Rural Public Expenditure and Agricultural Growth in Bolivia[*]

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1 Introduction

Agriculture is one of the most important sectors in the Bolivian economy, both in terms of its contribution to the economy and as an employer in rural areas – it accounts for 27% of GDP (including agro-industry) and employs close to 90% of the economically active people living in rural areas (in 2007) (WDI, 2010). Agriculture is also the key component of the food security and poverty reduction strategy of the Government of Bolivia. Understanding what factors and, in particular, what policy choices promote agricultural growth is critical for formulating government interventions in a context of large agro-ecological diversity and strong emphasis on decentralization of public resources and responsibilities.

The importance of agriculture is not uniform across regions, reflecting both the agro-ecological diversity of Bolivia, as well as differences in the orientation of production. The traditional agricultural sector, with small units of production, is concentrated in the Western highlands and valleys and contributes between 4% and 9% of the Departments' GDP, while the Eastern lowlands are characterized with a more intensive agricultural production and agribusiness, with a mixture of large and small producers. In the lowlands, the contribution of agriculture (excluding agribusiness) to the Departments' GDP ranges between 16% and 32%.

The process of decentralization in Bolivia, among other institutional developments, has been characterized by sharp increases in the volume of public transfers to sub-national governments. In agriculture, this has resulted in greater involvement on sub-national governments in agricultural investments. Half of the public resources in agriculture in 2008 were spent by sub-national governments, including Departments and municipalities[1]. However, the impact of this spending on agricultural growth has not been previously assessed.

This paper presents empirical results on the effects of sub-national rural public expenditure on agricultural growth in Bolivia and the empirical methodology used to obtain them. The results suggest that allocating more resources to research and development (as compared to non-core spending categories in agriculture) would have an important positive effect on agricultural growth. Specifically, a 10% increase in the share of R&D expenditure would raise per capita agricultural growth by at least

[*] This paper was produced as an input to the Agricultural Public Expenditure Review (PER) for Bolivia (2010).
[1] There are currently 9 departments in Bolivia and 337 municipalities.

3%, and the impact could go up to 7% (depending on the specification). These results have important policy implications for the composition and level of public spending in agriculture in Bolivia.

2 Estimating the Growth Effects of Public Expenditure

Inter-sectoral allocations of public resources provide an indication of allocative efficiency of fiscal policy. The relative effectiveness of public expenditure across different sectors is an important factor in inter-sectoral allocations of public spending, considering the total budget resources of the Government. There is, however, limited empirical evidence on inter-sectoral allocations of public resources. It is unclear how scarce resources should be allocated across different sectors of the economy – such as agriculture, infrastructure, health, and education – for maximizing development outcomes. As Fan et al. (2009) note: "governments […] face a dearth of information about which types of public investments contribute the most to development goals."

Intra-sectoral allocations refer to the technical efficiency of public resources within a given sector. From such perspective, different categories of agricultural expenditure can have different impacts on growth in the sector, both in combination and individually. However, identifying those with the greatest positive impact is difficult. A priori, a certain balance between investments and maintenance is needed to ensure the productivity in the sector. Similarly, it is important how much is spent on public goods, such as agricultural research and extension and irrigation, vis-à-vis items that can be provided by the private sector (for a related discussion, see Policy Note for Indonesia Public Expenditure Review, World Bank, 2010). An empirical analysis is required to determine how the *level* of public spending in the sector and its *composition* contribute to agricultural output growth.

However, even if certain types of public expenditure are beneficial for agricultural growth in absolute terms, this does not necessarily imply that governments should finance them. The financing mechanism (e.g. distortionary taxation) imposes a cost on the economy that may or may not exceed the benefits. For example, a tax on farm income may in principle reduce the incentives of farmers to upgrade their equipment (i.e. crowd out investment by farmers).

Given that the growth effects of changes in the level of public spending and its composition (both inter-sectoral and intra-sectoral) do differ, it is therefore essential that the modeling framework specifies which fiscal change is being estimated so that the results are relevant to address different concerns of the policy makers. Problems to estimate the growth effects of public expenditure are often aggravated by unreliable data, insufficient variation in the data within countries (short time series), and/or unobserved heterogeneity. These issues need to be taken into account when defining the functional specification for a particular country.

