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Food Insecurity and Public Agricultural Spending in Bolivia

Putting Money Where Your Mouth Is?

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Abstract

This paper explores the reduction of food insecurity in Bolivia, adopting a supply side approach that analyzes the role of agricultural spending on vulnerability. Vulnerability to food insecurity is captured by a municipal level composite—developed locally within the framework of World Food Program food security analysis—that combines welfare outcomes, weather conditions and agricultural potential for all 327 municipalities in 2003, 2006 and 2007. Our econometric results indicate that levels of public agricultural spending are positively associated with high or very high vulnerability. The authors interpret this to indicate that agricultural spending allocation decisions are driven by high or very high vulnerability levels. In other words, more agricultural spending appears to be destined to where it is more needed in line with previous findings in other sectors in Bolivia. This is confirmed through a number of specifications, including contemporaneous and lagged relationships between spending and vulnerability. They also find evidence of public spending on infrastructure and research and extension services having a significant (but very small) effect towards reducing high vulnerability. This indicates the importance of the composition of public agricultural spending in shaping its relationship with vulnerability to food insecurity.

This paper is a product of the Poverty Reduction and Equity Unit, Poverty Reduction and Economic Management Network; and the Agriculture and Rural Development Unit of the Sustainable Development Department in the Latin America and Caribbean Region. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The authors may be contacted at jcuesta@worldbank.org and sedmeades@worldbank.org.

Food Insecurity and Public Agricultural Spending in Bolivia: Putting Money Where Your Mouth Is?

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1. Introduction

The recent food price crisis has contributed to a shift in many developing countries, including Bolivia, toward food security as a key policy objective. Even prior to the international food price crisis of 2008, Bolivia had brought food security and sovereignty to the center stage of its development agenda, defined in the National Development Plan 2006-2010. The food price crisis and recurrent climate change phenomena are adversely affecting the country and have created a sense of urgency in better understanding and addressing food security. Food security and sovereignty feature prominently in the Government Plan 2010-2015 and are key elements of several government programs currently under implementation.

Food security is a complex phenomenon involving multiple factors. In Bolivia, declining food security could be the result of a number of trends:[2] (i) reduced cultivated land area and increased land fragmentation; (ii) strengthening export-oriented agriculture by large-scale producers; (iii) increased food imports and dependence on international markets; (iv) growing urbanization and movement of labor away from rural areas; (v) dietary changes from traditional foodstuffs like potato to manufactured agricultural products; and (vi) environmental shocks such as droughts and floods. These trends are accentuated by structural factors, such as the rigid geography of the country and limited road coverage, which inhibit domestic market integration.

Considering the multiple factors affecting an individual's ability to easily access food that adequately satisfies their needs—the widely accepted definition of food security[3]—a single, "silver bullet" policy for addressing food insecurity is likely to have a limited impact. As a result, food security interventions in Bolivia, as in other countries, span several sectors. A rigorous attempt to assess the impact of the many different interventions would be a major undertaking requiring a great deal of data and analytical sophistication to encompass all programs and address counterfactual and endogeneity issues. This paper takes a supply-side approach by looking at the association of agricultural spending (broadly defined) and food security. Agricultural spending in Bolivia—totaling about 13 percent of GDP in 2008—captures a large portion of the public money being destined to food security, and as such is a good indicator of public interventions that aim at reducing vulnerability. However, it provides only a partial perspective on addressing food security, as spending in other sectors (health, education) is also important for reducing vulnerabilities. In any case, to the best of our knowledge, this is the first attempt to make inferences about the relationship between sectoral spending in agriculture and food security in Bolivia.[4] By showing linkages between public expenditure and a measure of

[2] See Ormaechea, 2009, Cuesta et al. 2009, and World Bank, 2010a for more on the causes of food insecurity in Bolivia.

[3] The definition of food security and sovereignty adopted in Bolivia is based on FAO 2006, which incorporates not just food availability but also stable access and the use of food as part of an adequate diet and the stability of access. Consistent with those guidelines, Bolivia's definition (UPB 2008, 26) covers risk exposure, capacity to address food insecurity and current situation as part of a historical trend.

[4] Previous studies, such as Faguet (2004) or Inchauste (2009), have focused on the link between public spending and welfare in the contexts of decentralization and the Heavily Indebted Poor Country debt-relief initiatives, respectively. Faguet (2004) singles out the association between agricultural investments and municipal needs (proxied by municipal malnutrition rates) concluding that the 1994 decentralization reform implied a relatively modest increase in agricultural investments but an improvement in the needs-based allocation of those investments (as it was the case in several social sectors).

vulnerability (Vulnerability Analysis and Mapping, or VAM), both defined at the municipal level, this paper is a first step to guiding policy recommendations on food security in the country.

The analysis generates several key findings: (i) public agricultural spending is associated with high levels of vulnerability, which may imply that resource *allocation* decisions in agriculture take into account food insecurity; (ii) incremental public spending in agriculture has a (statistically significant) *impact* towards reducing vulnerability, but in the short run this association is negligible in magnitude; (iii) the *composition* of public expenditure matters, as the effects of resource allocations in agriculture are not uniform across its categories; and (iv) there are important department specific effects across Bolivia.

2. Agriculture and Food Security in Bolivia

Agriculture plays an important role in the economy of Bolivia and it is one of the key components of the government's poverty reduction strategy, particularly in rural areas. The sector accounts for 13 percent of GDP or 27 percent if agribusiness is considered. Despite the decline in rural population (currently 33 percent of the total population), the sector employs almost 90 percent of the economically active people living in rural areas (World Bank, 2010b). The vast majority of the rural population employed in agriculture is poor: 85 percent live in poverty and 75 percent in extreme poverty (UDAPE, 2006).

Agriculture is a very spatially heterogeneous sector and its importance varies across regions. This reflects 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 focuses on food production primarily destined for domestic markets. The sector's contribution to departmental economies in this region ranges between 4 percent and 9 percent of GDP, with a high level of non-agricultural income. On the other hand, the eastern lowlands are characterized by more intensive agricultural production and agribusiness, with a mixture of large and small producers, focusing primarily on export markets. In the lowlands, the contribution of agriculture (excluding agribusiness) to departmental GDP ranges between 16 percent and 32 percent, and the weight of agricultural income in total household income is very large (World Bank, 2010c).

Despite the sector's potential, agricultural productivity in Bolivia is among the lowest in Latin America. Agricultural output growth has exhibited higher volatility due to adverse climatic pressures and lack of adequate mechanisms to respond to risk. Recurrent climate disasters related to the *El Niño* and *La Niña* phenomena affect the volume of agricultural production. Climate disasters explain around 5 percentage points of the 17 percent food price inflation rate observed in 2003, due to their effects on agricultural output (World Bank, 2010a). Risk management interventions have been recent and led by the state. A state-owned enterprise, the Food Production Assistance Company (*Empresa de Apoyo a la Producción de Alimentos*—EMAPA), was created in 2007 to support food production by small and medium size producers through financing, intermediation of inputs and final products and access to machinery. A universal agricultural insurance policy, proposed by the Government Plan 2010-2015, is currently being designed as an incentive for agricultural production and food security.

The agricultural sector strategy (*Plan for a Rural, Agrarian and Forestry Revolution*) identifies three main objectives: (i) attain food security and sovereignty; (ii) enhance the condition of rural populations by increasing agricultural and forest production; and (iii) assure the sustainable management of natural resources. The first objective spans several sectors, which makes sector-specific impact assessments challenging. The second objective is a core agricultural sector objective and in Bolivia, as in other countries, public investment in the core public goods such as research and extension, and to a limited extent in irrigation, has been able to increase agricultural growth (Bolivia APER, 2011).

Interventions to address food insecurity in Bolivia are being undertaken within a broader political context and span different sectors (see Annex 1 for a complete list): (i) land redistribution; (ii) promotion of food production and exports by state-owned enterprises such as EMAPA, among others; (iii) food security programs, including support to communities and small producers based on traditional and indigenous technologies; and (iv) nutritional programs for children, pregnant women and mothers with lactating infants, and school meals, among others.

The current focus of the Rural Plan is on strengthening family agriculture and small agricultural units, including indigenous and other rural communities, with emphasis on productivity and food security. This is done through a myriad of programs implemented at the national, departmental and municipal levels under mandates of several ministries. Four of the ten programs currently implemented by the Ministry of Rural Development and Lands (*Ministerio de Desarrollo Rural y Tierras*—MDRyT) have food security provisions: (i) food security at the municipal level; (ii) creating rural food initiatives; (iii) organizing self-governing rural development; and (iv) state support for rural food enterprises. The Program for Support to Food Security (*Programa de Apoyo a la Seguridad Alimentaria*—PASA) became a de-concentrated entity of the MDRyT, and has a national mandate for food security. Although these programs represent a large portion of the public resources spent on food security, they do not capture the whole range of initiatives. They represent mostly the food production and distribution aspects of food security, with nutritional programs mostly covered under the mandates of other ministries.

To the best of our knowledge, there are no rigorous evaluations or assessments on the effectiveness of these programs. Previously, Faguet (2004) concluded that the 1994 decentralization reform increased investments in agriculture as well as several social sectors (education, water and sanitation – but not healthcare) and urban development. Furthermore, the observed increase in investments was unambiguously needs-based, with municipal malnutrition rates found a statistically significant factor driving the allocation of agricultural spending in the decentralized context. Unfortunately, the study has two important limitations: it does not provide any evidence on the effects of agricultural investments on malnutrition rates; and data refers to the period 1987-1996. Inchauste (2009), looking at the effects of poor-poor spending (as categorized by the HIPC initiative) between 2000 and 2005, rejects a strong link between spending on education, healthcare and infrastructure and improvements in municipal welfare indicators. Unfortunately, the study does not consider any nutritional or food security related indicator and does not single out agricultural spending.

