WPS6666

Policy Research Working Paper 6666

Excluding the Rural Population

The Impact of Public Expenditure on Child Malnutrition in Peru

Gissele Gajate-Garrido

The World Bank
Development Economics Vice Presidency
Partnerships, Capacity Building Unit
October 2013

Policy Research Working Paper 6666

Abstract

Why is the urban–rural gap in child malnutrition increasing in Peru despite government efforts to improve the provision of public services? To answer this question, the impact of regional public expenditure in Peru on young children's nutritional outcomes is examined. To account for policy endogeneity, public expenditures are instrumented using unanticipated regional mining revenues. Even after accounting for changes in expenditure composition due to increases in mining revenues, public spending has a significant and positive impact on children's outcomes only in urban areas. However, even in urban areas, barriers exist that diminish the effectiveness of public expenditure, so indigenous and frailer children in these areas do not benefit from public spending. These children face constraints that limit their ability to use public services. This result reveals the paramount importance of initial conditions. In rural areas, possibly because of the lower quantity and quality of public services, there is no positive effect for any children.

This paper is a product of the Partnerships, Capacity Building Unit, Development Economics Vice Presidency. 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 author may be contacted at g.gajategarrido@cgiar.org.

Excluding the rural population: the impact of public expenditure on child malnutrition in Peru

Gissele Gajate-Garrido [*]

JEL classification: D13; H51; I12; J13

Sector board: Health, Nutrition and Population (HNP)

Keywords: Child; Nutrition; Public spending; Urban; Rural

---

[*] Gissele Gajate-Garrido (corresponding author) is a Research Fellow at the International Food Policy Research Institute (IFPRI); her email address is g.gajategarrido@cgiar.org. The author thanks Dora L. Costa, Pascaline Dupas, John Hoddinott, Naomi Lamoreaux, Arleen Leibowitz, Marc Luppino, the anonymous referees from the World Bank Economic Review, and participants in the UCLA applied micro seminars for thoughtful comments and suggestions. She is also grateful to Javier Escobal and Monica Lizama for providing her with access to the Young Lives survey data and to Milagros Villagarcia and Julio Mejia for providing public expenditure data. The data used in this study come from Young Lives, a 15-year survey investigating the changing nature of childhood poverty in Ethiopia, India (Andhra Pradesh), Peru, and Vietnam (www.younglives.org.uk). Young Lives is core-funded by UK aid from the Department for International Development (DFID) and co-funded from 2010 to 2014 by the Netherlands Ministry of Foreign Affairs. The views expressed here are those of the author. They are not necessarily those of Young Lives, the University of Oxford, DFID, or other funders. The usual disclaimers apply.

In the first half of the last decade, Peru grew relatively steadily and quickly, and its public budget expanded. Both the GNP and public expenditure in regions of Peru increased annually by 4% on average, whereas regional health expenditures grew by almost 7% every year. During this period, the country experienced increased awareness of the importance of early childhood, and its policy agenda featured the announcement of the National Plan of Action for Childhood and Adolescence (PNAI 2002–10). However, child nutrition worsened, and disparities between urban and rural areas widened. This is a serious concern because nutritional deprivation negatively impacts cognitive development (Glewwe et al. 2001; Walker et al. 2005) and hinders human capital formation (Glewwe and Jacoby 1995; Maluccio et al. 2006). By 2005, 30% of Peruvian children younger than five years of age endured chronic malnutrition[1], with drastic urban–rural differences. In urban areas, 14% of children were malnourished, compared to 46% in rural areas. This difference of 32 percentage points represented an increase from 26% in 2000[2]. Van de Poel et al. (2007) found that Peru had the largest urban–rural gap in the nutritional levels among 47 developing countries.

This paper aims to determine who benefits from increasing public spending in Peru and to identify potential explanations for the increase in the urban–rural malnutrition gap. I analyze the impact of changes in total regional public expenditure on changes in child nutritional outcomes using longitudinal data from a panel of children who were studied from their first birthday until age six. This approach contrasts with most previous papers in the literature, which perform cross-country analyses (Filmer and Pritchett 1999; Baldacci et al. 2002; Gupta et al. 2003). The use of panel data allows me to control for unobserved household–child heterogeneity.

[1] Source: 2004–6 Continual Demographic and Family Health Survey (ENDES). This is a nationally representative survey. The percentages belong to children in the same age group in two different points of time.

This study also provides exogenous variation to correct for the potential endogeneity of regional public expenditure. The variation comes from the use of lagged regional mineral extraction multiplied by non-predictable mineral price changes, which I refer to hereafter as unanticipated mining revenues. The instrument is a function of natural resource extractions in each political region of Peru during 2001 and the change in the world prices of these resources between 2002 and 2006. This instrument has a strong impact on public spending because it is directly related to the amount of natural resource royalties that regional governments receive each year. The instrument that I use is the improvement in health input prices, which are typically used in the health economic literature (Schultz 2004), because it is not altered by individual regional migration. Any omitted factors need to fluctuate within regions over time in the same non-linear way as unanticipated revenues in the mining sector to have a confounding effect on child malnutrition. Two possibilities are that (1) regional income increases with increases in unanticipated mining revenues and (2) health outcomes worsen with increases in these revenues. I show that both concerns are unsubstantiated. It is also possible that regional governments changed their patterns of expenditure in response to the amount of royalties received, spending more in sectors that directly influence child health. I verify that changes in the composition of expenditures are not responsible for the differentiated impact of public expenditure.

In addition, this paper differs from the existing literature because it analyzes the potential barriers that diminish the effectiveness of public expenditure. I find that public expenditure is ineffective and even harmful in rural areas, possibly due to lower quantity and quality of public services in these areas. In urban areas, public spending does have the ability to improve

[2] Source: 2004–6 ENDES.

nutritional status. However, in cities, despite the availability of effective public goods and services, demand and efficient use may be limited by the lack of complementary private assets. I confirm that the consumption levels of public goods and services differ depending on child characteristics. The children whom public spending does not help have indigenous mothers and the lowest birth weights.

The remainder of this paper is divided into four sections. The next section briefly describes the link between public spending and child malnutrition. Section two presents the estimation procedure and the conceptual framework. Section three describes the results. Finally, the paper concludes with a discussion of the findings.

I. PUBLIC SPENDING AND CHILD MALNUTRITION

This study focuses on the impact of public investment on the nutritional level of children from infancy until early childhood. This period is a particularly important developmental stage for children. Authors such as Knudsen et al. (2006) and Heckman (2007) have emphasized the importance of early experiences, which have a considerable influence on the development of diverse skills as well as on biological processes. These skills and processes determine the mental potential of individuals and, consequently, their ability to achieve strong economic productivity in adulthood.

The causes of stunting are multiple and intertwined[3]. A child's nutritional status results from a process that begins, even before birth. Children with low birth weights, inadequate nutritional intake, and high burdens of disease will become stunted. Furthermore, diseases such as diarrhea and acute respiratory infections can cause a vicious cycle of malnutrition and illness

(Ehiri and Prowse 1999). Malnutrition in Peruvian children is caused by food deprivation and infectious diseases, which, in turn, are related to poverty, lack of access to markets, deficient transportation, inadequate health and sanitary infrastructure, and low levels of education (Valdivia 2004; Escobal et al. 2005; Aguiar et al. 2007).

Public goods and services may directly affect a child's nutrition by providing access to health facilities, better sanitary infrastructure, or nutritional programs (McGinnis et al. 2002). In addition, building roads lowers transportation costs, thereby allowing food to reach previously disconnected areas and potentially diversifying or enhancing a child's diet. Building a dam may improve the agricultural productivity of a region and can consequently increase the food supply and ensure food availability. Furthermore, government investments in research and infrastructure may stimulate growth that may lead to greater income-earning opportunities (Fan et al. 2000). Additionally, it is important to measure the impact of total public expenditure because bundled public services have been shown to affect welfare more strongly than separate interventions (Escobal and Torero 2002; Chong et al. 2003). Hence, this paper examines the impact of total public expenditure rather than only the effect of increases in public health spending.

The impact of public spending on child nutrition does not depend only on the amount of money spent. The quality of the goods and services provided is crucial to their effectiveness. In Peru, the amounts spent and the quality of expenditure differs considerably between urban and rural areas. Finally, public expenditures will not be effective if households are not able or willing to access public goods and services due to child frailty, language barriers, or lack of economic resources. These concerns are addressed in this study.

---

[3] A child is stunted if he/she falls two standard deviations below the height-for-age z-score. The z-score is calculated using the World Health Organization Child Growth Standards (WHO 2006).

II. METHODOLOGY

Public expenditure at a regional level is determined by factors that may simultaneously affect the nutritional levels of children. Maternal characteristics that induce mothers to choose to live in a specific location with a specific level of public expenditure may also affect their ability to care for their children. Moreover, the government may decide to spend more in an area where there is a greater need for public intervention (Rosenzweig and Wolpin 1986). This incentive creates reverse causality[4]. I address this endogeneity problem using an instrumental variable approach. My exogenous variation in public expenditures comes from unanticipated regional mining revenues.

Source of Exogenous Variation: Unanticipated Mining Revenues

Unanticipated mining revenues are composed of revenues from the exploitation of minerals (gold, zinc, lead, silver, iron tin, copper, and molybdenum), oil, and gas. These three are lumped together as "mining resources" in Peruvian national accounts. The Mining Canon Regulations (Supreme Decree No 005-2002-EF) approved in 2002 state that regional and local governments are entitled to all of the mining royalties collected in their region (these are equivalent to 50% of the income and rents obtained by the central government from the exploitation of mining activities in their jurisdictions)[5]. At the national level, royalties

[4] I conducted a Wu-Hausman F test statistic to test whether public spending was, in fact, exogenous. I was able to reject the null hypothesis (p-value = 0.053). This means that the endogeneity among the regressors would have deleterious effects on OLS estimates.

[5] According to the law, the amount of royalties generated in a year is distributed with a delay of a year and a half. This results in a disassociation between the time at which these amounts are generated and when they are spent.

represented 1.1% and 3.5% of total regional expenditure in 2002 and 2006, respectively[6]. I use unanticipated mining revenues as an instrument of public spending because they determine the magnitude of mining royalties but can be considered exogenous. The instrument uses the extraction levels in each region prior to the new law (2001 volumes) and the changes in the world prices of these resources between 2002 and 2006. By using lagged extraction, identification is driven only by unanticipated price changes rather than by changes in extraction rates, which may have been endogenous to the policy. To show the variation in the instrument, I create a figure comparing the changes between 2002 and 2006 in the value of mineral production in each region (there are 25 regions in Peru). The value is calculated by multiplying the change between 2002 and 2006 in international prices by the amount of minerals produced in each region in 2001. This figure, as well as figures showing the changes in mineral prices and the geographical variation of royalties between 2002 and 2006 (Figures S1.1-S1.5), can be found in the supplemental appendix (at the end of this document). These figures illustrate the huge increases in international prices during the period of analysis, the wide geographic variation in the value of royalties across regions, and the variation of the instrument across regions.

The Instrument's Strength

Given the way the law was designed, royalties in Peru have a multiplier effect on public spending. By law, during the period studied in this paper, royalties had to be spent on the maintenance of local infrastructure projects, feasibility studies for investment projects, and scientific and technological research. Furthermore, public funds could only be assigned to regional or local governments for investment projects if they had approved feasibility studies that

[6] These numbers are much larger if Lima is excluded from the calculations (2.7% and 7.6%, respectively) because, due to the highly centralized nature of the government, public spending in Lima is

showed they were economically sound. Producing a feasibility study is a costly activity that can usually only be financed if the authorities have access to external funds, such as royalties. Hence, royalties may allow regional and local governments to hire specialists to produce sound feasibility studies that would increase the probability that their projects would be approved and that they would receive more public funds. In addition, investing in scientific and technological research may result in the development of sounder investment proposals with higher probabilities of being financed and, hence, higher regional public spending. If I run a simple regression of unanticipated mining revenues on changes in public expenditure using region-year data and only controlling for regional debt and a year fixed effect, I find that 100 million soles of additional mining revenues increase total spending by 2.8 million soles[7].

