Government Spending Multipliers and Distribution of Commodity Booms in the Spatial Economy*

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Abstract

This paper examines government spending effects using regional data from Peru. Identification relies on increased sub-national funds from a mineral price boom and predetermined redistribution rules, which I use to calculate a local open economy relative multiplier and assess impacts on households, workers, and firms. Findings show spending raises relative output, wages, expenditures, and income but not labor or value added. To address this discrepancy, I incorporate insights from trade theory. Spatial Auto-Regressive analysis supports these insights and provides evidence that trade-related indirect effects on output are as important as local direct effects.

Keywords: Fiscal Multiplier, Interregional Trade, Commodity Boom, Spatial Econometrics

JEL Codes: C31, E62, O13, Q33, R12

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1 Introduction

The importance of fiscal policy as a stabilization tool has been actively revisited in recent years, especially since the global financial crises exposed limitations of monetary policy (Ramey, 2019). In developing economies, fiscal policy is not only regarded as a means of stabilization but also as a tool for bridging infrastructure gaps, improving socioeconomic outcomes related to public services, and fostering overall development. In these contexts, internal trade and migration costs, and other geography-related barriers are more heterogeneous than those in the United States and Europe, where most of the available research on the topic focuses.

Recent empirical macroeconomic research has focused on using plausibly exogenous local-level variations in government purchases to estimate local fiscal multipliers. This evidence, sometimes supported by model-based aggregations, has narrowed the range for spending multipliers to 0.6 to 1[1]. However, there is still surprisingly little research incorporating the spatial transmission of local spending. This paper addresses that gap by providing a new analysis of the impact of local government spending in Peru, that incorporates how trade between locations affects the fiscal multiplier.

Although the geography of trade within a country is relevant in almost every developing economy, especially those with varied landscapes, Peru provides an ideal setting for studying this question from the point of view of identifying plausibly exogenous sources of variation in local spending. I begin by describing the setting and how the Peruvian natural resources revenue redistribution rules enabled an increase in available funds to local governments through transfers from the central government. Two features of these rules make these transfers as reasonable instruments for local government purchases. First, the allocation of funds included districts and provinces not directly involved in extractive sectors. Second, the redistribution rules were fixed before the commodity price boom in the 2000s, which increased many of Peru's main exports. Revenue growth led to increased local government funds driven by international conditions, rather than endogenous local conditions or counter-cyclical policies.

Next, I conduct first an empirical analysis of the relative effects of government spending following a standard approach that does not explicitly incorporate spillovers. This step aims to provide a baseline reference point to test the influence of the identification strategy in the estimations. I use the resources-related transfers stated at the start of each year as the instrument for the actual local government spending by the end of the corre-

[1]See Nakamura and Steinsson (2018); Ramey (2011, 2019); Chodorow-Reich (2019) for reviews of the literature. Reviews that pay special attention to developing countries can be found in Sheremirov and Spirovska (2022); Ilzetzki, Mendoza, and Végh (2013); Restrepo (2020); Raga (2022).

sponding year. I focus on two separate sets of outcomes. First, I analyze outcomes measured using data from household and firm surveys, which include information on income, expenditure, production, investment, and wages at the household, worker, and firm levels throughout the country. I find that, after controlling for the direct effect of mining production, provinces with higher transfer-induced increases in expenditure experienced relative increases in income, household expenditures, and wages. Second, I estimate an open economy relative local multiplier of 0.376 for government investment spending. The impacts on household income and expenditures, and on wages, align with such multiplier. However, there is no corresponding rise in labor—neither in terms of employment at the extensive margin nor in work hours—nor in the value added by formal firms in provinces that gain the most from government spending compared to those with less fiscal stimulus. These results motivate the need to explicitly characterize the spatial mechanisms through which local spending affects local activity. I attribute the absence of a labor and value-added response of the same extent as income, expenditure, and wages to frictions that affect labor mobility more than trade of goods.

To interpret this trade-related mechanism in the simplest setup, I incorporate local government spending into a quantitative spatial model as location-based directed transfers. This framework allows me to characterize the comparative statics of spending changes consistent with theoretically-founded expressions of intranational trade. From the model's equilibrium conditions, potential SUTVA violations and omitted variable bias from ignoring trade-related propagation mechanisms can be explicitly identified. I demonstrate that these indirect effects are a function of bilateral trade costs and a multiregional dependence term, which measures the degree of substitution between goods in different locations. These conditions are then mapped into an empirical specification using a Spatial Auto-Regressive (SAR) model. The estimates suggest that the indirect effects of local spending, through trade-related spatial spillovers, can exceed direct local effects. The main takeaway from this analysis is that estimations excluding these mechanisms provide lower bounds of the true aggregate effects.

This paper contributes to the body of empirical research that estimates fiscal multipliers using local variations. From a empirically methodological point of view, the baseline procedures align with studies like those in Barro and Redlick (2011); Nakamura and Steinsson (2014); Auerbach, Gorodnichenko, and Murphy (2020); Acconcia, Corsetti, and Simonelli (2014), among others, who estimate fiscal multipliers by regressing regional growth rates against spending changes relative to lagged per capita production to measure coefficients that can be interpreted as spending multipliers consistent with the theoretical framework pioneered by Barro and King (1984). I contribute to this literature in two ways. First, I exploit plausibly exogenous windfall shocks to local budgets, which translate into purchases, rather than focusing on specific government purchases as most of this literature does, typically military spending associated with procurement for buildups or wars. Using budget-driven spending increases provides the advantage of evaluating heterogeneous effects depending on what local governments purchase, which is key to properly characterizing aggregate effects of government spending (Cox, Müller, Pasten, Schoenle, & Weber, 2024). Second, I complement recent empirical work that explores spatial spillovers— for instance, (Feyrer, Mansur, & Sacerdote, 2017; Cox et al., 2024; Auerbach et al., 2020)— by examining these spillovers with a trade-related theoretical foundation whose equilibrium conditions map to established procedures of spatial econometrics.

This approach of guiding the cross-sectional analysis of government spending through space with a structural foundation is related to recent work by Flynn, Patterson, and Sturm (2022); Baqaee and Farhi (2018); Bouakez, Rachedi, and Santoro (2023), who rely on input-output network analysis, and more closely to Norris (2019), who characterizes fiscal multipliers through the lens of a trade model. Compared to these efforts, the setting I study allows me to focus on spending that is not financed through taxes, which enables an emphasis on the spatial transmission channel and mapping equilibrium conditions to explicit reduced-form spatial auto-regressive estimations.

Lastly, my results also contribute to the very active literatures on (i) the transmission of commodity price fluctuations (Schmitt-Grohé & Uribe, 2018; Drechsel & Tenreyro, 2018; Fernández, González, & Rodriguez, 2018; Mendoza, 1995; Kose, 2002), and (ii) the effects of resource windfalls (Caselli & Michaels, 2013; Arellano-Yanguas, 2019; Loayza & Rigolini, 2016; Orihuela & Echenique, 2019; Aragón & Rud, 2013; Arellano-Yanguas, 2019). In relation to the first, my findings highlight that government spending is an important mechanism channel of commodity price booms related to mining, which explains why non-mining sectors in Peru also experienced rapid growth during the period of analysis, even though mining is a sector otherwise not connected with the rest of the economy.[2] Regarding the second, this paper relates to other recent studies in Peru that take advantage of these windfall transfers, particularly to Agüero, Balcázar, Maldonado, and Ñopo (2021), who find positive effects on school performance; Aragón and Winkler (2023), who find no evidence of significant improvements in access to public services, poverty, or inequality; and most closely to Bancalari and Rud (2024), who focused on the response of local economic activity to these transfers. In contrast to the latter, who focus on a sparse population of non-extractive districts in order to take advantage of clean and likely SUTVA-compliant

[2] For example, in 2007, it employed just 1 percent of the total labor force and required only 2 percent of the goods and services provided domestically (Cuba & Toma, 2024).

identification that excludes the influence of spatial spillovers, I incorporate all local spending at the district and province levels—including mining-producing locations—because my goal is to measure the role of those spillovers when they exist.

The rest of the paper continues as follows. First, I describe the data sources in Section 2. Next, Section 3 details the institutional framework and the commodity boom that are the focus of this study. Then, Section 4 introduces an identification strategy to examine the responses of households and firms, and estimate open economy relative local spending multipliers. After a discussion of the previous results, in Section 5, I proceed to incorporate inter-regional trade in the analysis, using a theoretical model to provide intuition and a SAR model to obtain new empirical estimates. Section 6 provides some extensions and robustness checks. Finally, Section 7 concludes the paper with a synthesis of its contributions and outlines the next steps.

2 Data

Throughout the paper, I use different datasets that allow me to measure the effect of local spending on output at the local level, as well as on economic activity in households and firms across Peru. All the raw data for these datasets are publicly available from various sources. The current version of the paper provides results based on data from the years 2011 to 2016; however, complete processing of the data will allow the use of information from 2007 to the present. This section briefly describes the sources and contents of these datasets.

Budget and spending

Budget and spending data is published online in the website *Transparencia Económica* (MEF, 2023) of the Ministry of Finance. The data provide comprehensive information on planned and executed expenditures and funding sources, all of which are disaggregated by categories, time, rate of execution, location, and administrative spending units. They are available at the country, region, province, and district levels since 2007. In this paper, I use both district and province-level data, aggregated to the level of the 194 provinces of Peru. For example, for a given province, the spending I consider is made by the province-level spending executing unit, as well as all the district-level units located within that province.

National Household Survey (*Encuesta Nacional de Hogares*, ENAHO)

This survey is collected by INEI and it is Peru's main survey on living standards. The survey contains information related to diverse socioeconomic characteristics of households and individuals. The employment module includes data on occupation, earnings, and time use by activity, as well as earnings from non-wage work and self-employment for individuals older than fourteen years. It also enables the identification of household expenditures, consumption quantities, and unit values, disaggregated by regions and commodities.

Annual Economic Survey (*Encuesta Económica Anual*, EEA)

This survey is conducted by INEI on an annual basis for national accounting and sector analysis. It is mandatory for all formal firms that are selected or that have net sales above a certain threshold for the corresponding year's sample. In practice, it serves as a census for all medium and large firms. The format of the survey resembles standard financial statements tailored to each industry. These statements include information on sales, revenues, costs, exports, value added, salaries, staff numbers, fixed assets, value of plant and equipment, and other assets and liabilities. It covers firms in all sectors except for those in mining and extractive industries, which instead report the results of their activities to the Ministry of Energy and Mines.

