Check for updates

Received: 8 October 2018 | Revised: 2 October 2021 | Accepted: 24 November 2021

DOI: 10.1111/ecpo.12209

ORIGINAL ARTICLE

ECONOMICS & POLITICS WILEY

Natural resource windfalls and efficiency in local government expenditure: Evidence from Peru

Stanislao Maldonado[1] | **Martin Ardanaz**[2]

[1]Universidad del Rosario, Bogota, Colombia

[2]Inter-American Development Bank, Washington, DC, USA

Correspondence
Stanislao Maldonado, Universidad del Rosario, Bogota, Colombia.
Email: stanislao.maldonado@urosario.edu.co

Abstract

We study the role of natural resource windfalls in explaining the technical efficiency of public expenditure. Using a rich dataset of expenditure and public good provision for 1836 municipalities in Peru for the period 2001–2010, we estimate a nonmonotonic relationship between the efficiency of public good provision and the level of natural resource transfers. Local governments that were extremely favored by the boom in mineral prices were more efficient in using fiscal windfalls, whereas those that only benefited from modest transfers were more inefficient. These results can be explained by the increase in political competition associated with the boom. However, the fact that increases in efficiency were related to reductions in public good provision casts doubts on the beneficial effects of political competition in promoting efficiency.

KEYWORDS

intergovernmental transfers, local government efficiency, resource booms

1 | INTRODUCTION

The recent natural resource boom in developing countries has renewed the interest of the international media, policy-makers, and scholars in longstanding questions regarding the role of natural resources in economic development. Whereas an abundance of natural resources has usually been linked to poor economic and political performance (Karl, 1997; Sachs &

 © 2022 John Wiley & Sons Ltd.

Warner, 1995; Ross, 1999, among others), the empirical evidence in this regard is largely inconclusive.

This is particularly evident in the case of the fiscal consequences of resource booms. The dramatic increase in the international prices of oil, minerals, and some agricultural products has been associated with an important expansion of fiscal resources in resource-rich countries, which has created extraordinary opportunities to improve people's living conditions. This is also true in the case of subnational governments, which have experienced large increases in their budgets as a result of the implementation of legal frameworks that have granted them access to a significant portion of these fiscal resources in many countries around the world.[1]

Whether subnational governments are using these fiscal resources in an efficient manner from a technical point of view has become a critical issue in many countries in which these allocation rules are in place, yet very little is known about how these systems work in practice and how they affect the behavior of subnational politicians.[2] In particular, the media has highlighted cases of perverse behavior by political authorities in which these authorities are portrayed as inefficient and corrupt, although systematic evidence is lacking in this regard.[3]

In this paper, we study the Peruvian experience to shed light on these issues, exploiting subnational variations in natural resource rents induced by a set of rules regarding the allocation of a portion of the taxes paid by mining companies to the districts from which the mineral resources were extracted.[4] In Peru, these rules are known as the Canon Minero (mining Canon).[5] We are particularly interested in the role of natural resource rents in explaining the level of efficiency of local governments in Peru, paying attention to the way in which these rents can distort the behavior of local politicians. This issue has recently attracted a lot of interest among scholars (Ardanaz, 2014) because anecdotal and previous empirical evidence has shown that the fiscal expansions related to resource booms have not been accompanied by increases in public good provision and improvement in citizens' wellbeing (Caselli & Micheals, 2013; Ferraz and Monteiro, 2012),[6] suggesting that these fiscal resources are being wasted.

To understand the link between natural resource rents and local government efficiency, we suggest studying the behavior of local politicians. Following some recent studies (Caselli, 2005; Maldonado, 2020), we believe that this relationship is nonmonotonic. The basic idea is that resource booms are related to high levels of political competition as a result of a high value of holding office. Conversely, there is also an incumbency advantage because mayors have more fiscal resources with which to influence electoral outcomes. In a simple economy in which the production of a commodity depends on a public good (such as roads), the incumbent politician can prevent entry of a potential competitor by increasing the provision of this public good, thereby increasing the opportunity cost of becoming a politician. The optimal response of the potential competitor would be to produce this commodity rather than become a politician. However, for high values of natural resource rents, the value of holding office would be higher than the profits of commodity production, in which case the agent's optimal response would be to run for office against the incumbent politician. Since the probability of re-election is low with the competitor's entry, the optimal response of the incumbent politician would be to increase his political rents and to reduce the provision of public goods. As a result, a nonmonotonic (inverse U-shaped) relationship between natural resource rents and public good provision is expected.