The multiplier effect is even clearer in the size of the parameters found in the first-stage regression for both urban and rural areas, as Table 1 shows. An increase of 100 million soles in the amount of unanticipated mining revenues will increase the level of total expenditure by 1,095 and 635 million soles in rural and urban areas, respectively. Both coefficients are significant at a 1% level. The effect is especially large in rural areas, most likely due to the distribution rule within regions, which favored rural areas[8]. In addition, I assess the strength of the instrument using the first-stage F statistic. Estimators can perform poorly when instruments are weak, resulting in non-normal sampling distributions of IV statistics and unreliable standard IV point estimates, hypothesis tests, and confidence intervals[9]. The null hypothesis is that the instrument

---

approximately 20 times the maximum spending in the rest of the regions.

[7] The coefficient is significant at the 10% level.

[8] See supplemental appendix section S4.3 for more detail on the distribution rule.

[9] A set of instruments is defined as weak if the concentration parameter is small enough that inferences based on conventional normal approximating distributions are misleading. The concentration parameter is a unitless measure of the strength of the instruments (Stock et al. 2002; Stock and Yogo

is weak. For all of the estimations, the F statistic (at a 5% significance level) ensured that the maximal bias of the IV estimator relative to OLS was no larger than 5%. This fits the definition of a strong instrument according to Stock et al. (2002).

The Instrument's Validity

Changes in the amount of unanticipated regional mining revenues do not respond to local circumstances. They only depend on the price of minerals in the international market and on the volume of minerals produced prior to the change in the royalties' legislation. Variations in the amount of unanticipated mining revenues do not lead directly to an increase in economic activity in the areas where the resource is located. Indeed, the correlation between the changes in per capita GDP and the changes in unanticipated mining revenues is quite small (0.203)[10], indicating that changes in unanticipated mining revenues cannot affect per capita GDP (or, for that matter health) other than through changes in public expenditures. Furthermore, changes in these revenues have no impact on changes in consumer price indexes for commodities that could affect child well-being, such as food, medicines, and health care, as shown in Table S4.2 in the supplemental appendix[11].

Unanticipated mining revenues are thus arguably unrelated to children's nutritional outcomes provided that an increase in these revenues is uncorrelated with changes in net income per capita, expenditure categories, and migration patterns and that mining does not directly affect child health. First, I verify that increases in mining revenues do not directly increase income per

---

2002). One measure of whether a set of instruments is strong is whether the concentration parameter is sufficiently large.

[10] I calculated this correlation using region-year data between 2002 and 2006. In addition, I conducted a regression of changes in unanticipated mining revenues on changes on GDP per capita and found no statistically significant effect of mining revenues on GDP per capita.

capita by running a panel fixed effects model with region-year data. Changes in these revenues have no statistically significant effect on changes in income per capita (see Table S4.2 in the supplemental appendix).

Second, mining revenues may affect health status directly. Increased mining activities may generate enough additional pollution to worsen the general population's health. However, changes in mining revenues do not have a statistically significant impact on changes in the probability of suffering a chronic illness, nor do they modify the predicted probability of suffering a self-reported life threatening illness[12] (see Tables S4.2 and S4.3 in the supplemental appendix). Finally, I verify that the level of mining revenues do not affect migration patterns and that changes in expenditure composition only explain a small fraction of the impact of total spending. These results and detailed explanations can be found in sections S4.1 and S4.2, respectively, of the supplemental appendix.

Specification

My first stage equation is

$$P_{jt} = \delta_j + \phi_t + \rho_1 Z_{jt} + \rho_2 X_{ijt}^{c} + \rho_3 \hat{H}_{ijt}^{c} + \rho_4 X_{ijt}^{H} + \rho_5 X_{ijt}^{C} + \rho_6 p_{ijt}^{n} + \rho_7 X_{jt}^{R} + \varepsilon_{jt} \quad . \tag{1}$$

P_{jt} is the level of public expenditure in period t and region j, Z_{jt} is the level of unanticipated mining revenues obtained by each region j at time t, δ_j are region fixed effects, and ϕ_t are year fixed effects. I controlled for other regional characteristics that vary over time (X^R_{jt}),

[11] I used data that varied at the region-year level and found no statistically significant effect of changes in mining revenues on changes with either of these consumer price indexes.

[12] I tested the effect of mining revenues on the predicted probability of suffering a life-threatening illness for children in the Young Lives Study sample because I use this variable as a control in my main regressions. See the specification subsection for further explanation.

the price of the nutritional input (p_t^n)[13], and child (X^c), household (X^H), and community (X^C) characteristics that also vary over time[14]. Child's health status (H_t^c) is a dummy indicating that the child suffered a life-threatening illness[15]. This is an endogenous variable because it is a choice and is likely to be affected by public spending. Hence, I instead use in the regression its predicted value ($\hat{H}_{ijt}{}^c$), where the predictors of an episode of a serious illness are the intensity of air and water pollution in the community. My second stage equation is

$$(2) \qquad N_{ijt}^c = \theta_i + \delta_j + \phi_t + \alpha P_{jt} + \beta_1 X_{ijt}{}^c + \beta_2 \hat{H}_{ijt}{}^c + \beta_3 X_{ijt}{}^H + \beta_4 p_{ijt}{}^n + \beta_5 X_{jt}{}^C + \beta_6 X_t{}^R + \mu_{ijt} \ ,$$

where $N^c{}_{ijt}$ is the height-per-age z-score level for the child and θ_i represents the individual fixed effects. μ_{ijt} represents unobserved attributes related to both the mother and the child, such as resilience, maternal initiative, and determination. I use a first difference approach and cluster the standard errors at the region-year level to account for any variation within region and year[16].

Main Variables

The nutritional status of the child is measured using height z-scores. Height has proven to be an informative long-term indicator of the nutritional status of children. Z-scores are constructed using the new World Health Organization (WHO) international child growth

---

[13] The price chosen is the price of rice, the main staple in Peruvian diets. Some of the rice prices were missing, so they were imputed using the province averages to replace the missing values.

[14] I did not include maternal characteristics that vary over time because the only one I could control for, maternal education, had coding issues between rounds.

[15] Using acute health conditions instead of minor episodes allowed me to avoid capturing seasonal health problems and to reduce potential biases in reporting health conditions.

[16] The clustering level is the region-year. Hence, clusters are defined for non-movers as well as for movers. Thus, there is a cluster for children who lived in Lima in 2002 and stayed in Lima in 2006, and there are different clusters for children who lived in Lima in 2002 but moved to other regions in 2006.

standards. Specifically, the z-scores are defined as the standard for well-nourished children. For example, the height-for-age z-score for a child *i* in age and gender group *c* is constructed as

$$Z_{ic} = \frac{(H_{ic} - MedianH_c)}{\sigma_c} \quad (3)$$
,

where H_{ic} is the measured height of the child and $MedianH_c$ and σ_c are the age- and gender-specific median height and the standard deviation of the height, respectively, of well-nourished children. A risk indicator is falling two standard deviations below this z-score measure. In round one, 18% of children in the sample were malnourished, compared with 32% in round two. In urban areas, stunting increased from 11% to 21% between rounds, whereas in rural areas, it increased from 20% to 58%.

The independent variable of interest used in this study is the level of public expenditure in each region. The total public expenditure is defined as the summation of investment and current expenditure. The unit of measurement is 100 million soles (approximately 33 million dollars). During the period analyzed (2002–6), total per capita government expenditure increased by 34%[17].

III. RESULTS

The following section describes the different data sources used in this study and presents the results. It includes explanations of the different pathways through which public spending improves child well-being and the possible exclusion mechanisms at work.

---

[17] Statistics from the Ministry of Economics and Finance (www.mef.gob.pe).

Data

The analysis relies on three main sources of data. I use the Young Lives International Study of Childhood Poverty, which tracks the lives of 2,052 Peruvian children born in the years 2000–1 for 15 years. The first round of data was collected in 2002, and the second round was collected between late 2006 and early 2007. The rate of attrition in the study was small (4.39%), and, as Table S3.1 in the supplemental appendix confirms, the only significant differences at a 5% level of means are for mother's height and the probability of having an immunization program in the child's community. I also test and discard the hypothesis that attrition can be explained by the spending patterns within regions. This survey includes information about each child as well as the household and the social, economic, and environmental context of the community in which the child resides. These data allow me to control for different aspects in the child's life that may affect his or her nutrition, such as age and household attributes. A description of the design of this study can be found in section S3.1 in the supplemental appendix.

Second, I match these data with statistics at the regional level using the 2002 and 2006 National Household Surveys (ENAHO). These are yearly surveys conducted throughout the entire country to measure living conditions, poverty levels, and the impact of social programs. The ENAHO surveys are representative at both the regional level and the urban–rural level. Finally, I collect information about public expenditure, and I construct the value of unanticipated mining revenues using information from the Ministry of Economics and Finance statistics database.

Descriptive Statistics. The differences between urban and rural areas for both rounds of the survey are illustrated in Table 2. The most remarkable divergences are related to the possession of private assets, such as maternal education and wealth. In addition, community characteristics, such as the size of the population and the probability of living in the highlands, differ greatly. There is differential access to health professionals, such as general physicians, pediatricians, and trained midwives, that persists for the two rounds. The differential access to public health facilities and programs narrows in the second round, with significant increases in rural areas. Finally, children in rural areas have a much worse height z-score and almost three times the probability of being undernourished in comparison to their counterparts in urban areas. Between the two rounds, these differences increase. Child nutrition outcomes and household characteristics differ between these areas, according to several authors (Smith et al. 2005; van de Poel et al. 2007; Larrea et al. 2005). One explanation for the nutritional gap may be the high altitude at which most of Peru's rural population lives. In their 2007 study, van de Poel et al. said that child growth retardation could be caused by hypoxia (oxygen shortage), which is common at high altitudes. Similarly, growth retardation could be the result of the highlands diet, which is characterized by low protein and micronutrient intake (Larrea et al. 2005).

The impact of regional public expenditure on a child's z-score

Given the disparities between urban and rural areas, I perform separate estimations of the conditional demand functions for the nutritional level of children for these areas and for the whole sample. The separate estimations measure the impact of changes in total regional expenditure on children living in either urban or rural areas. Hence, the coefficient calculated for urban areas represents how an additional unit of public spending in a region affects the average z-score of children living in an urban area. The results are shown in Table 3. The first column shows the results for simple panel data estimation without instrumenting changes in total public expenditure. The second column provides second-stage estimates for a panel estimation in which changes in total public expenditure are instrumented using changes in unanticipated regional mining revenues. The third and fourth columns display the second-stage panel IV results for the rural and urban samples, respectively. All specifications include regional and time fixed effects. I control for child's age, child's predicted health status, household characteristics (number of children under five years of age, availability of drinking water in the household, household size, and wealth score), community characteristics (rice price, population size, a dummy for living in the highlands, a dummy for living in an urban area, and a poverty index), and regional variables (debt payments)[18]. According to the simple panel data estimate for the whole sample, changes in total public spending appear to have a negative but not statistically significant effect on changes in a child's nutritional status (the coefficient is equal to -0.052). This result is consistent with the reverse causality hypothesis that the government will spend more in areas where there are pressing social demands. The instrumental variable panel estimation for the whole sample shows a positive but not significant coefficient (0.041)[19]. In contrast, in rural areas, the IV estimation shows a very small, negative (-0.078), and statistically significant impact of public spending. However, in urban areas, conditional on the inclusion of the control variables described above, there is a positive (0.238) and significant impact of changes in public expenditure on changes in a child's nutritional outcome (almost twice the size of a non-instrumented panel estimation for urban areas[20]). Furthermore, I verify that the difference in the urban and rural coefficients is statistically significant at a 5% level. For an increase equal to the average annual change in

[18] Individual time-invariant variables, such as birth weight, ethnicity, gender, maternal height, and maternal age at birth, were excluded from the estimation because individual fixed effects are included. All of the controls are expressed in changes.