GDP Data

To obtain output data at the province level, I combine the official information in national accounts published by the national statistics agency (*Instituto Nacional de Estadística e Informática*, INEI) with subnational estimates of output and growth as performed by Seminario and Palomino (2022). Seminario and Palomino (2022) provide GDP estimations for the 1,874 Peruvian districts from 1992 to 2018 expressed in 1990 Geary-Khamis dollars. To make these estimations, they follow a methodology based on Geary and Stark (2002), and Henderson, Storeygard, and Weil (2012) using household-level income data, population density series, and satellite luminosity data from the National Geophysical Data Center (NGDC) and the National Oceanic and Atmospheric Administration's (NOAA) datasets. For this paper, I aggregate the results from Seminario and Palomino (2022) at the province level to calculate each province's share of GDP relative to the regions to which they belong. Then, I use these shares to disaggregate the INEI's official GDP series for the 24 regions of Peru, which are available from 2007 to 2022 and measured in the local currency, into series for the 194 provinces. These estimates, of course, do not have the same quality as more aggregate output data or other indicators of economic activity such as employment or the ENAHO or EEA survey data. This limitation, however, is not exclusive to my context, but also common to other countries, including the US. For this reason, as surveyed by (Chodorow-Reich, 2019), many geographic cross-sectional studies report employment multipliers rather than output multipliers.

Mining Production

The source of information for mining activity is the production reports published by the Ministry of Energy and Mines. These reports are elaborated based on official statistics, which are reported monthly and directly by mining firms in the country. The production reports facilitate the measurement of metric tons of production by location. To aggregate them into production values at the province level, I compile the production quantities from all mines in each province and use the yearly international prices of the country's main minerals—which include copper, gold, iron, lead, silver, tin, and zinc—to express them in current USD.

Geography and Demographic Information

To construct the indicators defined in the Empirical Strategy section, I complement the data mentioned above with information from other sources, including local population projections at different levels provided by INEI, and geographic data on political boundaries and locations in shapefile format supplied by Peru's official cartographic agency, (*Instituto Geográfico Nacional, IGN*).

3 Background

I introduce my identification strategy by providing information on the significance of the extractive sector in Peru, detailing how the government capitalizes on its resources, and explaining the redistribution of local revenues across the country. Additionally, I describe how the commodity boom starting in the late 2000s provides a means to plausibly measure exogenous sources of increases in local spending nationwide.

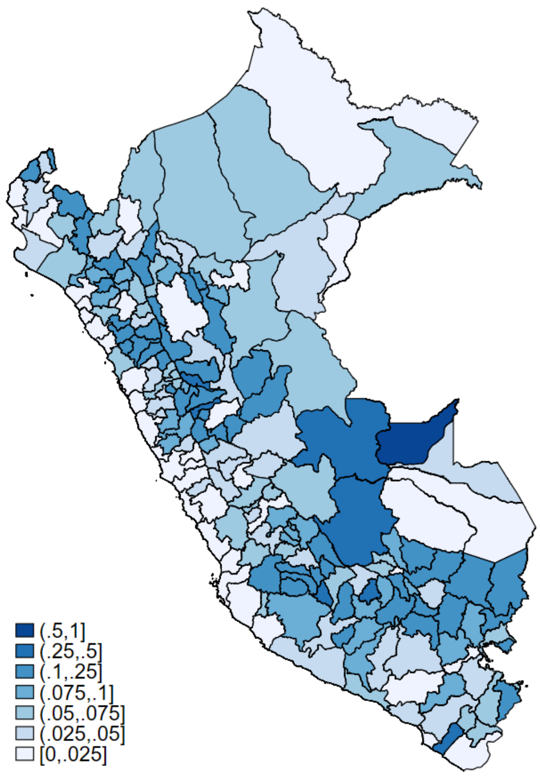
Peru is a middle-income economy endowed with diverse natural resources. Throughout its history, the country's economic development main driver has varied in response to global demand trends. Mining, in particular, has played a key historical role since colonial times, profoundly influencing the nation's institutional framework, with effects that persist to this day (Dell, 2010). However, post-independence, the sector's economic significance has seen considerable variation. Over the last 125 years, mining exports have ranged from 10% to 70% of the total exports (Orihuela & Echenique, 2019). A consistent trend through this period is that the mining output has almost invariably been exported directly overseas (Tamayo, Salvador, Vásquez, & Zurita, 2017), as it was during the colony.

One institutional trait that persists since the nation's birth, despite many reforms, is the state ownership of natural resources. Minerals, oil, gas, fisheries, and forestry are all properties of the central government. The current legal basis for mining production was set in the National Constitution of 1993 (Art. 66), which allows the private sector to conduct extractive operations while the state retains ownership. Since then, all formal mining production in Peru operates under concession agreements, with transnational firms frequently at charge.[3]

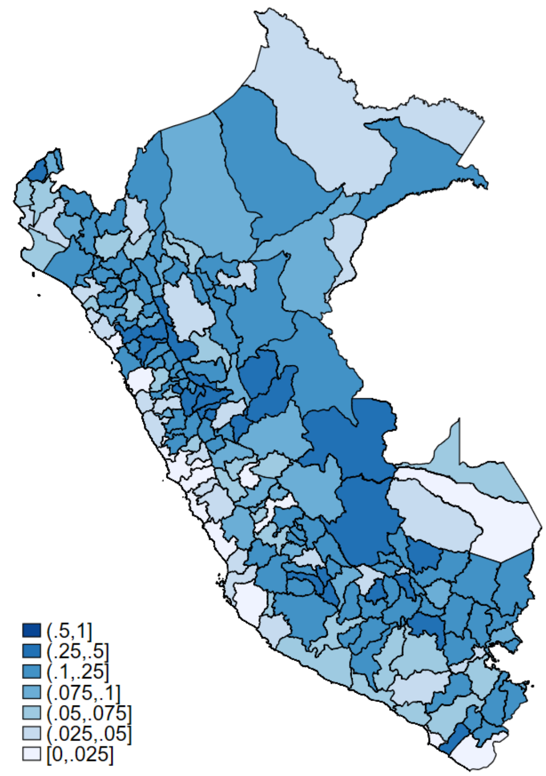
A recent political-administrative process that is relevant for the collection and redistribution of resources from mining is the decentralization process the country underwent. While it was part of a broader regional trend in Latin America (Brosio & Jiménez, 2012), Peru's decentralization was expedited in the early 2000s due to political pressures following the fall of Fujimori's centralized and authoritarian regime (Arellano-Yanguas, 2019). Initiated in 2001 and completed by 2007, the decentralization process led to the establishment of regional governments and expanded administrative autonomy for existing province- and district-level municipalities, including increased responsibility for planning and executing spending. During the period this paper examines, local spending—comprising both district and provincial expenditures—equated to about 10.8% of the GDP for the median province (6.5% for investment spending alone). Figure 1 illustrates

[3]This does not strictly apply to all extractive sectors. Particularly, in the oil industry, the main state-owned company, PetroPeru, was not part of the privatization efforts of the 1990s.

the spatial distribution of local government size relative to province-level GDP for the year 2016.



(a) Local Public Investment Spending as a share of GDP



(b) Local Total Government Spending as a share of GDP

Figure 1: Government relative size at the province level - 2016

Notes: Calculations made using data from the National Institute of Statistics, the Ministry of Finance, and Seminario and Palomino (2022).

The decentralization process established guidelines for the distribution of revenues from natural resources, as stipulated in Law 27506 (Congreso de la República del Perú, 2001), which became effective in 2004 following certain amendments and the ratification of its regulations. According to the law, "canon" refers to the share of income and rents derived from natural resources that regional and local governments are entitled to. The central government collects the canon and redistributes it to local governments for it to be used in public investment projects. Specifically for mining[4], the "Canon Minero" equals 50% of the income tax collected from mining activities, which stands at 30%. The distri-

[4]While the redistribution rules for other natural resources are based on similar frameworks, their specific regulations differ. Given their comparatively lower value and their exclusion from the identification strategy of this paper – the economic activities in those sectors has not benefited from a similar growth –, those particulars are omitted here.

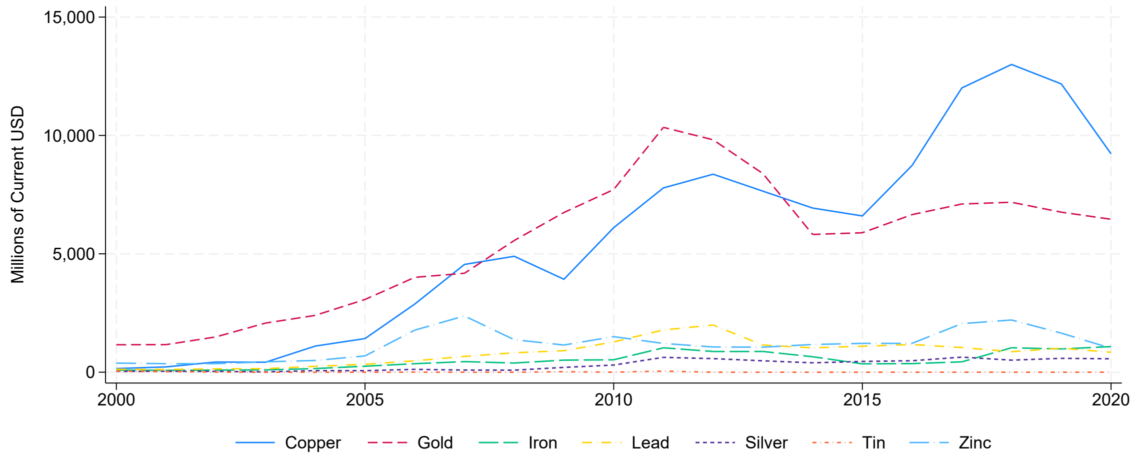
bution of canon from a particular mine proceeds as follows: 10% to the mine's district, 25% to non-producing districts in the same province, 40% to non-producing provinces, 20% to the regional government, and 5% to public universities. The allocation formula for non-producing local governments is progressive and relies on local socioeconomic index measured prior to the period of analysis [5]. Additionally, mining companies are required to pay royalties of 1% to 3% of their production value, with the rate varying based on the amount of production.

A significant aspect of government involvement in mining is that it enables the country to benefit from an industry that is otherwise largely detached from the rest of the economy. The export-oriented nature of mining means it has few connections to other industries via input-output linkages. While mining accounted for approximately 61% of exports in 2010, it constituted only 6% of the GDP. Moreover, given that modern mining operations are not labor-intensive, the rapid expansion of the sector has consistently employed less than 1% of the total workforce.

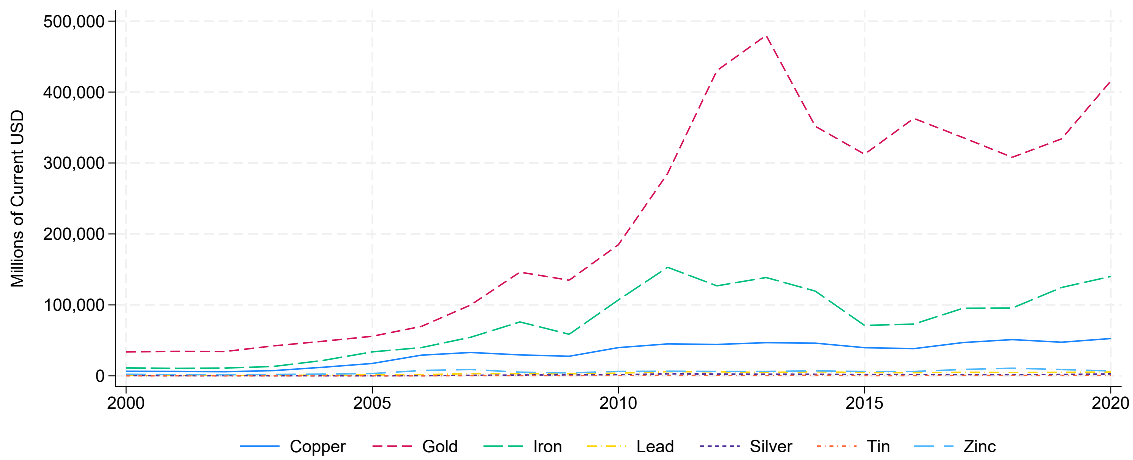
The identification strategy of this paper takes advantage on the fact that the aforementioned rule changes were established prior to—and not as a consequence of—the commodity boom that benefited the mining sector. Following stagnation in the 1990s, the Peruvian mining sector experienced growth due to favorable international economic conditions. This surge is depicted in Figure 2. Specifically, panel (c) of Figure 2 shows a sharp increase in international prices of Peru's most significant mineral products, which boosted the value of exports for countries that export these commodities, including Peru. This is particularly evident in the cases of gold and copper, as shown in panel (a) of Figure 2.