3 Function Specification and Data

3.1 Fiscal Variables

We use Bolivia budget data from 1996 to 2007 to construct variables for various public expenditure categories at the sub-national level which includes spending by departments and municipalities[2]. To capture actual impact, we use actual (executed) expenditure rather than planned (budgeted) expenditure. Our data are disaggregated by level of government and by functional composition of expenditure at each level (national, departmental and municipal). This enables us to classify public spending into relevant categories for the rural sector. In this paper, we exploit variation among departments. Total departmental expenditure for a given category is the sum of spending by the departmental government and by all municipal governments within this department in that category[3].

There are three reasons why we use sub-national expenditure. First, there is insufficient variation in the share of national expenditure allocated to the rural sector - the number of years available in the dataset is small, and expenditure by the central government cannot be disaggregated geographically (i.e. there is no information about where it was spent) which implies that there is no cross-sectional dimension in the national expenditure data that could be exploited. In contrast, for sub-national spending, there is variation both over time and across departments. In addition, data on sub-national public expenditure are centrally collected, which minimizes problems related to unobserved heterogeneity due to differences in the classification of budget items.

Second, by focusing on sub-national variation, differences across departments can be taken into account. As previously mentioned, this is important in the context of Bolivia with its geographic and climatic heterogeneity and related agricultural production patterns.

Third, the use of sub-national data is further justified by our focus on the expenditure side of the budget. While expenditure assignments are shared among the three tiers of government, it is only the central government that has the responsibility for defining tax bases and tax rates for all broad-base taxes, and borrowing at the sub-national level is limited. In this respect, in the rural sector, there is limited variation in taxation and borrowing across departments. Therefore in our analysis we assume that the budget is always balanced, i.e. there is no variation in borrowing at the sub-national level, neither among the departments nor over time.

However, national expenditure represents a large share of total expenditure in the rural sector, as shown in Table 1. We capture the effects of national expenditure, thereby avoiding the omitted variable bias, by including time effects in the regressions as explained below. In other words, if we were to include national expenditure in our analysis, there would only be variation across time, but the

[2] Expenditure data in Bolivia is typically recorded by program and project and aggregated at the national level. With the help of UDAPE (Ministry of Planning) and FAM (NGO), the expenditure data on agriculture and rural development was disaggregated by function, economic classification and level of government (national, departmental and municipal) for a period of 13 years – from 1996 to 2008.

[3] When we aggregate municipal expenditure up to the departmental level, missing observations are effectively counted as zero spending in the particular category. We address this issue by excluding municipal expenditure all together, as a robustness check. In other words, we subtract municipal expenditure from total sub-national (i.e. departmental and municipal) expenditure and re-run all regressions based on this alternative dataset.

effects would be common for all departments. Time dummies therefore capture the effects of national expenditure.

Table 1: Share of rural expenditure by level (mean values for 1996 to 2007)

Level	Percentage of total rural expenditure
National *(central government)*	**71.28%**
Sub-national *(departmental and municipal)*	**28.71%**

3.2 Dependent variable

As a dependent variable we use the growth rate of agricultural output (agricultural GDP) by department per rural inhabitant. As agricultural output is largely produced in rural areas, dividing agricultural output by the total population (rural and urban) of the department could be misleading and underestimate the actual impact. Therefore we consider agricultural growth per rural inhabitant to better capture the impact of spending. This is also in line with the model introduced below.

3.3 Control variables

Agricultural output growth is affected by a number of factors other than public spending. In our empirical analysis, we account for them by including land under cultivation (per rural inhabitant), density of roads, and climatic effects (precipitation and temperature).

We re-scale land under cultivation by rural inhabitant to partially account for missing information on agricultural labor force at the departmental level and to also balance the analysis, given the definition of the dependent variable. We assume that there is strong correlation between the size of the rural population and the agricultural labor force. We also include road density (measured by the length of paved roads divided by the surface in each department) as an indicator of integration of agricultural markets and ease of access to them.

To account for climatic effects on agricultural production, we include annual average precipitation and minimum (night) temperature in the main city of each department. Given the geography of Bolivia, there is significant variation in the climatic conditions of departmental capitals. For instance, in Potosí, average annual precipitation between 1996 and 2006 was around 340mm, whereas in Cobija, the average was around 1,900mm. There is also considerable variation in annual average minimum temperatures, ranging from around -2 degrees Celsius in Potosí to about 20 degrees Celsius in Trinidad.