[19] I also calculated the instrumental variable pool estimator, which also showed a positive but not significant coefficient (0.535).

[20] Simple panel data estimations were performed for urban and rural areas. In rural areas, public spending appears to have a statistically significant at 1% and a negative effect on children's stunting (with a coefficient of -.115). In urban areas, there is a small, positive, and statistically significant effect at 1% (with a coefficient of 0.141).

spending in a region between 2002 and 2006, the average urban child z-score would have increased by 19% of a standard deviation. In addition, the coefficient for urban areas is almost six times larger than the one estimated for the whole sample[21]. This magnitude should be understood in the context of a growth curve.

I use growth charts[22] to assess the extent to which increasing public expenditure in urban areas can improve a child's nutritional level. A growth chart consists of a series of percentile curves that show the distribution of height-for-age for boys and girls since birth. Using these tables, a child's height can be compared to the expected height parameters of children of the same age and sex to determine whether the child is growing appropriately. I find that more than 61% of the increase in malnutrition disparities between rural and urban areas can be explained by the increase in total public expenditure during the two rounds of the survey (63% for boys and 60% for girls).

As a robustness check, I estimate the impact of changes in public spending on changes in child height between the two periods[23]. The results are consistent with the ones obtained with z-scores of height for age. In rural areas, there is no statistically significant effect. In urban areas, every increase of 100 million soles in public expenditures increases the average child's height by 0.83 cm. Furthermore, for an increase equal to the average change in public expenditures between survey rounds, a child's height will change by 15.9 cm.

[21] I performed additional estimations to address the possibility of non-linear effects in spending. I used a logarithmic transformation of the expenditure variable as the independent variable. I found no statistically significant effect of spending for the total sample or for rural areas. As before, I found a statistically significant and positive effect of public expenditure on z-scores in urban areas. According to this estimation, a 1% increase in expenditures would increase z-scores by 0.007.

[22] Source: World Health Organization.

[23] I include as an additional control the lag value of height, which relaxes the assumption that the coefficient on the lag is equal to 1.

Pathways through which public spending improves child well-being

The results reinforce the findings of Valdivia (2004) that the expansion in health infrastructure in Peru during the 1990s had a significant causal impact on children's nutrition only in urban areas. Worse health outcomes for the rural population may thus be a consequence of the lack of effectiveness of public services in these areas.

Differences in public services availability between urban and rural areas. The lack of effectiveness of public spending may be related to the differences in the availability of public services between urban and rural areas. The availability of health professionals, health facilities, and programs in a given locality may be pathways through which public spending improves child well-being. To assess these pathways, I estimate IV panel models in which the dependent variable is the change in an access measure at the community level. The community level measures include the change in the probability of accessing a general physician, a pediatrician or gynecologist, a midwife, a child growth control program, and a public health center[24]. The results are presented in Table 4. Changes in public spending only increase access to local health professionals and child growth controls in urban areas. However, in rural areas, public spending does not modify access to local health professionals, but it decreases access to child growth controls while increasing the probability of accessing public health centers. This is not a surprising result because, according to Table 2, public health centers increased dramatically in rural areas during the period of analysis.

[24] These community level measures were obtained from the community survey, so the access to health professionals and facilities is not conditional on health. All of these estimations include regional and time fixed effects. As controls, I use community characteristics (the average household wealth score in the community, population size, a dummy for living in the highlands and a poverty index) and regional variables (average level of education in the region and debt payments). I cluster the standard errors at the region-year level.

Differences in public spending quality between urban and rural areas. High rates of absenteeism and irregular working hours usually characterize poorly monitored public health facilities in rural areas (Devarajan and Reinikka 2004; Chaudhury et al. 2006; Banerjee and Duflo 2011). These limitations could explain the reduced effectiveness of these services. If this is the case, public expenditure should also have a differential effect between urban and rural areas on alternative child health outcomes, such as the probability of suffering a life-threatening illness and weight-for-height z-scores. A more detailed explanation of this alternative hypothesis and a table with the regression results can be found in section S5.1 in the supplemental appendix. The results support the claim that rural areas have less effective public services and that increases in public spending that are mainly directed to health centers may actually worsen child health outcomes.

Exclusions at work

Disadvantaged groups may profit little from public expenditures if the access to and use of services provided by the government are affected by the possession of private assets (Filmer and Pritchett 1999; Filmer et al. 2000; Filmer 2003; Castro-Leal et al. 1999; O'Donnell 2007; O'Donnell et al. 2007; Thomas et al. 1991). This situation leads to heterogeneous treatment effects. Hence, the estimates obtained are “local average treatment effects” (LATE) instead of what we should aim to measure, which are the effects of the treatment on the treated (TT) (Heckman and Vitlacyl 1999). The initial results may underestimate the actual impact of increasing public expenditure on those who are able to access the services. Therefore, I also estimate the effect of total public expenditure on the sub-samples defined by child, maternal, and household characteristics[25]. In Table 5, estimates are presented from urban and rural samples to differentiate the effect of a lower quantity and quality supply of public goods and services from the impact of a lack of access to key private assets. A detailed explanation of each of the outcomes analyzed and a further interpretation of these results can be found in the supplemental appendix, section S5.2. In the following subsections, I present a summary of the findings.

The impact of public spending according to child resilience. In urban areas, changes in public expenditure have a statistically significant and positive impact only on changes in the nutritional level of children who are above the 25th birth weight percentile. The coefficient estimate for the sub-sample in the highest percentiles for birth weight is larger than the one for the whole urban sample (0.296 vs. 0.238). These results are consistent with a favorable selection hypothesis[26]. In contrast, in rural areas, changes in public expenditure have a negative impact (significant at the 5% level) on children in the higher birth percentiles. There is no statistically significant impact for the non-resilient group in either area. The differential impact across the urban subsamples is statistically significant, but this is not the case for the rural parameters.

The impact of public spending according to child's initial nutrition status. The previous result showed that children with higher birth weights in urban areas are the only ones who benefit from public spending. This result could be explained by a health production function in which poor early life health outcomes magnify over time. If that were the case, one would not expect public spending to play a major role in explaining the widening in the urban–rural malnutrition gap. To test this hypothesis, I divide the children into two groups: those who were

[25] The instrumental variable in all of the following estimations was tested and proved to be strong.

[26] These results may be thought to be driven by the mother's own frailty. To discard this hypothesis, I divided the sample between the children with shorter mothers (belonging to the lowest height quartile) and the children with the tallest mothers. In both urban and rural areas, there was no statistically significant differential impact of public spending between taller and shorter mothers.

malnourished during the first round (with a z-score below -2 S.D.) and those who were not malnourished. The estimates in Table 5 show that changes in public expenditure have a statistically significant and positive impact on changes in the nutritional level only of initially well-nourished children. The coefficient estimate is slightly larger than the one for the whole urban sample (0.283), which attests to the importance of early circumstances. In rural areas, changes in public expenditure only have a statistically significant and negative impact on children with worse initial nutritional status. In both areas, the differential impact across the sub-sample is not statistically significant. Hence, initial conditions do not solely explain the results.

The impact of public spending according to maternal mother tongue. An "indigenous" mother tongue can be a barrier with regard to communicating with medical professionals as well as a source of lack of self-confidence. I define as "indigenous" a mother with a mother tongue other than Spanish (the official language) and as "not indigenous" a mother with Spanish as her mother tongue. In rural areas, even though there is a negative and statistically significant effect of changes in public spending for non-indigenous mothers, the differential impact across subsamples is not significant. In urban areas, the impact of changes in public expenditure is positive and significant only for mothers who are not indigenous. This impact is much stronger than for the whole urban sample (0.346). Furthermore, the differential impact of public spending across ethnic groups is statistically significant.

The impact of public spending according to household wealth level. Households with tighter budget constraints are less prone to dedicate time to child-enhancing activities. I define poor households as those with an initial household wealth score below the regional household wealth median[27], which translates to an average income per capita of approximately $2 per day.

[27] The regional household wealth median was calculated using the ENAHO surveys.

The poor seem to have worse z-scores due to increases in public spending in rural areas. In urban areas, changes in public expenditure only affect positively (and statistically significantly) the nutritional level of children belonging to “non-poor” households. However, the differential impact across samples is not significant for either area.

IV. DISCUSSION

This paper offers new evidence on the differential impact of public expenditure on child health outcomes in a developing country. In contrast to previous work, it exploits variations in unanticipated mining revenues. This instrumental variable is shown to be unrelated to child nutrition except through public spending. This paper differs from the existing literature because it analyzes the potential barriers that diminish the effectiveness of public expenditure. I provide evidence that changes in public expenditure are ineffective and even harmful in rural areas. A lower quantity and quality of services and the crowding out of private expenditure in those areas are possible explanations for this result. In urban areas, changes in public expenditure appear to positively affect child nutrition. Even there, however, only some children are able to benefit from the consumption of public goods and services. The children whom public expenditure does not help have indigenous mothers and are the ones with the worst initial conditions. The consequence is a regressive distribution of stunting. These findings are consistent with previous studies that indicate an anti-poor bias, represented in this study by indigenous status, of public spending in developing countries (Castro-Leal et al. 1999; O'Donnell et al. 2007; Wagstaff and Watanabe 2000). Public spending is not helping the most destitute children and is thus unable to break the cycle of poverty and malnutrition. This result indicates that disparities in outcomes may widen in the future.

Another finding of this paper is that initial conditions are of paramount importance. Nutrition production varies across age groups, and there are periods in which public expenditure can be more critical than others. Indeed, in urban areas with readily available higher-quality public goods and services, children with low birth weights are not able to benefit from public spending. Hence, governments should focus their efforts on the initial stages of child development.

A limitation of this paper is that the results obtained can only be interpreted as local average treatment effects because this study measures the impact of changes in public expenditure when influenced by mining revenues. Future research should focus on finding other sources of exogenous variation with higher levels of external validity and on exploring how to raise the quality and utilization of health services in rural areas.

REFERENCES

Aguiar, C., J. Rosenfeld, B. Stevens, S. Thanasombat, and H. Masud. 2007. "An Analysis of Malnutrition Programming and Policies in Peru." Paper prepared for the International Economic Development Program, the Gerald R. Ford School of Public Policy and School of Public Health, University of Michigan; Ann Arbor, MI.

Baldacci, D., M.T. Guin-Siu, and L. de Mello. 2002. "More on the Effectiveness of Public Spending on Health Care and Education: A covariance Structure Model." IMF Working Paper (2) 90; Washington, DC.

Banerjee A. and E. Duflo. 2011. Poor Economics, a radical rethinking of the way to fight global poverty. New York, NY: Public Affairs.

Castro-Leal, F, J. Dayton, L. Demery, and K. Mehra. 1999. "Public social spending in Africa: do the poor benefit?" *World Bank Research Observer* 14 (1): 49–72.

Chaudhury, N., J. Hammer, M. Kremer, K. Muralidharan, and F.H. Rogers. 2006. "Missing in Action: Teacher and Health Worker Absence in Developing Countries." *Journal of Economic Perspectives* 20 (1): 91–116.

Chong, A., J. Hentschel, and J. Saavedra. 2003. "Bundling and household welfare in the delivery of social services in developing countries using panel data: The case of Peru." World Bank Policy Research Working Paper 3310; Washington, DC.

Devarajan, S. and R. Reinikka. 2004. "Making Services Work for Poor People." *Journal of African Economies* 13 (1): i142–66.

Ehiri, J. and J. Prowse. 1999. "Child health promotion in developing countries: the case of integration of environmental and social interventions?" *Health Policy and Planning* 14 (1): 1–10.

Escobal, J., J. Saavedra, P. Suárez, S. Huttly, M. Penny, C. Lanata, and E. Villar. 2005. "The Interaction of Public Assets, Private Assets and Community Characteristics and its Effect on Early Childhood Height-for-Age in Peru." Young Lives: An International Study of Childhood Poverty Working Paper 14. Lima, Peru.

