determinant of agricultural productivity

		System-ordinary-least-squares	S-2SLS	S-3SLS
Agriculture	K^{AGR}	0.0058733	0.0043099	0.0041859
		(0.0048)	(0.0050)	(0.0045)
	rain	0.0015426	0.0015783	0.00123
		(0.0012)	(0.0012)	(0.0010)
	land/household	–2.345597*	–2.429116**	–2.267958**
		(1.2243)	(1.2276)	(1.0693)
	althi	–0.144644	–0.207076	–0.3148728
		(0.9056)	(0.9080)	(0.7901)
	sh.seed	7.134519	6.174791	1.310289
		(13.8322)	(13.8694)	(12.1705)
	sh.irrig.	6.409159**	6.583235**	7.429033***
		(2.7522)	(2.7590)	(2.4094)
	sh.pest.	8.436073	8.529788	7.03293
		(6.5303)	(6.5396)	(5.6997)
	sh.fert.	1.906399	1.923865	1.945616
		(2.8582)	(2.8622)	(2.5043)
	Constant	9.30266***	9.593535***	10.10134***
		(1.7483)	(1.7640)	(1.5466)
	PI effect (%Δ)	*0.052*	*0.038*	*0.037*
Road infrastructure	K^{ROD}	0.0191324***	0.0198417***	0.019815***
		(0.0016)	(0.0017)	(0.0016)
	sh.urban	1.01081	0.8448688	0.8389041
		(0.9449)	(0.9565)	(0.9141)
	pop.dens.	–0.00111	–0.000931	–0.0008942
		(0.0011)	(0.0011)	(0.0010)
	Constant	–0.019083	–0.054499	–0.0569279
		(0.2151)	(0.2175)	(0.2073)
	PI effect (%Δ)	*1.665*	*1.727*	*1.725*
Education	K^{EDU}	0.0013633***	0.0014382***	0.0013977***
		(0.0002)	(0.0002)	(0.0002)
	sh.urban	–0.38861*	–0.43503**	–0.380588*
		(0.2095)	(0.2169)	(0.2046)
	dist95	–0.032***	–0.03187***	–0.034046***
		(0.0100)	(0.0100)	(0.0094)
	Constant	0.5131153***	0.50435***	0.5123307***
		(0.0554)	(0.0565)	(0.0536)
	PI effect (%Δ)	*0.229*	*0.242*	*0.235*
Health	K^{HLT}	–0.004582	–0.008506*	–0.0084996*
		(0.0045)	(0.0048)	(0.0046)
	sh.urban	–7.672327**	–5.86153*	–6.20289*
		(3.3637)	(3.4647)	(3.2904)
	malaria.vuln.	1.535785	1.650498	1.664079
		(1.2237)	(1.2351)	(1.1696)
	Constant	7.339445***	7.360968***	7.401786***
		(0.8340)	(0.8413)	(0.7994)
	PI effect (%Δ)	*–0.06*	*–0.120*	*–0.120*

Table 7.10 Continued

	System-ordinary-least-squares		S-2SLS		S-3SLS	
	R^2 (percent)	F-statistic	R^2 (percent)	F-statistic	R^2 (percent)	χ^2
Equation						
Agriculture	31.9	2.22**	31.7	2.13**	30.0	21.05***
Road infrastructure	82.7	68.45***	82.6	65.96***	82.6	216.26***
Education	58.6	20.28***	58.5	19.61***	58.5	66.51***
Health	25.7	4.96***	24.4	5.57***	24.4	19.46***
Hausman test				$\chi^2(12) = 2.46$; p-value = .9983		

Notes: Standard errors in parentheses. $N = 53$. Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. althi—midlands/highlands dummy; dist95—zonal-average distance in kilometers to the nearest school; land/household—average household land size in hectares; malaria.vuln.—share of population that is vulnerable to malaria; pop.dens.—population density (persons per square kilometer); rain—mean rainfall in millimeters; sh.fert—share of cultivable land using fertilizer; sh.irrig—share of cultivable land that is irrigated; sh.pest—share of cultivable land using pesticides; sh.seed—share of cultivable land using improved seeds; sh.urban—share of population that is urban.

spending on the various sectoral performance variables in the context of the first-stage results, as specified in equation (6). Table A.4 in the Appendix shows descriptive statistics for variables not already presented in Chapter 4. The unit of analysis is the zone. The public spending variables are measured at the regional level, because data were not disaggregated to the zonal level in a consistent manner for all years considered in the analysis.

For any given table—since each column reflects estimation of four sector-specific effects in a system of equations framework—each of these equations has its own constant, measure of fit, and so forth. The primary specification is that represented in Table 7.9. The other estimations in Tables 7.10–7.12 are used to examine the specification robustness of the agricultural sector equation. Specification is varied with respect to two factors: the inclusion of cross-sector effects and the inclusion of effects related to agricultural inputs. We also assess the robustness of the results by comparing each model using three different systems estimation methods: system-ordinary least squares, system-two-stage-least-squares (S-2SLS), and S-3SLS. Across all four tables, a Hausman specification test of the difference between the two latter estimation methods firmly establishes S-3SLS as the appropriate model.

The first specification is a priori selected as the primary model, since the effects of the included inputs (improved seed, fertilizer, irrigation, and pesticides) are heavily dependent on public expenditure and should thus be accounted for through the public investment variable. We also hypothesized the existence of cross-sectoral synergies, especially for agriculture. For example, better road infrastructure may reduce transaction costs for both agricultural inputs and the marketing of agricultural outputs, both potentially leading to improved productivity.

Similarly, in areas with greater exposure to health risks, agricultural labor productivity may be lower, which, ceteris paribus, may reduce yields. We were careful not to assess cross-sectoral effects by determining the impact of public expenditure in one sector on outcomes in another sector, but rather by assessing the influence of realized outcomes (or in the case of health, the existent risks) in one sector on outcomes in another.

We also focused our determination of cross-sector effects on agriculture. In gen-

Table 7.11 Public spending and sectoral outcomes: Specification including cross-sector complementarities and agricultural inputs

		System-ordinary-least-squares	S-2SLS	S-3SLS
Agriculture	K^{AGR}	0.0059742	0.004761	0.0039689
		(0.0050)	(0.0052)	(0.0045)
	rain	0.001688	0.0017447	1.51×10^{-3}
		(0.0012)	(0.0012)	(0.0011)
	land/household	–2.247827*	–2.306646*	–2.291261**
		(1.1968)	(1.1993)	(1.0219)
	althi	0.0524677	0.0249794	–0.068863
		(0.9143)	(0.9155)	(0.7792)
	sh.seed	4.730748	3.712523	–2.565539
		(14.3049)	(14.3541)	(12.2900)
	sh.irrig.	6.119541**	6.218199**	7.399994***
		(2.7081)	(2.7122)	(2.3161)
	sh.pest.	5.803208	5.955844	4.601991
		(6.6070)	(6.6142)	(5.6385)
	sh.fert.	1.236816	1.243842	1.635666
		(2.8134)	(2.8158)	(2.4086)
	dist.road	–0.166706	–0.171932	–0.184515*
		(0.1102)	(0.1104)	(0.0945)
	malaria.vuln.	–1.571835	–1.467524	–1.233133
		(1.5410)	(1.5459)	(1.3173)
	Constant	11.40777***	11.55699***	11.98128***
		(2.1199)	(2.1271)	(1.8168)
	PI effect (%Δ)	*0.053*	*0.042*	*0.035*
Road infrastructure	K^{ROD}	0.0191324***	0.0198208***	0.0197767***
		(0.0016)	(0.0017)	(0.0016)
	sh.urban	1.01081	0.8497608	0.8414219
		(0.9449)	(0.9551)	(0.9128)
	pop.dens.	–0.00111	–0.000936	–0.000905
		(0.0011)	(0.0011)	(0.0010)
	Constant	–0.019083	–0.053455	–0.05398
		(0.2151)	(0.2172)	(0.2071)
	PI effect (%Δ)	*1.665*	*1.725*	*1.722*
Education	K^{EDU}	0.0013633***	0.0014382***	0.0013976***
		(0.0002)	(0.0002)	(0.0002)
	sh.urban	–0.38861*	–0.435055**	–0.366382*
		(0.2095)	(0.2169)	(0.2041)
	dist95	–0.032***	–0.03187***	–0.03564***
		(0.0100)	(0.0100)	(0.0094)
	Constant	0.5131153***	0.5043452***	0.5159903***
		(0.0554)	(0.0565)	(0.0537)
	PI effect (%Δ)	*0.229*	*0.242*	*0.235*
Health	K^{HLT}	–0.004582	–0.008325*	–0.008519*
		(0.0045)	(0.0048)	(0.0046)
	sh.urban	–7.672327**	–5.945024*	–6.087179*
		(3.3637)	(3.4618)	(3.3091)
	malaria.vuln.	1.535785	1.645209	1.810696
		(1.2237)	(1.2341)	(1.1787)
	Constant	7.339445***	7.359976***	7.290448***
		(0.8340)	(0.8406)	(0.8033)
	PI effect (%Δ)	*–0.065*	*–0.118*	*–0.121*

Table 7.11 Continued

	System-ordinary-least-squares		S-2SLS		S-3SLS	
	R^2 (percent)	F-statistic	R^2 (percent)	F-statistic	R^2 (percent)	χ^2
Equation						
Agriculture	38.5	2.25**	38.4	2.19**	36.6	30.45***
Road infrastructure	82.7	68.45***	82.6	66.55***	82.6	217.9***
Education	58.6	20.28***	58.5	19.61***	58.4	68.5***
Health	25.7	4.96***	24.5	5.54***	24.4	19.04***
Hausman test			$\chi^2(12)$ = 2.44; p-value = .9984			

Notes: Standard errors in parentheses. N = 53. Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. althi—midlands/highlands dummy; dist95—zonal-average distance in kilometers to the nearest school; dist.road—average distance in kilometers to the nearest all-weather road; land/household—average household land size in hectares; malaria.vuln.—share of population that is vulnerable to malaria; pop.dens.—population density (persons per square kilometer); rain—mean rainfall in millimeters; sh.fert—share of cultivable land using fertilizer; sh.irrig—share of cultivable land that is irrigated; sh.pest—share of cultivable land using pesticides; sh.seed—share of cultivable land using improved seeds; sh.urban—share of population that is urban.

eral, complementarities across sectors can be expected where the "affected" sector is measured by a (sectoral) performance variable, rather than by a more intermediate variable. For example, if the dependent variable in the health equation is a measure of a given population's exposure to ill health (for example maternal mortality or child stunting), then it would be necessary to account, for example, for how levels of education (via income effects and information) or agricultural performance (via its likely impact on access to food) would affect the "health" dependent variable. However, since the dependent variable in this second-stage estimation, average distance to a health center, can be better understood as an intermediate outcome variable for the health sector, we do not expect to see such cross-sector effects on the health variable. The analogous idea holds for education and road infrastructure in our model. The agricultural outcome variable is less "intermediate" and thus more likely to be influenced by the outcome of investments in other sectors, hence our focus on considering alternative specifications for the agriculture equation in the system of equations.