4 Modeling Framework

Underlying our empirical framework is a version of the endogenous growth model by Devarajan et al. (1996) which we adapt to the agricultural sector in Bolivia. We assume that agricultural output Y_j in department *j* is produced using land, agricultural labor, and a range of public inputs, G_i, which also differ by department:

$$Y_j = A_j L^{\sum_i \alpha_i}{}_j K^{1-\sum_i \alpha_i} \sum_i G_{ji}{}^{\alpha_i} \tag{1}$$

A is a function of departmental characteristics such as road infrastructure and climatic factors. Dividing both sides by the number of rural inhabitants in a given department, L_j yields the following equation:

$$\frac{Y_j}{L_j} = A_j \left(\frac{K_j}{L_j} \right)^{1-\alpha_1-\alpha_2} \sum_i G_{ji}{}^{\alpha_i} \tag{2}$$

The public inputs to private production, G_i, differ in their contribution to rural growth and are financed by taxation. They can be expressed as:

$$G_i = \tau \phi_i y \tag{3}$$

where τ denotes the rate of taxation (which in this simple model coincides with total expenditure, since we consider a balanced budget) and where ϕ_i represents the share of public spending on G_i in total expenditure.

From the first-order conditions of the private agents in the economy, we can derive the per capita growth rate of agricultural output, γ. It can be shown that under standard assumptions, it is, among other factors, a function of *A*, τ and ϕ_i. As a reduced form, it can be expressed as:

$$\gamma = \gamma(A, \tau, \phi_i) \tag{4}$$

In this paper, the ϕ_i are the parameters of interest. The growth rate is considered to be a concave function of the ϕ_i, given that $\sum_i \phi_i = 1$ always holds. No change in the expenditure shares can therefore be understood in isolation due to the government budget constraint, as presented in the Devarajan et al. (1996) model.[4] Changes in the share of any given public expenditure type must be financed by changes in the shares of other expenditure types. In general, any changes to public spending imply (compensating) changes to other aspects of fiscal policy, which themselves may have an effect on growth, thereby reinforcing or offsetting the growth effects of the original public expenditure change. While this means that the government budget constraint has to be taken into account, there would be perfect collinearity among all expenditures as, by definition, they add up to one. Therefore, in consistency with previous empirical work, we omit some expenditure categories in the regression analysis. Following Kneller et al. (1999) we exclude those expenditure shares which are

[4] Unless it was assumed that the public spending variable of interest was the only fiscal policy change that affects growth. The existing empirical evidence leads us to argue against such a view.

expected to have small growth effects. This approach avoids collinearity and ensures that the coefficient estimates of the expenditure shares (i.e. of the ϕ_i) represent the effects of increasing the particular ϕ_i and decreasing (on a pro rata basis) one or a combination of the omitted expenditure categories.

We distinguish two broad types of public spending: "core" rural expenditure and "other" rural expenditure. Each type is created by grouping relevant functional categories of rural spending, as shown in Table 2. A priori, we expect "core" rural expenditure to have positive growth effects, whereas we expect "other" rural expenditure to be less critical for growth. The functional classification of rural expenditures was organized using FAO guidelines as well as country-specific definitions of spending.

Table 2: Classification of Public Expenditure (average shares over the period 1996 2007)

Rural Expenditure Category	Functional description	Share of total *rural* spending	Share of total (*rural and non-rural*) spending)
Core	R&D, extension services, irrigation, rural electrification, rural roads, pest control	69.8%	14.6%
Other	Different kinds of support, administration, subsidies, others, capacity building for unions, communities and associations, environmental risk management, commercialization, equipment and machines, other infrastructure (excluding roads, electricity and irrigation)	30.2%	6.31%

5 Estimation

We use two empirical specifications of equation (4) to estimate the effects of both inter- and intra-sectoral spending composition. In order to take into account the possibility of lagged effects of public spending, we use five-year forward moving averages of agricultural growth per rural inhabitant as the dependent variable. This also reduces a possible co-movement of agricultural production with government expenditure composition.