3. Vulnerability Analysis and Mapping (VAM)

VAM is a tool to identify the degree of food insecurity and vulnerability at the municipal level in Bolivia. It assigns a value from 1 to 5 to each municipality according to level of food insecurity and vulnerability, where 1= very low, 2 = low, 3 = medium, 4 = high, 5 = very high.[5] Developed by the Universidad Privada de Bolivia and Social and Economic Policy Analysis Unit (*Unidad de Analisis de Políticas Sociales y Ecónomicas*—UDAPE) in the Ministry of Development Planning, the VAM uses a World Food Program methodology (WFP, 2010)[6] and it is widely accepted in Bolivia as a formal measurement of food insecurity. VAM measures are available for 2003, 2006 and 2007 for all 327 municipalities across the nine departments that constitute Bolivia.

The VAM is constructed with community-level data using principal component analysis. Among the components used for all three iterations are: urbanization rate, rural population density and its square, proportion of institutionally attended births, schooling years, log of per capita consumption, under-five malnutrition rate, altitude, rainfall and a flood propensity categorical variable (four values). Components used only in the 2003 VAM and not used in subsequent updates include: dependency rate, life expectancy, agricultural potential (a categorical four-point scale variable capturing soil capacity), forestry potential, road density, draught frequency, frost days per year, low weight at birth and per capita household food expenditures.

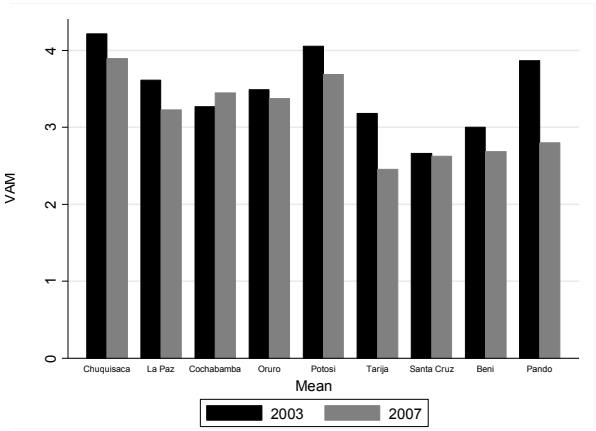
Although changes in VAM scores between 2003 and 2007 were not uniform, the average vulnerability status by department decreased over time, suggesting that, on average, municipalities within each department have reduced their vulnerability to food insecurity (Figure 1). The exception is Cochabamba, the only department where average vulnerability to food insecurity increased over time. Tarija and the three *llanos* departments of Santa Cruz, Beni and Pando registered, on average, between moderate and low vulnerability in 2007.[7]

[5] Specifically, the methodology estimates each municipality's probability of pertaining to each one of these vulnerable categories, that is, five probabilities per municipality, and the largest of which determining the final vulnerability status the municipality is assigned to. Thus, if the estimated probability – conditioned to a number of controls– of a given municipality to pertain to VAM=5 is 85%, that municipality is said to have a very high vulnerability status to food insecurity. These probabilities are used below for the correlation analysis – see Figure 5.

[6] WFP (2010) identifies five categories of food security situations. Phase 1 refers to generally food secure; Phase 2 - moderately/borderline food insecure; Phase 3 - acute food and livelihood crisis; Phase 4 - humanitarian emergency and Phase 5 - famine/humanitarian catastrophe. See http://fsa.wfp.org/special_documents/FSA_Factsheet_EN.pdf

[7] Similar results are obtained comparing VAM 2003 and VAM 2006.

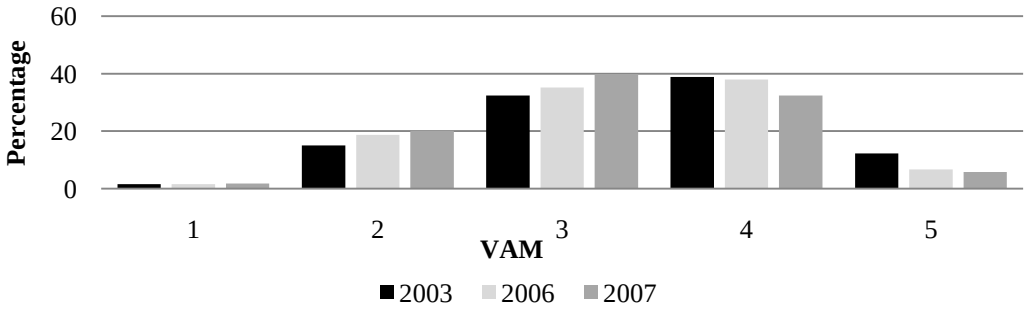
Figure 1. Vulnerability Status by Department



Source: Authors from World Bank (2010) Agricultural Public Expenditure Database (APER).

At the municipal level, 62 percent of the municipalities were categorized in 2007 as having a moderate to very low vulnerability to food insecurity (VAM 1 to 3), while 38 percent were in the high to very high vulnerability (4 and 5) categories. The percentage of municipalities with high or very high levels of vulnerability to food insecurity decreased from 51 percent in 2003 to 38 percent in 2007 (Figure 2).

Figure 2. Percentage of Municipalities by Vulnerability Status



Source: Authors from World Bank (2010) APER database.

However, this reduction masks important variations in the vulnerability situation across municipalities. Evidence suggests that mobility across vulnerability levels is limited and asymmetric. Transition matrices (Table 1) indicate that 80 percent of municipalities did not change either their low/moderate or high/very high vulnerability status between 2003 and 2007. For each municipality that worsened its status from low to high vulnerability, more than two improved from high to low vulnerability. This is also true comparing 2003 to 2006.

Table 1. Vulnerability Transition Matrix by Municipality

		2006		2007	
		Low vulnerability	High vulnerability	Low vulnerability	High vulnerability
2003	Low vulnerability	146 (45%)	14 (4%)	148 (45%)	12 (4%)
	High vulnerability	35 (11%)	132 (40%)	54 (17%)	113 (35%)

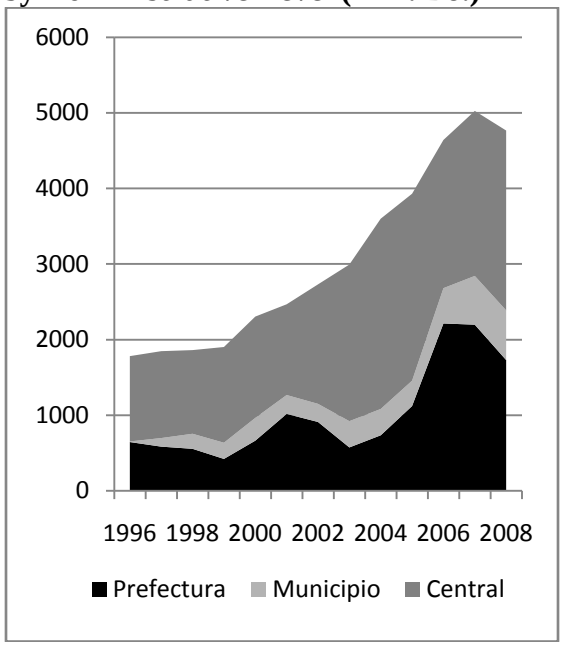
Source: Authors from World Bank (2010) APER database.

4. Public Agricultural Expenditure in Bolivia

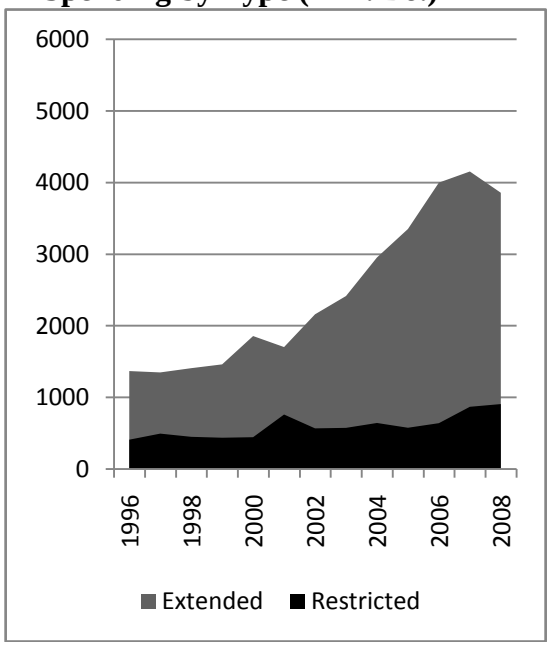
Public spending in agriculture (including rural development) has historically been low in Bolivia—13 percent of GDP in 2008. It has predominantly focused on resources for productive infrastructure (e.g. roads, irrigation, and rural electrification) and less so on agricultural innovation. In the last five years public agricultural spending both in nominal and real terms has increased markedly (Figure 3a), as has rural development spending in general. The participation of sub-national governments in the allocation of public resources has also been more prominent in recent years (Figure 3a), both in terms of extended (agriculture and rural development) and restricted (just agriculture) spending (Figure 3b). Investment spending has dominated current spending for both extended and restricted agricultural spending, although relative weights are subject to sizeable yearly variations (Figures 3c and 3d).