In addition to the temporal variation arising from the commodity boom, spatial variation is influenced by differing patterns of resource specialization, since natural resources are distributed unevenly across ecological regions and Peru's mining exports are not concentrated in only a single commodity, and the characteristics of the distribution rules. Figure 3 illustrates the distribution of mining production and canon and royalties across various provinces in the country for 2016. While mining production is concentrated in a few highland provinces, the transfers from canon and royalties extend to a broader range of provinces at lower altitudes as well.

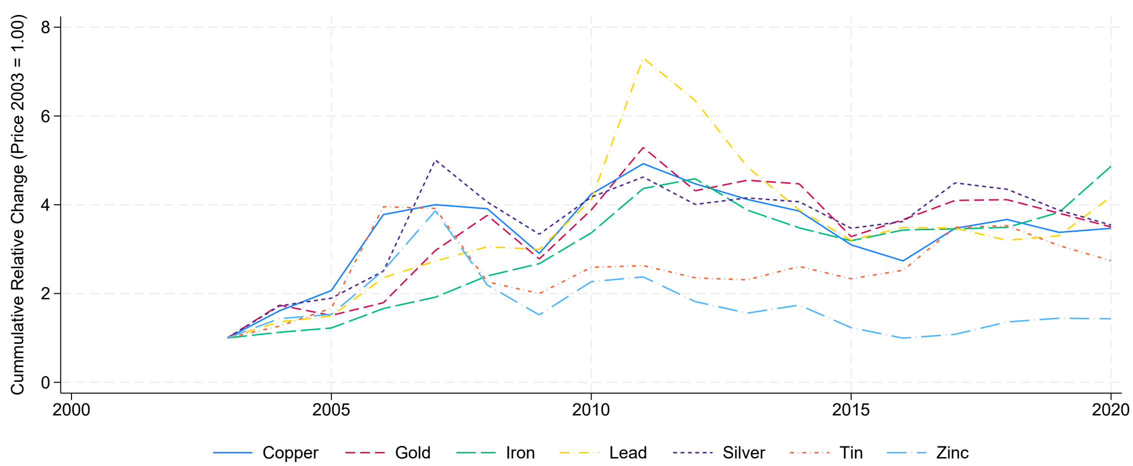
[5] This multidimensional index is derived from data spanning the 1994 Agricultural Census, the 2005 Census of Children Heights, the 2007 Population Census, and the altitude of districts above sea level. The presence of this indexing criteria demands the incorporation of district fixed effects in regression models that uses microdata, which is reflected in my specifications.



(a) Peruvian Exports



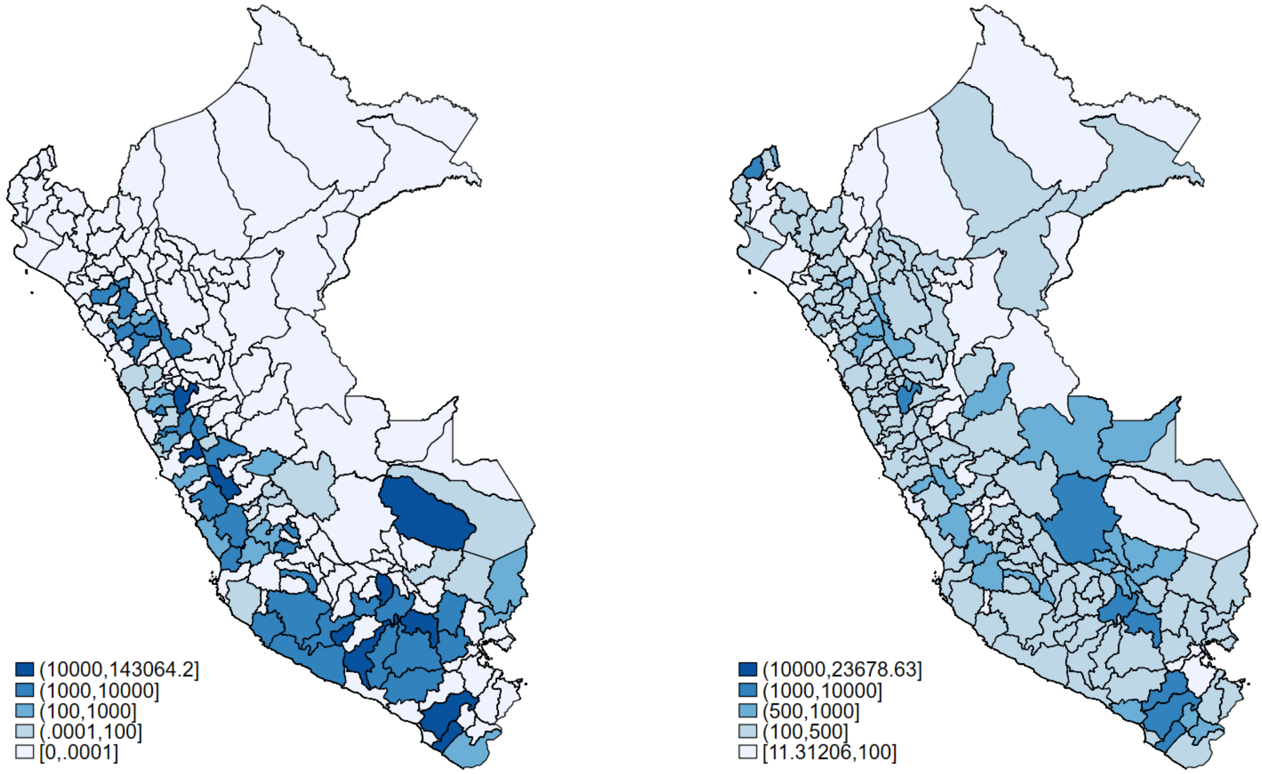
(b) Rest of the World Exports



(c) Mineral Prices

Figure 2: Exports of main mineral Peruvian commodities

Notes: Calculations made using data from the BACI version of COMTRADE (Gaulier & Zignago, 2010), and international commodity prices obtained from BCRP/Reuters.



(a) Value of mining production per capita (Current USD)

(b) Local canon transfers per capita (Current Soles)

Figure 3: Spatial distribution of canon transfers and mining production at the province level

Notes: Calculations made using data from the Ministry of Finance, the Ministry of Energy and Mines, and international commodity prices.

4 Local Effects and Open Economy Relative Multipliers

In this section, I embed the canon distribution rule into an instrumental variable approach that resembles standard procedures in the literature on the estimation of government spending multipliers using microdata. Household and firm-level microdata analysis reveal results on wages, expenditures, and income consistent with a positive spending multiplier. After discussing the relative success of the instrument in estimating an open economy relative multiplier, I show that the lack of a labor response implies the need to incorporate trade mechanisms, as will be done in the next section.

4.1 Empirical Strategy

4.1.1 Local Effects of Government Purchases

Based on the redistribution rule described on Section 3, I estimate the following specification to analyze the impact of government spending in variables available in microdata at the household, individual, and firm level, for which information is typically available only for the year of the survey.

$$y_{i,d,t_{d\in p}} = \alpha + \beta\tilde{g}_{p,t} + \gamma I[\textit{Mining Production}_{p,t} > 0]m_{p,t} + \alpha_d + \alpha_t + \epsilon_{i,d,t} \quad (1)$$

In Equation 1, $g_{p,t}$ and $m_{p,t}$ are the logs of per capita effective end-of-period government spending and mining production, respectively. The log of canon transfers as outlined in the opening budget, $cr_{p,t}$, serves as the instrumental variable for $g_{p,t}$. I include the log of mining production only when positive, as indicated by $I[\textit{Mining Production}_{p,t} > 0]$ next to γ. Additionally, while the identification strategy uses variations at the province level, the spatial fixed effects α_d are specified at the district level to capture effects of differences in non-time-varying characteristics among districts within the same province. Firm-level estimations include industry fixed effects, and individual estimations control for characteristics such as age, education, and gender.

4.1.2 Local Open Economy Relative Multipliers

To estimate the government spending multiplier in line with the what is done in the literature (see, for example, Barro and Redlick (2011); Auerbach and Gorodnichenko (2013); Acconcia et al. (2014); Nakamura and Steinsson (2014)) I define the following province-level baseline specification:

$$Y_{p,t} = \beta G_{p,t} + \alpha_p + \alpha_t + \mathbf{X}_{p,t}\gamma + u_{p,t} \quad (2)$$

Variables are defined as follows: $Y_{p,t}$ is the rate of growth of GDP per capita y_p; that is, $Y_{p,t} = (y_{p,t} - y_{p,t-1})/y_{p,t-1}$. $G_{p,t}$ represents the year-on-year change in spending per capita g_p relative to the lagged GDP: $G_{p,t} = (g_{p,t} - g_{p,t-1})/y_{p,t-1}$. Defining both variables relative to the lagged GDP per capita allows the coefficient β to be interpreted as the spending multiplier, as guided by early frameworks such as Barro and King (1984). The vector $\mathbf{X}_{p,t}$ includes a set of observable characteristics that could also explain changes in growth rates. α_p and α_t are province and time fixed effects, respectively, and $u_{p,t}$ is the error term. When discussing results, I refer to Equation 2 as the Fixed Effects Least Squares specification.

To incorporate the resource windfall-based identification strategy discussed in Section 3, I modify Equation 2 as follows:

$$Y_{p,t} = \beta \tilde{G}p,t + \gamma Mp,t + \alpha_p + \alpha_t + u_{p,t} \tag{3}$$

In Equation 3, variables are defined as in Equation 2 with the following modifications: $\tilde{G}p,t$ indicates that the effect of Gp,t is measured through the use of an instrumental variables (IV) approach. The instrument I use is $CR_{p,t} = (cr_{p,t} - cr_{p,t-1})/y_{p,t-1}$, where $cr_{p,t}$ represents canon and royalty transfers per capita as outlined in the opening budget—that is, before the start of the fiscal year in which $G_{p,t}$ is disbursed. Additionally, I include the change in mining production per capita relative to lagged output $M_{p,t} = (m_{p,t} - m_{p,t-1})/y_{p,t-1}$ as a control variable. Here, $m_{p,t}$ aggregates the per capita value of production for Peru's main mineral exports—such as copper, gold, iron, lead, silver, tin, and zinc—at international prices. The identification strategy is designed so that, by controlling for growth in mining production, β in Equation 3 captures the output response to changes in government spending arising from additional resources allocated to local governments by the canon distribution rule. Estimation results from Equation 3 will be labeled as IV in the subsequent results discussion.