Escobal, J and M. Torero. 2002. "Asset complementarities: The case of rural Peru." Paper presented at the 2001 Global Development Network (GDN) Annual Conference, Rio de Janeiro; Lima, Peru.

Fan, S., P. Hazell, and S. Thorat. 2000. "Government Spending, Growth and Poverty in Rural India." *American Journal of Agricultural Economics* 82 (4): 1038–51.

Filmer D. 2003. "The incidence of public expenditures on health and education" Background note for the World Development Report 2004: Making services work for the poor. World Bank; Washington, DC.

Filmer, D. and L. Pritchett. 1999. "The impact of public spending on health: does money matter?" *Social Science & Medicine* 49: 1309–23.

Filmer D, J. Hammer, and L. Pritchett. 2000. "Weak links in the chain: a diagnosis of health policy in poor countries." *World Bank Research Observer* 15 (2): 199–224.

Glewwe, P., H.G. Jacoby, and E.M. King. 2001. "Early childhood nutrition and academic achievement: a longitudinal analysis." *Journal of Public Economics* 81: 345–368.

Glewwe, P., and H.G. Jacoby. 1995. "An Economic Analysis of Delayed Primary School Enrollment in a Low Income Country: The Role of Early Childhood Nutrition." *The Review of Economics and Statistics* 77 (1): 156–69.

Gupta, S., M. Verhoeven, and E.R. Tiongson. 2003. "Public spending on health care and the poor." *Health Economics* 12: 685–96.

Heckman J. 2007. "The Economics, Technology and Neuroscience of Human Capability Formation." NBER Working Papers 13195; Cambridge, MA.

Heckman, J., and E. Vytlacil. 1999. “Local instrumental variables and latent variable models for identifying the bounding treatment effects” *Proceedings of the National Academy of Sciences* 96 (8): 4730–4.

INEI. 2001. *Encuesta Demográfica y de Salud Familiar 2000 (ENDES 2000)*. Lima: Peru.

INEI. 2007. *Encuesta Demográfica y de Salud Familiar* Continua 2004–2006 *(ENDES* 2004–2006*)*. Lima: Peru.

INEI. “Encuesta Demográfica y de Salud Familiar.” http://www.inei.gob.pe/.

Knudsen, E., J. Heckman, J. Cameron, and J. Shonkoff. 2006. “Economic, Neurobiological, and Behavioral Perspectives on Building America’s Future Workforce." *Proceedings of the National Academy of Sciences* 103 (27): 10155–62.

Larrea, C., P. Montalvo, and A.M. Ricaurte. 2005. “Child Malnutrition, Social Development and Health Services in the Andean Region.” Inter-American Development Bank Research Network Working paper R-495; Washington, DC.

Maluccio, J.A., J. Hoddinott, J.R. Behrman, R. Martorell, A.R. Quisumbing, and A.D. Stein. 2006. “The Impact of Nutrition during Early Childhood on Education among Guatemalan Adults.” PSC Working Paper Series 06 (04); Philadelphia, PA.

McGinnis, J. M., P. Williams-Russo, and J.R. Knickman. 2002. “The Case for More Active Policy Attention to Health Promotion.” *Health Affairs* 21 (2): 78–93.

O’Donnell, O. 2007. “Access to health care in developing countries: breaking down demand side barriers.” *Cadernos de Saúde Pública* 23 (12): 2820–34.

O'Donnell O., E. van Doorslaer, R.P. Rannan-Eliya, A. Somanathan, S.R. Adhikari, D. Harbianto, C.C. Garg, P. Hanvoravongchai, M.N. Huq, A. Karan, G.M. Leung, C.W. Ng, B.R. Pande, K. Tin, K. Tisayaticom, L. Trisnantoro, Y. Zhang, and Y. Zhao. 2007. "The incidence of public spending on healthcare: comparative evidence from Asia." *World Bank Economic Review* 21: 93–123.

Rosenzweig, M., and K. Wolpin. 1986. "Evaluating the Effects of Optimally Distributed Public Programs: Child Health and Family Planning Interventions." *The American Economic Review* 76 (3): 470–82.

Schultz, P. 2004. "Health economics and applications in developing countries." *Journal of Health Economics* 23 (4): 637–41.

Smith, L., M. Ruel, and A. Ndiaye. 2005. "Why Is Child Malnutrition Lower in Urban Than in Rural Areas? Evidence from 36 Developing Countries." *World Development* 33 (8): 1285–305.

Stock, J. H. and M. Yogo. 2002. "Testing for Weak Instruments in Linear IV Regression." NBER Technical Working Paper 284; Cambridge, MA.

Stock, J. H., J. Wright, and M. Yogo. 2002. "A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments." *Journal of Business & Economic Statistics* 20 (4): 518–29.

Thomas, D., J. Strauss, and M. H. Henriques. 1991. "How does mother's education affect child height?" *The Journal of Human Resources* 26 (2): 183–211.

Valdivia, M. 2004. "Poverty, health infrastructure and the nutrition of Peruvian children." *Economics and Human Biology* 2 (3): 489–510.

Van de Poel, E., O. O'Donnell, and E. van Doorslaer. 2007. "Are Urban Children really healthier? Evidence from 47 developing countries." Tinbergen Institute Discussion Paper TI 2007-035/3; Amsterdam, The Netherlands.

Wagstaff, A., and N. Watanabe. 2000. "Socioeconomic inequalities in child malnutrition in the developing world." World Bank Policy Research Working Paper 2434; Washington, DC.

Walker S.P., S.M. Chang, C.A. Powell, and S.M. Grantham-McGregor. 2005. "Effects of early childhood psychosocial stimulation and nutritional supplementation on cognition and education in growth-stunted Jamaican children: prospective cohort study." *Lancet* 366: 1804–7.

World Health Organization. 2006. "WHO Child Growth Standards: methods and development." WHO Press, Geneva: Switzerland.

TABLE 1: First stage estimation - Impact of changes in unanticipated mining revenues on changes in public expenditure by area

Dependent variable:	Public Spending		
	Whole sample IV	Rural IV	Urban IV
Unanticipated mining revenues	8.119	10.952	6.352
	(0.206)***	(0.444)***	(0.201)***
Other controls	YES	YES	YES
Number of observations	1,902	688	1,213
Partial R^2 of excluded instrument	0.454	0.481	0.457
F-test for weak identification	1554	608	995

Source: Young Lives Study Round 1 and 2, ENAHO 2002, 2006, and Ministry of Economic and Finance Budgetary Expenditure for 2000–6.

Note: The independent variable is the level of unanticipated regional mining revenues. The estimations include regional fixed effects, time fixed effects, and all controls included in the second-stage estimation. Spending measured in 100 million soles. Robust standard errors clustered by region-year in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%. These include regional fixed effects and time fixed effects.

TABLE 2: Descriptive statistics for urban and rural areas for both rounds

Variable	Round 1				Round 2				Difference	
	Urban		Rural		Urban		Rural		Urban	Rural
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	Mean
Prob. of living in the area	65%	48%	35%	48%	69%	46%	31%	46%	4%	-4%
Prob. of being stunted	11%	31%	29%	45%	20%	40%	58%	49%	8%	26%
Z-score (height for age)	-0.49	1.24	-1.31	1.29	-1.20	1.05	-2.18	0.95	-0.67	-0.81
Z-score (weight for age)	0.18	1.13	-0.57	1.13	-0.29	1.04	-1.00	0.79	-0.43	-0.42
Age of child in months	12	3	12	4	65	4	61	4	53	50
Serious illness	0.31	0.46	0.33	0.47	0.19	0.39	0.23	0.42	-0.13	-0.09
Maternal education level	2.18	1.21	1.07	0.78	2.38	1.26	1.21	0.88	0.24	0.21
Number of children younger than 5 yrs	0.35	0.58	0.58	0.64	0.59	0.71	1.11	0.84	0.23	0.48
Household size	5.58	2.32	5.96	2.35	5.25	2.04	6.08	2.05	-0.33	0.00
Household wealth score	1.14	2.26	-2.10	1.16	1.07	2.25	-2.42	1.19	0.10	-0.20
General physician	80%	40%	27%	44%	78%	31%	32%	21%	2%	3%
Pediatrician/gynecologist	50%	50%	4%	19%	39%	36%	3%	11%	-8%	-2%
Midwife in locality	88%	32%	50%	50%	79%	26%	52%	20%	-6%	-2%
Public health center	80%	40%	21%	41%	99%	4%	92%	9%	19%	69%
Immunization	92%	26%	72%	45%	99%	3%	95%	6%	7%	22%
Disease prevention program	93%	25%	78%	41%	99%	3%	95%	6%	6%	16%
Child growth	93%	25%	79%	41%	99%	3%	95%	6%	6%	16%
Highlands	38%	49%	72%	45%	36%	48%	77%	42%	-1%	-2%
Population in locality	6076	3933	2431	3368	21246	24190	1769	4382	17070	-836

Source: Young Lives Study Round 1 and 2.

TABLE 3: Impact of changes in public expenditure on changes in a child's nutritional level and height by area

Dependent Variable:	Z-score (height for age)				Height (in cm)	
	Panel				Panel	
	Whole sample OLS	Whole sample IV	Rural IV	Urban IV	Rural IV	Urban IV
	(1)	(2)	(3)	(4)	(5)	(6)
Total public spending	-0.052	0.041	-0.078	0.238	0.050	0.825
	(0.058)	(0.068)	(0.029)**	(0.127)*	(0.224)	(0.328)**
Other controls	YES	YES	YES	YES	YES	YES
N	1,902	1,902	688	1,214	692	1,218
R^2	0.344					

Source: Young Lives Study Round 1 and 2, ENAHO 2002, 2006 and Ministry of Economic and Finance Budgetary Expenditure for 2000–6.

Note: The estimations include regional fixed effects, individual fixed effects, and time fixed effects. Controls: child's age, predicted child's health, number of children under 5 years of age in the household, availability of drinking water, household size, wealth score, rice prices in the community, population size, a dummy for living in the highlands, a dummy for being in an urban area, a poverty index, and the level of regional debt payments. For estimations (5) and (6), I include as an additional control the lag value of height. Spending measured in 100 million soles. The instrument for the IV estimation is the amount of unanticipated regional mining revenues. Robust standard errors clustered by region-year in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%.

TABLE 4: Impact of changes in public spending on changes in the probability of accessing a health professional, program, or facility in one's locality (by area)

Dependent Variable: Availability of … in your locality	Panel	
	Rural	Urban
	IV	IV
General physician	-0.049	0.524
	(0.070)	(0.128)***
Pediatrician/Gynecologist	-0.010	0.441
	(0.018)	(0.112)***
Midwife	-0.002	0.330
	(0.048)	(0.132)**
Child growth controls	-0.154	0.222
	(0.051)***	(0.113)*
Public health center	0.178	0.212
	(0.061)***	(0.127)
N	724	1235

Source: Young Lives Study Round 1 and 2, ENAHO 2002, 2006, and Ministry of Economic and Finance (2000–6).

Note: Each coefficient represents a separate regression. Robust standard errors clustered by region-year in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%. Includes the average household wealth score in the locality, the population size, the average educational level in the region, a dummy for belonging to the highlands, a poverty index, the level of regional debt payments, regional fixed effects, and time fixed effects. Spending measured in 100 million soles. The instrument for all IV estimations is the amount of unanticipated mining revenues.