Figure 3. Agricultural Spending in Bolivia (constant 2005 prices)

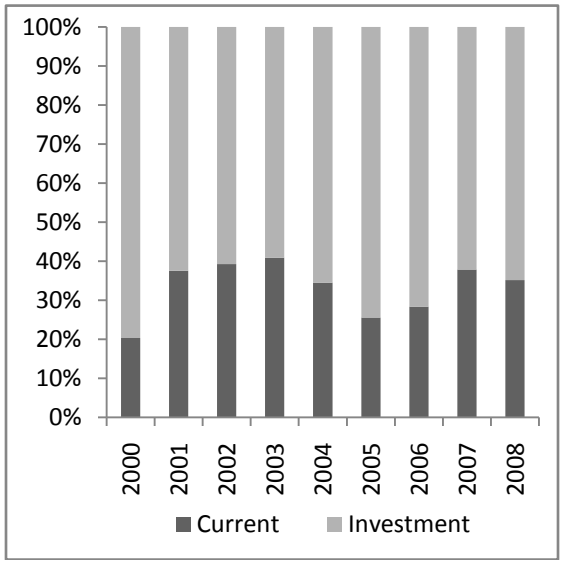
(a) Distribution of Agricultural Spending by Administrative Level (Mill. Bo.)



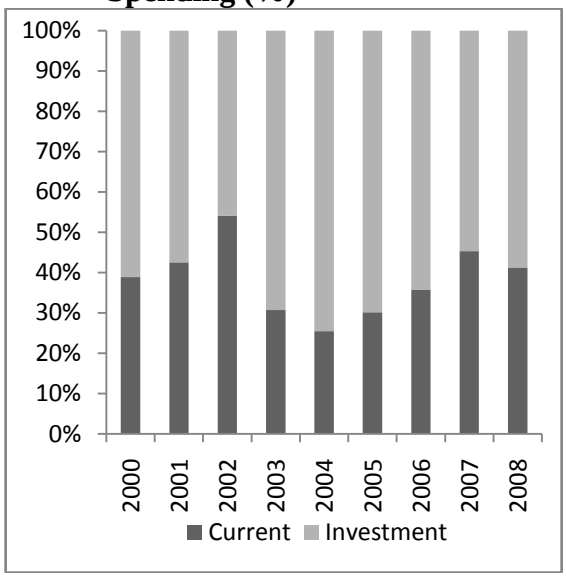
(b) Distribution of Municipal Agricultural Spending by Type (Mill. Bo.)



(c) Distribution of Extended Agricultural Spending (%)

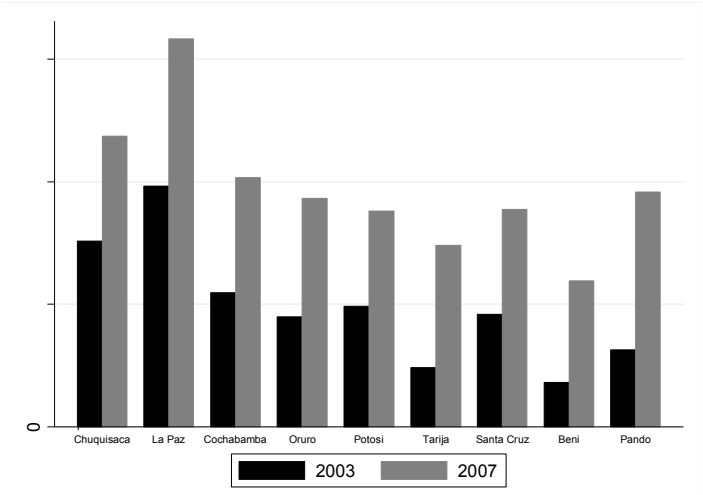


(d) Distribution of Restricted Agricultural Spending (%)



Note: In Figure 3b, 3c and 3d, "restricted" spending refers to narrowly defined agricultural spending (including spending in core public goods, such as research, extension, irrigation), and "extended" refers to rural development spending broadly defined (including expenditures in productive infrastructure, such as roads, rural electrification, etc.). The detailed definition is provided in Annex 2. "*Prefectura*" refers to the departmental government, currently called 'Gobernaciones'.
Source: World Bank APER (2010).

Figure 4. Per Capita Agricultural Spending by Department (constant 2005 prices)



Source: Authors from World Bank (2010) APER database.

The increasing trend of per capita agricultural public spending, however, is not uniform across departments (Figure 4). This is partly due to transfer mechanisms currently in Bolivia. Central government transfers constitute almost the sole source of income for departmental governments and the largest source of income for municipal governments. The discretionary use of transfers is

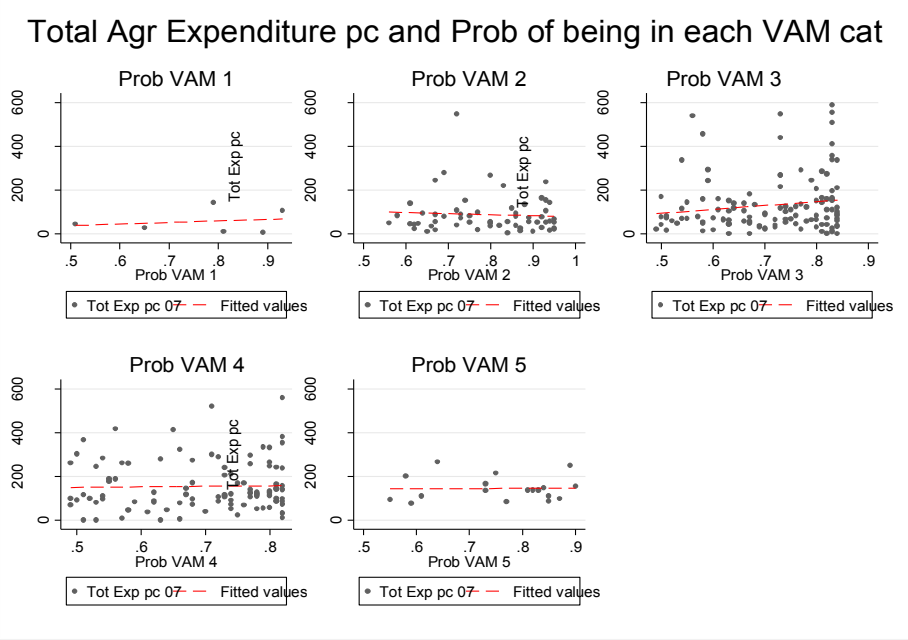
more restrictive at the departmental level. Defined by a number of decrees, departmental transfer amounts are based on population formulas, and implicit prioritization of social and productive infrastructure is used for allocating transfer resources. The discretionary use of transfers is broader at the municipal level. See Inchauste (2009) for a more detailed discussion of the transfer allocation formula.

The public expenditure data used in this paper was derived from the Accounting Department of the Ministry of the Economy and Public Finance of Bolivia. Expenditure data in Bolivia is typically recorded by program and project, and aggregated at the national level. The expenditure data on agriculture and rural development was disaggregated by function (research, extension, irrigation, rural roads, etc.), economic classification (current and capital) and level of government (national, departmental and municipal) for a period of 13 years (1996-2008). This provides a rich panel for analysis within and across levels of government or categories of spending. Annex 2 presents the definitions of categories used in this analysis.

5. Analyzing the Effects of Agricultural Spending on VAM

A simple correlation of the municipal distributions of agricultural spending and probabilities of each category of vulnerability to food insecurity indicates that total per capita agricultural spending and vulnerability to food insecurity are only weakly correlated at the municipal level. The correlation between per capita agricultural spending (in Bolivianos) and VAM is only 0.03 in 2007. The relationship between VAM scores across the 327 Bolivian municipalities and per capita total agricultural spending in 2007 in these municipalities is almost horizontal (Figure 5).

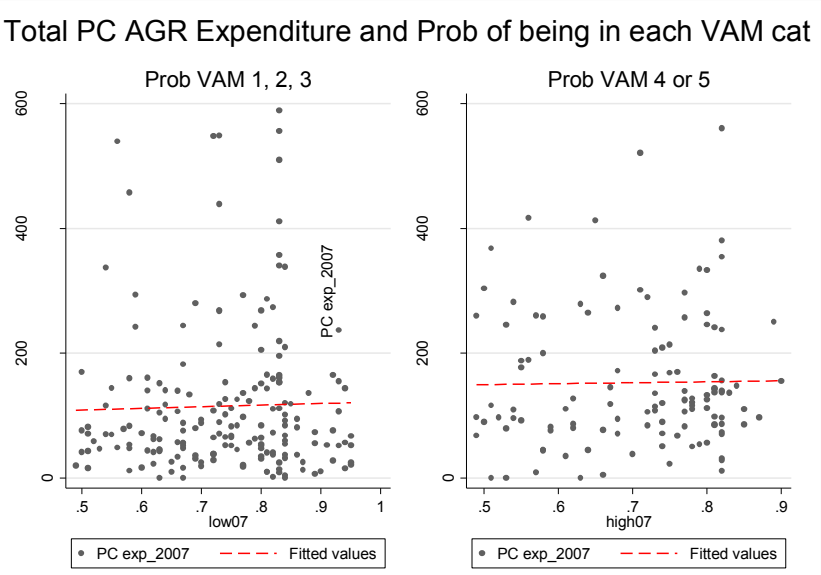
Figure 5. Per Capita Agricultural Expenditure and Probability of Being in Each VAM Category



Source: Authors from World Bank (2010) APER database.
Note: each figure depicts the association between the estimated probability of vulnerability across municipalities pertaining to the respective vulnerability category, 1 to 5 (as described in footnote 4 above).