4.2 Results

I now present my results, which examine the impact of increases in government spending driven by canon and royalties at the province level. Following the approach detailed in the methodology section, I begin by presenting the first-stage results. Then, I report the estimations of the effect of government purchases on variables measured in the micro-data. Subsequently, I report the results of the estimation of local open economy relative multipliers. Finally, I discuss these results, their limitations, and their implications for the analysis to be performed in Section 5.

4.2.1 First-Stage Results

Table 1 reports the results of regressing indicators of government purchases on the instruments that correspond to their definition and the equation of interest in which they are going to be used. The first three columns match the variables in year-to-year changes relative to GDP defined when discussing Equation 3, and the last three columns, those of Equation 1. Short names on top of them correspond to the following aggregations of spending: $G_{\textit{cur. spdg.}}$ is current spending, $G_{\textit{pub. inv.}}$ is public investment spending, and

G_{total} is total government purchases, i.e., the sum of the other two. The columns associated with spending in public investment are the ones that show the strongest correlation with the relevant excluded instrument – $M_{p,t}$ or the log of mining production per capita.

Table 1: First Stage Results (2011-2016)

	Changes rel. to lagged output			Log. of per capita values		
	$G_{cur.\ spdg.}$	$G_{pub.\ inv.}$	G_{total}	$g_{cur.\ spdg.}$	$g_{pub.\ inv.}$	g_{total}
$C_{p,t}$: Canon year to year change	0.463***	0.718***	0.705***			
	(0.048)	(0.063)	(0.057)			
$M_{p,t}$: Mining prod. year to year change	-0.004*	-0.000	-0.004			
	(0.002)	(0.011)	(0.012)			
Log(Canon Transf. per cap.)				0.005	0.148***	0.072***
				(0.008)	(0.023)	(0.016)
Log(Mining Production per capita)				0.005	0.042***	0.029***
				(0.004)	(0.011)	(0.007)
Observations	975	975	975	975	975	975
R^2	0.110	0.145	0.165	0.003	0.060	0.040
F-stat	48.138	65.983	77.093	1.111	24.816	16.129

Notes: Each column in the table corresponds to a different first stage regression and definition of government purchases. Short names on top of them correspond to the following aggregations of spending: $G_{cur.\ spdg.}$ is current spending, $G_{pub.\ inv.}$ is public investment spending, and G_{total} is total government purchases, i.e. the sum of the other two. The depending variable of the first three columns are yearly changes in spending per capita as a ratio of the lag of GDP per capita at the province level. $G_{p,t}$ and $M_{p,t}$ are defined in an equivalent way. The last three columns dependent variables, and their corresponding regressors, are expressed in logs.
Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The coefficients for current spending are lower in magnitude, and even not significant for the log definitions. This is consistent with the law that mandates the distribution rule's aim. Even though the increase of funds augments the slackness of local governments to facilitate current spending as well, the strength of the instrument is higher for measures of public investment because that is the aim of the distribution rule. The coefficients for total government spending are closer to the coefficients for public investment than to those for current spending. This is in turn consistent with most of the variation canon transfers induced in total spending should come from increases in public spending. Hence, I will report multipliers for the three spending indicators, but the microdata results that will be discussed hereafter will be focused in public investment. In Section 6, I briefly discuss the differences that arise when considering total government purchases instead.

4.2.2 Local Effects of Government Purchases

The findings summarized in Table 2 and Table 3 reflect the outcomes of estimating Equation 1 using various micro-level variables, with a focus on the effect of government investment spending. Initially, the analysis concentrates on household-level expenditure and per capita income. This is followed by an examination of individual-level labor responses to increased government spending. Finally, I compare these results with data from firms.

Table 2: Household and Worker Level Outcomes (2011-2016)

	Household		Worker				
	log(exp)	log(inc)	log(wage)	Hours Worked	Employed	Self-Employed	In-Migration
Log(Gov. Inv. Spend. per cap.)	0.148**	0.277***	0.195***	2.048	0.003	-0.035	-0.260
	(0.060)	(0.077)	(0.069)	(1.363)	(0.023)	(0.026)	(0.450)
Log(Mining Production per capita)	-0.004*	-0.005	-0.003	-0.057	0.004***	0.000	0.009
	(0.002)	(0.003)	(0.003)	(0.056)	(0.001)	(0.001)	(0.013)
Observations	179174	179170	304070	383612	357854	357854	349993
Mean	6.088	6.182	8.891	35.943	0.921	0.441	0.063
Kleibergen-Paap-Wald F stat	40.534	40.533	41.885	40.939	38.996	38.996	0.359
Clusters	1434	1434	1434	1434	1434	1434	1326

Notes: The excluded instrument for the log of government spending per capita is the log of canon and royalties transfers per capita. The value that captures the log of mining production per capita is included only if the value is positive. Work hours are in weekly units. Employment, self-employment, and in-migration are dummy outcomes. The data for the outcomes comes from National Household Survey (ENAHO). Kleibergen-Paap-Wald F statistics is included in place of the first-stage F statistic to address concerns regarding heteroskedasticity and to be consistent with clustering at the district level.
Standard errors clustered at the district level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Household income and expenditure per capita. Table 2 shows that a one percent increase in government spending per capita results in 0.15% and 0.28% rises in household per capita expenditure and income, respectively. Although these figures qualitatively align with findings presented in Table 4, they cannot be interpreted as multipliers in the same way due to the definition of the variables. Interestingly, the differentiated impact on expenditure and income suggests potential increases in savings, possibly reflecting that the shocks are expected to be temporary. Furthermore, the direct impact of mining on households is negligible, indicating that increased government spending through canon transfers is the principal way households benefited from the commodity boom.

Employment and wages. From the results in worker-related columns of Table 2, a one percent increase in government spending per capita results in a 0.19% rise in wages, consistent with the results on household income, with no increase in the equilibrium quantity of labor at the extensive or intensive margin, nor an increase in inward migration.

Table 3: Firm Level Outcomes (2011-2016)

	log(VA)	$\Delta \log(K_t)$	log(Av. Wage)	log(Personnel)
Log(Gov. Inv. Spend. per cap.)	0.194	0.101	0.523***	-0.009
	(0.282)	(0.080)	(0.186)	(0.228)
Log(Mining Production per capita)	0.005	0.002	-0.016	0.013
	(0.018)	(0.004)	(0.015)	(0.012)
Observations	45596	43420	47421	51688
Mean	15.297	0.146	10.474	3.772
Kleibergen-Paap-Wald F stat	15.302	19.891	16.413	15.732
Clusters	378	397	393	403

Notes: The excluded instrument for the log of government spending per capita is the log of canon and royalties transfers per capita. The log of mining production per capita is included only if the value is positive. Abbreviations of the names of the outcomes are included in top of each column. VA stands for value added, and ΔK_t is the change of physical capital stock with respect to the previous year. Firm outcomes come from the National Economic Survey (EEA). Kleibergen-Paap-Wald F statistics is included in place of the first-stage F statistic to address concerns regarding heteroskedasticity and to be consistent with clustering at the district level.

Standard errors clustered at the district level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Firm level results. The findings based on firm-level data align with the previous two sets of results. As indicated in the Table 3, a one percent increase in per capita government investment correlates with a 0.52% rise in the average wages that formal firms pay. No significant effects are observed on investment, value added, or firm size.

4.2.3 Local Open Economy Relative Multipliers

Table 4 presents the estimations of the local open economy multiplier using Equation 2 in the first three columns, and Equation 3 in the final three. I examine three spending variables: current government spending G_C, investment government spending G_I, and total government spending G_T. The Fixed Effects Least Squares (FELS) estimations suggest a modest and even negative correlation between economic growth and changes in government spending. The use of instrumental variables (IV) reveals, after accounting for mining production growth, a more pronounced positive response of economic growth to increases in government spending driven by canon and royalties transfers. Given that such transfers are intended for public investment, as discussed in Section 3, it is expected that the identification strategy should particularly work for the analysis of investment spending. In support of this expectation, Table 4 indicates an estimated multiplier of 0.376 for investment spending, substantially greater than the FELS estimate of 0.114, suggesting the IV approach adequately adjusts for bias according to the anticipated direction for this type of analysis. Although the standard errors are bigger, the multipliers when considering current and total spending are also correcting for bias in the same direction.

Table 4: Local Fiscal Multipliers Estimation - Province Level GDP (2011-2016)

	FELS			IV 2SLS		
	$G_{cur.\ spdg.}$	$G_{pub.\ inv.}$	G_{total}	$G_{cur.\ spdg.}$	$G_{pub.\ inv.}$	G_{total}
$G_{p,t}$: Gov. purch. year to year change	-0.237	0.110*	0.084	0.648	0.376**	0.287*
	(0.342)	(0.062)	(0.056)	(1.131)	(0.178)	(0.153)
$M_{p,t}$: Mining prod. year to year change	0.065***	0.066***	0.067***	0.057***	0.056***	0.057***
	(0.020)	(0.020)	(0.020)	(0.018)	(0.018)	(0.018)
Observations	975	975	975	975	975	975
R^2	0.014	0.018	0.017	0.365	0.360	0.364
Cragg-Donald-Wald F stat				70.758	91.096	105.914

Notes: Each column in the table corresponds to a different regression and definition of government spending. Short names on top of them correspond to the following aggregations of spending: $G_{cur.\ spdg.}$ is current spending, $G_{pub.\ inv.}$ is public investment spending, and G_{total} is total government purchases, i.e. the sum of the other two. The depending variable is the rate of growth of GDP per capita, and $G_{p,t}$ and $M_{p,t}$ are yearly changes in government spending per capita and mining production value per capita, both divided by the lagged value of GDP per capita. For the IV specifications, the excluded instrument used to identify the effects of $G_{p,t}$ is the relative to lagged GDP per capita change in canon and royalties transfers. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The estimated multiplier of 0.376 is more conservative than those reported in the most closely related literature. For example, Nakamura and Steinsson (2014) find state-level multipliers in the U.S. of approximately 1.5, while Auerbach et al. (2020) report city-level estimates between 1.05 and 1.10. Nonetheless, multipliers below one are not inconsistent with theory, and some empirical studies have documented similarly modest effects. For instance, aggregate data narrative analyses of austerity measures in OECD countries indicate multipliers as low as 0.3 (Alesina, Favero, & Giavazzi, 2019; Guajardo, Leigh, & Pescatori, 2014; Leigh et al., 2010), while time-series analyses by Ilzetzki et al. (2013) suggest multipliers between 0.3 and 0.7. Within Peru, according to estimates from the Central Bank and the Ministry of Finance (Central Reserve Bank of Peru, 2012; Galindo & Sánchez Tapia, 2013; Loyola, Rossini, & Quispe, 2012; Ministry of Finance of Peru, 2015) based on Blanchard and Perotti (2002), the capital-spending multipliers for short- and medium-term scenarios range from 0.24 to 1.42, depending on the economic cycle. It is difficult to directly compare these estimates due to differing underlying assumptions and context. Next iterations of the paper will explore more the relationship between these numbers, in particular with aggregated multipliers.