In the first specification, we estimate the effects of changes in the inter-sectoral expenditure composition (i.e. an increase of "core" rural expenditure financed by a decrease of non-rural expenditure and "other" rural expenditure):

$$\log(GROWTH) = \alpha + \sum_i^k \beta_i \log(EXP_i / TOTAL\_EXP) + \delta_1 \log(TOTAL\_EXP / GDP) + \delta_2 \log(CULTLAND) + \delta_3 \log(TEMP\_MIN) + \delta_4 \log(PREC) + \delta_5 \log(ROADS) \quad (5)$$

Where:

GROWTH denotes the rate of log difference of agricultural output per rural inhabitant (five-year forward moving average)

GDP denotes total departmental output (in current prices)
TOTAL_EXP denotes total departmental public expenditure (rural and non-rural expenditure)
EXP_i represents different categories of "core" rural expenditure in nominal terms (in particular, *R&D_EXP* denotes R&D expenditure, *EXT_EXP* denotes spending on extension services, *IRR_EXP* denotes spending on irrigation, *ELEC_EXP* denotes spending on electricity, *ROADS_EXP* denotes spending on roads, and *SAN_EXP* denotes spending on pest control)
CULTLAND denotes the size of the land under cultivation per rural inhabitant,
TEMP_MIN denotes the annual minimum temperature in the main city of the department,
PREC represents the amount of annual precipitation in the main city of the department,

Equation (5) includes the level of total expenditure in a given department to departmental GDP (in current prices) and the shares of all "core" rural expenditure categories in total expenditure. Including the total expenditure variable means that we hold the level of total (i.e. rural and non-rural spending) constant to ensure that we only capture composition effects (and not the growth effects of the level of total spending). We exclude "other" rural expenditure and also all non-rural expenditure, which *a priori* are expected to have less critical growth effects. The $ß_i$ represent the growth effects of allocating public resources from the omitted categories to the *EXPi* variables – we estimate the effects of this fiscal change on agricultural output growth.

The second specification is used to estimate the effects of changes in the intra-sectoral composition of public spending, i.e. allocations of spending within the rural sector. We now include the share of total *rural* spending in GDP in the regressions:

$$\log(GROWTH) = \alpha + \sum_{i}^{k} \beta_i \log(EXP_i / RURAL\_EXP) + \delta_1 \log(RURAL\_EXP / GDP) + \delta_2 \log(CULTLAND) + \delta_3 \log(TEMP\_MIN) + \delta_4 \log(PREC) + \delta_5 \log(ROADS) \quad (6)$$

Where:

RURAL_EXP denotes total rural departmental public expenditure

In equation (6) we include the rural expenditure variable to hold rural expenditure constant and to ensure that we only capture changes in the composition of rural spending. The omitted public spending category which offsets increases in "core" rural expenditure is now solely "other" rural expenditure. As a result, equation (6) allows us to estimate the effects of an increase in "core" rural expenditure financed by a pro-rata decrease in "other" rural expenditures. The $ß_i$ capture the effects of reallocating public resources from the excluded rural categories to the *EXPi* variables*.*

All the variables used for analysis are measured at the departmental level and are also available over time, during the period of 1996 and 2007. We use the log of all variables to estimate the linear equations. Table 3 provides descriptive information for each variable (in levels). The expenditure variables are included once in terms of shares of "total" expenditure, and once as shares of "rural" expenditure in line with our two empirical specifications.

Table 3: Descriptive statistics (not in logs)

Variable	Obs	Mean	Std. Dev.	Min	Max
Shares of Total expenditure					
TOTAL_EXP/GDP	108	12.9%	5.8%	4.9%	43.3%
R&D_EXP/TOTAL_EXP	104	0.3%	0.5%	0.0%	3.4%
EXT_EXP/TOTAL_EXP	104	0.2%	0.5%	0.0%	3.5%
IRR_EXP/TOTAL_EXP	104	1.9%	2.5%	0.0%	13.6%
ELEC_EXP/TOTAL_EXP	104	2.2%	2.3%	0.0%	11.8%
ROADS_EXP/TOTAL_EXP	104	9.5%	7.8%	0.3%	40.9%
SAN_EXP/TOTAL_EXP	104	0.1%	0.1%	0.0%	0.9%
Shares of Rural Expenditure					
RURAL_EXP/GDP	104	2.8%	3.2%	0.4%	22.3%
R&D_EXP/RURAL_EXP	104	2.0%	2.9%	0.0%	18.2%
EXT_EXP/RURAL_EXP	104	1.1%	1.8%	0.0%	10.1%
EXP_IRR/RURAL_EXP	104	9.0%	9.0%	0.0%	47.7%
EXP_ELEC/RURAL_EXP	104	11.3%	10.3%	0.0%	46.4%
EXP_ROADS/RURAL_EXP	104	45.5%	16.3%	4.0%	80.0%
EXP_SAN/RURAL_EXP	104	0.4%	0.9%	0.0%	6.5%
CULTLAND	63	1.99	3.18	0.0005	12.35
ROADS	108	0.005	0.004	0	0.013
TEMP_MIN	99	10.04	8.02	6.1	21.2
PREC	99	852	573	229	2,353