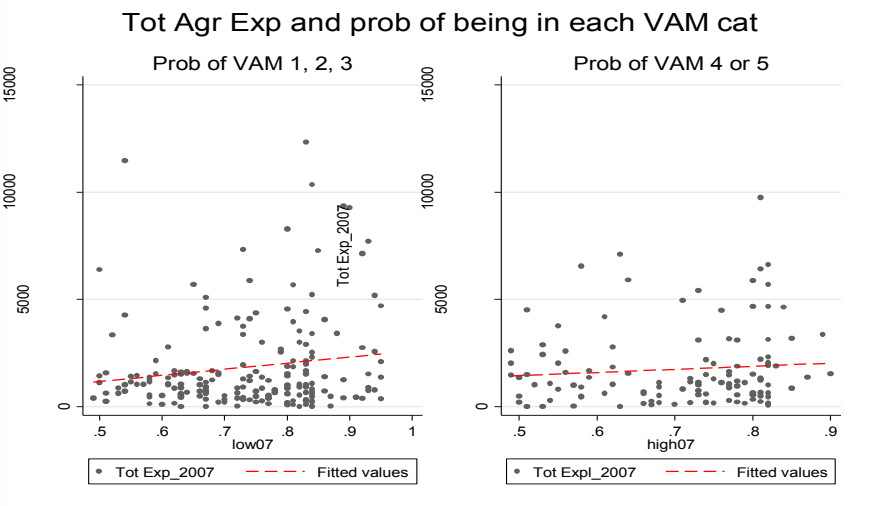
The weak correlation between the two variables also holds when the five categories of food insecurity are grouped as either (i) moderate or better, or (ii) high or very high vulnerability to food insecurity (Figure 6). When total agricultural spending (not in per capita terms) and vulnerability categories are compared, results remain very similar, thus confirming that scale considerations do not appear to drive these patterns (Figure 7).

Figure 6. Per Capita Agricultural Expenditure and Probability of Being in Each VAM Category Grouping



Source: Authors from World Bank (2010) APER database.
Note: each figure depicts the association between the estimated probability of vulnerability across municipalities pertaining to the respective vulnerability group, that is, low (categories 1 to 3) and high (categories 4 and 5)

Figure 7. Total Agricultural Expenditure and Probability of Being in Each VAM Category

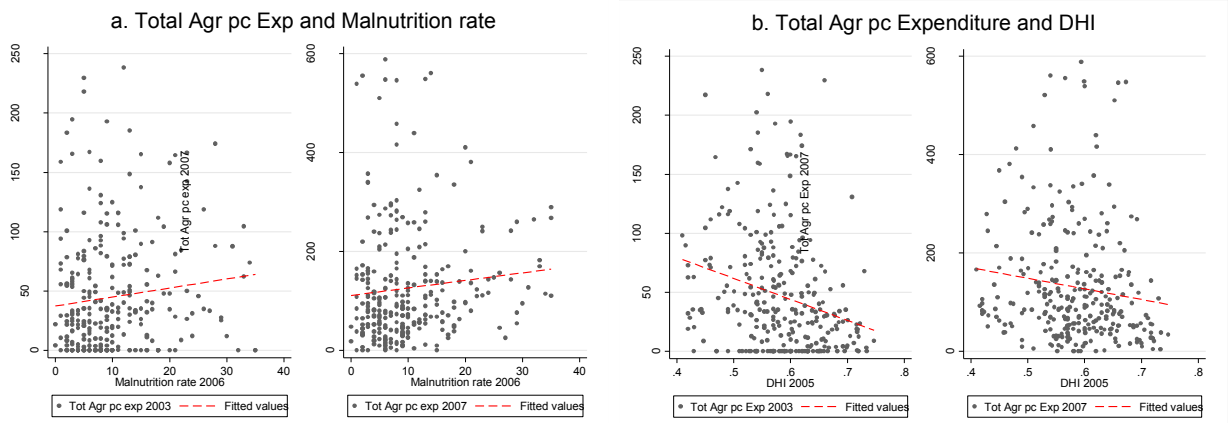


Source: Authors from World Bank (2010) APER database.

Note: each figure depicts the association between the estimated probability of vulnerability across municipalities pertaining to the respective vulnerability group, that is, low (categories 1 to 3) and high (categories 4 and 5)

There are several possible explanations for the weak association between agricultural expenditure and vulnerability to food insecurity. One is that agricultural spending alone has a weak direct impact on the reduction of vulnerability to food insecurity in Bolivia. A second possibility is that composition effects within agricultural spending may not be captured through an aggregate measure of sectoral spending. The correlations between categories of agricultural per capita spending and VAM are -0.18 for restricted and 0.43 for extended agricultural spending, respectively (see Annex 2 for definitions of each category). This suggests that the composition of spending may be important for reducing vulnerability to food insecurity, and that the two categories of spending may be working in different directions, offsetting their individual effects (which would explain the weak correlation for total spending). A third explanation may be that higher agricultural spending is poverty-driven (i.e. it is a proxy for lower development levels) rather than a variable able to pick up impacts on vulnerability to food insecurity. Per capita agricultural spending correlates positively with malnutrition rates (Figure 8a) and negatively with human development at the municipal level (Figure 8b). [8]

Figure 8. Per Capita Agricultural Expenditure and Welfare Measures



Source: Authors from World Bank (2010) APER database.
Note: Per capita expenditure in Bolivianos.

In addition to these simple correlations, the proposed econometric estimation strategy consists of predicting the probability of pertaining to categories 4 and 5 of VAM in a given year (V), determined by per capita agricultural spending, our key policy variable of analysis (A). Note that this analysis aims at understanding whether and how agricultural spending affects high and very high food insecurity risks. It does not answer the question of whether and how agricultural

[8] Other explanation mentioned in the context of public spending and welfare levels in Bolivia, see Inchauste (2009), refers to the misalignment between central and local government decisions. Although our paper does not test explicitly this hypothesis, the enormous quantity of agricultural programs, not always clearly delimited in terms of objectives or responsibilities, may be consistent with Inchauste's explanation.

spending affects the *overall* risk to food insecurity.[9] Implicit in this decision is the assumption that the ultimate policy objective related to food insecurity in Bolivia is to reduce high levels of vulnerability to food insecurity, rather than improving the *overall* vulnerability profile of the population (as that may not be enough to take the population away from a situation of a considerable insecurity risk).

The analysis of the effects of agricultural spending on high and very high vulnerability is conducted at a municipal level (for each municipality *j*). The covariates of interest in this study relate to agricultural spending by municipality, *Aj*, which is decomposed into multiple categorizations "*i*" of spending: restricted and extended; current and capital; and research and development, infrastructure, support, administrative and other. Equation 1 shows the estimated model, which follows a probit specification:

$$P(V_j = 1) = F(\alpha + \beta_i \sum_i A_{ji}) \qquad (1)$$

Where V_j=1 if municipality j is categorized as VAM type 4 or 5; 0 otherwise; and F ( ) is the cumulative distribution function of the standard normal distribution.

The analysis clusters errors by municipality, which allows controlling for variation within each municipality caused by unobserved variables. Additional variations within departments that are not municipality-specific are controlled by department dummies D (depicted in probit specification in Equation 2).

$$P(V_j = 1) = F(\alpha + \beta_i \sum_i A_{ji} + \lambda_n \sum_{n=1}^{N-1} D_n) \qquad (2)$$

Three alternative estimates of equation (2) are attempted based on the assumed inter-temporal relations of vulnerability and spending: (i) contemporaneous estimation; (ii) lagged estimation; and (iii) difference estimation.

Contemporaneous estimation

Equation (2) expressed in contemporaneous terms results in the following probit specification:

$$P[(V_j = 1)]_t = F(\alpha + \beta_i \sum_i A_{ji} + \lambda_n \sum_{n=1}^{N-1} D_n + u_j)_t \qquad (2')$$

[9] Hence, the analysis indicates whether spending more on agriculture may actually contribute to moving municipalities from very high or high vulnerable to moderate or low vulnerability, rather than whether spending may move a municipality up or down the distribution. For the latter question, a dependent variable would capture the level of vulnerability from 1 to 5, rather than whether or not the municipality belongs to categories 4 and 5. An analysis of the effects across all levels of vulnerability—that is, categories 1 to 5—is presented in Annex 3. Results are consistent with the results found in the simple correlations: there is not much association between per capita expenditure (extended and restricted) and the category of VAM associated to the municipality. As Tables 6 and 7 will show below this may well have to do with an asymmetric association of spending and vulnerability (that is, different associations across levels of vulnerability).

Results for 2003 are reported in Table 2. Per capita agricultural spending of a municipality is positively associated with an increased probability of belonging to high or very high vulnerability to food insecurity. This association is statistically significant (Column 1). Both restrictive and extended categories of agricultural spending have a significant positive association with high or very high vulnerability, the former exceeding the latter (Column 2). There appear to be strong compositional effects by category of spending: investment spending has a positive and statistically significant association on higher vulnerability to food insecurity (Column 3), as does infrastructure spending (Column 4). The results also suggest department-specific effects: Cochabamba, Tarija, Santa Cruz, and Beni have a significantly lower probability of pertaining to high or very high vulnerable status compared to La Paz, once controlling for agricultural spending, a result that holds across specifications. Tarija, Santa Cruz, Beni and Pando have the lowest average VAM.