We relate this nonmonotonic pattern to the efficiency of public expenditure. A small level of rents will have a limited impact on the value of holding office, allowing the incumbent to prevent entry. As a result, limited political competition is observed, enabling the inefficient

investment of the local government budget in public good provision because the mayor's position is not challenged. For medium levels of rents, the value of holding office is higher, meaning that the incumbent faces more competition. Yet, because more fiscal resources are available, the incumbent's position is not challenged because investment in public good provision is also high and the incumbency advantage effect dominates the political competition one. Before a threshold, the relationship between rents and efficiency is then negative. When the level of natural resource rents is large, the value of holding office is higher than the expected profit in the industrial sector for the potential competitor, so the mayor cannot prevent entry, and reduces the investment in public good provision. This reduction remains consistent with higher levels of efficiency because this indicator only reflects a ratio between the investment of fiscal resources and public goods actually provided, and mayors invest less when they do not expect to be re-elected. Since the adjustment is investment is faster than the adjustment in public goods produced, there is an improvement in efficiency. Therefore, we expect a nonmonotonic (U-shape) relationship between natural resource rents and the efficiency of local government's expenditures.

The Peruvian case offers an ideal scenario to explore the impact of resource booms on the efficiency of local governments. Peru is one of the most important mineral producers in the world,[7] and has experienced dramatic effects owing to the recent resources boom. Mineral production has increased more than fivefold (from 1.35 to 7.05 billion US$ dollars) and rents distributed to producer regions increased by 118-fold (from 7 to 827 US$ million) from 1996 to 2010. This extraordinary increase over a very short period of time has created a few rich municipalities that have experienced a dramatic increase in their budgets, thereby creating an ideal scenario in which to study the impact of natural resource windfalls on local government efficiency. A final reason is the nature of the local political environment, which is characterized by a high level of fragmentation and weak connections with national political parties, making Peru less sensitive to strategic interactions between local politicians and national political parties, which may affect the rules of mining rent distribution.

Using a two-way fixed effect difference-in-difference approach (TWFE-DD) with a quadratic specification to account for the nonmonotonicity implied by the conceptual framework, we find consistent evidence regarding the nonmonotonic relationship between mining Canon rents and public expenditures. We first document a nonmonotonic impact of mining Canon rents on different types of expenditures, particularly investment. Local governments with modest levels of mining transfers show a positive net effect, whereas those with extremely high levels of transfers show a negative effect.

We then use a Free Disposal Hull (FDH) approach to estimate the efficiency scores for a set of combinations of expenditures and public goods in transport, infrastructure, health, and education. These scores are essentially the same as those estimated using an alternative approach called data envelopment analysis (DEA). In a second stage, we relate these scores to mining Canon rents to evaluate the levels of association between them in a cross-sectional Tobit regression. We also find a nonmonotonic pattern. The effect is negative for a local government with an average level of mining Canon rents, implying that in these municipalities mining Canon rents are negatively associated with efficiency. Conversely, the effect is marginally positive for recipients of higher levels of rents, suggesting that richer local governments are more efficient.

After finding evidence consistent with the theoretical framework, we explore the role of political competition as the main mediating factor between mining Canon rents and efficiency in local government expenditure. We find robust evidence of a nonmonotonic relationship

between mining Canon rents and political competition along the lines of Maldonado (2020). The marginal effect is negative for the average municipality (implying a reduction in political competition) but positive for richer municipalities (implying an increase in political competition). Although this increase in efficiency may appear positive at first glance, the reduction observed in public expenditure, as well as a reduction in the provision of public goods for richer municipalities, offers a somewhat more negative interpretation. As a result of a higher level of political competition, the increase in efficiency along with a reduction in public good provision may reflect the strategic response of incumbent politicians to increase their rents because their political horizons have been reduced. It could also be consistent with a move towards alternative forms of redistribution (like clientelism) to influence electoral outcomes in a more competitive political environment.

Our results are robust in relation to an ample set of budgetary, socioeconomic, and geographical controls. They are also robust in relation to alternative ways to derive the efficiency scores, and are valid after relaxing the distributive assumptions of the second-stage Tobit model using a censored quantile regression approach. They are also robust in relation to the type of public good analyzed. We provide a large set of robustness checks to relax the parallel trends assumption and formally test the nonmotonicity relationship between mining Canon and policy outcomes along with other additional analysis to boost the credibility of our research design.