In Table 7.9, the public investment coefficients are significant or strongly significant for all sectors except agriculture. This result, as well as the size of the public investment effects, is generally robust across estimation methods. The only exception is the system-OLS estimation of the health equation, which departs in significance and size from that of the other two estimation approaches.

The magnitudes of the coefficients on public investment are not directly comparable with one another because the dependent variables are measured in different units. Therefore the last row in each equation of the system compares the percentage increase from the mean values of the sectoral performance variables implied by a one-birr increase in per capita public expenditure in each of the sectors. For example, referring to the S-3SLS results, a one-birr increase in per capita public expenditure in education and in the health sector is associated with a 0.23 percent increase in the primary enrollment rate and a 0.12 percent reduction in the distance to health facilities, respectively. The largest percentage increase is achieved in the road sector. However, while this interpretation of the expenditure coefficients facilitates comparison of expenditure returns across sectors by equalizing the units of measurement, the difference in the

Table 7.12 Public spending and sectoral outcomes: Base specification with neither sector complementarities nor agricultural inputs

		System-ordinary-least-squares		S-2SLS		S-3SLS	
Agriculture	K^{AGR}	0.0069475		0.0052469		0.0063545	
		(0.0051)		(0.0053)		(0.0049)	
	rain	0.0006684		0.0006547		4.82×10^{-5}	
		(0.0011)		(0.0011)		(0.0010)	
	land/household	–1.842511		–1.908293		–1.259917	
		(1.2775)		(1.2802)		(1.1510)	
	althi	0.4713677		0.3895522		0.1498832	
		(0.9018)		(0.9052)		(0.8157)	
	Constant	10.7617***		11.10981***		11.23652***	
		(1.8096)		(1.8318)		(1.6741)	
	PI effect (%Δ)	*0.062*		*0.047*		*0.060*	
Road infrastructure	K^{ROD}	0.0191324***		0.0199439***		0.0198053***	
		(0.0016)		(0.0017)		(0.0017)	
	sh.urban	1.01081		0.8209769		0.9342297	
		(0.9449)		(0.9600)		(0.9144)	
	pop.dens.	–0.00111		–0.000905		–0.000957	
		(0.0011)		(0.0011)		(0.0010)	
	Constant	–0.019083		–0.059599		–0.062427	
		(0.2151)		(0.2182)		(0.2077)	
	PI effect (%Δ)	*1.665*		*1.736*		*1.72*	
Education	K^{EDU}	0.0013633***		0.0013753***		0.0013471***	
		(0.0002)		(0.0002)		(0.0002)	
	sh.urban	–0.38861*		–0.39606*		–0.355101*	
		(0.2095)		(0.2221)		(0.2103)	
	dist95	–0.032***		–0.031979***		–0.033228***	
		(0.0100)		(0.0100)		(0.0094)	
	Constant	0.5131153***		0.5117085***		0.5158731***	
		(0.0554)		(0.0572)		(0.0543)	
	PI effect (%Δ)	*0.229*		*0.231*		*0.23*	
Health	K^{HLT}	–0.004582		–0.009286*		–0.008922*	
		(0.0045)		(0.0050)		(0.0047)	
	sh.urban	–7.672327**		–5.501199		–6.218437*	
		(3.3637)		(3.5273)		(3.2766)	
	malaria.vuln.	1.535785		1.673325		1.54191	
		(1.2237)		(1.2402)		(1.1500)	
	Constant	7.339445***		7.365251***		7.523325***	
		(0.8340)		(0.8445)		(0.7906)	
	PI effect (%Δ)	*–0.065*		*–0.131*		*–0.13*	
		R^2 (percent)	**F-statistic**	**R^2 (percent)**	**F-statistic**	**R^2 (percent)**	χ^2
Equation							
Agriculture		10.1	1.18	9.9	0.96	8.8	3.56
Road infrastructure		82.7	68.45***	82.6	64.84***	82.6	212.64***
Education		58.6	20.28***	58.6	17.38***	58.6	58.78***
Health		25.7	4.96***	23.8	5.65***	24.0	20.55***
Hausman test				$\chi^2(12) = 7.29$; *p*-value = .8379			

Notes: Standard errors in parentheses. $N = 53$. Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. althi—midlands/highlands dummy; dist95—zonal-average distance in kilometers to the nearest school; land/household—average household land size in hectares; malaria.vuln.—share of population that is vulnerable to malaria; pop.dens.—population density (persons per square kilometer); rain—mean rainfall in millimeters; sh.urban—share of population that is urban.

underlying outcome variables means that these figures are still indicative only of the comparative contribution of spending in the different sectors. By assessing household welfare effects, the third-stage estimation, discussed subsequently, allows for more direct comparability.

Examining the results across model specifications, that is across Tables 7.9–7.12, we see that the results of the three nonagricultural sectors are very stable vis-à-vis the changes in specification in the agriculture equation (for system-OLS they are of course identical). The coefficients in the agriculture equation are also relatively stable. The coefficient on the variable of interest, agricultural spending, is somewhat reduced when agricultural inputs are included (for example comparing Table 7.11 with Table 7.9, and comparing Table 7.10 with Table 7.12). This is quite intuitive, as the provision of agricultural inputs and infrastructure, such as fertilizer, seeds, and irrigation, is in great part enabled through public expenditures in agriculture.

The results for the second-stage analysis presented so far are based on public investment variables derived from equation (5) assuming a depreciation rate and discount rate of $\delta = 0.05$ and $r = 0.05$, respectively. It is useful to examine whether there are important qualitative changes in the core findings concerning the effect of public investments in the four sectors, or whether these results fundamentally hold. Table 7.13 gives a summary of the public investment coefficients for different parametric assumptions. The coefficients are presented for each of the three systems estimation methods and the four specifications of the agriculture equation that correspond to the specifications in Tables 7.9–7.12. Tables A.5–A.8 in the Appendix present the full results for these alternative parametric assumptions, based on the main variable specification (the specification as in Table 7.9).

Changing the magnitude of the depreciation and discount rate parameters within the range of 2–10 percent has important consequences for the public investment effects. Increasing these parameters increases the (absolute value of the) public investment coefficients by a factor of anywhere from 1.5 to 4. Varying the depreciation rate increases the coefficients by more than varying the discount rate by the same magnitude. For example, assuming $\delta = 0.02$ and increasing r from 0.02 to 0.10 results in an increase of the public investment coefficient by 53 percent, 47 percent, 59 percent, and 81 percent for the agriculture, road infrastructure, education, and health sectors, respectively (based on the main variable specification and 3SLS estimation). But increasing the depreciation rate value from 2 percent to 10 percent, holding the discount rate at 2 percent, increases the four respective coefficients by 90 percent, 81 percent, 106 percent, and 161 percent.

The qualitative impact of these different parameter assumptions follows from equation (5): an increase in either parameter reduces the cumulative public investment in any given sector, so that the marginal effect of public investment in the regression will be higher. What is not as immediate is the way in which changing these assumptions may affect inferences on the coefficients and the stability of the results with changing specifications. Table 7.13 and Tables A.5–A.8 in the Appendix show that our core results are highly robust to varying the parameter assumptions.

Third-Stage Analysis: Linking Household Welfare to Public Spending

As discussed in Chapter 5, the third-stage estimation draws on the first two stages of the analysis by using equation (9) to assess the effect on rural household consumption of a marginal increase in per capita public expenditure in various sectors. In Table 7.14 the first column draws on the first stage's main specification

Table 7.13 Public spending and sectoral outcomes: Summary of public investment coefficients for different parametric assumptions

Specification/sector		System-ordinary-least-squares	S-2SLS	S-3SLS	System-ordinary-least-squares	S-2SLS	S-3SLS
		$\delta = 0.02, r = 0.02$			$\delta = 0.10, r = 0.10$		
C	Agriculture	0.00448*	0.00339	0.00348	0.00734	0.00575	0.00670
	Road infrastructure	0.01176***	0.01298***	0.01292***	0.02430***	0.02509***	0.02478***
	Education	0.00079***	0.00082***	0.00080***	0.00183***	0.00182***	0.00180***
	Health	–0.00231*	–0.00423*	–0.00436*	–0.00715	–0.01340*	–0.01307*
I	Agriculture	0.00359	0.00265	0.00239	0.00693	0.00470	0.00467
	Road infrastructure	0.01176***	0.01267***	0.01276***	0.02430***	0.02490***	0.02475***
	Education	0.00079***	0.00086***	0.00084***	0.00183***	0.00191***	0.00187***
	Health	–0.00231	–0.00423*	–0.00435*	–0.00715	–0.01356*	–0.01314*
CI	Agriculture	0.00385	0.00300	0.00237	0.00650	0.00511	0.00418
	Road infrastructure	0.01176***	0.01263***	0.01268***	0.02430***	0.02488***	0.02473***
	Education	0.00079***	0.00086***	0.00084***	0.00183***	0.00191***	0.00186***
	Health	–0.00231	–0.00413*	–0.00435*	–0.00715	–0.01334*	–0.01330*
B	Agriculture	0.00423	0.00305	0.00367	0.00835	0.00632	0.00790
	Road infrastructure	0.01176***	0.01290***	0.01291***	0.02430***	0.02503***	0.02474***
	Education	0.00079***	0.00083***	0.00081***	0.00183***	0.00182***	0.00180***
	Health	–0.00231	–0.00466*	–0.00459*	–0.00715	–0.01474*	–0.01368*
		$\delta = 0.02, r = 0.10$			$\delta = 0.10, r = 0.02$		
C	Agriculture	0.00634	0.00497	0.00533	0.00771	0.00590	0.00662
	Road infrastructure	0.01834***	0.01921***	0.01904***	0.02275***	0.02358***	0.02334***
	Education	0.00129***	0.00130***	0.00127***	0.00169***	0.00168***	0.00165***
	Health	–0.00430	–0.00787*	–0.00789*	–0.00619	–0.01152*	–0.01138*
I	Agriculture	0.00557	0.00413	0.00405	0.00683	0.00478	0.00466
	Road infrastructure	0.01834***	0.01905***	0.01901***	0.02275***	0.02338***	0.02330***
	Education	0.00129***	0.00137***	0.00133***	0.00169***	0.00176***	0.00172***
	Health	–0.00430	–0.00795*	–0.00793*	–0.00619	–0.01166*	–0.01146*
CI	Agriculture	0.00565	0.00455	0.00384	0.00650	0.00511	0.00418
	Road infrastructure	0.01834***	0.01904***	0.01899***	0.02430***	0.02488***	0.02473***
	Education	0.00129***	0.00137***	0.00133***	0.00183***	0.00191***	0.00186***
	Health	–0.00430	–0.00778*	–0.00795*	–0.00715	–0.01334*	–0.01330*
B	Agriculture	0.00653	0.00499	0.00601	0.00823	0.00616	0.00759
	Road infrastructure	0.01834***	0.01913***	0.01899***	0.02275***	0.02351***	0.02330***
	Education	0.00129***	0.00131***	0.00128***	0.00169***	0.00168***	0.00165***
	Health	–0.00430	–0.00868*	–0.00835*	–0.00619	–0.01269*	–0.01195*

Notes: Abbreviations for specifications: B = base assumption, without complementarities and agricultural inputs; C = complementarities across sector investments; CI = cross-sector complementarities and agricultural inputs included; I = agricultural inputs included.