Table 2. Effects of Per Capita Agricultural Spending on Vulnerability to Food Insecurity 2003

	(1)	(2)	(3)	(4)
VARIABLES	Total exp	Restricted and extended definitions	Current and investment categories	By function
Total expenditure	2.0289***			
	(0.593)			
Restricted expenditure		3.4405***		
		(1.234)		
Extended expenditure		1.6372**		
		(0.677)		
Current expenditures			0.5661	
			(0.625)	
Investment expenditures			2.5370***	
			(0.931)	
Research and extension				-8.1926
				(5.661)
Infrastructure				2.6589***
				(1.019)
Support and development				4.1284*
				(2.495)
Administration and procedures				-1.4135
				(1.564)
Chuquisaca	0.1351	0.1205	0.1261	0.1184
	(0.134)	(0.134)	(0.137)	(0.139)
Cochabamba	-0.2879***	-0.2969***	-0.2909***	-0.2888***
	(0.084)	(0.084)	(0.085)	(0.086)
Oruro	-0.1407	-0.1564	-0.1305	-0.1399

	(0.100)	(0.100)	(0.100)	(0.100)
Potosí	0.1613	0.1492	0.1664*	0.1579
	(0.101)	(0.102)	(0.100)	(0.100)
Tarija	-0.3484***	-0.3765***	-0.3326***	-0.3804***
	(0.108)	(0.103)	(0.109)	(0.105)
Santa Cruz	-0.5676***	-0.5782***	-0.5675***	-0.5646***
	(0.051)	(0.052)	(0.052)	(0.053)
Beni	-0.4402***	-0.4429***	-0.4258***	-0.4233***
	(0.081)	(0.081)	(0.084)	(0.087)
Pando	0.0900	0.0722	0.1363	0.1112
	(0.166)	(0.173)	(0.161)	(0.163)
Observations	327	327	327	327
R2	0.279	0.282	0.284	0.293
***** p<0.01, ** p<0.05, * p<0.1**				

Note: Marginal effects reported; standard errors reported in parenthesis.
Source: Authors from World Bank (2010) APER database.

In general, the direction and compositional structure of the association in 2007 is the same as in 2003, but the magnitude is much lower (Table 3). The link between spending in agriculture and vulnerability is found to be statistically significant and positively, but with a markedly lower magnitude than in 2003 (Column 1). The estimated association is being driven predominantly by restricted spending, as it was in 2003 (Column 2). As in 2003, investment spending appears to have a positive relationship with vulnerability to food insecurity (Column 3), suggesting that more investment goes where higher vulnerability exists; however, the magnitude of the effect is much lower in 2007. A similar pattern emerges for infrastructure spending in 2007, but now research and extension spending is positively associated with food insecurity (Column 4). As in 2003, Tarija, Santa Cruz, Beni and Pando are less likely to belong to high/very high vulnerable categories than La Paz, but in 2007 Chuquisaca and Potosí are more likely than La Paz to pertain to high vulnerability categories (Columns 1 through 4). Chuquisaca and Potosí are the two departments with the highest vulnerability to food insecurity.

Table 3. Effects of Per Capita Agricultural Spending on Vulnerability to Food Insecurity 2007

	(1)	(2)	(3)	(4)
VARIABLES	Total exp	Restricted and extended definitions	Current and investment categories	By function
Total expenditure	0.5843***			
	(0.220)			
Restricted expenditure		1.2889***		
		(0.489)		
Extended expenditure		0.3106		

		(0.286)		
Current expenditures			0.6495	
			(0.577)	
Investment expenditures			0.5714**	
			(0.281)	
Research and extension				8.9864**
				(4.128)
Infrastructure				0.6776*
				(0.352)
Support and development				0.0562
				(0.991)
Administration and procedures				0.2547
				(0.860)
Chuquisaca	0.3885***	0.3702***	0.3995***	0.3799***
	(0.108)	(0.112)	(0.107)	(0.110)
Cochabamba	0.0951	0.0825	0.1042	0.0782
	(0.092)	(0.091)	(0.092)	(0.092)
Oruro	0.1316	0.1024	0.1437	0.1226
	(0.100)	(0.100)	(0.099)	(0.100)
Potosí	0.3162***	0.3089***	0.3178***	0.3080***
	(0.096)	(0.097)	(0.096)	(0.097)
Tarija	-0.3516***	-0.3640***	-0.3485***	-0.3470***
	(0.036)	(0.032)	(0.040)	(0.035)
Santa Cruz	-0.2899***	-0.2934***	-0.2830***	-0.2975***
	(0.060)	(0.058)	(0.061)	(0.057)
Beni	-0.3164***	-0.3148***	-0.3124***	-0.3339***
	(0.059)	(0.057)	(0.062)	(0.053)
Pando	-0.3711***	-0.3674***	-0.3750***	-0.3742***
	(0.034)	(0.032)	(0.033)	(0.033)
Observations	327	327	327	327
R2	0.217	0.223	0.217	0.226
***** p<0.01, ** p<0.05, * p<0.1**				

Note: Marginal effects reported; standard errors reported in parenthesis.
Source: Authors from World Bank (2010) APER database.

The results from both estimations do not provide a clear direction in the relationship between public spending in agriculture and vulnerability. It is possible—in fact, desirable—that public spending allocations are guided by levels of past vulnerability. Hence, endogeneity may be biasing the results.[10] Some categories of public spending, such as infrastructure, could be

[10] We investigate this relationship by regressing the impact of 2003 VAM levels on agricultural spending in 2007, at the municipal level. Annex 3 reports the results, which confirm that an endogenous relationship may well underlie

determined by levels of (or changes in) vulnerability. That is, reducing vulnerability would be one of the drivers of rural infrastructure spending decisions. On the other hand, vulnerability may or may not guide research and extension investments. Profitability, for example, may play a more prominent role in the allocation of such investments. Cumulative aspects may also be affecting such decisions. For example, only where previous investments in research and extension exist should further investments be expected—unless a critical threshold can be achieved, no investments will be initiated. In order to explore these issues, we proceed in sequential steps exploring two other estimation approaches.

Lagged estimation

We estimate the probability of pertaining to high or very high vulnerability categories in 2007 against spending in two past time periods: (i) levels of 2006 agricultural spending (Table 4); and (ii) levels of 2003 agricultural spending (Table 5), allowing for potentially longer-term inter-temporal effects. This is captured in specification (2'').

$$P[(V_j = 1)]_t = F(\alpha_{jt} + \beta_{jt-1} \sum_i A_{jit-1}) \qquad (2'')$$

We find that 2006 agricultural spending effect on 2007 VAM is statistically significant and positive, as it was the case for the contemporaneous 2007 results, although the size of the association is larger (Table 4, Column 1). Results also confirm a larger association of restricted vis-à-vis extended spending, similar to 2007. Although investment spending continues to have a positive and significant effect on VAM, the association of current spending appears to also be important and much larger. It is, however, unclear how current spending—mostly wages and salaries—may be related to vulnerability. Increasing current spending may be associated with a larger presence of civil servants as investment spending increases in most needed areas (pointing to a complementary rather substitutive nature between both types of spending). Other explanation might imply accepting a negative income effect on vulnerability associated with salaries of civil servants.[11] The one-year lag does not reveal important differences in the magnitude of the effects of the different functional classifications of agricultural spending vis-à-vis contemporaneous specifications. Infrastructure maintains its statistical significance and association with increased vulnerability, and there is a positive impact from spending in research and extension, which is the largest among all specifications and functional classifications. Department-specific effects remain unchanged with respect to 2007 contemporaneous effects.

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vulnerability and spending. The effect on VAM 2003 is found to be a statistically significant and positive factor of future agricultural spending. In other words, past vulnerability seems to affect agricultural spending allocations. Further work is needed to properly account for this potentially endogenous relationship. The preferred option, an instrumental variable approach, faces a number of difficulties, however. Finding good instruments is challenging, more so in this case, where many variables— including weather and geographic variables—— are already used to update the independent variable, VAM. Furthermore, political outcomes and managerial capacity of a municipality are arguably not exogenous to either spending decisions or vulnerability to food insecurity issues. Interestingly, Faguet (2004) analysis of determinants of agricultural spending finds that neither municipal capacity nor institutional features (in particular, the supervisory extent of civil society) are significant factors.

[11] We control for civil servant "density" as well as other variables capturing institutional public capacity in the robustness check section. We cannot, however, control for income effects associated with salaries and other current spending.

Table 4. Effects of Past Per Capita Agricultural Spending (2006) on Vulnerability to Food Insecurity (2007)

	(1)	(2)	(3)	(4)
VARIABLES	Total exp	Restricted and extended definitions	Current and investment categories	By function
Total expenditure	1.3166***			
	(0.333)			
Restricted expenditure		2.3526***		
		(0.569)		
Extended expenditure		0.9140**		
		(0.396)		
Current expenditures			2.0138**	
			(0.938)	
Investment expenditures			1.2630***	
			(0.353)	
Research and extension				13.2846***
				(4.328)
Infrastructure				1.2186***
				(0.364)
Support and development				-1.1690
				(1.804)
Administration and procedures				1.8195
				(1.406)
Chuquisaca	0.3188***	0.3154***	0.3133**	0.3379***
	(0.121)	(0.122)	(0.123)	(0.121)
Cochabamba	0.0950	0.0878	0.0948	0.1025
	(0.092)	(0.092)	(0.091)	(0.090)
Oruro	0.1452	0.1214	0.1404	0.1290
	(0.100)	(0.101)	(0.100)	(0.101)
Potosí	0.3194***	0.3205***	0.3184***	0.3235***
	(0.096)	(0.096)	(0.096)	(0.096)
Tarija	-0.3482***	-0.3620***	-0.3537***	-0.3482***
	(0.033)	(0.033)	(0.031)	(0.033)
Santa Cruz	-0.2887***	-0.2889***	-0.2889***	-0.2826***
	(0.059)	(0.059)	(0.060)	(0.057)
Beni	-0.3143***	-0.3215***	-0.3197***	-0.3148***
	(0.054)	(0.051)	(0.052)	(0.046)
Pando	-0.3957***	-0.3936***	-0.3985***	-0.3813***

	(0.034)	(0.034)	(0.033)	(0.035)
Observations	327	327	327	327
Pseudo R2	0.241	0.254	0.242	0.256
***** p<0.01, ** p<0.05, * p<0.1**				

Note: Marginal effects reported; standard errors reported in parenthesis.
Source: Authors from World Bank (2010) APER database.