This paper is related to recent studies exploring the economic and political effects of natural resource booms. One strand of the literature has explored the impact of resource booms on the behavior of politicians with respect to electoral outcomes such as re-election and political competition (Ferraz and Monteiro, 2012; Maldonado, 2020). Other scholars have explored the impact of resource booms on citizens' wellbeing via public good provision (Caselli & Micheals, 2013; Loayza et al., 2013; Maldonado, 2020) and demand for local inputs (Aragon & Rud, 2013). Other dimensions explored by researchers include corruption (Brollo et al., 2013; Maldonado, 2011; Vicente, 2010), politician quality (Brollo et al., 2013), conflict (Angrist & Kluger, 2008; Arellano, 2011a; Dube & Vargas, 2013), and citizens' confidence in political institutions and democracy (Maldonado, 2012).

This paper also contributes to a large body of literature on the efficiency of local governments, for example, Afonso and Fernandes (2008) in relation to Portugal, Gimenez and Prior (2007), and Benito et al. (2010) regarding Spain, Borge et al. (2008) and Revelli and Tovmo (2007) on Norway, Da Conceicao and Stosic (2005) in relation to Brazil, De Borger et al. (1994) and De Borger et al. (1996) regarding Belgium, Kalb et al. (2012) on Germany, Geys and Moesen (2009) in relation to Flanders, Stevens (2005) regarding England, Worthington (2000) on Australia and Herrera and Francke (2007) in relation to Peru. More closely related to this paper is Ardanaz (2014), who studies the role of oil royalties in explaining the efficiency of local government expenditure in Brazilian municipalities. Finally, this paper is a companion paper to Maldonado (2020). We complement the findings of that paper with a study of a relevant economic and policy outcome like technical efficiency and how this outcome is affected by a resource windfall, paying attention to the potential role of a political economy explanation in understanding this relationship.

The rest of the paper is organized as follows. Section 2 provides some basic details about the institutional setting. Section 3 introduces a basic theoretical framework, and Section 4 describes the data. Section 5 presents the empirical methodology and Section 6 presents the empirical results. Section 8 concludes the work.

2 | INSTITUTIONAL BACKGROUND[8]

2.1 | Local politics and public finance

Municipalities are governed by the mayor and a council, with the former having considerable discretionary power in municipal government decisions.[9] Mayors are granted 50% plus one seats on the municipal council, regardless of their share of the vote. In practice, this has constrained the ability of opposition local political parties to demand political accountability. Although the electoral rules allow local politicians a high degree of freedom, the weak institutional capacity of local governments acts as an important constraint on their political behavior.[10]

Local governments are highly dependent on central government transfers because their ability to collect taxes is very limited. For instance, 97% of taxes are collected by the central government (Polastri & Rojas, 2007). At the same time, transfers from the central government represent 57% of the local governments' budgets. These transfers can be universal or targeted. Of these targeted transfers, Canon transfers (including all sources of Canon such as oil, hydropower, forest, and gas Canon) represent 91% of the total, with mining Canon being the most significant (79% of all Canon transfers). Therefore, mining Canon represents a significant portion of local government's budgets in mineral-rich areas.[11]

2.2 | Mining legal framework

Along with a legal framework for the promotion of mining activity, in 1992 the central government passed the first mining Canon law (DS 014-92 EM), which stated that 20% of income taxes should be allocated to the areas in which the profits were generated. In 2001, as part of the decentralization process, this law was modified to increase the participation of these areas. The most important law is Law 27506 (known as the Canon Law), which states that 50% of the income tax paid by mining companies will be allocated to regional and local governments in the areas from which the minerals are extracted. This amount is distributed among the regional government (20%), the municipality of the district (10%), the municipalities located in the province (25%), and the municipalities located in the region where the resource is mined (40%). In addition, 5% is allocated to the public universities in the region. This distribution rule has been changed several times to reflect the criteria used to allocate transfers among local governments located in the same province and region of the mineral-producing districts. An important issue is that non-producer districts in a producer province and producer region are entitled to mining Canon transfers based on basic needs and population size, which can introduce an endogeneity problem. We will address this issue later. Annex 1 in the Supporting Information Appendix shows the legal framework related to mining Canon and other mineral resource-based rents.