(Table 7.6) and the second column uses the average-effects regression (Table 7.7) for comparison.

While the first-stage regression showed that two regions seem to stand out in terms of the strong effect that access to roads appeared to have on consumption, the third stage allows the effect of road infrastructure expenditure on household consumption to be quantified. For example, a one-birr increase in per capita expenditure on roads in Afar is found to lead to a five-birr increase

Table 7.14 Impact of public expenditure on household welfare: Two alternative first-stage specifications

	Based on second stage's specification C, main estimation (S-3SLS), and $\delta = 0.05$, $r = 0.05$	
	First stage: Direct and indirect effects	**First stage: Average effects**
Agriculture		
Afar	0.0104	0.0485
	(0.028)	(0.080)
Amhara	0.0465	–0.00210
	(0.056)	(0.070)
Beneshangul-Gumuz	0.2313	0.0561
	(0.314)	(0.564)
Dire Dawa	0.2971	0.5650
	(0.251)	(0.478)
Gambela	0.0457	0.0294
	(0.110)	(0.091)
Harari	0.3915	0.8555
	(0.336)	(0.718)
Oromia	0.0757	0.3703
	(0.068)	(0.314)
SNNP	0.1811	0.0019
	(0.151)	(0.099)
Somale	–0.1139	0.9052
	(0.247)	(0.827)
Tigray	0.1986	0.0664
	(0.178)	(0.178)
Road infrastructure		
Afar	5.0390***	8.1533***
	(1.527)	(1.995)
Amhara	11.9514***	11.2656***
	(2.922)	(3.644)
Beneshangul-Gumuz	–0.6973	–3.0122
	(3.477)	(4.013)
Gambela	0.1909	0.3524
	(0.499)	(0.540)
Oromia	1.2293	–4.7474*
	(2.258)	(2.948)
SNNP	–2.5089***	–4.4274***
	(0.667)	(1.059)
Somale	14.3842*	–5.9852
	(8.519)	(8.818)
Tigray	4.1785	0.8858
	(3.389)	(4.139)
Education		
Afar	1.8786**	–0.1400
	(0.777)	(0.815)
Amhara	0.1710	0.8305**
	(0.149)	(0.299)
Beneshangul-Gumuz	0.0149	1.1243
	(0.114)	(1.147)
Dire Dawa	0.5202**	—
	(0.218)	

(continued)

Table 7.14 Continued

	Based on second stage's specification C, main estimation (S-3SLS), and $\delta = 0.05$, $r = 0.05$	
	First stage: Direct and indirect effects	First stage: Average effects
Gambela	–0.2410**	—
	(0.101)	
Harari	0.5951***	—
	(0.194)	
Oromia	0.5254***	–0.0700
	(0.164)	(0.293)
SNNP	–0.0300	1.1826**
	(0.115)	(0.458)
Somale	2.0312***	—
	(0.660)	
Tigray	0.1073	1.0026*
	(0.122)	(0.542)
Health		
Afar	0.0715*	0.0667
	(0.044)	(0.049)
Amhara	0.0251	–0.0005
	(0.033)	(0.035)
Beneshangul-Gumuz	0.0171	0.0256
	(0.026)	(0.041)
Dire Dawa	–0.1776	–0.1923
	(0.157)	(0.181)
Gambela	–0.1035	–0.1380
	(0.076)	(0.097)
Harari	–0.1307	–0.0548
	(0.223)	(0.231)
Oromia	–0.0251	–0.0431
	(0.034)	(0.046)
SNNP	0.0256	–0.0235
	(0.037)	(0.038)
Somale	–0.0574	–0.0654
	(0.057)	(0.066)
Tigray	0.0245	–0.0559
	(0.052)	(0.070)

Notes: Standard errors in parentheses. Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. Abbreviation for specification: C—complementarities across sector investments. — indicates that an estimate of the coefficient could not be derived due to collinearity. SNNP—Southern Nations, Nationalities, and Peoples.

in per capita consumption of rural households in this region.[3]

The effects of spending on agriculture and health should be interpreted with caution, given that the standard errors obtained via the delta method are large. Nevertheless some tentative findings can be established. The strongest effects of spending appear to be associated with rural households in the city-states Dire Dawa and Harari. In these locations a one-birr increase in spending results in greater than 0.39 and 0.29 birr in-

[3]For ease of interpretation, the first-stage coefficients were first transformed so the third-stage results reflect the impact of spending on per-adult-equivalent household expenditure, rather than its log.

creases in per capita household consumption for the two regions, respectively. In comparison with the results on road expenditure, returns to agricultural expenditures, though not uniform, tend to be much more stable across regions than returns to spending on road infrastructure. What is also noticeable, however, is that the highest returns to road spending are substantially higher than the highest returns to agricultural spending.

The returns to public spending on education appear to be larger than those to agricultural expenditure, but they still fall substantially short of the investment returns for road infrastructure, although the former are significant for more regions. As with the level of returns, the interregional variation of the returns to education spending lies between that in agriculture and road infrastructure. Similar to the case of agriculture, significant results were not observed with regard to rural welfare returns to health spending. Unlike the agricultural sector, however, the results from the first-stage regression are weak for most regions.

This is not inconsistent with the findings of Collier, Dercon, and Mackinnon (2002), who reported that in Ethiopia the returns to public expenditure on the "quantity" of health care (which is what our measure of access to public services captures) are very low, especially in comparison to investments in the "quality" of health care.

It is certainly of note that the results give not just significant and low but even negative coefficients for SNNP and Gambela related to returns to road infrastructure and education spending, respectively. This finding arises from the first-stage analysis of the impact of sectoral performance on rural welfare. As discussed previously in the context of this first stage, this is likely to be due to the limitation of the partial analysis offered by this study: while road infrastructure, for example, may serve rural and urban residents alike, we are only considering its effects on rural households' incomes. Furthermore the design of public investments, for example in education, may serve purposes other than increasing income, including enhancing equity and meeting certain social goals—outcomes that may in some cases constitute a trade-off to increases in average income, and outcomes that are not captured in this study. This may suggest the need for additional work, including the consideration of other potential outcomes (beyond rural income) that may result from improvements in sector-specific performance indicators.

Finally Tables 7.15 and 7.16 extend to this third-stage analysis the previous robustness checks against different values for the depreciation and discount rate parameters in equation (5), and against exclusion of sets of observations associated with regions, respectively. With regard to the discount and depreciation rate sensitivity analysis, we find again that the core interpretation of the coefficients summarized earlier holds when deriving results for varying parameter assumptions.

On the other hand, Table 7.16 shows that results on returns to spending in the education sector are affected when observations of two regions are (separately) excluded. Excluding the data on either Afar or Oromia renders the returns to education expenditures significant (as well as higher in magnitude) in Amhara and Tigray; they are nonsignificant in the base model. Put another way, inclusion of households in the Oromia region will tend to "hide" the confidence in the results on the returns to education spending in certain other regions, and analogously for the case of inclusion of Afar in the analysis.

Results for the other three sectors are not affected to any great degree by the exclusion regressions (unlike the analogous case in the first stage; compare with Table 7.8). With returns in the education sector in the base model already statistically significant across more regions than the other sectors, the data robustness analysis presents findings that, if anything, lend additional confidence to the conclusion that the returns to education investments seem to be widely dispersed across Ethiopia, even if returns to infrastructure spending, which are more concentrated, are larger in magnitude where they are found to be statistically significant.

Table 7.15 Impact of public expenditure on household welfare: Four alternative second-stage parameter value assumptions

	Based on first stage's main specification (direct and indirect effects) and second stage's specification C (with cross-sector effects) and second stage's main estimation (S-3SLS)			
	$\delta = 0.02, r = 0.02$	$\delta = 0.02, r = 0.10$	$\delta = 0.10, r = 0.02$	$\delta = 0.10, r = 0.10$
Agriculture				
Afar	0.0064	0.0098	0.0121	0.012
	(0.017)	(0.027)	(0.034)	(0.035)
Amhara	0.0285	0.0438	0.0543	0.055
	(0.032)	(0.053)	(0.071)	(0.077)
Beneshangul-Gumuz	0.1421	0.2179	0.2704	0.273
	(0.181)	(0.295)	(0.389)	(0.416)
Dire Dawa	0.1825	0.2799	0.3474	0.351
	(0.129)	(0.234)	(0.336)	(0.382)
Gambela	0.0281	0.0431	0.0535	0.054
	(0.066)	(0.103)	(0.131)	(0.135)
Harari	0.2405	0.3688	0.4577	0.463
	(0.174)	(0.313)	(0.449)	(0.508)
Oromia	0.0465	0.0713	0.0885	0.089
	(0.036)	(0.063)	(0.090)	(0.101)
SNNP	0.1112	0.1706	0.2117	0.214
	(0.077)	(0.141)	(0.203)	(0.231)
Somale	–0.0700	–0.1073	–0.1332	–0.135
	(0.148)	(0.232)	(0.296)	(0.306)
Tigray	0.1220	0.1871	0.2322	0.235
	(0.094)	(0.167)	(0.236)	(0.265)
Road infrastructure				
Afar	3.2793***	4.8327***	5.9228***	6.290***
	(0.995)	(1.466)	(1.797)	(1.912)
Amhara	7.7778***	11.4621***	14.0477***	14.918***
	(1.904)	(2.806)	(3.440)	(3.665)
Beneshangul-Gumuz	–0.4538	–0.6688	–0.8196	–0.870
	(2.263)	(3.335)	(4.087)	(4.340)
Gambela	0.1242	0.1831	0.2244	0.238
	(0.325)	(0.479)	(0.587)	(0.623)
Oromia	0.8000	1.1789	1.4449	1.534
	(1.470)	(2.166)	(2.654)	(2.819)
SNNP	–1.6327***	–2.4062***	–2.9489***	–3.132***
	(0.435)	(0.641)	(0.785)	(0.836)
Somale	9.3610*	13.7952*	16.9071*	17.954*
	(5.545)	(8.172)	(10.016)	(10.642)
Tigray	2.7193	4.0074	4.9114	5.216
	(2.206)	(3.250)	(3.984)	(4.232)
Education				
Afar	1.1294**	1.7877**	2.3113**	2.522**
	(0.468)	(0.739)	(0.956)	(1.043)