TABLE 5: Impact of changes in public expenditure on changes in a child's nutritional level by child/household characteristics

Dependent Variable:	Z-score (height for age)					
	Rural IV		Statistically Significant Differential Impact	Urban IV		Statistically Significant Differential Impact
	Lowest birth weight quartile	Higher birth weight quartiles		Lowest birth weight quartile	Higher birth weight quartiles	
Total public spending	-0.038	-0.103		0.061	0.296	
	(0.041)	(0.043)*	No	(0.140)	(0.152)*	Yes
N	156	507		257	939	
	Malnourished in 1st round	Not malnourished in 1st round		Malnourished in 1st round	Not malnourished in 1st round	
Total public spending	-0.131	-0.032		0.216	0.283	
	(0.045)**	(0.043)	No	(0.277)	(0.124)**	No
N	196	492		129	1086	
	Indigenous	Not indigenous		Indigenous	Not indigenous	
Total public spending	-0.030	-0.103		-0.169	0.346	
	(0.086)	(0.034)***	No	(0.106)	(0.164)**	Yes
N	375	313		208	1006	
	Poor	Not poor		Poor	Not poor	
Total public spending	-0.079	-0.054		0.019	0.239	
	(0.036)**	(0.040)	No	(0.292)	(0.114)**	No
N	371	317		322	892	

Source: Young Lives Study Round 1 and 2, ENAHO 2002, 2006, and Ministry of Economic and Finance Budgetary Expenditure for 2000–6.

Note: Robust standard errors clustered by region-year in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%. Includes regional fixed effects, individual fixed effects, and time fixed effects and all previous controls in the original regression in Table 3. Spending measured in 100 million soles. The instrument for all IV estimations is the amount of unanticipated mining revenues. The instrument is proved to be strong for every sub-sample.

SUPPLEMENTAL APPENDIX

Excluding the rural population: the impact of public expenditure on child malnutrition in Peru

Contents

List of Tables

List of Figures

S1 Peruvian Mining Context

Peru has one of the world's leading mining sectors[28]. This sector has been growing consistently in the last few years with an annual real average growth of 6.5% in its GNP between 2002 and 2006[29]. The prices of minerals have increased dramatically since the beginning of 2002, reaching historic highs in 2006[30]. For example, the price of copper (the second most important metal in Peru) increased by 331% between those years (See **Figures S1.1** and **S1.2**)[31]. Hence the amount of royalties assigned to each region has increased dramatically due both to price increases and production upsurges. **Figure S1.3** illustrates the change in the value of mineral production in each region calculated using 2001 mineral production levels and changes in international prices between 2002 and 2006. Similarly, the value of royalties in different regions for both periods is shown in **Figures S1.4** and **S1.5**.

---

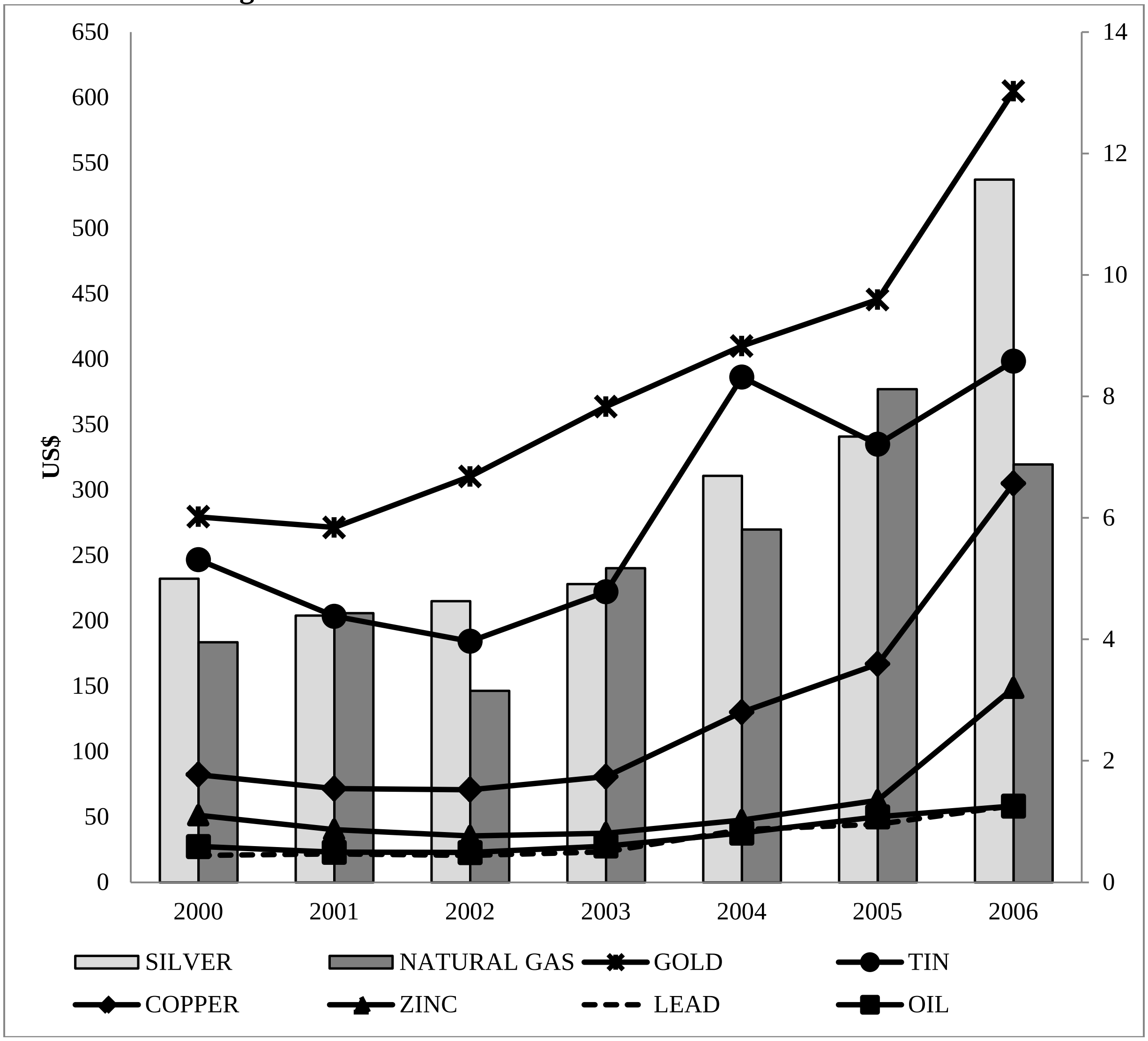
[28] According to statistics from the Peruvian Ministry of Energy and Mines, in 2006 Peru ranked worldwide 1st in the production of silver, 3rd in the production of copper, tin and zinc, 4th in the production of lead, and 5th in the production of gold.

[29] Statistics are from the Peruvian Ministry of Energy and Mines (MINEM).

[30] Between 2002 and 2006 the price of the leading exported metals (presented here in order of importance) increased enormously: silver by 150%, copper by 331%, tin by 116%, zinc by 321%, lead by 185%, and gold by 95%. Source: London Metal Exchange and London Bullion Market Association. Oil and gas prices also soared by 156% and 118% respectively. Source: NGA, annual reports. Oil Patch Research Group.

[31] These massive increases are not the product of a price drop in 2002 as can be seen in **Figure S1.1**, where prices are shown steadily increasing since 2000.

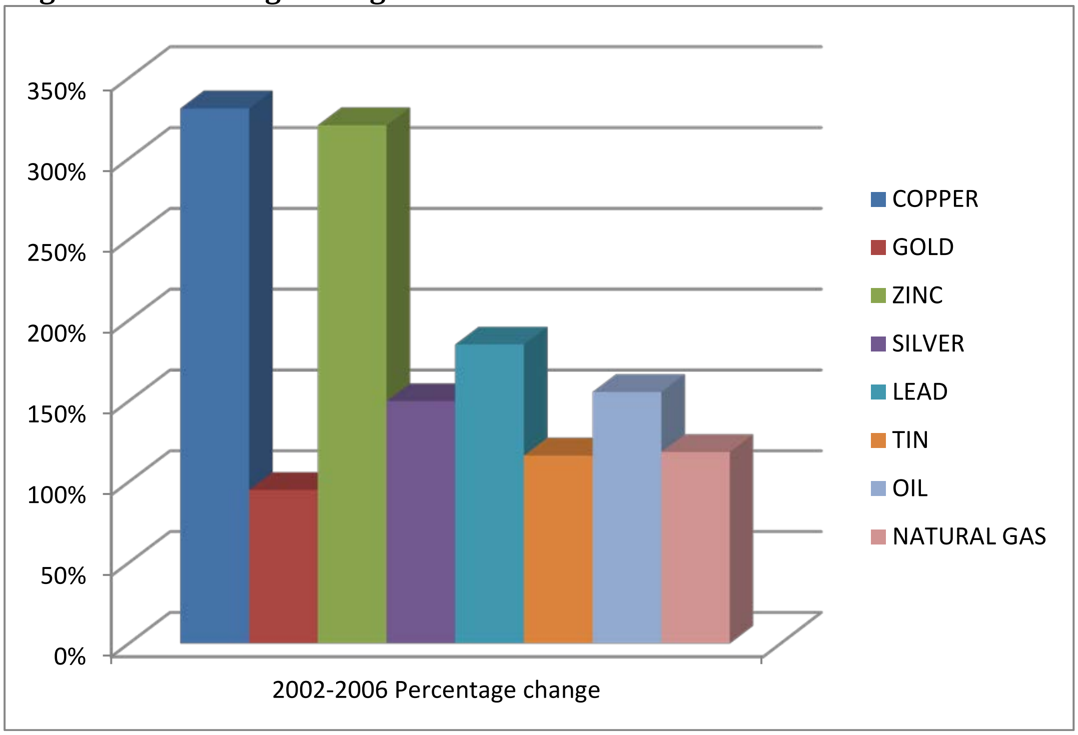
Figure 1: Evolution of World Mineral Prices: 2000–2006



Source: London Metal Exchange and London Bullion Market Association and NGA, annual reports, Oil Patch Research Group

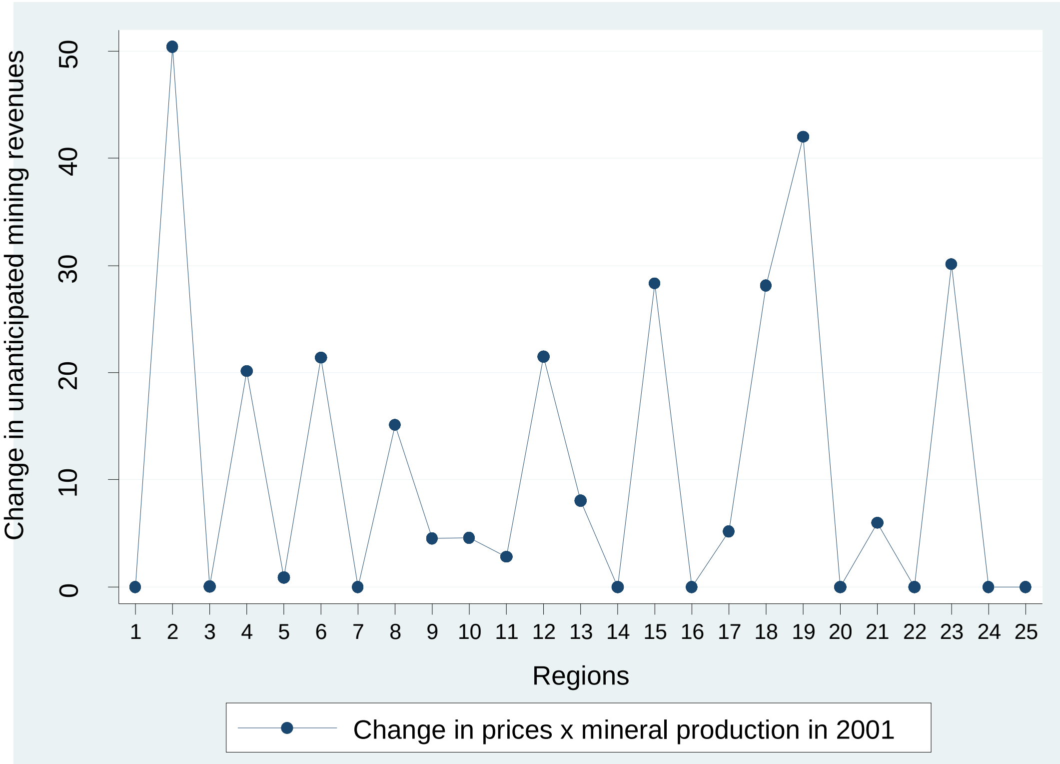
Note: Copper, zinc, lead, and tin are measured in US$/lb., gold and silver are measured in US$/oz.tr. Oil is measured in US$/bbl. and natural gas in US$ per 1000 feet^3. Silver and natural gas are measured on the right vertical axis.