Our specifications do not allow for estimating the effects of taxation or government borrowing although we are still taking into account the government budget constraint (see section 3). At the sub-national level, there is little taxation, and borrowing is likewise limited. Instead, sub-national jurisdictions rely on transfers from the central government. In addition, the tax burden in the agricultural sector is relatively light. Finally, through the government budget constraint, the effects of spending are intertwined with those of the financing instruments. The design of our research and the specifications used separate the two effects and only focus on the composition effects of public spending.

6 Results

The results suggest that reallocating public resources from other rural expenditure categories and other non-rural expenditure categories towards agricultural R&D and, to a lesser extent, to extension services and irrigation, has positive effects on agricultural output growth.

The results depicting the effects of changes in the inter-sectoral expenditure composition (i.e. the effects of increasing core rural expenditure at the expense of other rural expenditure and non-rural expenditure) are presented in Table 4. We find that a 10 percent increase in the share of agricultural R&D expenditure would raise agricultural growth per rural inhabitant by at least 3 percent and could go up to 7 percent (depending on the specification).

In column (1), we use department fixed effects to account for unobserved, time-invariant departmental variables. In column (2), we add time effects to account for unobserved shocks that affect agricultural growth in all departments equally and to account for national expenditure.

In both specifications, allocating more resources to agricultural R&D has significant and positive effects. The coefficients of the remaining expenditure variables (except expenditure on extension services and on irrigation which are only significant in one of the specifications) are not significant, which suggests - contrary to our expectations - that these expenditure types do not raise agricultural output growth more than the omitted expenditure categories.

In column (3), we use department and time fixed effects jointly. However, given that the control variables are slowly or rarely changing, so that there is high correlation with departmental dummies that control for unobserved departmental effects, we also use the *xtfevd* estimator, which addresses this issue in columns (4) and (5). Agricultural R&D expenditure remains positive and significant, and expenditure on extension remains positive as well. In one of the specifications, spending on pest control and on irrigation is positive and significant as well. The coefficients of the control variables have the expected signs and are mostly significant in specification (4), but they are not robust across different specifications.

Table 5 presents the effects of changes in the intra-sectoral expenditure composition by holding constant the total rural expenditure. The picture that emerges is similar: agricultural R&D expenditure is consistently positive and mostly significant, and spending on extension services and irrigation is positive and sometimes significant.

In column (1), we use department fixed effects. In column (2), we add time effects to account for common shocks and for national expenditure. In columns (3) to (5), we use department effects and time effects and the *xtfevd* estimator.

Table 4: The effects of changes in the inter-sectoral public spending composition