Table 7.15 Continued

	Based on first stage's main specification (direct and indirect effects) and second stage's specification C (with cross-sector effects) and second stage's main estimation (S-3SLS)			
	$\delta = 0.02, r = 0.02$	$\delta = 0.02, r = 0.10$	$\delta = 0.10, r = 0.02$	$\delta = 0.10, r = 0.10$
Amhara	0.1028	0.1627	0.2104	0.230
	(0.090)	(0.142)	(0.183)	(0.200)
Beneshangul-Gumuz	0.0089	0.0142	0.0183	0.020
	(0.069)	(0.109)	(0.140)	(0.153)
Dire Dawa	0.3128**	0.4950**	0.6400**	0.698**
	(0.131)	(0.208)	(0.269)	(0.293)
Gambela	–0.1449**	–0.2294**	–0.2966**	–0.324**
	(0.061)	(0.096)	(0.124)	(0.135)
Harari	0.3578***	0.5663***	0.7321***	0.799***
	(0.117)	(0.185)	(0.239)	(0.261)
Oromia	0.3158***	0.4999***	0.6464***	0.705***
	(0.099)	(0.156)	(0.202)	(0.220)
SNNP	–0.0181	–0.0286	–0.0369	–0.040
	(0.069)	(0.109)	(0.141)	(0.154)
Somale	1.2211***	1.9329***	2.4990***	2.727***
	(0.398)	(0.628)	(0.812)	(0.886)
Tigray	0.0645	0.1021	0.1320	0.144
	(0.073)	(0.116)	(0.150)	(0.164)
Health				
Afar	0.0369*	0.0668*	0.0963*	0.111*
	(0.023)	(0.041)	(0.059)	(0.068)
Amhara	0.0130	0.0235	0.0338	0.039
	(0.017)	(0.031)	(0.045)	(0.051)
Beneshangul-Gumuz	0.0088	0.0160	0.0231	0.027
	(0.013)	(0.024)	(0.035)	(0.040)
Dire Dawa	–0.0916	–0.1658	–0.2392	–0.275
	(0.081)	(0.147)	(0.212)	(0.244)
Gambela	–0.0534	–0.0967	–0.1395	–0.160
	(0.039)	(0.071)	(0.103)	(0.118)
Harari	–0.0674	–0.1221	–0.1762	–0.202
	(0.115)	(0.208)	(0.300)	(0.345)
Oromia	–0.0130	–0.0235	–0.0338	–0.039
	(0.018)	(0.032)	(0.046)	(0.053)
SNNP	0.0132	0.0239	0.0345	0.040
	(0.019)	(0.034)	(0.049)	(0.057)
Somale	–0.0296	–0.0536	–0.0773	–0.089
	(0.030)	(0.054)	(0.077)	(0.089)
Tigray	0.0126	0.0229	0.0330	0.038
	(0.027)	(0.049)	(0.070)	(0.081)

Notes: Standard errors in parentheses. Coefficients significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. Abbreviation for specification: C—complementarities across sector investments. SNNP—Southern Nations, Nationalities, and Peoples.

Table 7.16 Impact of public expenditure on household welfare: Robustness to exclusion of observations

Excluded observations	None	Afar	Amhara	Beneshangul-Gumuz	Dire Dawa	Gambela	Harari	Oromia	SNNP	Somale	Tigray
Road infrastructure											
Afar	5.0390***	—	5.0305***	5.0730***	5.0252***	5.0330***	5.0107***	4.9420***	5.1791***	5.0250***	4.9817***
	(1.527)		(1.477)	(1.515)	(1.536)	(1.531)	(1.535)	(1.574)	(1.497)	(1.54)	(1.521)
Amhara	11.9514***	11.5320***	—	11.6263***	12.2009***	12.0233***	12.2056***	12.7115***	10.9605***	12.2519***	12.3236***
	(2.922)	(2.911)		(2.916)	(2.933)	(2.924)	(2.929)	(2.948)	(2.948)	(2.928)	(2.933)
Beneshangul-Gumuz	–0.6973	–0.6213	–0.1970	—	–0.8917	–0.7529	–0.8961	–1.3466	–0.0830	–0.9247	–0.7394
	(3.477)	(3.495)	(3.536)		(3.459)	(3.471)	(3.463)	(3.458)	(3.518)	(3.457)	(3.477)
Gambela	0.1909	0.1793	0.2788	0.2176	0.1632	—	0.1670	0.1245	0.2164	0.1680	0.2002
	(0.499)	(0.5)	(0.495)	(0.497)	(0.501)		(0.5)	(0.502)	(0.499)	(0.501)	(0.499)
Oromia	1.2293	1.3448	0.6568	1.0397	1.3912	1.2315	1.4399	—	0.7509	1.4154	1.1827
	(2.258)	(2.256)	(2.236)	(2.25)	(2.273)	(2.26)	(2.27)		(2.255)	(2.269)	(2.266)
SNNP	–2.5089***	–2.5428***	–2.4991***	–2.5653***	–2.5022***	–2.5055***	–2.4821***	–2.3484***	—	–2.4668***	–2.4996***
	(0.667)	(0.657)	(0.7)	(0.68)	(0.662)	(0.665)	(0.658)	(0.626)		(0.653)	(0.665)
Somale	14.3842*	15.6577*	12.9036*	13.9622*	14.6697*	14.4798*	14.7371*	16.3984*	11.8623*	—	14.2440*
	(8.519)	(8.663)	(8.197)	(8.37)	(8.614)	(8.549)	(8.64)	(9.034)	(8.07)		(8.512)
Tigray	4.1785	4.0300	4.1368	4.2606	4.1669	4.1573	4.1777	4.0504	4.2889	4.1405	—
	(3.389)	(3.381)	(3.355)	(3.404)	(3.388)	(3.388)	(3.388)	(3.375)	(3.393)	(3.389)	
Agriculture											
Afar	0.0104	—	0.0120	0.0052	0.0117	0.0110	0.0129	0.0215	–0.0059	0.0133	0.0128
	(0.028)		(0.029)	(0.028)	(0.029)	(0.029)	(0.029)	(0.033)	(0.029)	(0.029)	(0.029)
Amhara	0.0465	0.0435	—	0.0387	0.0502	0.0476	0.0512	0.0674	0.0237	0.0525	0.0475
	(0.056)	(0.055)		(0.052)	(0.059)	(0.057)	(0.059)	(0.07)	(0.047)	(0.06)	(0.057)
Beneshangul-Gumuz	0.2313	0.2176	0.1968	—	0.2478	0.2357	0.2483	0.2871	0.1749	0.2510	0.2350
	(0.314)	(0.308)	(0.301)		(0.321)	(0.316)	(0.322)	(0.343)	(0.291)	(0.323)	(0.316)
Dire Dawa	0.2971	0.2804	0.3013	0.2887	—	0.2982	0.3010	0.3089	0.2804	0.3017	0.2999
	(0.251)	(0.238)	(0.254)	(0.244)		(0.252)	(0.254)	(0.261)	(0.237)	(0.255)	(0.253)
Gambela	0.0457	0.0412	0.0341	0.0387	0.0513	—	0.0507	0.0590	0.0383	0.0506	0.0447
	(0.11)	(0.109)	(0.106)	(0.108)	(0.112)		(0.112)	(0.115)	(0.108)	(0.112)	(0.11)
Harari	0.3915	0.3677	0.3995	0.3813	0.3952	0.3924	—	0.4047	0.3728	0.3960	0.3953
	(0.336)	(0.318)	(0.341)	(0.327)	(0.339)	(0.336)		(0.349)	(0.32)	(0.34)	(0.339)
Oromia	0.0757	0.0653	0.0863	0.0741	0.0750	0.0757	0.0749	—	0.0743	0.0751	0.0774
	(0.068)	(0.061)	(0.076)	(0.067)	(0.067)	(0.068)	(0.067)		(0.067)	(0.067)	(0.069)
SNNP	0.1811	0.1730	0.1808	0.1774	0.1833	0.1815	0.1835	0.1863	—	0.1833	0.1841
	(0.151)	(0.145)	(0.151)	(0.148)	(0.153)	(0.151)	(0.153)	(0.155)		(0.153)	(0.153)
Somale	–0.1139	–0.1678	–0.0639	–0.1110	–0.1196	–0.1157	–0.1210	–0.1584	–0.0611	—	–0.1068
	(0.247)	(0.271)	(0.225)	(0.243)	(0.252)	(0.248)	(0.253)	(0.276)	(0.225)		(0.246)
Tigray	0.1986	0.1894	0.1911	0.1886	0.2036	0.2002	0.2042	0.2221	0.1655	0.2069	—
	(0.178)	(0.172)	(0.172)	(0.171)	(0.182)	(0.18)	(0.183)	(0.197)	(0.154)	(0.185)	