Figure 2: Percentage change in World Mineral Prices between 2002 and 2006



Source: London Metal Exchange and London Bullion Market Association and NGA, annual reports, Oil Patch Research Group

Figure 3: Change in Mineral Production Values between 2002 and 2006 calculated using 2001 production quantities and changes in prices



Source: London Metal Exchange and London Bullion Market Association and NGA, annual reports, Oil Patch Research Group, U.S. Geological Survey, US Energy Information Administration and Ministry of Energy and Mines (2002–2006)

Figure 4: Variation in the amount of royalties assigned to each region in 2002

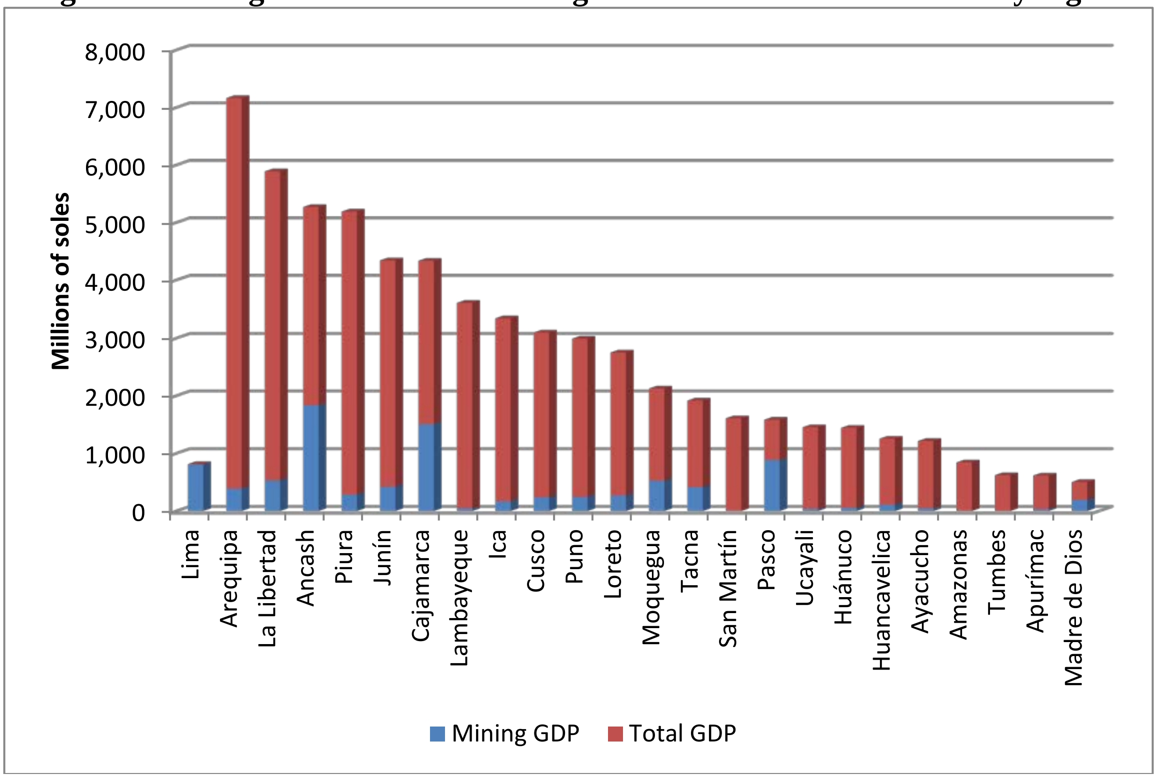
Source: Ministry of Economics and Finance (2002–2006)

Figure 5: Variation in the amount of royalties assigned to each region in 2006

Source: Ministry of Economics and Finance (2002–2006)

Mining in Peru is an economically isolated activity. Almost all mining is surface mining. This type of excavation entails removing soil and rock overlying the mineral deposit for which heavy equipment, such as earthmovers, and dragline excavators or bucket wheel excavators, are used[32]. Hence, the type of mining exploitation carried out in Peru requires great levels of capital investment and small amounts of highly specialized labor. Indeed, the mining sector represented around 6.4% of real GDP between 2002 and 2006[33] (see **Figure S1.6** for regional distribution), yet it employed less than 1% of the labor force[34].

Figure 6: Average total GDP and mining GDP between 2002 and 2006 by region



Source: National Institute of Information and Statistics (INEI)
Note: The total average GDP for Lima (64,710 million soles) has been excluded to better show the relationship between mining GDP and total GDP for the rest of the regions.

[32]This machinery is not produced in Peru, much less in the localities where this exploitation takes place.
[33] Source: National Institute of Information and Statistics (INEI) "Encuesta Demográfica y de Salud Familiar." http://www.inei.gob.pe/.
[34] 0.7% in 2003, 0.8% in 2005, and 0.9% in 2006. Source: Peruvian Ministry of Labor.

S2 Conceptual Framework

S2.1 The Model

I consider the nutritional level of the child (N_t^c) to be a choice that results from the household's efforts to maximize its utility (Becker 1965; Strauss and Thomas 1998; Currie 2000). The household is constrained financially, in time available, as well as by the child's nutritional production function, which is defined as follows:

$$N_t^c = F_N\left(T_t^{nM}, V_t^n, P_t, H_t^c, X_t^c, X_t^M, X_t^H, X_t^C, \mu_t\right) \quad (1)$$

Child nutrition is a result of the time the mother invested to produce a better outcome (T_t^{nM} e.g. time used to take the child to the hospital when sick), the goods purchased to produce a better outcome (V_t^n e.g. nutritious food), nutritional inputs publicly provided at the regional level (P_t: measured by the level of public expenditure in the region), child characteristics (X_t^c), child health status (H_t^c), parental characteristics (X_t^M), household characteristics such as wealth level (X_t^H), community characteristics (X_t^C), and unobserved attributes related to both the mother and the child (μ_t) such as resilience and maternal initiative and determination.

Maximizing household welfare subject to financial and time constraints implies that the child's nutritional status will also depend on the price for nutritional inputs (p_t^n)[35], as well as on the household wealth level[36]. Household wealth was chosen for this study instead of individual income since income data is not available in the Young Lives survey, which I relied upon. Since consumption is a function of wealth, this can be seen as a net cumulative indicator of economic well-being. The survey has a wealth indicator based on a series of household characteristics

[35] The price chosen is the price of rice, the main staple in Peruvian diets. Some of the rice prices were missing, so they were imputed using the province averages to replace the missing values.

[36] I am not able to directly control for income hence the solution to this maximization problem yields a conditional demand function for nutritional outcomes (Pollack 1971).

including flooring, walls and ceiling materials, ownership of goods, toilet facilities, and type of cooking fuel. I create my own wealth score summarizing household characteristics using a principal component analysis.

S2.2 Complementarities between public and private assets

The model used in this study established that the nutritional level of the child is a choice that results from the household's efforts to maximize its utility (Becker 1965; Grossman 1972; Gronau 1977; Wolfe and Behrman 1982; Strauss and Thomas 1998; Currie 2000; Mwabu 2008). This choice is constrained, among other factors, by the child's nutritional production function, which depends on the level of nutritional inputs such as public expenditure. It should be noted that a household's ability to take advantage of public goods and services to improve a child's nutrition is not determined only by their availability (the actual supply) and quality. It is also related to the household's capability and motivation to take full advantage of these goods and services. There can be very strong complementarities between public and private assets[37]. Even though public expenditure increases people's access to free public goods, this does not mean the cost of accessing these public goods and services is zero. Therefore, not everyone will be capable of accessing them. In a country like Peru, where households very close to the poverty line have an extremely high opportunity cost of time, longer waiting times in public health facilities could impose an access barrier. In addition public services provided in a language that differs from the mother's native tongue could be used less frequently or less effectively. A mother with a different native language may be unable to comprehend fully and carry out instructions given by doctors and other public providers.

On the other hand, some parents might be more motivated than others to take advantage of public goods. Parents with more resilient children (as proxied by higher birth weight or higher initial z-scores) could have a differential use of public facilities. These characteristics could not only mediate the impact of public expenditure on the child's nutritional status, but could also interact with other household and community characteristics. Hence I calculate separate estimations for these different subgroups in the results section of the paper.

[37] I define assets in a broad way, not only including material belongings but also taking into account personal characteristics that could be beneficial for the individuals.

S3 DATA SOURCES

S3.1 The Design of the Young Lives Study

The Young Lives study was designed to analyze the changing nature of childhood poverty in four developing countries (Ethiopia, India, Peru, and Vietnam) over 15 years. This is a long-term research project that has tracked the same children since 2000. In Peru the survey consists of a stratified (urban and rural) nationwide sample of over 2,000 children, in 20 geographical sites, ages 6 months to 17 months in 2002[38].

The Young Lives Sampling strategy selected approximately 100 children in 20 different clusters. These clusters were located in 14 different regions. In the first round about 60% of these regions had both urban and rural clusters. However, over 4% of the original sample migrated to a different region during the second round, which increased the number of regions in the sample to 23. In the second round, about 70% of the regions had both urban and rural geographical sites. I tested the existence of an association between unanticipated mining revenues and the classification of areas between urban and rural to rule out any confounding effects. I confirmed that unanticipated mining revenues are not related to the urban–rural divide either in levels or in changes by running a regression of unanticipated mining revenues on a dummy for being in an urban area and controlling for regional and time-fixed effects. I also looked into differences between urban and rural areas for both rounds of the survey and found that the differential access to public health facilities and programs narrows in the second round, with significant increases in rural areas. I tested if mining unanticipated mining revenues explains the narrowing of the differential access to public health centers in urban and rural areas between rounds by running a first difference regression of the change in access to public health centers on the change in unanticipated mining revenues, where all the regressors were interacted with an urban–rural dummy[39]. Changes in unanticipated mining revenues, for either region had no statistically significant differential effect on changes in access to public health centers for rural areas. The survey over-sampled individuals in poor areas and by design excluded the wealthiest 5% of the sample in order to focus more on poorer groups and ethnic minorities. Hence it is not a nationally representative sample, although it is representative of the Peruvian population in a broad array of socio-economic indicators (Escobal et al. 2008).

The Young Lives study has a modest attrition rate. The non-response rate was 4.39% for the younger cohort[40]. Tests for selection bias due to this attrition reveal almost no statistically significant differences between the sample of children who dropped out of the study during the second round and the children who continued in the sample as shown in **Table 1**[41]. The only significant differences at a 5% level of means are for mother's height and the probability of having an immunization program in the child's community[42]. I also test if attrition can be explained by the spending patterns within regions[43]. I find no statistically significant effect of

[38] An additional older cohort of 860 children aged between 7.5 years old and 8.5 years old—and not used in this analysis—was also sampled in 2002.

[39] I controlled for regional and time-fixed effects, as well community characteristics (the average household wealth score in the community, population size, a dummy for living in the highlands, and a poverty index) and regional variables (public spending in the region and debt payments). I cluster my standard errors at the region-year level.

[40] The survey team made sure to track migrating children between survey rounds.

[41] This table contains mean difference tests for a wide range of child, household, community, and region characteristics.

[42] Three other variables show small but statistically significant differences at a 10% level: gender, native tongue and the probability of living in the highlands.