Testing how 2003 expenditures affect vulnerability in 2007 (Table 5) show that agricultural spending in 2003 has a statistically significant and positive association with 2007 VAM levels (Column 1). Results also confirm a larger association of restricted vis-à-vis extended spending, both statistically significant and, as found earlier, with the former roughly double in magnitude of the latter. Current spending in 2003 does not appear to have a significant relationship on the vulnerability in 2007, while investment spending continues to have a positive and statistically significant association. With a four-year spending lag, research and extension has a significant but negative effect on vulnerability. The link between research and extension and the reduction of vulnerability to food insecurity is stronger when a longer lag of spending is considered. Department-specific effects remain unchanged with respect to the 2007 contemporaneous effects.

Table 5. Effects of 2003 Per Capita Agricultural Spending on 2007 Vulnerability to Food Insecurity

	(1)	(2)	(3)	(4)
VARIABLES	Total exp	Restricted and extended definitions	Current and investment categories	By function
Total expenditure	0.9888***			
	(0.338)			
Restricted expenditure		1.2450**		
		(0.562)		
Extended expenditure		0.6782**		
		(0.313)		
Current expenditures			-0.0250	
			(0.564)	
Investment expenditures			1.3207***	
			(0.491)	
Research and extension				-11.1869**
				(4.844)
Infrastructure				1.3973***
				(0.531)
Support and development				1.8166

				(1.723)
Administration and procedures				-0.9973
				(1.365)
Chuquisaca	0.3503***	0.3273***	0.3411***	0.3331***
	(0.115)	(0.117)	(0.117)	(0.121)
Cochabamba	0.1067	0.1136	0.1066	0.1141
	(0.093)	(0.092)	(0.094)	(0.094)
Oruro	0.1036	0.1256	0.1224	0.1206
	(0.102)	(0.103)	(0.103)	(0.103)
Potosí	0.3239***	0.3096***	0.3300***	0.3192***
	(0.095)	(0.096)	(0.095)	(0.095)
Tarija	-0.2877***	-0.3020***	-0.2832***	-0.2883***
	(0.086)	(0.074)	(0.090)	(0.088)
Santa Cruz	-0.2919***	-0.2965***	-0.2893***	-0.2816***
	(0.062)	(0.061)	(0.063)	(0.064)
Beni	-0.3139***	-0.3130***	-0.3063***	-0.3046***
	(0.068)	(0.063)	(0.072)	(0.072)
Pando	-0.3353***	-0.3765***	-0.3251***	-0.3303***
	(0.064)	(0.034)	(0.074)	(0.071)
Observations	327	327	327	327
Pseudo R2	0.223	0.218	0.227	0.235
***** p<0.01, ** p<0.05, * p<0.1**				

Note: Marginal effects reported; standard errors reported in parenthesis.
Source: Authors from World Bank (2010) APER database.

Differential estimation

We further explore the inter-temporal effects of agricultural spending on VAM by controlling for an initial level of spending, A_0 (2003 level), and estimating the effect that the inter-temporal change in spending, ΔA (the increase between 2006 and 2007), has on the observed risk of 2007 food insecurity. We call that change 'incremental spending". Hence, estimates in this section inform about the association between such spending increases and vulnerability changes over time. Equation (2''') introduces the new probit specification to be modeled:

$$P[(V_j = 1)]_t = F(\alpha_t + \beta_i \sum_i A_{ji0} + \zeta_m \sum_m \Delta A_{jmt,t-1}) \qquad (2''')$$

The dependent variable takes the value of 1 when the municipality moved into or remained at a high or very high vulnerability status (that is, VAM = 4 or 5) between 2006 and 2007.

Results show that 2003 spending still has a positive association with future levels of high or very high vulnerability (Table 6). It also shows that increases in agricultural spending between 2006 and 2007 are associated with reductions in vulnerability (Column 1). However, even though that association is statistically significant, it is negligible in size. This conclusion is robust to a non-

linear quadratic specification of incremental spending (Column 2). This finding suggests that agricultural spending alone, although sensitive to high levels of vulnerability, does not have a substantial effect in the short run. Department-specific results remain very similar to those reported in previous specifications.

Table 6 shows an interesting pattern of incremental effects. Evidence in Columns 2 to 5 show that the past levels of investment spending, in particular on infrastructure, have positive and significant relationship with high VAMs. Column 5 also shows that the effect of research and extension spending are statistically significant and working to reduce high VAMs (confirming the results in Table 5). Therefore, not only different categories of spending may have different associations on vulnerability to food insecurity, but also their long- and short-term effects may also differ.[12]

Table 6. Effects of Initial and Incremental Per Capita Spending on Vulnerability

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Total exp	Total exp (quadratic form for change)	Restricted and extended definitions	Current and investment categories	By function
Total expenditure 2003	0.9950***	0.9659***			
	(0.344)	(0.338)			
Restricted expenditure 2003			0.9361*		
			(0.533)		
Extended expenditure 2003			1.0241**		
			(0.465)		
Current expenditures 2003				0.0598	
				(0.562)	
Investment expenditures 2003				1.2893***	
				(0.494)	
Research and extension 2003					-10.5311*
					(6.056)
Infrastructure 2003					1.3837**
					(0.544)
Support and development 2003					1.7249
					(1.746)

[12] Two alternative specifications not reported here are considered, one that takes spending levels in 2003 as initial, i.e., $A_{0,}$ and increases between 2003 and 2007 as incremental spending, that is, ΔA; and, alternatively, levels in 2006 as A_0 and incremental spending between 2006 and 2007 as ΔA. Estimates from both specifications confirm previous results. Past levels of spending have an effect on 2007 vulnerability, but the incremental spending does not. When considering 2006 levels and 2006-07 increment in spending, other spending categories again play a disproportionate role, which disappears when we consider 2003 and 2003-07 increments in spending. In that case, infrastructure investments again play the key role, again suggesting that their allocation is sensitive to high vulnerability levels.

Administration and procedures 2003					-0.8587
					(1.351)
Change in per capita agricultural spending 06-07 ("incremental " effect)	-0.0001**	0.0001	-0.0001**	-0.0001*	-0.0001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Change squared in per capita agricultural spending 06-07 ("incremental" effect)		-0.0000			
		(0.000)			
Chuquisaca	0.3492***	0.3479***	0.3507***	0.3411***	0.3322***
	(0.117)	(0.118)	(0.114)	(0.119)	(0.122)
Cochabamba	0.1234	0.1135	0.1235	0.1231	0.1304
	(0.095)	(0.094)	(0.095)	(0.095)	(0.096)
Oruro	0.1238	0.1136	0.1245	0.1383	0.1262
	(0.104)	(0.103)	(0.104)	(0.104)	(0.104)
Potosí	0.3438***	0.3485***	0.3444***	0.3485***	0.3385***
	(0.097)	(0.099)	(0.097)	(0.096)	(0.097)
Tarija	-0.2784***	-0.2794***	-0.2779***	-0.2739***	-0.2799***
	(0.090)	(0.078)	(0.090)	(0.094)	(0.094)
Santa Cruz	-0.2895***	-0.2823***	-0.2892***	-0.2874***	-0.2803***
	(0.062)	(0.061)	(0.063)	(0.063)	(0.064)
Beni	-0.3124***	-0.3003***	-0.3125***	-0.3053***	-0.3038***
	(0.067)	(0.063)	(0.067)	(0.070)	(0.071)
Pando	-0.3320***	-0.3197***	-0.3313***	-0.3237***	-0.3298***
	(0.064)	(0.062)	(0.065)	(0.072)	(0.070)
Observations	322	322	322	322	322
R2	0.236	0.239	0.236	0.239	0.245
***** p<0.01, ** p<0.05, * p<0.1**					

Note: Marginal effects reported; standard errors reported in parenthesis.
Source: Authors from World Bank (2010) APER database.

Annex 5 conducts robustness checks by including additional political and managerial controls of the municipality and further investigating the association of agricultural spending with specific improvements of vulnerability (as well as specific cases of vulnerability deterioration). Key messages do not change.

6. Conclusions

This paper explores the reduction of food insecurity in Bolivia, adopting a supply side approach that analyzes the role of agricultural spending on vulnerability. Previous findings on the role of

public spending on welfare in Bolivia paint a picture of increasing allocation of resources based on needs without a strong effect in improving welfare. However, no study before had specifically analyzed food security and agricultural spending. Our results confirm that picture but also add some insights on the role that spending may have on reducing vulnerability. In addition, from a policy perspective, our analysis provides a number of relevant findings related to spending (and investment) decisions in a global context of increasing risks as food prices start to rise again.

First, vulnerability to food insecurity across municipalities, as measured by VAM, has on average been on the decrease between 2003 and 2007. However, this improvement has not been uniform, with only four departments exhibiting a moderate to low or very low risk of vulnerability (Tarija and the *llanos* departments).

Second, a simple correlation exercise suggests that increases in public spending in agriculture—both in absolute and per capita terms—are weakly associated with both decreases in high vulnerability and increases in low vulnerability to food insecurity. Both correlations do not appear to be strong, partly because of potentially offsetting compositional effects of spending and partly because agricultural spending alone may not be an adequate tool for significantly impacting vulnerability.

Third, our econometric results indicate that levels of public agricultural spending are positively associated with high or very high vulnerability. We interpret this to indicate that agricultural spending allocation decisions are driven by high or very high vulnerability levels. In other words, more agricultural spending appears to be destined to where it is more needed in line with previous findings in the literature for other sectors. This is confirmed through a number of specifications, including contemporaneous and lagged relationships between spending and vulnerability. This is particularly the case for restricted expenditures (those just on core agricultural spending, rather than rural development more generally), as well as for capital investments making a difference in terms of infrastructural improvements. This indicates the importance of the composition of public agricultural spending in shaping its relationship with vulnerability to food insecurity.

Fourth, there is evidence of important temporal effects of spending on the vulnerability to food insecurity. When considering levels, a one-year lag of spending appears to have a larger association on vulnerability as compared to a four-year lag. When considering the incremental effects of 2006-2007 spending, however, it is evident that the change in the levels of spending does not appear to be effectively associated with high vulnerability nor substantially deliver improvements in vulnerability status.