Health											
Afar	0.0715*	—	0.0743*	0.0736*	0.0711*	0.0713*	0.0710*	0.0631*	0.0811*	0.0694*	0.0735*
	(0.044)		(0.046)	(0.045)	(0.044)	(0.044)	(0.044)	(0.04)	(0.049)	(0.043)	(0.045)
Amhara	0.0251	0.0225	—	0.0263	0.0251	0.0251	0.0247	0.0201	0.0327	0.0237	0.0257
	(0.033)	(0.032)		(0.034)	(0.033)	(0.033)	(0.033)	(0.031)	(0.036)	(0.033)	(0.033)
Beneshangul-Gumuz	0.0171	0.0174	0.0185	—	0.0168	0.0170	0.0169	0.0147	0.0189	0.0168	0.0167
	(0.026)	(0.026)	(0.026)		(0.026)	(0.026)	(0.026)	(0.025)	(0.026)	(0.026)	(0.026)
Dire Dawa	–0.1776	–0.1780	–0.1740	–0.1760	—	–0.1780	–0.1786	–0.1797	–0.1815	–0.1771	–0.1753
	(0.157)	(0.156)	(0.154)	(0.156)		(0.158)	(0.158)	(0.16)	(0.157)	(0.158)	(0.157)
Gambela	–0.1035	–0.1042	–0.0999	–0.1027	–0.1040	—	–0.1042	–0.1046	–0.1039	–0.1042	–0.1032
	(0.076)	(0.076)	(0.074)	(0.075)	(0.077)		(0.077)	(0.077)	(0.076)	(0.077)	(0.076)
Harari	–0.1307	–0.1285	–0.1191	–0.1271	–0.1342	–0.1318	—	–0.1437	–0.1177	–0.1352	–0.1334
	(0.223)	(0.222)	(0.22)	(0.222)	(0.223)	(0.223)		(0.224)	(0.219)	(0.224)	(0.225)
Oromia	–0.0251	–0.0269	–0.0236	–0.0243	–0.0252	–0.0253	–0.0254	—	–0.0221	–0.0257	–0.0245
	(0.034)	(0.035)	(0.034)	(0.034)	(0.034)	(0.034)	(0.034)		(0.033)	(0.034)	(0.034)
SNNP	0.0256	0.0219	0.0319	0.0289	0.0244	0.0249	0.0237	0.0134	—	0.0221	0.0253
	(0.037)	(0.036)	(0.038)	(0.037)	(0.036)	(0.036)	(0.036)	(0.034)		(0.036)	(0.036)
Somale	–0.0574	–0.0601	–0.0535	–0.0575	–0.0568	–0.0572	–0.0580	–0.0612	–0.0529	—	–0.0578
	(0.057)	(0.059)	(0.056)	(0.057)	(0.057)	(0.057)	(0.058)	(0.06)	(0.055)		(0.057)
Tigray	0.0245	0.0216	0.0215	0.0247	0.0256	0.0244	0.0253	0.0225	0.0279	0.0244	—
	(0.052)	(0.052)	(0.053)	(0.053)	(0.052)	(0.052)	(0.052)	(0.051)	(0.053)	(0.052)	
Education											
Afar	1.8786**	—	1.7307**	1.7203**	1.9201**	1.8961**	1.9519**	2.4241**	1.2061*	2.0203**	1.8265**
	(0.777)		(0.771)	(0.766)	(0.781)	(0.779)	(0.784)	(0.853)	(0.731)	(0.792)	(0.772)
Amhara	0.1710	0.2344+*	—	0.1382	0.1758	0.1736	0.1823	0.2978+*	0.0108	0.2029	0.1472
	(0.149)	(0.154)		(0.15)	(0.15)	(0.149)	(0.15)	(0.161)	(0.151)	(0.151)	(0.149)
Beneshangul-Gumuz	0.0149	0.0621	–0.0176	—	0.0206	0.0170	0.0249	0.1045	–0.0978	0.0398	–0.0005
	(0.114)	(0.114)	(0.12)		(0.114)	(0.114)	(0.114)	(0.116)	(0.121)	(0.114)	(0.115)
Dire Dawa	0.5202**	0.6043**	0.4584**	0.4769**	—	0.5242**	0.5394**	0.7034**	0.2874	0.5668**	0.5019**
	(0.218)	(0.227)	(0.216)	(0.215)		(0.219)	(0.222)	(0.246)	(0.2)	(0.225)	(0.218)
Gambela	–0.2410**	–0.2033**	–0.2707**	–0.2632**	–0.2330**	—	–0.2321**	–0.1616*	–0.3458***	–0.2166**	–0.2494**
	(0.101)	(0.099)	(0.107)	(0.103)	(0.101)		(0.101)	(0.099)	(0.112)	(0.1)	(0.102)
Harari	0.5951***	0.6474***	0.5632***	0.5710***	0.5987***	0.5975***	—	0.6939***	0.4643**	0.6218***	0.5823***
	(0.194)	(0.2)	(0.189)	(0.191)	(0.196)	(0.195)		(0.213)	(0.178)	(0.199)	(0.194)
Oromia	0.5254***	0.6001***	0.4564**	0.4785***	0.5398***	0.5298***	0.5486***	—	0.3067**	0.5728***	0.5061***
	(0.164)	(0.174)	(0.166)	(0.161)	(0.167)	(0.165)	(0.167)		(0.147)	(0.17)	(0.163)
SNNP	–0.0300	0.0398	–0.0750	–0.0681	–0.0206	–0.0270	–0.0149	0.1166	—	0.0101	–0.0518
	(0.115)	(0.117)	(0.124)	(0.118)	(0.116)	(0.115)	(0.116)	(0.126)		(0.116)	(0.116)
Somale	2.0312***	2.2826***	1.8021**	1.8695**	2.0790***	2.0500***	2.1124***	2.6459***	1.2795**	—	1.9623***
	(0.66)	(0.694)	(0.656)	(0.649)	(0.67)	(0.664)	(0.674)	(0.756)	(0.6)		(0.657)
Tigray	0.1073	0.1607	0.0566	0.0794	0.1145	0.1104	0.1215	0.2244+*	–0.0492	0.1393	—
	(0.122)	(0.125)	(0.127)	(0.123)	(0.124)	(0.123)	(0.123)	(0.134)	(0.122)	(0.124)	

Notes: Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. — indicates not applicable. SNNP—Southern Nations, Nationalities, and Peoples. + denotes nontrivial changes from the base model.

CHAPTER 8

Conclusions and Policy Considerations

In this report we explored and compared the impact of different types of public spending on rural household welfare in Ethiopia. In order to get at this question empirically, we used a three-stage analysis: the first stage assessed the role of access to different sector-specific services and outcomes for rural household consumption, differentiating this effect geographically as well as tracing the effect that public services have on the productivity of household private assets. The second stage of the analysis determined the contribution of different types of public spending on key sector-specific outcomes, accounting both for the fact that this contribution is usually realized over time and for the fact that public expenditure volumes in a given sector may be affected by the state of development in that sector. The final stage of the analysis drew on results from the two previous stages to estimate the rural welfare effect of a unit increase in public spending across different sectors.

We find that, among the sectors considered, returns to public investments in road infrastructure are by far the highest. However, the geographic variability of welfare returns to public spending on roads is also higher than that in other sectors. This regional variability in returns to road investment suggests the need for careful region-specific investment policies in the road sector. Tentative evidence also suggests that higher returns are seen in areas having better-developed road networks and that the converse is also true. The presence of increasing returns to road investments, while not conclusive, may provide guidance for public policy in trading off the potentially higher gains from geographic concentration of road networks against equity concerns in the provision of infrastructure.

The household welfare impacts of public expenditure in agriculture are smaller than the effects of road spending, and they also did not emerge as statistically significant. The results of the first- and second-stage analyses suggest that the lack of significance derives from the poor link from public expenditures to performance of the agricultural sector, and not from a limited role of agriculture in rural welfare. The first-stage analysis shows in fact that performance of the agricultural sector contributes significantly to rural consumption both when considering this role on average for Ethiopia as a whole and when assessing regionally disaggregated effects.

Comparison of the impact of agricultural expenditures across regions shows that the largest returns are observed in two small regions that are each dominated by a major city. While proximity to markets is not explicitly analyzed herein, we suggest that the relatively high returns to agricultural spending for rural residents in the two most urbanized regions may be capturing the important role of market proximity in determining the effectiveness of public investments in agriculture. However, these findings can only be stated tentatively, given the low statistical significance associated with the third-stage results.

In contrast to the road infrastructure sector, returns to expenditures in education are characterized by wider reach, more homogeneity, and less intensity. Education spending has widespread effects on welfare, in that these returns are positive, significant, and similar across a broad range of regions, in contrast to the stronger concentration within a few regions of returns to expenditures in the road sector. This finding is further strengthened in robustness checks of the main results with regard to exclusion of sets of observations. The magnitude of returns to education spending is more constrained than in the road sector, but still larger and more significant than that of returns to investments in agriculture. Rural welfare returns to spending in the health sector do not emerge strongly, with significant findings in only one region, and the magnitude of the birr-for-birr returns is relatively low.

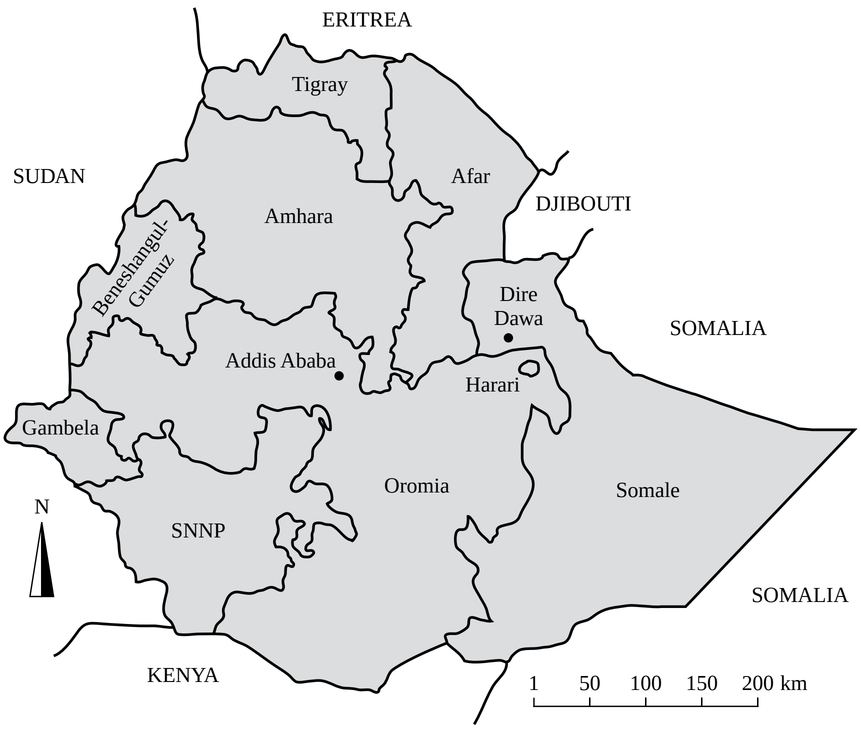
Some useful steps may be taken to further strengthen any conclusions arising from this analysis and provide new insights into the relative effectiveness of different types of public spending. First, the public expenditure and household data used in this study extend only to 2000. This was the most recent year for which public spending data were available at the time the data for this research were collected, and the most recent HICE survey also covered 1999/2000. A useful extension of this research would be to repeat the analysis for more recent years, when the composition of spending in Ethiopia saw important changes.