[43] I run a Probit using information from the first round. The dependent variable is the probability of dropping out from the sample and the independent variable is the level of public spending in the region. The specification includes regional fixed effects, child characteristics (age, gender, ethnicity, and health status), maternal characteristics (education), household characteristics (number of children under 5 years of age, availability of drinking water, household size, and wealth score), community characteristics (rice price, population size, a dummy for belonging to the highlands, a dummy for being in an urban area, and a poverty index), and regional variables (debt payments).

public expenditure on the probability of attrition. Moreover the effect is insignificant: a 100 million soles increase in public spending will increase the probability of attrition by 0.01%...

Table 1: Test for mean differences between attrite sample and continuing sample

Variable	Continued		Attrite		T -statistic
	Mean	S.D	Mean	S.D	Ho: diff = 0
Probability of being malnourished	0.17	0.01	0.24	0.05	-1.54
Z-score (height for age)	-0.78	0.03	-0.81	0.17	0.22
Gender	0.50	0.01	0.41	0.05	1.73
Birth weight	3201	12	3188	57	0.23
Age of child in months	11.54	0.08	11.63	0.38	-0.25
Serious illness	0.32	0.01	0.33	0.05	-0.29
Age of mother at birth	27	0.15	26	0.68	1.34
Mother's height	150	0.12	149	0.63	2.18
Maternal mother tongue is not Spanish	0.32	0.01	0.42	0.05	-1.94
Maternal education level	7.56	0.03	7.51	0.10	0.10
Number of children younger than 5 yrs	0.43	0.01	0.49	0.06	-0.97
Household size	5.71	0.05	5.52	0.24	0.76
Drinking water piped into household	0.77	0.01	0.72	0.05	1.11
Household Wealth score	0.01	0.06	-0.21	0.25	0.81
Immunization program in community	0.85	0.01	0.76	0.05	2.57
Number of people living in the locality	4.81	0.09	4.68	0.41	0.29
Highlands	0.50	0.01	0.59	0.05	-1.64
Poverty Index	0.14	0.00	0.14	0.01	-0.73
Urban	0.65	0.01	0.72	0.05	-1.37
Debt Repayment	11.02	0.60	10.70	2.76	0.11
Total Public Spending	29.34	1.28	28.63	5.93	0.12
Unanticipated mining revenues	20.15	23.92	20.97	22.95	-0.31

Source: Young Lives Study Round 1, ENAHO 2002, and Ministry of Economic and Finance Budgetary Expenditure for 2002. Note: Attrite sample: 90 children. Continuing children: 1962

S4 VALIDITY CHECKS

In order for an instrument to be valid it must be exogenous and relevant. I discuss both assumptions in this section.

S4.1 Instrument's validity

Variations in unanticipated mining revenues do not lead directly to an increase in economic activity in the areas where the resource is located. I test that changes in unanticipated mining revenues do not impact changes in consumer price indexes (CPI) for commodities that could affect child well-being (such as food, medicines, and health care) nor do they modify changes in net per capita income. I do so by running panel data models of changes in unanticipated mining revenues on changes in CPI for all these commodities as well as for changes in net per capita income. I use region-year data and I control only for changes in public spending and a year fixed effect. No statistically significant impact is found for any of the specifications (**Table 2**). Secondly, unanticipated mining revenues could be thought to affect health status directly. In order to test this hypothesis I use region-year data and run a panel model. The dependent variable is a change in the probability of a person suffering a chronic illness and the independent regressor is the change in the level of mining revenues. I only control for changes in public spending, regional debt and a year fixed effect. Changes in unanticipated mining revenues do not have a statistically significant impact on changes in the probability of suffering a chronic illness. These results are shown in the last column of **Table 2**. In addition, I used individual data from the Young Lives Study sample of children to verify that changes in unanticipated mining revenues do not modify the predicted probability of suffering a self-reported life threatening illness. Again I found that unanticipated mining revenues do not have a statistically significant effect on changes in this probability as shown in **Table 3**.

Table 2: Impact of changes in unanticipated mining revenues on changes in consumer price indexes, net income per capita and the probability of suffering chronic health problems

Dependent variable	CPI health care	CPI medicines	CPI food consumed at home	Net income per capita	Suffering a chronic illness
Unanticipated mining revenues	-0.10	0.00	0.02	29.47	0.00
	(0.21)	(0.32)	(0.07)	(18.10)	(0.00)
Public spending	0.57	-1.24	1.66	-510.89	-0.03
	(2.77)	(4.18)	(0.97)	(237.15)**	(0.01)*
N	24	24	24	25	25
R^2	0.01	0.00	0.16	0.39	0.15

Source: ENAHO 2002, 2006 and Ministry of Economic and Finance Expenditure Statistics for 2002–2008.
Note: Unanticipated mining revenues and public spending are measured in 100 million soles and net per capita income in soles per year. Controls: regional debt and year-fixed effects. Robust standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%. Geographical Regions 25, for CPI regressions region Callao is omitted.

Table 3: Impact of changes in unanticipated mining revenues on changes in the predicted probabilities of suffering a life threatening illness

Dependent variable:	Predicted Probability of suffering a life threatening illness
Unanticipated mining revenues	-0.023
	(0.135)
Other Controls	YES
N	1902
R^2	0.59

Source: Young Lives Study Round 1 and 2, ENAHO 2002, 2006, and Ministry of Economic and Finance Budgetary Expenditure for 2000–2006.
Note: The estimations include regional-fixed effects, individual-fixed effects, and time-fixed effects. Controls: child's age, z-score of height per age, number of children under 5 years of age in the household, availability of drinking water, household size, wealth score, rice prices in the community, population size, a dummy for living in the highlands, a dummy for being in an urban area, a poverty index, and the level of regional debt payments. Spending measured in 100 million soles. Robust standard errors clustered by region-year in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%.

Finally, households could be migrating to regions with higher levels unanticipated mining revenues. Around 5% of the households in the survey moved to another region. Hence, unanticipated mining revenues could be related to individual preferences[44]. But in fact, unanticipated mining revenues do not have a statistically significant impact on the probability of migrating to another region. The results are presented in **Table 4**. These results are consistent with the assumption that unanticipated mining revenues are indeed exogenous.

Table 4: Impact of unanticipated mining revenues on the probability of migrating to another region by area

Dependent variable:	Probability of migrating	
	Rural	Urban
Unanticipated mining revenues	0.000	-0.000
	(0.001)	(0.000)
Other Controls	YES	YES
N	1360	602

Source: Young Lives Study Round 1 and 2, ENAHO 2002, 2006, Ministry of Economic and Finance Expenditure Statistics for 2002 –2006.
Note: Public Spending and Unanticipated mining revenues are measured in 100 million soles. Controls: poverty index and total public spending. Robust standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are clustered by region. Geographical Regions: 23. Marginal effects calculated at the means.

S4.2 Changes in the composition of regional public expenditure

The results obtained suggest public expenditure in rural areas is not effective due to the inadequate quality and quantity of public services. This theory might help us understand how malnutrition disparities could be increasing between urban and rural areas despite an increase in average public expenditure. Yet, it is also possible that the type of expenditure made in each region drives the results.

[44] I test this hypothesis by running a reduced form Probit regression. The dependent variable is the probability of moving (a dummy variable that indicates if the child migrated to another region) and the independent regressor is the level of regional mining revenues. I use a poverty index and the level of government spending as controls and I cluster the estimates by region.

We have to consider that regional governments with higher levels of royalties due to larger mining revenues could have different patterns of expenditure than other regions. Regional governments that receive more royalties could spend more in sectors that directly influence child health, such as health and sanitation. This could bias the results. Following Altonji and Card (1991), I avoid introducing any bias that might be due to the amount of unanticipated regional mining revenues, by using the expenditure structure present in 1999 to generate the fraction spent in each sector in 2002 and 2006. In 1999, most regions (56%) did not receive royalties and the royalties represented only 1.7% of total expenditure. Due to changes in the law in 2002[45], the percentage of mining income assigned to royalties increased greatly. During 2002 and 2006 royalties represented on average 5.6% of total expenditure, furthermore, 92% of regions received royalties. In order to test the hypothesis that the type of expenditure made in each region could be driving the urban–rural impact differential, I run a regression that measures the impact on nutritional outcomes of the total amount spent on education, poverty alleviation programs[46], health, sanitation, transport, and agriculture in each region. These are the most important expenditure groups in terms of average regional participation in total spending[47], but most importantly they are also the ones that could most directly be related to improvements in the nutritional status of children. In addition, per capita expenditure in each of these areas increased dramatically during the study period (2002–2006). Educational expenditures grew by 35%, expenditure in poverty alleviation programs by 16%, health and sanitary infrastructure spending by 38%, transportation expenditures by 40%, and agriculture by 19%.

[45] In January 2002 the Mining Canon Regulations (Supreme Decree No 005-2002-EF) were approved. This meant that starting in the year 2002 regional and local governments would be entitled to 50% of the income and rents obtained by the central government from the exploitation of mining activities in their jurisdictions (Mining Royalties). Before 2002, this percentage was only 20%.

[46] This sector finances most nutritional interventions in Peru.

[47] Education represented 35% of the average regional total spending, poverty alleviation programs 27%, health and sanitary infrastructure 14%, transport 9%, and agriculture 5%.

I did not separate these categories but used their summation since these spending categories could interact with each other in affecting z-scores. The instrument used in this estimation is constructed by multiplying the sum of the region-specific share of expenditures given to each of these types of spending in 1999 with the total amount of unanticipated regional mining revenues. It should be noted that the remaining types of spending categories are not included since they have no direct relationship with child nutrition[48]. According to the results presented in **Table 5**, spending, in the categories included, explains variations in the z-score of children for both urban and rural areas. In rural areas there is again a very small but negative effect of changes in public spending on z-scores, which is almost identical to the one obtained using all expenditure categories. In urban areas, there is a positive and statistically significant effect which is slightly larger than the average effect of all expenditures. There is a 0.250 improvement in z-scores per additional 100 million of soles spent. In terms of overcoming the urban–rural gap these results translate into these categories of spending and explain 39% of the increase in this gap (39% for boys and 38% for girls). This result is smaller than the 62% closure in the gap obtained when including total expenditure without taking into consideration possible changes in the composition of expenditure categories within regions. These results indicate that changes in royalties might have changed the structure of expenditure in each region however these changes are not driving the results in urban areas. The changes in expenditure composition only explain a fraction of the impact of total spending. After controlling for changes in composition, there is still an important portion of the urban–rural gap that changes in public spending are able to explain.

[48] These spending categories include: Administration, Justice, Defense, Energy, Labor, Fishing, Industry, Housing, Communications, Exterior, and Legislature. They only represent around 10% of the average regional spending between 2002 and 2006.

Table 5: IV Panel Data Estimation - Impact of changes in public expenditure of key government sectors on changes in a child's nutritional level by area

Dependent variable:	Z-score (height for age)	
	Rural	Urban
Total Public Spending in key sectors	-0.079	0.250
	(0.030)**	(0.139)*
Other Controls	YES	YES
N	688	1,214

Source: Young Lives Study Round 1 and 2, ENAHO 2002, 2006 and Ministry of Economic and Finance Budgetary Expenditure for 2000–2006.

Note: each coefficient represents an independent regression. Robust standard errors clustered by region-year in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%. They include regional-fixed effects, individual-fixed effects, and time-fixed effects and all the controls used in the main regressions. Spending measured in 100 million soles. The instrument for the IV estimations is the amount of unanticipated mining revenues multiplied by the summation of the region-specific share of expenditures given to education, poverty alleviation programs, health and sanitation, transport, and agriculture in 1999.

S4.3 Assessing the instrument's strength for the selected spending categories

According to the first stage regression parameters (see **Tables 6**) the instrument is relevant for the whole sample as well as for rural and urban areas. It is significant at a 1% level for all specifications and it displays a positive and non-immaterial effect on the level of expenditure in the most important sectors (health and sanitation, education, poverty alleviation programs, transport, and agriculture). For example, an increase of 100 million soles in the amount of unanticipated mining revenues will increase the level of selected expenditure by 1,142 million soles and 640 million soles in rural and urban areas, respectively. The multiplier effect is especially big in rural areas probably due to the distribution rule inside regions, which favored rural areas[49]. Both specifications have an F statistic that ensures that the IV estimator is strong according to Stock et al. (2002).