4.3 Discussion

The results outlined in the preceding three paragraphs are consistent with each other but leave open some questions regarding the relationship between economic activity as captured by spending and production measures. If there is no growth in employment or value added, what supports the observed increase in wages and income? Assume there exists a production function for province i such that $Q_{it} = AK_i^{\alpha}(N_{it}E_{it})^{1-\alpha}$ is a function of capital K_i, employment E_{it}, and hours per worker N_{it}. In that case, denoting expenditure as X_{it} and income as Y_{it}, we would have expected $X_{it} \propto Y_{it} = Q_{it}$. This would allow me to use the following equivalence:

$$\underbrace{\frac{d\ln X_{it}}{d\ln G_{it}}}_{\beta_X} \propto \underbrace{\frac{d\ln Y_{it}}{d\ln G_{it}}}_{\beta_Y} = (1-\alpha)\Big(1 + \underbrace{\frac{d\ln N_{it}}{d\ln E_{it}}}_{\chi}\Big)\underbrace{\frac{d\ln E_{it}}{d\ln G_{it}}}_{\beta_E}, \tag{4}$$

where χ is the elasticity of hours per worker to total employment, to infer better measured spending multipliers using employment data (Chodorow-Reich, 2019).

Wages, income, and expenditure move in the same direction, as we would expect from Equation 4. However, the last part of the expression doesn't hold as labor has not increased neither at the extensive or intensive margin. This raises the question: if there are increases in local income and expenditure, but not in local employment, where are the additional expenditures being directed to? One explanation might be that economic output is reaching its potential and the supply of labor is relatively inelastic, thus driving up wages. However, as shown in Table 2, with an unemployment rate of 7.9%—and potentially a larger pool of underutilized labor given a self-employment rate of approximately 44%—there may be other mechanisms playing a more central role. A possibility is that prices are reacting more rapidly than quantities in the labor and goods markets, but we don't see a corresponding increase in the firms' value added. A natural hypothesis is to consider that the effects might be affected by district and province-level trade. Also, mechanically, transfers are breaking trade balance in the economy and potentially producing equilibria with excess of labor demand. This is explored in detail in the following section.

5 Spatial Spillovers and Multipliers in the Space

This section provides an extension to the methodology for estimating local multipliers when considering output spillovers due to trade between provinces. To introduce the intuition in the simplest possible setup, I incorporate local government spending in the form of transfers into an Armington model setup (Armington, 1969; Anderson & Van Wincoop, 2003; Anderson, 1979). The purpose is to explicitly characterize the indirect effect of local government spending through its impact on trade between different places. From the equilibrium conditions of the model, I obtain an expression that maps into a reduced form Spatial Autoregressive Model. I present the estimation results to conclude the section.

5.1 Theoretical Framework: Multipliers with Gravitas

Setup. Consider an economy with N regions indexed by i and j, each producing a unique differentiated good.

Each region j has a representative consumer whose preferences are CES with an elasticity of substitution equal to σ. They choose quantities q_{ij} from the differentiated goods of every region i, taking their disposable income Y_j and prices p_{ij} as given, to solve the following problem:

$$\max_{\{q_{ij}\}_{i=1}^{N}} U_j = \left(\sum_{i=1}^{N} a_{ij}^{\frac{1}{\sigma}} q_{ij}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \quad s.t. \quad \sum_{i=1}^{N} p_{ij} q_{ij} = Y_j \tag{5}$$

From the solution of this problem, region j's demand q_{ij} for each good i, and its corresponding value $X_{ij} = p_{ij} q_{ij}$ are:

$$q_{ij} = \frac{a_{ij} p_{ij}^{-\sigma}}{P_j^{1-\sigma}} Y_j; \;\; X_{ij} = a_{ij} \left(\frac{p_{ij}}{P_j} \right)^{1-\sigma} Y_j \tag{6}$$

Where P_j is the CES ideal price index $P_j = \left(\sum_i a_{ij} p_{ij}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$.

In the production side, each region has a fixed labor endowment L_i and a technology of production with constant returns to scale. The differentiated goods are traded in perfect competition, then prices are:

$$p_i = p_{ii} = \frac{w_i}{A_i} \; and \; p_{ij} = \frac{\tau_{ij} w_i}{A_i} \; \forall i, j \tag{7}$$

Where $\tau_{ij} \geq 1$ are iceberg trade costs and A_i is the labor productivity of region i.

Government. In addition, there is a central government which has an exogenous endowment of resources G that redistributes as a direct transfer to each region j:

$$\sum_j G_j = G \ \ with\ G \geq 0 \tag{8}$$

The condition $G \geq 0$ hints that we can interpret this budget balance condition as a tax and transfers redistribution scheme between regions when $\sum_j G_j = 0$, or the redistribution of exogenous government funds $G > 0$.

Market Clearing and Equilibrium. Product market clearing in this economy, requires that the gross income in region j equals the spending of all their trade partners i in the goods they produced:

$$X_j = \sum_i X_{ji} \tag{9}$$

Hence, after net transfers from the central government, disposable income in region j is described by:

$$Y_j = \sum_i X_{ji} + G_j \tag{10}$$

The equilibrium of this economy will consist of quantities $\{q_{ij}\}_{i=1,j=1}^{N,N}$ and prices $\{w_i\}_{i=1}^{N}$, $\{p_{i,j}\}_{i=1,j=1}^{N,N}$, $\{P_j\}_{j=1}^{N}$ such that given exogenous fundamentals $\{a_{ij}\}_{i=1,j=1}^{N,N}$, σ, $\{A_i\}_{i=1}^{N}$, and $\{L_i\}_{i=1}^{N}$, and fiscal policy $\{G_j\}_{j=1}^{N}$, the representative consumer solves their problem and market clearing conditions hold.

Taking all relevant conditions together, the equilibrium disposable income in each region j will come from the following expression:

$$Y_j = \sum_i a_{ji} \left(\frac{\tau_{ji} w_j}{A_j P_i}\right)^{1-\sigma} Y_i + G_j \tag{11}$$

This system of N equations shows there is an indirect effect of transfers G_j on Y_j. By construction, the production quantity in this economy is given and solely determined by technology and labor endowments. However, real wages, disposable income and welfare effects of changes in G_j in region j will be affected by trade with all other regions i, particularly through indirect effects in w_j, P_i and Y_i.

Government Spending Multipliers in a Trade Economy. Let's consider first the case with no government transfers to the regions, i.e. $G_j^0 = 0$ for all j. Let's denote the equilibrium quantities and prices in this scenario with the superindex 0, e.g. w_j^0, P_i^0, and Y_j^0.

We can find a linear approximation of the effects of government transfers by log-linearizing the system in Equation 11 around this non-government equilibrium. This results in the following system of N equations:

$$\Delta_{\%}Y_j = \lambda_j \sum_{i=1}^{N} \omega_{ji} \left[(1-\sigma)\Delta_{\%}w_j + (\sigma-1)\Delta_{\%}P_i + \Delta_{\%}Y_i\right] + \Delta_{Y_j^0}G_j, \quad \forall j = 1, N \tag{12}$$

Where $\Delta_{\%}z_j := (z_j - z_j^0)/z_j^0$ stands for the log-deviation of each variable z_j with respect to its own initial value z_j^0, $\Delta_{Y_j^0}G_j := (G_j - G_j^0)/Y_j^0 = G_j/Y_j^0$ is the change of government transfers as a ratio of the initial income, $\lambda_j = \frac{\left(w_j^0/A_j P_j^0\right)^{1-\sigma}}{Y_j^0}$, and $\omega_{ji} = a_{ji}\tau_{ji}^{1-\sigma}\left(P_i^0\right)^{\sigma-1}$.

Taking initial conditions as given, coefficients λ_j and ω_{ji} in Equation 12 provide an intuitive interpretation. First, we can notice that ω_{ji} suggests that the specific interdependence between any pair of regions j and i is governed by the iceberg trade costs τ_{ji} between them. Second, we can interpret λ_j as a multiregional dependence term, which is governed by the elasticity of substitution σ. Notice that estimations of Equation 2 and Equation 3 are going to be consistent with this equation, and therefore this economy, only in the extreme case in which $\sigma \to \infty$, i.e., when the elasticity of substitution diverges to infinity and the representative consumer is indifferent between goods. For any finite elasticity of substitution, the estimation of equations Equation 2 and Equation 3 are misspecified for this economy. Hence, the estimation of the effect of $\Delta_{Y_j^0}G_j$ on $\Delta_{\%}Y_j$ in Equation 2 and Equation 3 will suffer from a trade-related source of bias.

In the next subsection, I will modify the baseline specification to explicitly incorporate the relationship between $\Delta_{\%}Y_j$ and $\Delta_{\%}Y_{-j}$ and evaluate the relative magnitude of the indirect transmission of $\Delta_{Y_j^0}G_j$.[6]

Further theoretical explorations in future versions of the paper will use an extended framework to correct for the missing intercept problem, which is common to regional macro (Nakamura & Steinsson, 2014; Chodorow-Reich, 2020) and trade (Topalova, 2010; Kovak, 2013), and in this case is associated to the national aggregate effects of local government spending. A more explicit structure would allow measuring the aggregate multiplier via simulation, describing the aggregate consequences of alternative local government schedules, and relate the response in wages and expenditure to excess in labor demand shocks (Adao, Arkolakis, & Esposito, 2023).

[6] I am preliminarly not incorporating $\Delta_{\%}P_{-j}$ and $\Delta_{\%}w_j$ in the specification. First, changes in prices are difficult to map to available data – there are no estimations of price indexes at the province level). Second, changes in wages will be proportional to changes in income because they are explicitly linked to each other. Even if available, the inclusion of wage changes as a covariate would be a bad control since it is one of the mechanisms through which $\Delta_{Y_j^0}G_j$ impacts $\Delta_{\%}Y_j$. In Section 6, I take a glance at the sensitivity of the results to this decision, by incorporating spatial lags in the error terms.

5.2 Government Multipliers in a Spatial Autoregressive Framework

As discussed in the previous subsection, the relative multipliers resulting of the estimation of Equation 2 and Equation 3 underestimate the effect of the overall response of all units to the changes in particular when subject to spillovers arising from trade. The subsequent reduced-form specification is an initial exploration of the impact of these considerations.

$$Y_{p,t} = \lambda \sum_{q \in P} \omega_{p,q} Y_{q,t} + \beta_{CR} CR_{p,t} + \gamma M_{p,t} + \alpha_p + \lambda_t + u_{p,t} \tag{13}$$

In Equation 13, there are two principal modifications from Equation 2. First, instead of examining changes in government spending, I concentrate on the effects of canon and royalty transfers. Second, I include $\lambda \sum_{q \in P} \omega_{p,q} Y_{q,t}$, which is a standard spatial-autoregressive (SAR) term. The notation and intuition of the elements in Equation 13 mirrors what Equation 12 suggests. $\omega_{p,q}$ is an spatial weight that captures the degree of influence of the output growth of province q in the growth of province p for all $p \neq q$. P is the size n set of all provinces in the country. That is, the SAR term can connect the growth of province p with that of every other province, as defined by the spatial weights $\omega_{p,q}$.