Second, while this report assesses how rural household consumption is affected by public expenditure, our findings may also be used to simulate the poverty effects of public spending. Third, given the prominence of agriculture-driven development in Ethiopia's current poverty reduction strategy, it may not be doing full justice to the policy dimension of this inquiry to examine the impact of public expenditure in the aggregate. Additional studies may be warranted to examine separately the role of the various components of this investment, such as agricultural extension, agricultural research, and food security spending. At present the lack of regionally disaggregated time series data on spending in the various agricultural subsectors necessitates analysis of agricultural expenditure as a whole. Future efforts in collecting additional data from the regional bureaus of agriculture and others would alleviate this constraint. However, cross-sector comparisons of returns to agricultural spending with returns to education, infrastructure, and other spending would call for a similar subsectoral or functional disaggregation of spending in these other sectors, to maintain symmetry in analysis.

An issue that goes beyond the scope of this report but is clearly worthy of additional study is the efficiency of public spending. The utility of public investments for household welfare and poverty reduction depends on at least two things: (1) the portfolio of the public budget, or the appropriateness of the allocation of resources across sectors, and (2) the efficiency with which resources are used in any given sector or subsector. This report focused on the former issue. In a way the results of this report provoke an inquiry into the second question, and they do so pointedly in the Ethiopian context, with respect to agricultural investments. This is both because agriculture strongly dominates Ethiopia's economy and because the government's development strategy emphasizes the agricultural sector. A substantial body of research suggests that a strategic focus on agriculture may be appropriate given Ethiopia's stage of development (for example Diao et al. 2007). Therefore an investigation into the drivers of efficiency in the country's agricultural public spending may be the next important step in policy research in Ethiopia.

APPENDIX

Figure A.1 Administrative map of Ethiopia



Source: Based on data from the United Nations Office for the Co-ordination of Humanitarian Affairs.
Note: SNNP—Southern Nations, Nationalities, and Peoples.

Table A.1 Per capita household expenditure, based on the Household Income, Consumption and Expenditure (HICE) Surveys

	1999				
	Total	Urban	Rural	1995 rural	Rural growth, 1995–99 (percent)
Addis Ababa	2,465.7	2,482.9	1,540.4	1,685.9	–8.6
Afar	1,537.7	2,302.0	1,127.0	1,520.5	–25.9
Amhara	1,165.6	1,754.4	1,095.7	974.4	12.4
Beneshangul-Gumuz	1,158.3	2,014.3	1,088.4	1,075.0	1.3
Dire Dawa	1,767.0	1,899.3	1,394.4	1,682.8	–17.1
Gambela	1,330.3	1,898.1	1,255.7	1,706.7	–26.4
Harari	1,904.9	2,106.2	1,618.7	2,388.7	–32.2
Oromia	1,208.4	1,701.0	1,144.5	1,282.9	–10.8
SNNP	1,080.1	1,768.9	1,025.2	1,021.3	0.4
Somale	1,626.7	2,106.7	1,395.1	1,975.4	–29.4
Tigray	1,189.5	1,536.7	1,120.9	1,209.6	–7.3
Ethiopia	1,222.5	1,921.0	1,109.9	1,136.6	–2.3

Source: Central Statistical Authority (2001).
Note: SNNP—Southern Nations, Nationalities, and Peoples.

Table A.2 Per-adult-equivalent household expenditure, based on the Welfare Monitoring Surveys

Region	Zones	1995	1999	Growth (percent)
Addis Ababa		1,543.3	1,521.0	–1.4
Afar		2,038.6	1,770.1	–13.2
Amhara 1	East and West Gojam, Agawi	1,493.4	1,937.8	29.8
Amhara 2	North and South Gondar	1,264.0	1,629.2	28.9
Amhara 3	North Wollo, Wag Hamra	1,211.1	1,430.1	18.1
Amhara 4	South Wollo, Oromiya, North Shewa	1,483.3	1,501.8	1.2
Beneshangul-Gumuz		1,296.7	1,347.0	3.9
Dire Dawa		1,595.9	1,573.9	–1.4
Gambela		1,464.3	1,021.6	–30.2
Harari		2,615.7	1,901.4	–27.3
Oromia 1	East and West Hararghe	2,087.8	1,631.3	–21.9
Oromia 2	East and West Wellega	1,732.9	1,809.7	4.4
Oromia 3	East Shewa, Arsi, Bale, Borena	1,664.4	1,599.8	–3.9
Oromia 4	Illubabor, Jimma	1,893.4	1,501.4	–20.7
Oromia 5	North and West Shewa	1,965.1	1,928.8	–1.8
SNNP 1	Hadiya, Kambata, Gurage	1,319.9	1,197.3	–9.3
SNNP 2	North and South Omo, Derashe, Konso	1,708.0	2,059.0	20.5
SNNP 3	Sidama, Gedeo, Burji, Amaro	1,257.8	1,106.9	–12.0
SNNP 4	Yem, Keficho, Maji, Shekicho, Bench	1,492.9	1,514.9	1.5
Somale		2,597.2	2,313.3	–10.9
Tigray		1,412.8	1,409.9	–0.2

Source: World Bank (2005d).
Note: SNNP—Southern Nations, Nationalities, and Peoples.

Table A.3 Spending in each region, 1998 (percent of total regional expenditures)

	Addis Ababa	Afar	Amhara	Beneshangul-Gumuz	Dire Dawa	Gambela	Harari	Oromia	SNNP	Somale	Tigray	Regional total
Roads	27.4	3.8	17.8	5.1	0.0	3.0	0.0	22.4	10.5	5.2	4.7	100.0
Education	7.9	2.6	21.9	2.0	0.9	2.9	1.0	33.7	18.3	2.7	6.2	100.0
Health	8.4	4.5	21.7	3.8	1.2	2.3	1.9	23.6	15.4	5.1	12.1	100.0
Agriculture	1.0	4.1	23.4	2.9	0.6	1.0	0.3	31.0	25.2	5.5	4.9	100.0
Natural resources	27.8	13.1	13.8	1.5	0.3	0.4	0.4	22.2	8.8	2.8	8.9	100.0
Energy and mining	0.0	0.5	51.6	1.0	5.5	0.0	11.4	3.5	0.7	0.0	25.9	100.0
Transportation and communications	26.6	4.1	14.6	3.7	6.5	0.0	0.0	41.4	0.3	2.6	0.2	100.0
Other	24.3	6.3	16.4	4.5	1.9	2.4	1.2	16.5	13.8	7.0	5.7	100.0
Total	15.8	5.1	19.4	3.4	1.1	2.2	1.0	24.8	15.8	4.9	6.6	100.0
Population	3.9	1.9	25.6	0.8	0.5	0.3	0.3	35.2	19.7	5.8	5.8	100.0

Source: Authors' own calculations using data from Ministry of Finance and Economic Development.
Note: SNNP—Southern Nations, Nationalities, and Peoples.

Table A.4 Zonal averages for selected variables used in second-stage regression

Zone, by region	dist95	dist. road	malaria. vuln.	sh.urban	pop. dens.	althi	rain	land/ household	sh.seed	sh.irrig	sh.pest	sh.fert
Afar Region												
Afar 1	1.8890	1.6280	100.0	14.2	12	No	282.7	0.60	0.00	99.34	0.00	0.37
Afar 2	n.a.	n.a.	100.0	2.5	9	No	268.5	n.a.	0.00	0.00	0.00	0.00
Afar 3	11.2440	12.8280	100.0	26.7	12	No	501.4	0.30	0.10	0.24	7.86	9.64
Afar 4	n.a.	n.a.	100.0	1.5	15	No	439.1	n.a.	0.00	0.00	0.00	0.00
Afar 5	0.6670	27.8720	100.0	0.0	62	No	648.1	n.a.	0.00	0.00	0.00	0.00
Amhara Region												
Agewawia	2.5420	12.7460	41.8	10.8	156	Yes	1,635.5	1.23	2.81	1.09	0.43	46.48
East Gojam	2.1970	8.6230	33.7	10.2	153	Yes	1,306.0	1.10	3.17	0.11	1.28	44.16
North Gonder	2.5670	6.6540	53.2	13.4	62	No	1,295.7	1.22	1.32	0.06	0.52	10.39
North Shewa	3.0130	8.7490	41.8	11.2	123	Yes	1,114.5	1.10	0.61	0.33	5.39	26.22
North Wolo	4.3150	7.0560	27.6	8.4	126	Yes	820.9	0.70	1.29	0.03	0.53	7.66
Oromiya	7.7470	6.5620	100.0	10.2	138	No	959.7	0.60	0.04	0.03	0.48	6.31
South Gonder	2.5620	13.4100	47.0	7.9	153	Yes	1,275.6	1.00	0.81	0.22	1.31	19.49
South Wolo	1.7170	5.9640	42.2	11.8	158	Yes	1,048.8	0.70	0.88	0.26	0.25	15.73
Waghamera	10.4750	18.5850	100.0	5.1	42	Yes	705.6	0.90	0.07	0.11	0.26	1.51
West Gojam	2.2080	6.2270	52.8	7.2	175	Yes	1,459.7	1.10	6.97	0.47	1.02	52.09
Beneshangul-Gumuz Region												
Asosa	2.3820	1.8950	58.8	9.4	18	No	1,228.6	0.99	0.67	0.00	0.90	5.60
Kemeshi	n.a.	15.9800	83.6	0.0	7	No	1,543.7	1.24	3.05	0.00	0.22	5.45
Metekel	5.9440	10.7300	84.7	11.5	10	No	1,283.7	1.40	1.69	0.02	0.16	15.06
Dire Dawa Region												
Dire Dawa	1.2030	1.0690	100.0	73.1	237	No	729.7	0.50	13.22	9.75	1.09	20.79
Gambela Region												
Gambela 1	5.6550	1.6280	100.0	50.3	12	No	1,347.0	0.20	0.00	0.00	1.08	0.74
Gambela 2	n.a.	4.7790	100.0	9.6	3	No	1,403.1	0.50	n.a.	n.a.	n.a.	n.a.
Gambela 3	n.a.	n.a.	100.0	1.8	14	No	1,028.7	0.20	n.a.	n.a.	n.a.	n.a.
Gambela 4	n.a.	n.a.	n.a.	11.9	26	No	1,699.0	0.60	n.a.	n.a.	n.a.	n.a.
Godere	n.a.	8.5690	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Harari Region												
Harari	0.7400	0.7690	100.0	61.2	452	Yes	799.8	0.60	3.00	3.92	4.60	55.58
Oromia Region												
Arsi	3.2870	5.4980	17.1	11.7	120	Yes	978.0	1.25	1.35	0.16	23.91	72.36
Bale	1.2230	2.6700	29.6	12.8	27	No	690.0	1.01	1.12	0.04	14.09	39.14
Borena	4.6610	2.8410	27.7	11.0	27	No	675.1	0.50	1.50	0.00	0.31	10.41
East Harerge	2.2110	4.0330	74.1	6.5	113	No	701.7	0.50	2.91	2.01	2.32	40.39
East Shewa	1.1120	1.4570	93.4	30.7	176	Yes	900.4	1.40	3.70	0.00	15.69	55.18
East Wellega	3.4640	8.7930	81.9	13.2	79	Yes	1,659.1	1.20	7.38	0.11	1.65	40.22
Illibabor	4.0610	7.9560	94.7	11.3	73	Yes	1,918.3	1.10	8.82	0.02	5.82	26.67