2.3 | Fiscal windfalls and the boom in mineral resources

Figure 1 shows the evolution of the real value of mineral production during the period 1996–2010. After 2000, mineral production experienced an extraordinary increase of around 200%. The increase in prices has played even a more significant role. Figure 2 shows the

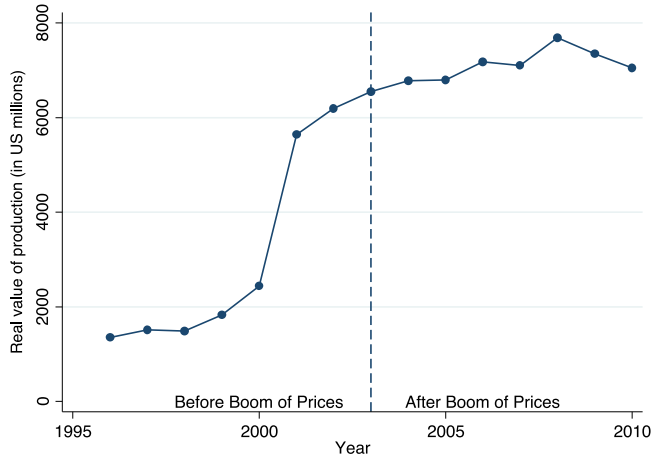


FIGURE 1 Evolution of mineral production. *Source*: Authors' elaboration based on administrative data from the Ministry of Energy and Mines. Calculations are based on real production values in 2001 prices. The vertical line represents 2003, the year in which the boom is considered to have started

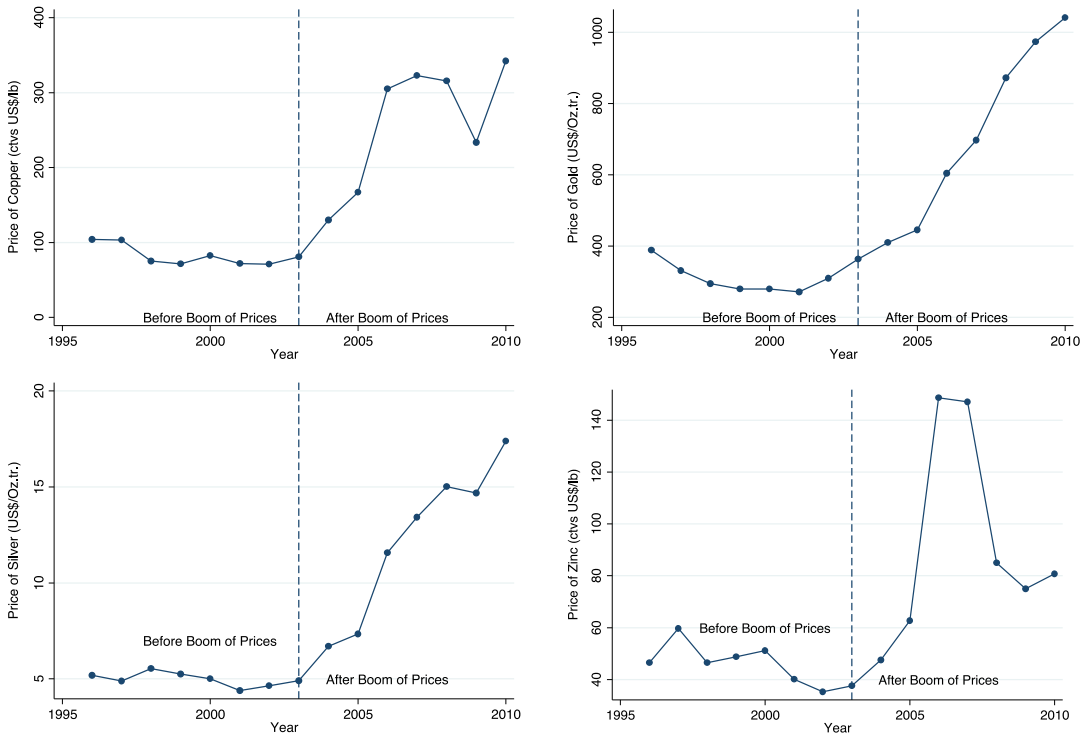


FIGURE 2 Evolution of mineral prices (1996–2010). *Source*: Authors' elaboration based on administrative data from the Ministry of Energy and Mines. The vertical line represents 2003, the year in which the boom is considered to have started.

evolution of the international prices of the four most important mineral resources produced by Peru (copper, gold, silver, and zinc) during the period of reference. As shown in the figure, these prices were quite stable from 1995 to 2003, and then saw an extraordinary rise until 2010. In almost all cases, the prices in 2010 were two or three times greater than the average prices before 2003.