[49] Inside the region, royalties were distributed by the central government according to the following rule: 20% went to the district and provincial governments of the province where the natural resource was located (distributed according to population density but weighing the rural population double the urban population to give preference to rural areas), 60% went to the district and provincial governments of the region where the natural resource was located (distributed simply according to population density), the remaining 20% went directly to the regional government. In July 2005, the intra-regional distribution rules for mining royalties were modified by the law 28322. Yet since the distribution of royalties is done with 18 months of delay it should only affect royalties starting in 2007.

Table 6: First stage estimation - Impact of changes in unanticipated mining revenues on changes in public expenditure for key categories, by area

Dependent variable:	Public Spending	
	Rural IV	Urban IV
Unanticipated mining revenues	11.424	6.397
	(0.434)***	(0.196)***
Other Controls	YES	YES
Number of observations	688	1,214
Partial R^2 of excluded instrument	0.513	0.473
F-test for weak identification	692	1063

Source: Young Lives Study Round 1 and 2, ENAHO 2002, 2006, and Ministry of Economic and Finance Budgetary Expenditure for 2000–2006.
Note: The independent variable is the amount of unanticipated mining revenues. The estimations include regional-fixed effects, time-fixed effects, and all controls included in the 2nd stage estimation. Spending measured in 100 million soles. Robust standard errors clustered by region-year in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%. They include regional-fixed effects and time-fixed effects.

S5 ALTERNATIVE INTERPRETATIONS OF THE RESULTS

S5.1 Differences in public spending quality between urban and rural areas

When public expenditure expands in rural areas this could lead to the displacement of more effective private services (e.g. pediatricians) as demand switches to the cheapest public service (public health center). Given that rural markets are very small, it is quite possible that an enlarged public sector could leave no space for the private sector to make a profit. This could have a harmful effect on child well-being if public health centers (the only access measure increasing in rural areas) are less effective than other health facilities. This is probably the case since neither doctors nor nurses work at public health centers. These centers are equipped with health technicians who provide care following manuals which guide and limit their functions. Furthermore the high rates of absenteeism and irregular working hours that usually characterize poorly monitored public health facilities in rural areas (Devarajan and Reinikka 2004; Chaudhury et al. 2006; Banerjee and Duflo 2011) will reduce the effectiveness of the services rendered. Chaudhury et al (2006) conducted a survey focused on the presence of teachers and health workers at public primary schools and primary health centers in several countries including Peru. They found that 44% of health workers in Peru were absent at least once during two unannounced visits. Moreover, the absence rate was higher in rural areas.

To investigate whether public spending is indeed less effective in rural areas due to differences in quality, I assess the impact of public expenditure on alternative child health outcomes. The results are found in **Table 7.** I ran two IV panel specifications where the probability of suffering a life threatening illness and the weight for height z-score of children are the dependent variables. In rural areas increases in public spending increase the probability of suffering a life threatening illness and reduce weight for age. In contrast, in urban areas public expenditure has not statistically significant impact on these outcomes. The results support the claim that rural areas have less effective public services[50].

Table 7: IV Estimation - Impact of changes in public expenditure on changes in child health outcomes by area

Dependent variable	Probability of suffering a life threatening illness		Z-score (weight for age)	
	Rural	Urban	Rural	Urban
Total Public Spending	0.060	0.074	-0.128	0.038
	(0.022)**	(0.047)	(0.026)***	(0.052)
Other Controls	YES	YES	YES	YES
N	701	1228	693	1216

Source: Young Lives Study Round 1 and 2, ENAHO 2002, 2006, and Ministry of Economic and Finance Budgetary Expenditure for 2000–2006. Note: Robust standard errors * Significant at 10%; ** significant at 5%; *** significant at 1%. Spending measured in 100 million soles. The instrument for all the IV estimations is unanticipated mining revenues. For all estimations the IV is strong. In all specifications I used as controls child's age, household characteristics (number of children under 5 years of age, availability of drinking water, household size, and wealth score), community characteristics (price of rice, population size, a dummy for living in the highlands, and a poverty index) and the level of regional debt payments. In addition, for the 1st estimation I include controls for water and air pollution as well as the predicate height for age z-score of the child (calculated using rice prices). In the second estimation I include a control for predicted health status. I clustered the standard errors at the region-year level and I used individual, time, and regional fixed.

[50] In all specifications I used as controls child's age, household characteristics (number of children under 5 years of age, availability of drinking water, household size, and wealth score), community characteristics (price of rice, population size, a dummy for living in the highlands, and a poverty index) and the level of regional debt payments. In addition, for the 1st estimation I include controls for water and air pollution as well as the predicate height for age z-score of the child (calculated using rice prices). In the second estimation I include a control for predicted health status. I clustered the standard errors at the region-year level and I used individual, time, and regional fixed.

S5.2 Exclusions at work

S5.2.1 The impact of public spending according to child resilience

Children with a lower birth weight may be more fragile and less resilient. Parents with more resilient children could either use public facilities less than the average mother (confidence selection[51]) or be more intense users of public services (favorable selection[52]). To evaluate these contrasting hypotheses I divide the children in two groups: those belonging to the lowest birth weight quartile and those belonging to the other quartiles[53].

I found a contrasting positive impact of public spending on the nutritional level of children who are above the 25th birth weight percentile in urban areas and a negative impact on rural ones. To understand the results for rural areas it is necessary to consider again the possibility of the crowding out of higher quality private goods and services by lower quality public goods and services. According to previous results, the availability in the community of certain services such as child growth controls is reduced when public spending increases. The children of mothers who actively look for these services (the ones with the most resilient children according to the favorable selection hypothesis) would be the ones who could be more hurt by this crowding out effect.

S5.2.2 The impact of public spending according to child's initial nutrition status

If poor early life health outcomes magnify as time passes, children with a lower height for age z-score during the first round will not be able to "catch up" to the healthiest children and

[51] Mothers whose pregnancies are full term and whose children have higher birth weight could consider their children to be at a very low risk of having a poor nutrition outcome. These women may delay care and only take their children to sporadic checkups (Frick and Lantz 1996).

[52] Mothers with more resilient children are mothers who took better care of themselves during their pregnancies. These health-conscious women probably see their resilient children as an investment and are motivated to use public goods and services to take good care of them. Also, they might adhere more firmly to health providers' advice and so promote a better outcome in their children (Frick and Lantz 1996).

[53] There were 270 children that did not have information about their birth weight. If this information was not available, children prematurely born were considered to be in the lowest birth weight quartile. Children with missing data for birth weight and born not prematurely were not included in the estimation.

differences will persist over time (Bozzoli et al. 2009). Widening rural–urban differences in nutritional status would then just be a reflection of the mechanical relationship between health in the past and in the present given that rural children had initial worse height for age z-scores than urban children. If early nutritional status is the only determinant of future nutritional status we will see an impact of public spending in both urban and rural areas but only for initially healthy children. This is not the case as public spending has a positive impact again only in urban areas and furthermore the differential impact across subsamples is not statistically significant.

S5.2.3 The impact of public spending according to maternal mother tongue

Another personal characteristic that could influence access and demand levels of public goods and services is maternal mother tongue. Specifically a mother whose mother tongue is not Spanish (the official language) will face difficulties. The language barrier could decrease her ability to comply with medical advice or to comprehend publicly available information related not only to health but also to hygiene and feeding practices. This limitation could increase the risk of acquiring infectious diseases and decrease the ability of fighting them better. In addition, non-Spanish speakers, when visiting a public facility, might not be able to communicate adequately with the service providers. This inadequacy could create in these mothers a lack of self-confidence and a fear of inferior treatment (Rogers et al. 2002). These premises are shown to be well founded, since the results show only mothers whose mother tongue is Spanish benefit from public spending in urban areas.

S5.2.4 The impact of public spending according to household wealth level

In general, one can consider public goods and services to be free. Nevertheless, in order to be able to consume them, the household has to give up valuable time that could otherwise be used for other productive activities. Longer waiting times in public health facilities will increase the cost of taking children there. This cost will increase as the household's opportunity cost of time increases. Households very close to the poverty line in Peru have an extremely high opportunity cost of time. Poor households in Peru are characterized not by unemployment but by underemployment[54]. The poor usually have multiple low paying jobs that, in conjunction, entail long hours. Taking a child to a public health facility with long waiting times could mean that parents will not be able to earn enough income to feed the rest of their family. Households below the regional household wealth median are considered to be "poor" given that during that period the average per capita income for those households was the equivalent of $719[55]. This hypothesis is not confirmed in the data since even though only children form urban households who are not considered "poor" are benefiting from increases in public spending, the differential impact across subsamples is not statistically significant.

[54] According to the 2005–2010 Permanent Employment Survey, during 2006 only 8% of the labor force in Metropolitan Lima was unemployed. However of the remaining 92%, 52% was underemployed.

[55] There is no information about income in the Young Lives Study. To create an income measure I estimated an OLS regression using information from the ENAHO surveys. I regressed per capita income on age, education level, insurance ownership, type of toilet facility, household size, household wealth score, regional public expenditure level, a time dummy, and regional dummies. Using the estimated coefficients, I estimated predicted per capita income for the sample in the Young Lives Study. Then I calculated the mean value of this predicted income for households with wealth scores below the regional household wealth median and for households above the median annual predicted per capita income of $1,311.

References

Altonji, J. and D. Card. 1991. "The Effects of Immigration on the Labor Market Outcomes of Less-Skilled Natives." In *Immigration, Trade and the Labor Market*, edited by J. Abowd and R. Freeman,201–234. Chicago, IL, University of Chicago Press.

Becker, G. 1965. "A Theory of the Allocation of Time." *Economic Journal* 75: 493–517.

Bozzoli, C., A. Deaton, and C. Quintana-Domeque. 2009. "Adult height and childhood disease." *Demography*, 46(4): 647–669.

Currie, J. 2000. "Child Health in Developed Countries." In *Handbook of Health Economics*, edited by A. J. Culyer and J. P. Newhouse,.1 (19): 1053–1090. Elsevier.

Escobal, J., S. P. Ames, S. Cueto, M. Penny, and E. Flores. 2008. "Young Lives: Peru Round 2 Survey." *Young Lives: An International Study of Childhood Poverty Country Report*.

Frick, K.D. and P.M. Lantz. 1996. "Selection Bias in Prenatal Care Utilization: An Interdisciplinary Framework and Review of the Literature." *Medical Care Research and Review* 53(4): 371–396.

Gronau, R. 1977. "Leisure, Home Production and Work – The Theory of the Allocation of Time Revisited." *Journal of Political Economy* 85(6): 1099–1123.

Grossman, M. 1972. "On the Concept of Health Capital and the Demand for Health." *Journal of Political Economy* 80(2): 223–255.

Mwabu, G. 2008. "Health Economics for Low-Income Countries." In *Handbook of Development Economics*, edited by T. Paul Schultz and John A. Strauss (4)53: 3305–3374.

Pollack, R.A. 1969. "Conditional Demand Functions and Consumption Theory." *The Quarterly Journal of Economics*. 83 (1): 60–78.

Rogers, B., S. Rajabiun, J. Levinson, and K. Tucker. 2002. "Reducing Chronic Malnutrition in Peru: A Proposed National Strategy." *Tufts Nutrition*, Discussion Paper 2.

Stock, J. H., J. Wright, and M. Yogo. 2002. "A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments." *Journal of Business & Economic Statistics* 20(4): 518–529.

Strauss, J. and D. Thomas. 1998. "Health, Nutrition, and Economic Development." *Journal of Economic Literature* 36 (2): 766–817.

Wolfe, B. and J. Behrman. 1982. "Determinants of child mortality, health and nutrition in a developing country." *Journal of Development Economics* 11(2):163–193.