For tractability, it is useful to write Equation 13 using matrix notation as follows:

$$\mathbf{Y}_t \quad = \quad \lambda \mathbf{W} \mathbf{Y}_t + \beta \mathbf{CR}_t + \gamma \mathbf{M}_t + \mathbf{u}_t \tag{14}$$

The expresion in Equation 14 is parallels a panel specification where fixed effects are included within the vector of shocks $\mathbf{u}_t$, and $\mathbf{W}$ is a $n \times n$ spatial weighting matrix. This matrix groups all the $\omega_{p,q}$ defined in Equation 13, and zeroes in the main diagonal. Using this specification, I estimate the model with the quasi-maximum likelihood (QML) estimator as derived by Lee and Yu (2010) for fixed effects panel spatial data. I then calculate marginal effects using established methods of spatial econometrics as delineated by LeSage and Pace (2009)

To define the marginal effects, let's start by considering the reduced-form conditional mean prediction of $\tilde{\mathbf{Y}}_t$:

$$E\left[\tilde{\mathbf{Y}}_t | \mathbf{CR}_t, \mathbf{M}_t, \mathbf{W}\right] = (\mathbf{I} - \lambda \mathbf{W})^{-1} (\beta \mathbf{CR}_t + \gamma \mathbf{M}_t) \tag{15}$$

From here, the impacts of $X_{p,t} \in \{CR_{p,t}, M_{p,t}\}$ are calculated as follows. First, the **total impact** of the independent variable $X_{p,t}$ is the average of the marginal effects it has in the reduced form mean defined in Equation 14,

$$\frac{1}{nT}\sum_{t=1}^{T}\sum_{p=1}^{N}\sum_{q=1}^{N}\frac{\partial E\left[\tilde{Y}_{p,t}|\mathbf{CR}_t,\mathbf{M}_t,\mathbf{W}\right]}{\partial X_{q,t}}$$

where $E\left[\tilde{Y}_{p,t}|\mathbf{CR}_t,\mathbf{M}_t,\mathbf{W}\right]$ is the p-th element of $E\left[\tilde{\mathbf{Y}}_t|\mathbf{CR}_t,\mathbf{M}_t,\mathbf{W}\right]$ and $X_{q,t}$ is the value of X_t for province q-th. The total impacts can be decomposed in their direct and indirect components.

The **direct impact** of an independent variable is the average of each provinces' own marginal effects:

$$\frac{1}{nT}\sum_{t=1}^{T}\sum_{p=1}^{N}\frac{\partial E\left[\tilde{Y}_{p,t}|\mathbf{CR}_t,\mathbf{M}_t,\mathbf{W}\right]}{\partial X_{p,t}}$$

The average of the remaining marginal effects is the **indirect impact** of the independent variable, and measure the spillovers as estimated by Equation 13:

$$\frac{1}{nT}\sum_{t=1}^{T}\sum_{p=1}^{N}\sum_{q=1,q\neq p}^{N}\frac{\partial E\left[\tilde{Y}_{p,t}|\mathbf{CR}_t,\mathbf{M}_t,\mathbf{W}\right]}{\partial X_{q,t}}$$

5.3 Results

Table 5 displays the estimation results of Equation 13. Ideally, the weights utilized would reflect the expected level of connectivity between spatial units matching more closely the structure proposed in the theoretical model, or more elaborated versions of it. Preliminarily, in Table 5 I offer results using three alternative versions of the weight matrix that outline basic potential connections. These are: Direct neighbors (1), where the contiguity matrix assigns an equal positive weight ($w = 1$) to contiguous provinces; Neighbors of neighbors (2), where the contiguity matrix augments (1) by including weights for secondary neighbors ($w = 1$ for direct neighbors and $w = 0.5$ for neighbors of neighbors); and Inverse distance (3), in which the the matrix is constructed using the inverse of the distance between provinces. As delineated in Section 4, all matrices feature zeroes along their main diagonal.

These reduced-form results, which concentrate on the impact of canon and royalties transfers, are naturally expected to yield lower coefficients than those in the IV set of results from Table 4, yet they tell a similar story. These findings hint the presence of spatial output spillovers since the coefficient of spatial autocorrelation λ is significant across all three versions of the weight matrix. Although there is variability in estimates of indirect effects among the matrices—with the indirect effect of canon and royalties transfers growth

Table 5: SAR Reduced Form Estimations - Province Level GDP (2011-2016)

	Dependent variable: Rate of growth of GDP per capita					
	(1)		(2)		(3)	
$CR_{p,t}$	0.211**	(0.088)	0.268***	(0.096)	0.232**	(0.105)
$M_{p,t}$	0.036**	(0.015)	0.038**	(0.016)	0.049***	(0.018)
λ :						
Direct Neighbors	0.801***	(0.031)				
Neighbors of Neighbors			0.889***	(0.035)		
Inverse Distance					0.939***	(0.029)
Observations	965		965		965	
Number of provinces	193		193		193	
Observations per province	5		5		5	
Direct Effects						
$CR_{p,t}$	0.247**	(0.104)	0.300***	(0.108)	0.250**	(0.114)
$M_{p,t}$	0.043**	(0.018)	0.042**	(0.018)	0.053***	(0.019)
Indirect Effects						
$CR_{p,t}$	0.615**	(0.287)	1.512**	(0.761)	3.096	(2.153)
$M_{p,t}$	0.106**	(0.047)	0.213*	(0.112)	0.654	(0.403)
Total Effects						
$CR_{p,t}$	0.862**	(0.386)	1.812**	(0.849)	3.346	(2.239)
$M_{p,t}$	0.149**	(0.063)	0.255**	(0.127)	0.707*	(0.416)

Notes: The three columns in the table are estimations of Equation 13 only differing in the matrix of spatial spillover weights, which is indicated on the left below λ, which is the parameter that measures the degree of spatial correlation. The depending variable is the rate of growth of GDP per capita, and $CR_{p,t}$ and $M_{p,t}$ are respectively yearly changes in in canon and royalties transfers per capita and mining production value per capita, both divided by the lagged value of GDP per capita. The effects on the bottom of the table are average marginal effects obtained by taking the empirical derivatives of the expected conditional mean as defined in Equation 15.
Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

ranging from 0.615 to as much as 3.096—they consistently demonstrate that indirect effects outweigh direct ones that are around 0.25 and 0.3. These marginal effects required cautious interpretation due to the ad hoc nature of the underlying weights I used; particularly, results in (3) are limited by the small sample size relative to the number of partial derivatives required from Equation 15 to calculate indirect effects. Nonetheless, this set of results implies that output spillovers play a significant role in the transmission of local government spending. Additionally, the effects of canon and royalties transfers are always larger than those of mining production, which reinforces the idea that government spending plays a big role in making the extractive sector success to positively impact the rest of the economy.

6 Additional Analysis and Robustness Checks

In this section, I provide some additional analysis that either hint next directions for the paper or explore identification threats.

Micro Level Analysis for Total Government Spending. The results presented in Table 2 and Table 3 used investment spending as the relevant indicator for government purchases because the canon law was mainly aimed to stimulate investment. In Table 6 and Table 7 I report the results obtained when using total government spending instead. Most results are qualitatively the same, though the magnitudes become slightly larger and the effects on hours worked (positive) and self-employment (negative) become slightly significant. This suggests that government spending might be increasing the relative intensity and quality of employment but in lower magnitudes than the relative impact in income and wages.

Local Effects and Multipliers by Function. The budget data allows disaggregation of purchases by function, i.e., categories of spending as health, transport, education, agriculture promotion, housing, among others. I replicated the main analysis for the functions that have the largest shares according to Table 10. The instrument is not strong for purchases related to transport and agriculture, but it is strong for purchases related to health, education, and social protection. The corresponding multipliers and effects in wages, income, and housegold expenditure are larger than the estimated in the main analysis. This heterogeneity of the impact of spending depending of the type of purchases relates to the discussion in Cox et al. (2024). Future steps to measure the effect of government spending might need to incorporate a more explicit analysis of these.

Labor Market Effects by Sector. In Table 12, I explore heterogeneity in the response of labor outcomes by occupation sector. Occupations are aggregated in five categories: services, agriculture, industry, government, and mining. Except for a increase in employment in the government sector, canon-induced increases in government spending do not have a effect on sector composition of labor. The effects for wages are larger for workers in agriculture, and negative for workers in mining. Workers in agriculture are about 46.7% of the sample and, frequently, the ones that work for lower wages or self-employed subsistence workers. The larger effect on them might suggest larger effects in low income workers. On the other hand, mining workers are less than 2% of the sample. The negative coefficient associated with them might suggest that, taken together, the results hint distributional consequences by sector.

Drop Producing Provinces. The estimations of the effect of government spending presented in Table 2 and Table 3 control for mining production. Although the coefficients associated to mining production are frequently not explanatory and suggest that the main channel is government spending, a more direct strategy to analyze the effect of canon-induced government spending would have been to focus the analysis in provinces that do not have mining production and estimate directly the following specification:

$$y_{i,d,t_{d\in p}} = \alpha + \beta \tilde{g}_{p,t} + \alpha_d + \alpha_t + \epsilon_{i,d,t}, \tag{16}$$

where the definitions are the same as those described in Equation 1. The results are reported in Appendix B. The results are all qualitatively equivalent with the same significant results slightly larger in magnitud.

Division Bias. The instrumental variables results in Table 4 use yearly changes in canon transfers per capita relative to lagged GDP as the instrument for yearly changes of government spending per capita relative to lagged GDP as well. Since both variables have the same denominator, there is a risk that there is a relevant source of correlation with the instrument merely coming from the denominator. In Appendix E, I compare those results with the results obtained by using the change in canon per capita is measured relative to the GDP per capita of two periods before instead. Although the standard errors are slightly larger, the results with this alternative specification are almost the same.

Spatial Auto-Regression Analysis with Lags in the Error Term. The spatial auto-regression analysis conducted by the estimations of Equation 13 focus on trade-related spillovers from changes in output in other provinces. However, Equation 12 suggested that the general equilibrium trade-related spillovers have impact through other variables as well, particularly through wages and the ideal price index. To assess the spatial effect of those variables that are not included in the regression, the following specification considers spatial correlation in the error terms as well:

$$\begin{aligned} \mathbf{Y}_t &= \lambda \mathbf{W_y} \mathbf{Y}_t + \beta \mathbf{CR}_t + \mathbf{M}_t + \mathbf{u}_t \\ \mathbf{u}_t &= \rho \mathbf{W_u} \mathbf{u}_t + \mathbf{v}_t \end{aligned} \tag{17}$$

Where $\mathbf{W_y}$, and $\mathbf{W_u}$ are $n \times n$ spatial weighting matrices. Since the theoretical framework we discussed suggest the same foundation for these weights, I consider both of them to be the same and I use the same three alternative preliminary matrices. The results of this estimations are in Appendix F. The main differences are as follows: i) The direct effects of the growth of canon transfers are larger, ii) the direct effects of mining production growth are smaller, iii) the except for the results using a matrix of direct neighbors, iv) for the results using the neighbor-of-neighbors and the inverse distance matrix, the coefficients of spatial correlation are high and relatively close to the baseline case with output only spillovers, and v) both coefficients of spatial correlation are close to each other, which suggest that the frictions and spillovers between provinces unobservables have the same fundamentals as the output ($\lambda = \rho$).