(*continued*)

Table A.4 Continued

Zone, by region	dist95	dist. road	malaria. vuln.	sh.urban	pop. dens.	althi	rain	land/ household	sh.seed	sh.irrig	sh.pest	sh.fert
Jimma	2.2720	6.1120	29.5	11.6	147	Yes	1,666.4	0.90	5.60	0.00	22.25	36.07
North Shewa	3.4120	5.7910	35.9	8.9	138	No	1,600.4	1.20	1.00	0.10	4.79	29.76
West Harerge	3.0080	2.1780	68.5	9.1	98	Yes	885.0	0.70	1.62	1.36	0.32	16.93
West Shewa	3.0740	4.0600	17.6	11.6	150	Yes	1,288.4	1.20	2.87	0.23	26.13	56.43
West Wellega	4.4450	6.7790	69.5	10.3	86	No	1,600.4	1.00	6.84	0.17	1.56	30.37
SNNP Region												
Amaro	3.5420	12.1200	100.0	3.7	93	Yes	927.0	0.40	0.87	9.80	1.91	8.50
Bench-Maji	3.6800	6.5310	18.0	8.6	18	No	1,296.8	0.30	2.00	0.00	0.00	7.00
Burji	2.2080	3.6070	100.0	13.6	33	No	964.0	0.70	0.24	0.00	2.03	6.33
Derashe	5.0000	6.2080	100.0	10.8	86	No	1,113.0	0.80	0.02	3.49	0.27	0.90
Gedio	1.7100	3.1250	57.7	13.7	505	Yes	1,564.8	0.30	1.87	0.00	0.00	31.17
Gurage	3.6290	5.6980	20.0	5.9	239	Yes	1,111.4	0.50	10.49	0.09	10.78	61.80
Hadiya	2.5370	4.4290	43.9	7.7	371	Yes	1,148.0	0.60	6.35	0.02	33.66	82.82
Keficho-Shek.	2.6050	12.2380	34.0	9.2	71	Yes	1,886.9	0.70	1.00	0.00	5.00	5.00
Kembata	2.3040	4.6850	59.4	8.4	395	Yes	1,089.3	0.60	6.21	0.00	18.57	71.94
Konso	1.6470	4.2890	100.0	4.2	88	No	878.0	0.60	0.00	2.66	0.03	30.55
North Omo	3.3470	8.4940	77.4	8.1	144	Yes	1,463.4	0.40	5.29	0.00	0.47	40.04
Sidama	2.3960	2.9780	75.7	8.4	382	Yes	1,235.9	0.30	13.51	0.13	0.00	49.93
South Omo	3.6320	7.8740	85.4	8.0	19	No	784.5	0.40	2.26	0.05	0.55	3.54
Yem	5.4170	6.3370	n.a.	2.0	94	Yes	1,214.0	1.10	4.18	0.00	4.69	39.90
Somale Region												
Afder	n.a.	n.a.	100.0	8.1	6	No	232.8	0.60	n.a.	n.a.	n.a.	n.a.
Degehabur	n.a.	n.a.	100.0	21.1	9	No	355.9	1.50	n.a.	n.a.	n.a.	n.a.
Fiq	n.a.	n.a.	87.8	10.9	18	No	337.0	1.50	n.a.	n.a.	n.a.	n.a.
Gode	n.a.	n.a.	100.0	23.9	12	No	193.8	0.80	n.a.	n.a.	n.a.	n.a.
Jijiga	7.8540	0.8260	87.5	21.3	58	Yes	599.8	1.30	0.49	0.13	0.12	0.17
Korahe	n.a.	n.a.	100.0	17.2	10	No	340.1	0.70	n.a.	n.a.	n.a.	n.a.
Liben	n.a.	n.a.	100.0	10.6	14	No	440.6	1.30	0.00	0.00	0.15	0.92
Moyale Zone	n.a.	3.3260	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Shinele	5.9170	1.6390	100.0	16.6	13	No	493.6	1.20	7.02	52.19	0.44	17.54
Warder	n.a.	n.a.	100.0	8.6	7	No	159.2	1.40	n.a.	n.a.	n.a.	n.a.
Tigray Region												
Central Tigray	3.0590	6.8800	68.8	11.6	111	Yes	782.7	0.80	0.49	0.13	2.09	46.25
East Tigray	4.0160	3.9280	n.a.	17.4	111	Yes	564.3	0.50	1.40	0.18	0.59	42.44
Mekelle	0.2390	0.7280	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
South Tigray	5.0690	7.1220	30.4	27.7	96	Yes	677.5	0.84	2.25	2.89	1.35	18.39
West Tigray	4.2200	12.2620	100.0	13.9	34	No	1,089.3	1.00	0.04	0.10	0.63	33.90

Source: World Bank data for the draft Country Economic Memorandum.

Notes: althi—midlands/highlands dummy; dist95—zonal-average distance in kilometers to the nearest school; dist.road—average distance in kilometers to the nearest all-weather road; land/household—average household land size in hectares; malaria.vuln.—share of population that is vulnerable to malaria; pop.dens.—population density (persons per square kilometer); rain—mean rainfall in millimeters; sh.fert—share of cultivable land using fertilizer; sh.irrig—share of cultivable land that is irrigated; sh.pest—share of cultivable land using pesticides; sh.seed—share of cultivable land using improved seeds; sh.urban—share of population that is urban; SNNP—Southern Nations, Nationalities, and Peoples. n.a.—Not available.

Table A.5 Second-stage results based on parameter assumptions $\delta = 0.02$, $r = 0.02$

		System-ordinary-least-squares	S-2SLS	S-3SLS
Agriculture	K^{AGR}	0.0044797*	0.0033914	0.0034781
		(0.0024)	(0.0026)	(0.0024)
	rain	0.0009935	0.001008	4.39×10^{-4}
		(0.0011)	(0.0011)	(0.001)
	land/household	–1.637964	–1.727924	–1.433136
		(1.1822)	(1.1872)	(1.0746)
	althi	0.602288	0.5119205	0.3532481
		(0.8595)	(0.8644)	(0.783)
	dist.road	–0.265243***	–0.267989***	–0.250751***
		(0.1012)	(0.1014)	(0.0924)
	malaria.vuln.	–1.666477	–1.548046	–1.402959
		(1.4374)	(1.4439)	(1.3099)
	Constant	12.72732***	13.05328***	13.30384***
		(2.0723)	(2.0925)	(1.9013)
	PI effect (%Δ)	*0.040*	*0.030*	*0.031*
Road infrastructure	K^{ROD}	0.0117571***	0.0129775***	0.0129211***
		(0.001)	(0.0011)	(0.0011)
	sh.urban	0.8812084	0.4031352	0.5177511
		(0.9471)	(0.986)	(0.941)
	pop.dens.	–0.001282	–0.000798	–0.000934
		(0.0011)	(0.0011)	(0.001)
	Constant	0.0755635	–0.013774	–0.008778
		(0.2118)	(0.219)	(0.2086)
	PI effect (%Δ)	*1.023*	*1.130*	*1.125*
Education	K^{EDU}	0.0007938***	0.0008212***	0.0008047***
		(0.0001)	(0.0001)	(0.0001)
	sh.urban	–0.335511	–0.362845	–0.302744
		(0.2053)	(0.2199)	(0.2079)
	dist95	–0.029898***	–0.029744***	–0.03166***
		(0.0101)	(0.0101)	(0.0095)
	Constant	0.4759638***	0.469175***	0.4733645***
		(0.0586)	(0.0618)	(0.0589)
	PI effect (%Δ)	*0.133*	*0.138*	*0.135*
Health	K^{HLT}	–0.00231	–0.004233*	–0.004356*
		(0.0023)	(0.0026)	(0.0024)
	sh.urban	–7.807733**	–6.159527*	–6.478289**
		(3.3016)	(3.4424)	(3.2854)
	malaria.vuln.	1.522323	1.62267	1.868623
		(1.2229)	(1.2338)	(1.1729)
	Constant	7.34797***	7.375999***	7.283328***
		(0.8347)	(0.8414)	(0.8018)
	PI effect (%Δ)	*–0.033*	*–0.060*	*–0.062*

	R^2 (percent)	F-statistic	R^2 (percent)	F-statistic	R^2 (percent)	χ^2
Equation						
Agriculture	27.9	2.59**	27.6	2.3**	26.8	14.37**
Road infrastructure	82.8	68.8***	82.1	64.23***	82.2	213.05***
Education	58.3	20.03***	58.3	17.04***	58.2	59.03***
Health	25.6	4.94***	24.5	5.45***	24.2	19.44***
Hausman test				$\chi^2(12) = 4.18$; p-value = .9943		

Notes: Standard errors in parentheses. $N = 53$. Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. althi—midlands/highlands dummy; dist95—zonal-average distance in kilometers to the nearest school; dist.road—average distance in kilometers to the nearest all-weather road; land/household—average household land size in hectares; malaria.vuln.—share of population that is vulnerable to malaria; pop.dens.—population density (persons per square kilometer); rain—mean rainfall in millimeters; sh.urban—share of population that is urban.