Fifth, there are department-specific effects, which may point to a more 'regional' pattern of impacts of spending on municipal vulnerability. The valley departments of Chuquisaca and Cochabamba appear to be more likely to observe high or very high levels of vulnerability than the rest. For the *altiplano* Andean departments of La Paz, Potosi and Oruro, we find no specific effects once we control for spending. For the *llanos* departments of Beni, Santa Cruz and Pando and the valley department of Tarija, we find specific effects pointing towards lower vulnerability to food insecurity.

There are two main areas for further research that emerge from this analysis. First, the endogenous relationship between spending and vulnerability needs further scrutiny. Unfortunately, the very construction of VAM and its updating leaves very little room for the selection of strong instruments. Potential candidates such as weather shocks, political economy or managerial capacity of municipalities are already used in the construction of VAM or are proven bad candidates. A final consideration is the inclusion of relevant public spending in the analysis. Agricultural spending used in our analysis includes a variety of programs and projects that are not necessarily conceived to reduce food insecurity. Likewise, as indicated in the introduction, the Government of Bolivia considers other programs—such as cash and in-kind transfers—to be part of its strategy to reduce vulnerability. Future work will address the need to construct a precise classification of food insecurity related public spending.

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Annex 1: Current List of Programs and Projects that Support Food Security Strategy

1. National Plan for Land Titling

This program is intended to provide legal security in land tenure to all sectors.

2. National Plan for Land Distribution and Human Settlements

The strategy is aimed both at reducing pressure on land resources and natural resources in general, caused by the intensive use and misuse of land, and to incorporate standards and practices of sustainable management of natural resources. To this end, it shall promote the integrated sustainable development into new communities, and lands based on the sustainable management of natural resources and economic activities to ensure the family income.

3. Planting the Right for Food (SEMBRAR)

SEMBRAR promotes the human right to adequate food from the local level, through the development of information processing, communication and training, and coordinate partnerships between public, private and civil society to establish institutions and mechanisms for the promotion local production of food.

4. Creation of Rural Food Initiatives (CRIAR)

The initiative is to strengthen peasant family agriculture on the basis of a community, and support food production for local markets

5. Organized Enterprises for Development (EMPODERAR)

EMPODERAR supports the development of productive initiatives in agriculture and strengthens local institutional capacity to boost rural productive development, including agro-forestry and non-agricultural rural producers through non-reimbursable transfers, with partnerships with local counterpart financing. The Rural Alliances Project (PAR) financed by the World Bank is an important component of this program. Another one is the Local Agricultural Economic Development Project (DELA) financed by Denmark.

6. Renewal of the Role of the State in Rural Food Businesses (RECREAR)

This program supports farmers in basic food production and wholesale marketing, as well as promotes processing of renewable natural products to ensure strategic access to its benefits for local people and the country's development

7. Development of territorial, integration and cross-sectoral production complexes

This strategy will develop the municipal land use planning to establish the productive potential and land suitability for different human activities (industrial, tourism, mining, energy) and its extensions of agriculture and forestry, agroforestry, apiculture, and flowers.

8. National Plan for Coca Development

The plan proposes that the state set the conditions for industrialization and commercialization of coca leaf for domestic and foreign markets and promote awareness of alternative uses internationally, as well as the development of the producing areas.

9. Sustainable Use of Natural Resources (SUSTENTAR)

SUSTENTAR encourages value-added production and trade of goods and services derived from biodiversity, creating fair and equitable benefits to local people, under the criteria of ecological sustainability, social and economic and organizational support mechanisms, financial and technical, to promote the generation of productive capacities of indigenous peoples, peasant communities and traditional users of the forest, harvesting, processing and marketing of forest products.

10. Conservation of Nature and Environmental Quality (CONSERVAR)

CONSERVAR is designed to create a better understanding and awareness of potential climate change effects, as well as building capacity to develop adaptation measures based on new information and traditional knowledge.

11. Food Security Support Program (PASA)

PASA enhances the availability, access to and use of food by the poorest sectors of society by financing investment projects. The program operates in all nine departments of Bolivia. PASA I (1997-2008) has implemented 342 projects and PASA II (2005-2010) – 109 projects. It became a de-concentrated entity in 2007 and has a national mandate for food security. The investment is done through transfers – 85 percent

of the project amount with the remaining 15 percent being local counterpart. The average budget execution for PASA during the period 2006-2009 is 49 percent.

12. Multisectoral Program of Zero Malnutrition

The goal of the program is to eradicate malnutrition in children under two years of age. The program has been implemented in two phases. The first phase includes 52 municipalities; the second phase includes 114 municipalities. Municipalities are prioritized according to the Vulnerability Index Map for Food Security (VAM 4 and 5).

13. School Breakfast and Lunch Program

The program ensures the provision of nutritious food to school children and provides workshops for community awareness about the importance of feeding the population segments in order to reduce levels of malnutrition and improving school performance.

Source: Adapted from MVI Social (2010).

Annex 2: Definitions

Area	Category	Type	Current/Investment Expenditure
Research, studies	Research & Extension	Restricted	Current
Technical assistance, seminars	Research & Extension	Restricted	Current
Water and irrigation	Infrastructure	Restricted	Investment
Support	Support & Development	Restricted	Current
Assets and machinery	Infrastructure	Restricted	Investment
Seeds, fertilizer	Infrastructure	Restricted	Current
Infrastructure	Infrastructure	Restricted	Investment
Health support	Support & Development	Restricted	Current
Administration, regulation	Administration & Procedures	Restricted	Current
Development	Support & Development	Restricted	Current
Support	Support & Development	Restricted	Current
Roads and bridges	Infrastructure	Extended	Investment
Electricity infrastructure	Infrastructure	Extended	Investment
Warehousing and commercialization	Support & Development	Extended	Current
Risk management	Administration & Procedures	Extended	Current
Environmental management	Administration & Procedures	Extended	Current
Land organization	Administration & Procedures	Extended	Current
Organizational support	Administration & Procedures	Extended	Current
Education	Research & Extension	Extended	Current

Annex 3: Effect of Past VAM on Current Agricultural Spending

Per Capita Agricultural Spending in 2007 and 2003 VAM	
	(1)
VARIABLES	Total Exp
vam2003	0.0760***
	(0.025)
Chuquisaca	0.0997***
	(0.028)
Cochabamba	0.0758**
	(0.030)
Oruro	0.0410**
	(0.020)
Potosi	0.0066
	(0.018)
Tarija	0.6483***
	(0.157)
Santa Cruz	0.0237
	(0.021)
Beni	0.0962***
	(0.036)
Pando	0.6225***
	(0.149)
Constant	0.0518***
	(0.019)
Observations	327
R-squared	0.447
Pseudo R2	.
Robust standard errors in parentheses	
***** p<0.01, ** p<0.05, * p<0.1**	

Note: Marginal effects reported; standard errors reported in parenthesis
Source: Authors from World Bank (2010) APER database.

The estimated specification is:

$$A_j = \alpha + \beta V_{jt-1} + \lambda_n \sum_{n=1}^{N-1} D_n + u_{jt}$$

Where A_j and D_j refer to per capita spending by municipality, D are dummy variables capturing department, respectively, and V_j refers to the vulnerability category from 1 to 5.

Annex 4: Ordered Probit

Ordered Probit VAM 2007				
	(1)	(2)	(3)	(4)
VARIABLES	vam_2007	vam_2007	vam_2007	vam_2007
Total Expenditure	0.2233			
	(0.180)			
Restricted expenditure		0.1471		
		(0.514)		
Extended expenditure		0.2726		
		(0.277)		
Operational Expenditure			-1.0325*	
			(0.558)	
Investment Expenditure			0.5923*	
			(0.335)	
Research and Education				-8.9508
				(8.244)
Infrastructure				0.5755*
				(0.331)
Support and Development				-1.6714*
				(0.990)
Administration and procedures				-0.9669
				(1.002)
cut1	-2.0575***	-2.0577***	-2.0889***	-2.1098***
	(0.170)	(0.171)	(0.173)	(0.177)
cut2	-0.7334***	-0.7334***	-0.7541***	-0.7647***
	(0.087)	(0.087)	(0.087)	(0.087)
cut3	0.3402***	0.3403***	0.3299***	0.3239***
	(0.079)	(0.079)	(0.079)	(0.078)
cut4	1.6105***	1.6104***	1.6092***	1.6047***
	(0.118)	(0.118)	(0.117)	(0.117)
Constant				
Observations	327	327	327	327
Robust standard errors in parentheses				
***** p<0.01, ** p<0.05, * p<0.1**				

Note: Marginal effects reported; standard errors reported in parenthesis.

Annex 5: Robustness Checks

Differential estimation

We also explore the symmetry of the effects of incremental spending on vulnerability. Table A1 reports the results of past spending (in 2003) and marginal increases (2006-07) in the probability of meaningful decreases in vulnerability. By 'meaningful' we consider changes in vulnerability categories that move a municipality from high or very high levels of risk in 2003 into moderate or low/very low levels of vulnerability in 2007. In other words, we include all improvements in vulnerability status except for those changes that simply move the municipality from very high to high levels of vulnerability.

Results change substantively with respect to the probability of moving into or staying at high or very high levels of vulnerability reported in Table 6. Now, neither past nor incremental spending has statistically significant associations (Column 1), nor does even restricted spending seem to have an association on vulnerability reduction. Investment spending has no longer statistically significant effect,[13] and no single other category of spending is found to be significant either.