VARIABLES	(1) pc. agr. growth	(2) pc. agr. growth	(3) pc. agr. growth	(4) pc. agr. Growth	(5) pc. agr. growth
TOT_EXP/GDP	1.484**	2.466***	0.952	1.915***	1.484***
	(0.589)	(0.724)	(1.193)	(0.538)	(0.418)
R&D_EXP/**TOTAL_EXP**	0.308**	0.353***	0.677**	0.506***	0.308***
	(0.117)	(0.112)	(0.274)	(0.0942)	(0.0791)
EXT_EXP/**TOTAL_EXP**	0.129	0.184*	0.543	0.0846	0.129
	(0.0974)	(0.0967)	(0.303)	(0.123)	(0.0791)
IRR_EXP/**TOTAL_EXP**	0.0937	0.236*	0.385	0.274**	0.0937
	(0.108)	(0.120)	(0.278)	(0.0968)	(0.0844)
ELEC_EXP/**TOTAL_EXP**	-0.109	-0.113	-0.173	-0.263**	-0.109*
	(0.0699)	(0.0731)	(0.182)	(0.0916)	(0.0628)
ROADS_EXP/**TOTAL_EXP**	-0.109	-0.0651	-0.181	-0.130	-0.109
	(0.164)	(0.164)	(0.267)	(0.147)	(0.145)
SAN_EXP/**TOTAL_EXP**	-0.00120	0.0457	0.376	0.174*	-0.00120
	(0.0721)	(0.0755)	(0.201)	(0.0875)	(0.0582)
ROAD DENSITY	-0.568	0.498	-1.970	0.470*	-0.568***
	(0.540)	(1.166)	(3.288)	(0.211)	(0.192)
MIN TEMPERATURE	-0.538	-0.634	0.753	-0.671***	0.0542
	(0.377)	(0.417)	(0.608)	(0.149)	(0.0972)
PRECIPITATION	-0.0642	0.264	-1.423	2.843***	0.429
	(0.416)	(0.460)	(0.757)	(0.627)	(0.327)
CULTIVATED LAND			3.761**	0.0683	
			(1.492)	(0.158)	
Constant	0.511	8.032	6.457	-9.097***	-3.880*
	(5.010)	(8.482)	(15.98)	(2.832)	(2.095)
Observations	51	51	28	28	51
R-squared	0.439	0.688	0.937	0.950	0.769
Number of stateID	8	8	7		
Department FE	YES	YES	YES	XTFEVD	XTFEVD
Year FE	NO	YES	YES	NO	NO

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Estimates based on 1996 - 2007.
All variables are in logs.
Agricultural pc growth rate 5-year forward moving averages.

Other rural expenditure and non-rural expenditure are the omitted fiscal categories.

Table 5: The effects of changes in the composition of rural public spending (i.e. intrasectoral changes)

VARIABLES	(1) pc. agr. growth	(2) pc. agr. growth	(3) pc. agr. growth	(4) pc. agr. growth	(5) pc. agr. growth
RURAL_EXP/GDP	0.319	0.506	1.334*	1.009***	0.319*
	(0.277)	(0.396)	(0.621)	(0.189)	(0.175)
R&D_EXP/**RURAL_EXP**	0.232*	0.286**	0.589*	0.392***	0.232***
	(0.120)	(0.130)	(0.248)	(0.0786)	(0.0822)
EXT_EXP/**RURAL_EXP**	0.119	0.152	0.437*	0.368***	0.119
	(0.104)	(0.114)	(0.220)	(0.0988)	(0.0839)
IRR_EXP/**RURAL_EXP**	0.0763	0.153	0.464	0.432***	0.0763
	(0.139)	(0.149)	(0.246)	(0.111)	(0.108)
ELEC_EXP/**RURAL_EXP**	-0.0793	-0.113	-0.123	0.0818	-0.0793
	(0.0755)	(0.0926)	(0.203)	(0.0671)	(0.0686)
ROADS_EXP/**RURAL_EXP**	-0.214	-0.287	0.135	0.839**	-0.214
	(0.359)	(0.407)	(0.495)	(0.310)	(0.327)
SAN_EXP/**RURAL_EXP**	-0.0548	-0.0386	0.354	0.411***	-0.0548
	(0.0734)	(0.0830)	(0.186)	(0.0914)	(0.0635)
ROAD DENSITY	-0.756	-0.952	-1.777	-3.741***	-0.756***
	(0.576)	(1.316)	(2.614)	(0.403)	(0.221)
MIN TEMPERATURE	-0.319	-0.0771	0.438	0.644***	0.0775
	(0.390)	(0.476)	(0.560)	(0.150)	(0.104)
PRECIPITATION		-0.109	-1.004*	-6.193***	0.0980
		(0.535)	(0.510)	(0.803)	(0.346)
CULTIVATED LAND			3.768**	1.368***	
			(1.466)	(0.183)	
Constant	-3.525	-4.973	5.076	27.61***	-6.178***
	(5.017)	(9.075)	(15.54)	(4.609)	(2.129)
Observations	51	51	28	28	51
R-squared	0.357	0.567	0.939	0.962	0.735
Number of stateID	8	8	7		
Department FE	YES	YES	YES	XTFEVD	XTFEVD
Year FE	NO	YES	YES	NO	NO

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Estimates based on 1996 - 2007.
All variables are in logs.
Agricultural pc growth rate 5-year forward moving averages.