Table A.6 Second-stage results based on parameter assumptions $\delta = 0.10$, $r = 0.10$

		System-ordinary-least-squares	S-2SLS	S-3SLS
Agriculture	K^{AGR}	0.0073434	0.0057452	0.0066954
		(0.0075)	(0.0078)	(0.0072)
	rain	0.0010063	0.0010165	4.56×10^{-4}
		(0.0011)	(0.0011)	(0.001)
	land/household	–1.908901	–1.930527	–1.475565
		(1.2028)	(1.2038)	(1.089)
	althi	0.3651228	0.3357826	0.1736439
		(0.8704)	(0.8716)	(0.7893)
	dist.road	–0.257332**	–0.261514**	–0.239186**
		(0.1058)	(0.106)	(0.0963)
	malaria.vuln.	–1.550002	–1.469256	–1.446769
		(1.5026)	(1.5068)	(1.3667)
	Constant	13.41324***	13.55598***	13.65455***
		(2.1052)	(2.1139)	(1.9178)
	PI effect (%Δ)	*0.066*	*0.051*	*0.060*
Road infrastructure	K^{ROD}	0.0242953***	0.0250874***	0.0247825***
		(0.0021)	(0.0022)	(0.0021)
	sh.urban	1.16459	1.02368	1.162543
		(0.9745)	(0.9834)	(0.9365)
	pop.dens.	–0.001139	–0.000983	–0.000882
		(0.0011)	(0.0011)	(0.0011)
	Constant	–0.009194	–0.040016	–0.061268
		(0.2227)	(0.2246)	(0.2134)
	PI effect (%Δ)	*2.115*	*2.184*	*2.157*
Education	K^{EDU}	0.0018312***	0.0018203***	0.0017971***
		(0.0003)	(0.0003)	(0.0003)
	sh.urban	–0.398097*	–0.393029*	–0.35299*
		(0.2133)	(0.2238)	(0.2122)
	dist95	–0.033659***	–0.033663***	–0.03715***
		(0.0101)	(0.0101)	(0.0094)
	Constant	0.5451092***	0.5458659***	0.5556882***
		(0.0539)	(0.0548)	(0.0519)
	PI effect (%Δ)	*0.308*	*0.306*	*0.302*
Health	K^{HLT}	–0.007151	–0.013396*	–0.013068*
		(0.007)	(0.0077)	(0.0074)
	sh.urban	–7.572664**	–5.63839	–6.144851*
		(3.4144)	(3.571)	(3.4072)
	malaria.vuln.	1.545672	1.671328	1.858777
		(1.2244)	(1.2371)	(1.1816)
	Constant	7.331402***	7.346333***	7.277983***
		(0.8337)	(0.8413)	(0.804)
	PI effect (%Δ)	*–0.101*	*–0.190*	*–0.185*

Table A.6 Continued

	System-ordinary-least-squares		S-2SLS		S-3SLS	
	R^2 (percent)	F-statistic	R^2 (percent)	F-statistic	R^2 (percent)	χ^2
Equation						
Agriculture	23.7	2.07*	23.6	2.00*	22.8	11.92*
Road infrastructure	81.4	62.91***	81.4	61.43***	81.4	198.84***
Education	57.8	19.65***	57.8	17.07***	57.7	60.68***
Health	25.7	4.96***	24.4	5.54***	24.4	19.3***
Hausman test			$\chi^2(12) = 3.81$; p-value = .9983			

Notes: Standard errors in parentheses. $N = 53$. Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. althi—midlands/highlands dummy; dist95—zonal-average distance in kilometers to the nearest school; dist.road—average distance in kilometers to the nearest all-weather road; land/household—average household land size in hectares; malaria.vuln.—share of population that is vulnerable to malaria; pop.dens.—population density (persons per square kilometer); rain—mean rainfall in millimeters; sh.urban—share of population that is urban.

Table A.7 Second-stage results based on parameter assumptions $\delta = 0.02$, $r = 0.10$

		System-ordinary-least-squares	S-2SLS	S-3SLS
Agriculture	K^{AGR}	0.0063388	0.0049654	0.0053344
		(0.0046)	(0.0047)	(0.0044)
	rain	0.000978	0.0009943	4.12×10^{-4}
		(0.0011)	(0.0011)	(0.0010)
	land/household	–1.783875	–1.832495	–1.436365
		(1.1957)	(1.1977)	(1.0829)
	althi	0.4605443	0.4106586	0.2486524
		(0.8655)	(0.8675)	(0.7850)
	dist.road	–0.256326**	–0.260707**	–0.238641**
		(0.1037)	(0.1039)	(0.0945)
	malaria.vuln.	–1.645407	–1.544346	–1.462392
		(1.4757)	(1.4799)	(1.3417)
	Constant	13.08958***	13.30181***	13.46663***
		(2.0948)	(2.1051)	(1.9099)
	PI effect (%Δ)	*0.057*	*0.044*	*0.048*
Road infrastructure	K^{ROD}	0.0183379***	0.0192091***	0.0190418***
		(0.0016)	(0.0017)	(0.0016)
	sh.urban	1.047392	0.8364875	0.9771267
		(0.9523)	(0.9661)	(0.9210)
	pop.dens.	–0.001116	–0.000887	–0.000887
		(0.0011)	(0.0011)	(0.0010)
	Constant	–0.04497	–0.091583	–0.103041
		(0.2179)	(0.2209)	(0.2104)
	PI effect (%Δ)	*1.596*	*1.672*	*1.658*
Education	K^{EDU}	0.001292***	0.0013044***	0.0012737***
		(0.0002)	(0.0002)	(0.0002)
	sh.urban	–0.390548*	–0.398687*	–0.34193
		(0.2099)	(0.2221)	(0.2104)
	dist95	–0.031873***	–0.031849***	–0.034501***
		(0.0100)	(0.0100)	(0.0094)

(*continued*)

Table A.7 Continued

		System-ordinary-least-squares		S-2SLS		S-3SLS	
	Constant	0.5111955***		0.5096438***		0.5174259***	
		(0.0556)		(0.0573)		(0.0545)	
	PI effect (%Δ)	*0.217*		*0.219*		*0.214*	
Health	K^{HLT}	–0.004304		–0.00787*		–0.007886*	
		(0.0043)		(0.0047)		(0.0044)	
	sh.urban	–7.667972**		–5.911767*		–6.33169*	
		(3.3647)		(3.505)		(3.3445)	
	malaria.vuln.	1.536393		1.647922		1.843428	
		(1.2237)		(1.2349)		(1.1793)	
	Constant	7.339579***		7.360521***		7.295791***	
		(0.834)		(0.8409)		(0.8035)	
	PI effect (%Δ)	*–0.061*		*–0.111*		*–0.112*	
		R^2 (percent)	**F-statistic**	**R^2 (percent)**	**F-statistic**	**R^2 (percent)**	**χ^2**
Equation							
Agriculture		25.5	2.28**	25.3	2.14*	24.5	12.88**
Road infrastructure		82.4	67.01***	82.3	64.89***	82.3	211.99***
Education		58.5	20.24***	58.5	17.45***	58.4	60.41***
Health		25.7	4.96***	24.5	5.50***	24.4	19.40***
Hausman test					$\chi^2(12) = 3.64$; p-value = .9973		

Notes: Standard errors in parentheses. $N = 53$. Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. althi—midlands/highlands dummy; dist95—zonal-average distance in kilometers to the nearest school; dist.road—average distance in kilometers to the nearest all-weather road; land/household—average household land size in hectares; malaria.vuln.—share of population that is vulnerable to malaria; pop.dens.—population density (persons per square kilometer); rain—mean rainfall in millimeters; sh.urban—share of population that is urban.

Table A.8 Second-stage results based on parameter assumptions $\delta = 0.10$, $r = 0.02$

		System-ordinary-least-squares	S-2SLS	S-3SLS
Agriculture	K^{AGR}	0.0077097	0.0059015	0.0066208
		(0.0066)	(0.0068)	(0.0063)
	rain	0.0010027	0.0010146	4.52×10^{-4}
		(0.0011)	(0.0011)	(0.0010)
	land/household	–1.863791	–1.897678	–1.464665
		(1.1989)	(1.2005)	(1.0860)
	althi	0.4115358	0.3690294	0.2089996
		(0.8690)	(0.8708)	(0.7885)
	dist.road	–0.25694**	–0.261539**	–0.240368**
		(0.1048)	(0.1049)	(0.0954)
	malaria.vuln.	–1.598452	–1.500066	–1.455414
		(1.4903)	(1.4947)	(1.3557)
	Constant	13.25734***	13.44773***	13.56946***
		(2.1032)	(2.1132)	(1.9177)
	PI effect (%Δ)	*0.069*	*0.053*	*0.059*

(*continued*)

Table A.8 Continued

		System-ordinary-least-squares	S-2SLS	S-3SLS
Road infrastructure	K^{ROD}	0.0227498***	0.0235789***	0.0233372***
		(0.0019)	(0.0020)	(0.0020)
	sh.urban	1.064426	0.9032573	1.037949
		(0.9535)	(0.9642)	(0.9186)
	pop.dens.	–0.001111	–0.000935	–0.000874
		(0.0011)	(0.0011)	(0.0010)
	Constant	0.0015711	–0.032491	–0.049865
		(0.2168)	(0.2189)	(0.2082)
	PI effect (%Δ)	*1.980*	*2.05*	*2.031*
Education	K^{EDU}	0.0016877***	0.0016794***	0.0016468***
		(0.0003)	(0.0003)	(0.0003)
	sh.urban	–0.394779*	–0.390597*	–0.342232
		(0.2113)	(0.2224)	(0.2108)
	dist95	–0.033027***	–0.033033***	–0.036275***
		(0.0101)	(0.0101)	(0.0094)
	Constant	0.5322592***	0.5329491***	0.5425204***
		(0.0544)	(0.0556)	(0.0527)
	PI effect (%Δ)	*0.284*	*0.282*	*0.277*
Health	K^{HLT}	–0.006192	–0.011518*	–0.011378*
		(0.0061)	(0.0067)	(0.0064)
	sh.urban	–7.620974**	–5.7575	–6.219435*
		(3.3907)	(3.5435)	(3.3814)
	malaria.vuln.	1.540637	1.660062	1.856967
		(1.2241)	(1.2362)	(1.1807)
	Constant	7.335046***	7.352886***	7.282146***
		(0.8339)	(0.8412)	(0.8039)
	PI effect (%Δ)	*–0.088*	*–0.163*	*–0.161*

	R^2 (percent)	F-statistic	R^2 (percent)	F-statistic	R^2 (percent)	χ^2
Equation						
Agriculture	24.5	2.16**	24.3	2.05*	23.6	12.34*
Road infrastructure	82.3	66.73***	82.2	64.72***	82.3	210.42***
Education	58.3	20.03***	58.3	17.23***	58.1	60.57***
Health	25.7	4.96***	24.4	5.52***	24.4	19.34***
Hausman test				$\chi^2(12) = 3.84$; p-value = .9982		

Notes: Standard errors in parentheses. $N = 53$. Coefficients are significant at the * 10 percent, ** 5 percent, and *** 1 percent levels, respectively. althi—midlands/highlands dummy; dist95—zonal-average distance in kilometers to the nearest school; dist.road—average distance in kilometers to the nearest all-weather road; land/household—average household land size in hectares; malaria.vuln.—share of population that is vulnerable to malaria; pop.dens.—population density (persons per square kilometer); rain—mean rainfall in millimeters; sh.urban—share of population that is urban.

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