Department-specific results also change in terms of significance and signs. There is no department better positioned (controlling for spending) to reduce its vulnerability vis-à-vis La Paz, and three—Chuquisaca, Cochabamba and Santa Cruz—appear to be less likely to reduce their vulnerability to food insecurity than La Paz. This is certainly an odd group, as it includes the department with the highest vulnerability to start with, Chuquisaca, and one with one of the lowest vulnerabilities, Santa Cruz. These results are consistent with the scarce or negligible effect of spending on vulnerability found before: increases in the short run do not appear to be effectively associated with reductions in high vulnerability nor with improvements in vulnerability status.

Table A1. Effects of Past and Incremental Per Capita Spending on Improvements in Vulnerability Status

	(1)	(2)	(3)	(4)
VARIABLES	Total exp	Restricted and extended definitions	Current and investment categories	By function
Total expenditure 2003	-0.0947			
	(0.115)			
Restricted expenditure 2003		0.0598		
		(0.204)		
Extended expenditure 2003		-0.2253		
		(0.220)		
Current expenditures 2003			-0.2083	

[13] These results are also consistent with those presented in Annex 4 on the effect of spending on vulnerability along the entire distribution of risk, that is, from very low to very high categories. The asymmetric effect of spending at different sections of the distribution substantiates an insignificant combined effect.

			(0.251)	
Investment expenditures 2003			-0.0591	
			(0.121)	
Research and Extension 2003				6.9071**
				(3.144)
Infrastructure 2003				-0.1012
				(0.122)
Support and development 2003				0.1489
				(1.084)
Administration and procedures 2003				-0.8850
				(0.986)
Change in per capita agricultural spending 06-07 ("incremental" effect)	0.0000	0.0000	0.0000	0.0000*
	(0.000)	(0.000)	(0.000)	(0.000)
Chuquisaca	-0.0595*	-0.0606*	-0.0605*	-0.0612**
	(0.033)	(0.033)	(0.033)	(0.027)
Cochabamba	-0.0919***	-0.0915***	-0.0919***	-0.0900***
	(0.027)	(0.026)	(0.027)	(0.025)
Oruro	-0.0377	-0.0386	-0.0370	-0.0322
	(0.038)	(0.038)	(0.039)	(0.037)
Potosí	-0.0491	-0.0503	-0.0488	-0.0436
	(0.033)	(0.032)	(0.033)	(0.032)
Tarija	-0.0047	-0.0052	-0.0040	-0.0207
	(0.072)	(0.071)	(0.072)	(0.056)
Santa Cruz	-0.1183***	-0.1181***	-0.1181***	-0.1179***
	(0.025)	(0.025)	(0.025)	(0.024)
Pando	0.0168	0.0067	0.0217	0.0443
	(0.073)	(0.068)	(0.078)	(0.085)
Observations	303	303	303	303
R2	0.0913	0.0940	0.0918	0.116
***** p<0.01, ** p<0.05, * p<0.1**				

Note: Marginal effects reported; standard errors reported in parenthesis.
Source: Authors from World Bank (2010) APER database.

Additional Controls

This section reports the estimates from alternative specifications of Equation 2 that address two potentially important issues: scale effects and the inclusion of observable controls in the areas of municipal capacity and political issues. In all previous estimations, agricultural spending variables are expressed in per capita terms, in order to get rid of scale effects—that is, the possibility of vulnerability impacts are being driven mainly by the magnitude of spending rather than its efficiency. Estimations were also undertaken using total spending, thus capturing the

effect of the *actual* total spending rather than per capita spending. Population of the municipality is included, as a separate control.

The results by and large confirm those obtained in per capita terms (Table A2). Increasing total expenditure in agriculture remains associated with a higher vulnerability to food insecurity; restricted spending has a significant positive relationship with vulnerability; and investment has a significant positive link with vulnerability, but unsubstantial in magnitude. These results are observed for 2003 (Columns 1 to 3) but not for 2007, where the associations of all categories of spending are statistically insignificant (Columns 4 to 6). The finding of distinctive long- and short-term effects (reported above in Table 6) is also confirmed for total spending as well (Columns 7 to 9). Past total spending is associated with higher vulnerability to food insecurity, but the 2006-2007 incremental change reduces vulnerability, although again negligibly. Evidence also suggests different patterns of long- and short-term effects by type of spending. Investment spending has the only significant incremental effect in addition to the significant effect of past total spending, which is again negligible in magnitude (Column 9).

Table A2. Effects of Total Agricultural Spending

Dependent Variable	High VAM in 2003			High VAM in 2007			Increasing VAM from 06-07		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES									
Total expenditure	0.0001***			0.0000			0.0000*		
	(0.000)			(0.000)			(0.000)		
Restricted expenditure		0.0002**			0.0000			0.0000	
		(0.000)			(0.000)			(0.000)	
Extended expenditure		0.0000			0.0000			0.0000	
		(0.000)			(0.000)			(0.000)	
Current expenditure			-0.0000			-0.0001			-0.0001
			(0.000)			(0.000)			(0.000)
Investment expenditure			0.0001***			0.0000			0.0000**
			(0.000)			(0.000)			(0.000)
Change in total per capita agricultural spending 06-07 ("incremental" effect)							-0.0001**		-0.0001**
							(0.000)		(0.000)
Change in restricted per capita agricultural spending 06-07 ("incremental" effect)								-0.0001	
								(0.000)	
Change in extended per capita agricultural spending 06-07 ("incremental" effect)								0.0000	

									(0.000)
Regional dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes
Population	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	327	327	327	327	327	327	322	309	322
R2	0.301	0.304	0.303	0.265	0.271	0.266	0.292	0.305	0.297
***** p<0.01, ** p<0.05, * p<0.1**									

Note: Marginal effects reported; standard errors reported in parenthesis.
Source: Authors from World Bank (2010) APER database.

Finally, as acknowledged in the construction of the VAM, there are a number of additional controls that might affect the vulnerability of a municipality to food insecurity in Bolivia. We can conceptualize those factors in broad economic terms as demand and supply factors. Demand factors refer to individual, household and municipal characteristics that increase the *demand* for food, such as socioeconomic status of households, individual preferences, household composition and municipality demographics. Supply factors that may affect the capacity to *provide* food to satisfy its demand include agricultural production and productivity, available arable land, infrastructure (roads in particular), social transfers, climatic and demographic conditions, municipal capacity and governance and political economy considerations. An expanded single equation model for food insecurity vulnerability can capture those factors, Z_{jk}, as presented in the probit specification 3:

$$P(V_j = 1) = F(\alpha + \beta_i \sum_i A_{ji} + \gamma_k \sum_k Z_{jk}) \qquad (3)$$

However, a host of these potential factors are already used to annually update the probability of pertaining to each VAM category, such as urbanization rate, density of rural population, institutionally assisted births, schooling years, total per capita consumption, malnutrition rate, altitude, rainfall and a flood dummy. This limits the selection of possible controls in our analysis, as we cannot include variables used already to estimate the dependent variable. As a result, we focus on a variable capturing the capacity of the municipality C_j, proxied by three alternatives: percentage of own resources used to finance investment expenditure budgets; the number of civil servants by municipality (in per capita terms); or the percent of executed vis-à-vis approved budgets. We also include a political economy variable, P_j, which captures whether the political party in office at the municipal level is the same as the party in office at the national level (MAS); and S_j., which captures per capita social spending (in health and education) accruing to each municipality. All these controls refer to 2006, in an attempt to avoid a potential contemporaneous endogenous problem. Equation 3 below depicts the expanded model:

$$P(V_j = 1) = F(\alpha + \beta_i \sum_i A_{ji} + \delta\, C_j + \rho\, P_j + \upsilon\, S_j + \lambda_n \sum_{n=1}^{N-1} D_n) \qquad (3)$$

Table A3. Effects of Per Capita Agricultural Spending with Observed Controls, 2007

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total expenditure	0.5399**	0.5776***	0.6113*	0.3190*	0.5842***	0.5839*		
	(0.217)	(0.221)	(0.328)	(0.178)	(0.221)	(0.325)		

Restricted expenditure							1.7848**	
							(0.778)	
Extended expenditure							-0.0856	
							(0.522)	
Current expenditure								0.8600
								(0.964)
Investment expenditure								0.5380
								(0.408)
Civil servants pc, 2006	2.0963					0.1927	-0.8149	0.6524
	(11.532)					(23.856)	(22.781)	(23.946)
Political party in office, 2006		0.0683				0.0782	0.0937	0.0792
		(0.063)				(0.078)	(0.080)	(0.078)
% budget executed over approved (2006)			-0.0003*			-0.0003*	-0.0003*	-0.0003*
			(0.000)			(0.000)	(0.000)	(0.000)
% of investment financed by own resources (2006)				-0.0000***				
				(0.000)				
Per capita social spending, 2006					-0.0000	-0.0001	-0.0001	-0.0002
					(0.000)	(0.000)	(0.000)	(0.000)
Regional dummies	yes	yes	yes	Yes	yes	yes	yes	yes
Population	yes	yes	yes	Yes	yes	yes	yes	yes
Observations	300	327	234	314	327	227	227	227
R2	0.214	0.22	0.237	0.27	0.217	0.225	0.235	0.225
***** p<0.01, ** p<0.05, * p<0.1**								

Note: Marginal effects reported; standard errors reported in parenthesis.
Source: Authors from World Bank (2010) APER database.

Results suggest that neither political party in office nor density of civil servants have a significant association with vulnerability, after controlling for agricultural spending (Table A3). Although both social spending and the extent of budget execution at the municipal level are associated with reductions in the probability of high vulnerability, their magnitude is rather small. Interestingly, in all cases, per capita total agricultural spending maintains a positive and statistically significant relationship with high vulnerability, with restricted categories of spending being more dominant than extended categories. Investment spending is not found to have a statistically significant relationship with high vulnerability.