Other rural expenditure is the omitted fiscal category.

7 Robustness Checks

We perform a number of robustness checks to address potential limitations in our estimation approach (these are summarized in the Appendix). One concern is multicollinearity among the fiscal variables. Perfect collinearity would arise if we included additional expenditure types so that the sum of the expenditure shares would be nearly one. However, we only include core expenditure categories, and according to Table 2, these only account for around 15% of total and 70% of rural expenditure. Table and 7 in the Appendix display pair wise correlations of the fiscal variables (not in logs) included in specifications (5) and (6), respectively. The tables show that the correlation between the expenditure shares (except for agricultural R&D expenditure and expenditure on extension services) is mostly small or not significant.

Another concern is potential endogeneity of some of the explanatory variables. There is a possible co-movement of the business cycle with government expenditure. For instance, aggregate output growth determines government revenue which in turn determines the volume of public spending. In addition, government decisions in the context of fiscal policy may be triggered by changes in output. We address this problem by using forward-moving averages of agricultural growth per capita. In addition, while the volume of public spending may indeed be influenced by aggregate output, it seems unlikely that agricultural output drives public spending composition which we focus on. On the one hand, available revenue at the departmental level is to a large extent determined by transfers from the central government and not by departmental agricultural output growth. Moreover, growth theory provides no clear link between output and public spending composition. On the other hand, the government does not observe agricultural output in real time, but only subject to lags of several years. In this sense, the government is unable to set public spending composition in response to contemporaneous agricultural output which further limits possible endogeneity.

In order to account for poor data quality at the municipal level, we re-run the regressions with municipal expenditure excluded, but the implications of the results do not change the main results. In addition, we estimate equations (5) and (6) but change the classification of the expenditure variables and include one broad expenditure category that includes spending on extension services, sanitation, environmental risk management and other types of agricultural spending categories, irrigation, and roads. Tables 8 and 9 in the Appendix show that results are indeed sensible to the definition of public expenditure categories. This is not surprising as broader public expenditure categories exacerbate problems related to unobserved heterogeneity if the subcategories they include greatly differ in terms of their effects and if the composition of these categories differs across time and departments. Our results suggest that this is the case.

8 Conclusions

Given the importance of agriculture in Bolivia, it is critical for policy makers to understand what policy choices promote agricultural output growth. This paper has focused on a central policy area, namely public expenditure policy, and has examined the effects of changes in: (a) inter-sectoral composition of public spending and (b) intra-sectoral composition of public spending within the rural sector on agricultural growth per rural inhabitant, using sub-national data. The results suggest that public spending composition matters and, more specifically, that allocating a greater share of public spending to agricultural R&D expenditure and extension services, and also to some extent on irrigation would have positive growth effects over the medium run. These results seem to be fairly robust across all empirical specifications.

9 Appendix

Table 6: Correlation of fiscal variables in specification (5)

	R&D_EXP/TOTAL_EXP	EXT_EXP/TOTAL_EXP	IRR_EXP/TOTAL_EXP	ELEC_EXP/TOTAL_EXP	ROADS_EXP/TOTAL_EXP
R&D_EXP/TOTAL_EXP					
EXT_EXP/TOTAL_EXP	0.42***				
IRR_EXP/TOTAL_EXP	-0.19**	-0.08			
ELEC_EXP/TOTAL_EXP	-0.09	0.12	0.27***		
ROADS_EXP/TOTAL_EXP	0.1	0.38***	0.19**	0.29***	
SAN_EXP/TOTAL_EXP	-0.05	0.03	-0.12	-0.12	-0.03

Table 7: Correlation of fiscal variables in specification (6)