7 Conclusion

In this paper, I leveraged the commodity boom-induced increase and distribution of mining revenues to Peruvian local governments to estimate its impact on micro-level outcomes related to income, labor, and production, and to estimate local province-level fiscal multipliers. The identification strategy takes advantage of a distributional rule defined before the rapid increase in international demand for Peruvian mineral exports. The identification strategy appears to mitigate bias in directions consistent with our expectations regarding the endogenous nature of government spending and its connection to economic activity.

Taken together, the results suggest that canon and royalties-induced increases in government spending, specifically investment spending, were able to stimulate growth in Peruvian provinces, reflected in larger wages and household income and expenditures. In addition, they suggest that the main mechanism through which mining activity can impact communities is through the role of government use of the revenues mining generates. This has policy implications regarding the avoidance of the natural resource curse, especially if it is used to improve public services (Agüero et al., 2021), even if the evidence regarding the direct effects of mining production is mixed, as it is in the case of Peru (Orihuela & Echenique, 2019; Loayza & Rigolini, 2016; Arellano-Yanguas, 2019).

A key claim I also make in the paper is that spatial spillovers are a relevant threat to the interpretation of local fiscal multipliers. To express how the methodology should be adapted to incorporate inter-regional trade in a parsimonious structure, I incorporate local government spending in the form of transfers into an Armington model setup. From the equilibrium conditions of the model, I provide intuition for how local income and wages can react even if labor supply and value added do not, and I obtain an expression that maps into a reduced form Spatial Autoregressive (SAR) Model. Based on the estimation results, I discuss that the magnitude of the trade-related indirect effects of government spending is relevant and has to be explicitly incorporated in the analysis, as in the related efforts made by Norris (2019) and Flynn et al. (2022). However, it would also require including considerations relevant to developing economies: significant intranational trade costs, labor market frictions that decouple unemployment from the output gap—evidenced by the prevalence of subsistence sectors and high levels of underemployment—and the importance of commodities' demand shocks for government revenues, which are subsequently redistributed among local governments.

The evidence presented in the paper is preliminary and spans the years from 2011 to 2016. The complete processing of the available data will allow me to expand the period of analysis from 2007 to the present day. This will not only increase statistical power through the increase in sample size but also through the incorporation of the effects of mineral price variations pre-2010 and post-2015, and their distributional implications. In addition, future empirical extensions could explore more mechanisms regarding local government behavior, in the context of their evolution considering decentralization is still in its infancy in the country and has faced many challenges and poor results (Loayza, Rigolini, & Calvo-González, 2014; Bancalari, 2024).

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A Micro-Level Results for Total Government Spending

Table 6: Household and Worker Level Outcomes (2011-2016)

	Household		Worker				
	log(exp)	log(inc)	log(wage)	Hours Worked	Employed	Self-Employed	In-Migration
Log(Gov. Spend. per cap.)	0.211***	0.392***	0.317***	3.363*	-0.001	-0.062*	-0.155
	(0.079)	(0.101)	(0.085)	(1.742)	(0.030)	(0.032)	(0.122)
Log(Mining Production per capita)	-0.003	-0.003	-0.002	-0.049	0.004***	0.000	0.005*
	(0.002)	(0.003)	(0.003)	(0.052)	(0.001)	(0.001)	(0.003)
Observations	179174	179170	304070	383612	357854	357854	349993
Mean	6.088	6.182	8.891	35.943	0.921	0.441	0.063
Kleibergen-Paap-Wald F stat	54.864	54.862	57.440	54.847	52.801	52.801	3.509
Clusters	1434	1434	1434	1434	1434	1434	1326

Notes: The excluded instrument for the log of government spending per capita is the log of canon and royalties transfers per capita. The value that captures the log of mining production per capita is included only if the value is positive. Work hours are in weekly units. Employment, self-employment, and in-migration are dummy outcomes. The data for the outcomes comes from National Household Survey (ENAHO). Kleibergen-Paap-Wald F statistics is included in place of the first-stage F statistic to address concerns regarding heteroskedasticity and to be consistent with clustering at the district level.

Standard errors clustered at the district level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Firm Level Outcomes (2011-2016)

	log(VA)	$\Delta \log(K_t)$	log(Av. Wage)	log(Personnel)
Log(Gov. Inv. Spend. per cap.)	-0.080	0.136	0.690**	-0.243
	(0.324)	(0.101)	(0.285)	(0.242)
Log(Mining Production per capita)	0.006	0.003	-0.008	0.011
	(0.014)	(0.004)	(0.013)	(0.011)
Observations	45596	43420	47421	51688
Mean	15.297	0.146	10.474	3.772
Kleibergen-Paap-Wald F stat	26.168	27.992	26.475	25.332
Clusters	378	397	393	403

Notes: The excluded instrument for the log of government spending per capita is the log of canon and royalties transfers per capita. The log of mining production per capita is included only if the value is positive. Abbreviations of the names of the outcomes are included in top of each column. VA stands for value added, and ΔK_t is the change of physical capital stock with respect to the previous year. Firm outcomes come from the National Economic Survey (EEA). Kleibergen-Paap-Wald F statistics is included in place of the first-stage F statistic to address concerns regarding heteroskedasticity and to be consistent with clustering at the district level.

Standard errors clustered at the district level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B Micro-Level Results Excluding Mining Provinces

Table 8: Household and Worker Level Outcomes (2011-2016)

	Household		Worker				
	log(exp)	log(inc)	log(wage)	Hours Worked	Employed	Self-Employed	In-Migration
Log(Gov. Inv. Spend. per cap.)	0.231**	0.357***	0.247**	1.629	0.030	0.013	-0.244
	(0.093)	(0.119)	(0.107)	(1.807)	(0.032)	(0.033)	(0.388)
Observations	122127	122125	210507	265982	247367	247367	237512
Mean	6.078	6.158	8.871	35.487	0.925	0.446	0.065
Kleibergen-Paap-Wald F stat	25.287	25.287	24.366	25.930	24.508	24.508	0.498
Clusters	1036	1036	1036	1036	1036	1036	911

Notes: These estimations exclude mining-producing provinces. Work hours are in weekly units. Employment, self-employment, and in-migration are dummy outcomes. The data for the outcomes comes from National Household Survey (ENAHO). Standard errors clustered at the district level in parentheses. $^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Table 9: Firm Level Outcomes (2011-2016)

	log(VA)	$\Delta \log(K_t)$	log(Av. Wage)	log(Personnel)
Log(Gov. Inv. Spend. per cap.)	0.588*	-0.054	0.606**	0.182
	(0.329)	(0.083)	(0.241)	(0.253)
Observations	40463	38257	41974	45659
Mean	15.361	0.145	10.515	3.797
Kleibergen-Paap-Wald F stat	6.687	6.170	7.036	6.778
Clusters	246	262	264	268

Notes: These estimations exclude mining-producing provinces. VA stands for value added, and ΔK_t is the change of physical capital stock with respect to the previous year. Firm outcomes come from the National Economic Survey (EEA). Standard errors clustered at the district level in parentheses. $^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

C Analysis by Function

C.1 Local Government Spending Share by Function and Year

Table 10: Local Government Spending Share by Function and Year

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Health	12.9	14.3	14.9	16.1	17.4	16.8	15.7	18	16.6	18.1	21.6	16.6	17.1	12.9	14.3
Transport	15.8	16.4	15.6	16.0	15.1	16.8	17.2	15.9	15	16.9	17.6	17.0	19.8	26.1	23.1
Education	9.8	12.1	13.6	12.1	11.2	11.9	14.4	13.8	15.4	12.8	12.6	14.6	10.7	7.8	10.1
Agriculture	4.0	6.5	10.1	10.1	9.4	9.1	8.8	8.5	7.7	8.2	8.8	11.2	10.1	9.9	9.9
Social Protection	14.3	10.8	6.8	6.4	6.2	5.1	5.0	5.0	4.8	4.3	4.2	4.1	4.1	3.6	3.4
Housing	2.7	2.9	2.4	2.0	2.0	2.4	3.0	3.2	3.5	3.5	2.8	3.3	3.4	4.4	5.3
Energy	2.3	2.4	2.3	1.8	1.5	1.4	1.1	1.1	0.6	0.7	0.6	0.8	0.5	0.3	0.4
Industry	2.4	2.3	2.2	2.2	1.5	1.6	1.6	1.7	1.3	1.2	1.3	1.4	1.2	1.1	1.2
Security	0.0	0.0	1.1	1.2	1.5	1.8	2.5	2.7	3.3	3.8	3.6	3.1	3.2	5.0	3.3
Communications	0.0	0.0	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Fishery	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Employment	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.3	0.2	0.0	0.0	2.0	3.4
Others	35.8	32.1	30.6	31.6	33.9	32.9	30.5	29.5	31.6	29.9	26.6	27.6	29.7	26.8	25.5

Source: Own calculations with data scrapped from *Transparencia Económica* (MEF, 2023).

The category "Others" includes administrative spending and non-executive State powers (e.g. judiciary).

C.2 Spending Multipliers by Function

Table 11: Fixed Effects Panel Estimation - Province Level GDP (2011-2016)

	FELS					IV 2SLS				
	G_{health}	G_{transp}	G_{educ}	G_{agr}	G_{sp}	G_{health}	G_{transp}	G_{educ}	G_{agr}	G_{sp}
Gp	0.220	-0.079	0.285*	-0.115	0.398	2.349*	18.198	0.877**	5.874*	1.936**
	(0.160)	(0.190)	(0.170)	(0.306)	(0.423)	(1.223)	(30.947)	(0.413)	(3.395)	(0.917)
$M_{p,t}$	0.066***	0.066***	0.065***	0.065***	0.067***	0.053***	0.094	0.051***	0.076***	0.059***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.019)	(0.092)	(0.018)	(0.025)	(0.018)
Observations	975	975	975	975	975	975	975	975	975	975
R^2	0.016	0.014	0.017	0.014	0.015	0.229	-7.227	0.368	0.050	0.361
Cragg-Donald-Wald F stat						13.350	0.301	120.045	7.447	154.964

Notes: Each column in the table corresponds to a different regression and definition of government spending. Short names on top of them correspond to the government spending in different functions: G_{health} is health spending, G_{transp} is transport spending, G_{educ} is education spending, G_{agr} is agriculture spending, and G_{sp} is social protection spending. The depending variable is the rate of growth of GDP per capita, and $G_{p,t}$ and $M_{p,t}$ are yearly changes in government spending per capita and mining production value per capita, both divided by the lagged value of GDP per capita. For the IV specifications, the excluded instrument used to identify the effects of $G_{p,t}$ is the relative to lagged GDP per capita change in canon and royalties transfers.