As a result, there was an extraordinary increase in mining Canon transfers. This was also accompanied by a change in the rule of allocation regarding mining Canon transfers that increased the shares received by regional and local governments in the areas from which the mineral resources were extracted from 20% to 50%. This change was implemented in November 2001 during the transition government of Valentin Paniagua. Figure 3 shows this evolution. The amount of transfers as a result of royalties and mining Canon were relatively low during 2001 and 2002, but there has been a spectacular increase since then.[12] This windfall was particularly beneficial for mineral-producing districts as a result of the allocation rule, creating a highly unequal distribution of rents across local governments.[13] This is a critical element because previous evidence for the Peruvian case suggests that the behavior of municipalities with extraordinarily high levels of mining Canon transfers differs from that of the average Canon recipient.[14]

The observed variation in mining Canon rents is the combination of variations in prices and quantities, as well as changes in the mining Canon allocation rules. Although these three sources of variation are present in our design, we argue that most of the observed variation in rents in explained by the price variation. Figure SA.1 in the Supporting Information Appendix shows the evolution of price and quantum indexes in the period under analysis for the four main mineral products. Although there is an increase in mineral production, this increase occurred before 2003, the year is which mineral prices started to raise. This increase is explained by the measures implemented by the national government to promote the mining activity in 1992 and are unrelated with the increase in prices. Interestingly, mineral production

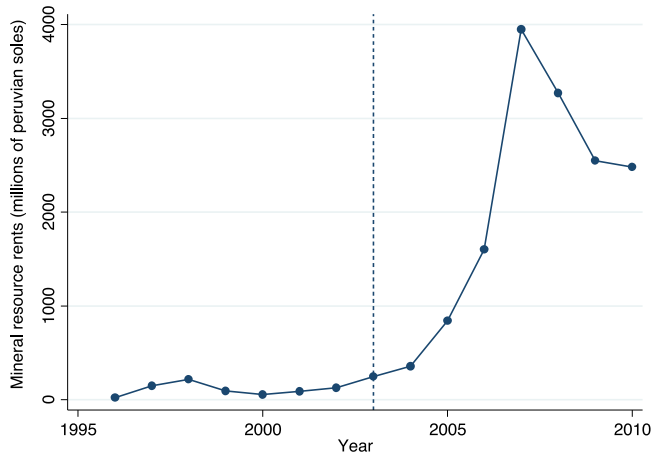


FIGURE 3 Evolution of mining Canon rents distributed to local governments (1996–2010). *Source*: Authors' elaboration based on administrative data from the Ministry of Economy and Finance. Monetary values are expressed in 2001 Lima prices. The vertical line represents 2003, which is the year in which the boom is considered to have started.

remained quite stable even after the rise of mineral prices. The most important variation is the variation in prices, which mainly explains the observed evolution in mining Canon rents.

3 | THEORETICAL FRAMEWORK

To understand the relationship between local government efficiency and natural resource rents, it is critical to understand the behavior of local politicians and political elites in the face of a resource boom. Recent theoretical scholarship has suggested that this relationship might be nonmonotonic. For instance, Caselli and Cunningham (2009) propose a model where there are potential nonmonotonic responses in the presence of a resource boom. The logic behind this is that resource booms attract more competitors (political competition effect) but at the same time provide more fiscal resources that incumbents can use to retain power through the public good provision and private transfers (incumbency advantage effect). Which effect is dominant will depend on the magnitude of the boom. For booms of small size, the incumbency advantage effect will dominate since the opportunity cost of potential challengers is low. For large levels of transfers, no amount of public good can prevent the entry of political challengers. This basic intuition is exploited in Maldonado (2020), who adapts this basic model to analyze electoral competition in the presence of exogenous natural resource rents.[15] This model predicts an inverse U-shape relationship between mining Canon and public good provision and public good expenditures.