	R&D_EXP/RURAL_EXP	EXT_EXP/RURAL_EXP	IRR_EXP/RURAL_EXP	ELEC_EXP/RURAL_EXP	ROADS_EXP/RURAL_EXP
R&D_EXP/RURAL_EXP					
EXT_EXP/RURAL_EXP	0.59***				
IRR_EXP/RURAL_EXP	-0.28***	-0.24**			
ELEC_EXP/RURAL_EXP	0.01	-0.03	-0.06		
ROADS_EXP/RURAL_EXP	-0.25***	-0.06	-0.32***	-0.35***	
SAN_EXP/RURAL_EXP	-0.04	-0.05	-0.22**	-0.16*	0.14

Table 8: The effects of intersectoral public spending composition – alternative expenditure classification

	(1)	(2)	(3)	(4)	(5)
VARIABLES	pc. agr. growth	pc. agr. growth	pc. agr. growth	pc. agr. growth	pc. agr. growth
TOT_EXP/GDP	0.534	0.602	2.205**	0.759*	0.534*
	(0.451)	(0.556)	(1.008)	(0.426)	(0.267)
EXT2_EXP/TOTAL_EXP	0.0539	0.105	-0.117	-0.0462	0.0539
	(0.140)	(0.159)	(0.221)	(0.201)	(0.134)
IRR2_EXP/TOTAL_EXP	0.0690	0.150	0.837***	0.447**	0.0690
	(0.0851)	(0.111)	(0.258)	(0.158)	(0.0639)
ROADS2_EXP/TOTAL_EXP	-0.179	-0.190	-0.280	-0.258	-0.179**
	(0.107)	(0.126)	(0.222)	(0.172)	(0.0844)
ROADS	-1.297**	-0.699	3.641	-1.586***	-1.297***
	(0.493)	(1.079)	(2.725)	(0.349)	(0.248)
MIN TEMP	-0.236	-0.187	-0.0811	-0.132	0.292***
	(0.376)	(0.456)	(0.484)	(0.145)	(0.0949)
PREC	0.234	0.0400	0.207		
	(0.360)	(0.469)	(0.721)		
CULTLAND			3.677***	0.535***	
			(1.142)	(0.180)	
Constant	-9.418*	-6.941	10.70	-6.749	-2.878
	(5.134)	(7.608)	(13.86)	(4.332)	(2.671)
Observations	62	62	32	32	62
R-squared	0.302	0.420	0.666	0.852	0.685
Number of stateID	9	9	8		
Department FE	YES	YES	YES	XTFEVD	XTFEVD
Year FE	NO	YES	YES	NO	NO

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 9: The effects of changes of the composition of rural expenditure (i.e. intrasectoral changes) – alternative expenditure classification

	(1)	(2)	(3)	(4)	(5)
VARIABLES	pc. agr. growth	pc. agr. growth	pc. agr. growth	pc. agr. growth	pc. agr. growth
RURAL_EXP/GDP	0.769*	0.552	-1.197	-1.252***	0.769***
	(0.421)	(0.627)	(1.050)	(0.228)	(0.180)
EXT2_EXP/TOTAL_EXP	-0.143	-0.0242		0.166	-0.143
	(0.178)	(0.238)		(0.191)	(0.145)
IRR2_EXP/TOTAL_EXP	0.0102	0.0658	0.809**	0.650***	0.0102
	(0.0914)	(0.138)	(0.323)	(0.181)	(0.0571)
ROADS2_EXP/TOTAL_EXP	-0.446**	-0.396	0.393	0.359**	-0.446***
	(0.191)	(0.269)	(0.473)	(0.140)	(0.0982)
ROADS	-0.832	-0.642	-0.404	-2.506***	-0.832***
	(0.558)	(1.151)	(2.474)	(0.473)	(0.197)
MIN TEMP	-0.139	-0.0807	0.350	-0.643***	0.369***
	(0.363)	(0.443)	(0.480)	(0.169)	(0.0994)
PREC	0.0870	0.0908	-0.157		
	(0.354)	(0.478)	(0.773)		
CULTLAND			4.363***	-0.539**	
			(1.269)	(0.236)	
Constant	4.727	1.009	-32.07	-42.61***	8.000**
	(10.06)	(15.08)	(21.67)	(7.216)	(3.791)
Observations	62	62	32	32	62
R-squared	0.330	0.413	0.595	0.859	0.697
Number of stateID	9	9	8		
Department FE	YES	YES	YES	XTFEVD	XTFEVD
Year FE	NO	YES	YES	NO	NO

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

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