C.3 Government Spending Effects Coefficients by Function

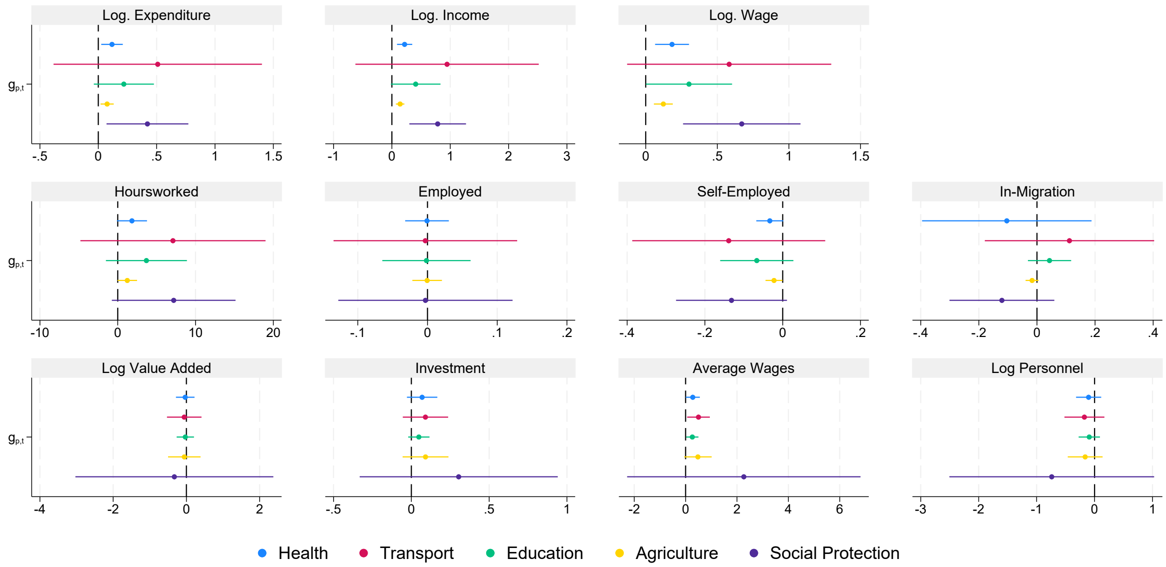

Figure 4: Government Spending Effects Coefficients by Function

These graphs plot the coefficients of the log of government spending per capita in regressions equivalent to those of Table 2 and Table 3, but for different disaggregations of government purchases by function.

C.4 Mining Production Coefficients by Function

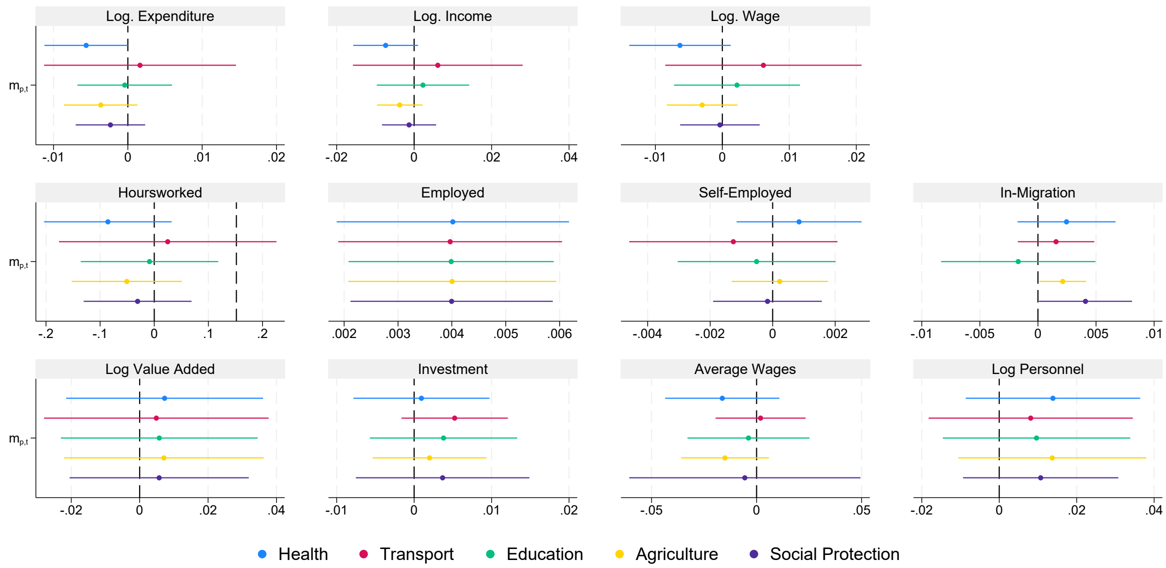

Figure 5: Mining Production Coefficients by Function

These graphs plot the coefficients of the log of mining production per capita in regressions equivalent to those of Table 2 and Table 3, but considering different disaggregations of government purchases by function.

D Household Outcomes by Sector of Occupation

Table 12: Household and Worker Level Outcomes (2011-2016)

	Services	Agriculture	Industry	Government	Mining
Panel A. Participation in the Sector					
Log(Gov. Inv. Spend. per cap.)	-0.012	-0.021	0.010	0.024*	0.004
	(0.034)	(0.036)	(0.021)	(0.014)	(0.010)
Log(Mining Prod. per cap.)	0.000	-0.001	0.001	-0.000	-0.000
	(0.001)	(0.002)	(0.001)	(0.001)	(0.000)
Observations	312456	312456	312456	312456	317472
Mean	0.333	0.467	0.150	0.050	0.016
Kleibergen-Paap-Wald F stat	41.548	41.548	41.548	41.548	43.160
Clusters	1434	1434	1434	1434	1434
Panel B. Log. Wages					
Log(Gov. Inv. Spend. per cap.)	0.039	0.381***	0.027	0.050	-0.564***
	(0.090)	(0.125)	(0.145)	(0.137)	(0.171)
Log(Mining Prod. per cap.)	-0.005	-0.008	-0.001	-0.005	0.028
	(0.004)	(0.006)	(0.007)	(0.006)	(0.017)
Observations	97699	87806	43813	15355	4725
Mean	9.169	8.327	9.065	9.789	10.070
Kleibergen-Paap-Wald F stat	32.157	43.968	35.180	30.595	29.676
Clusters	1270	1393	1205	852	446
Panel C. Hours Worked					
Log(Gov. Inv. Spend. per cap.)	-0.977	2.773	3.664	-2.816	-4.878
	(1.880)	(1.805)	(2.523)	(3.989)	(4.760)
Log(Mining Prod. per cap.)	0.039	-0.270***	-0.023	0.025	0.096
	(0.095)	(0.085)	(0.075)	(0.109)	(0.342)
Observations	103936	145916	46751	15380	4826
Mean	38.785	28.760	40.127	43.777	49.551
Kleibergen-Paap-Wald F stat	32.627	38.129	33.899	30.658	29.113
Clusters	1272	1399	1212	854	446

Notes: The excluded instrument for the log of government spending per capita is the log of canon and royalties transfers per capita. The log of mining production per capita is included only if the value is positive. Participation in each sector is conditional to being employed and only considers the main occupation. Work hours are in weekly units. Household and worker outcomes are measured using data from the National Household Survey (ENAHO). Kleibergen-Paap-Wald F statistics is included in place of the first-stage F statistic to address concerns regarding heteroskedasticity and to be consistent with clustering at the district level.

Standard errors clustered at the district level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

E Division Bias Check

Table 13: Fixed Effects Panel Estimation - Province Level GDP (2011-2016)

	$CR = \Delta cr_t/y_{t-1}$			$CR = \Delta cr_t/y_{t-2}$		
	G_C	G_I	G_T	G_C	G_I	G_T
$G_{p,t}$: Gov. purch. year to year change	0.648	0.376**	0.287*	0.397	0.372*	0.272*
	(1.131)	(0.178)	(0.153)	(1.001)	(0.193)	(0.160)
$M_{p,t}$: Mining prod. year to year change	0.057***	0.056***	0.057***	0.056***	0.056***	0.057***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Observations	975	975	975	975	975	975
R^2	0.365	0.360	0.364	0.367	0.361	0.365
Cragg-Donald-Wald F stat	70.758	91.096	105.914	92.503	76.639	95.123

Notes: Each column in the table corresponds to a different regression and definition of government spending. Short names on top of them correspond to the following measures of government spending: G_C is current spending, G_I is investment spending, and G_T is total spending. The depending variable is the rate of growth of GDP per capita, and $G_{p,t}$ and $M_{p,t}$ are yearly changes in government spending per capita and mining production value per capita, both divided by the lagged value of GDP per capita. Both sets of columns are IV specifications. For the first three columns the excluded instrument used to identify the effects of $G_{p,t}$ is the relative to lagged GDP per capita change in canon and royalties transfers. For the following three columns, the change in canon per capita is measured relative to the GDP per capita of two periods before instead.

F Spatial Auto-Regression with Lags in the Error Term

Table 14: SAR Reduced Form Estimations - Province Level GDP (2011-2016)

	(1)		(2)		(3)	
$C_{p,t}$	0.280***	(0.099)	0.348***	(0.106)	0.294***	(0.109)
$M_{p,t}$	0.025*	(0.014)	0.030*	(0.016)	0.038**	(0.017)
Direct Neighbors						
λ	0.017	(0.139)				
ρ	0.796***	(0.065)				
Neighbors of Neighbors						
λ			0.608***	(0.125)		
ρ			0.646***	(0.118)		
Inverse Distance						
λ					0.888***	(0.054)
ρ					0.887***	(0.055)
Observations	965		965		965	
Number of provinces	193		193		193	
Observations per province	5		5		5	
Direct Effects						
$C_{p,t}$	0.280***	(0.099)	0.358***	(0.109)	0.306***	(0.113)
$M_{p,t}$	0.025*	(0.014)	0.031*	(0.016)	0.040**	(0.018)
Indirect Effects						
$C_{p,t}$	0.004	(0.034)	0.417*	(0.234)	2.039	(1.342)
$M_{p,t}$	0.000	(0.003)	0.036	(0.027)	0.265	(0.185)
Total Effects						
$C_{p,t}$	0.284***	(0.106)	0.776**	(0.305)	2.345*	(1.414)
$M_{p,t}$	0.025*	(0.015)	0.067*	(0.041)	0.305	(0.197)

Notes: The three columns in the table are estimations of Equation 17 only differing in the matrix of spatial spillover weights, which is indicated on the left on top of λ and ρ, which are the parameter that measures the degree of spatial correlation in output and the error terms respectively. The depending variable is the rate of growth of GDP per capita, and $CR_{p,t}$ and $M_{p,t}$ are respectively yearly changes in in canon and royalties transfers per capita and mining production value per capita, both divided by the lagged value of GDP per capita. The effects on the bottom of the table are average marginal effects obtained by taking the empirical derivatives of the expected conditional mean defined similarly to in Equation 15.

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$