A natural extension of this framework is to link the effects on the political competition with the incentives local politicians have to use local government budgets efficiently. When the increase in natural resource rents is modest, local politicians do not face significant political competition. In fact, some competitors will leave the political market to take advantage of the economic opportunities related to the expansion of the stock of public goods. This reduction in competition creates an opportunity to manage the local government budget less efficiently because the incumbent's position is not challenged, but more fiscal resources are available.[16] However, when this increase is large, incumbents face a higher level of political competition. Public good provision cannot prevent the entry of potential competitors, reducing incumbent's ability to remain in power. This creates incentives to reduce public good provision, leading to a more efficient provision due to a faster adjustment of inputs over outputs. This suggests a U-shape relationship between mining Canon and efficiency.

The relationship between political competition and local government efficiency suggested by this framework is consistent with alternative political economy models.[17] Scholars from the Chicago School have always emphasized the efficiency of political competition (Stigler, 1972; Wittman, 1989), but other scholars have suggested that high levels of political competition could lead to the inefficient provision of public goods (Polo, 1998; Svensson, 1998). The idea is that more political competition can create political instability, increasing the incentive to seek rents, which is consistent with Caselli (2006), Caselli and Cunningham (2009), and several other political economy models (e.g., Acemoglu & Robison, 2006; Lizzeri & Persico, 2005). Recent theoretical and empirical contributions suggest that the welfare-improving effects of political competition seem to be more relevant (Ashworth et al., 2014; Besley et al., 2010), but as Besley et al. (2010) argue, there is no general theoretical presumption that this will always be the case.

Our conceptual framework suggests that both approaches can be accommodated. The model predicts that more political competition increases efficiency, but at the same time it

reduces public good provision. Whereas most scholars in the efficiency field seem to believe that more efficiency is related to more public good provision (Ashworth et al., 2014), there is no reason to believe that this should always be the case. At the end of the day, an efficiency indicator measures the maximum level of output for a given level of inputs. Therefore, it is perfectly possible to observe a reduction in public good provision consistent with an increase in efficiency.

We test the empirical implications of this theoretical framework in the following sections.

4 | DATA

4.1 | Data sources

We constructed a unique dataset using several data sources. A key element is the data on revenues and Canon transfers from the central government at the district level over the period 1998–2010. These data were collected from the Ministry of Economy and Finance and include detailed information about all types of transfers received by local governments as well as information about other regular sources of income (e.g., taxes, contributions, and fees for services). Critically, this includes information about different types of expenditure that are critical inputs for the efficiency indicators.

The information about public goods was obtained from different sources, the most important of which is the Registro Nacional de Municipalidades (RENAMU). This is an annual Census of municipalities that has been conducted since 2001. The second source is the Census 2007. We constructed public good measures at the district level.

We also collected information on mineral production and prices for the period 1996–2010 from the Ministry of Energy and Mines. Data are available for each production unit. We aggregated the information at the district level for each producer district.

We also used electoral data for the period 2002–2010 to evaluate the role of political factors in explaining local government efficiency. These data were collected from the National Office of Electoral Processes. We constructed an indicator of political competition based on the Herfindahl–Hirschman (HH) index of market competition adapted from Skilling and Zeckhauser (2002). This measure uses vote shares to calculate the complement of the HH index. This measure is also known as the "effective number of parties" in the political science literature.

We used various sources to construct a set of control variables for the determinants of local government efficiency. From RENAMU, we created a set of geographical controls and socioeconomic characteristics for all the municipalities. Information for the period 2002–2010 was available for the analysis. We also took advantage of preboom data from Census 1993.

4.2 | Summary statistics

Table 1 presents summary statistics on the mining Canon transfers. We distinguish between three types of districts: producers, Canon recipients (excluding producers), and non-Canon recipients. On average, mineral-producer districts received 475 nuevos soles per capita during the period under analysis. This represents 25% of the average monthly per capita income in these areas. Canon recipient districts (excluding producers) received 92 nuevos soles per capita

TABLE 1 Summary statistics

	Recipients	Producers	Nonrecipients
Transfers			
Mining transfers (per capita)	92.32	474.47	–
p10	0.09	0.39	–
p25	0.70	2.64	–
p50	4.92	27.75	–
p75	44.04	281.85	–
p90	179.31	877.38	–
p99	1272.58	9479.57	–
Municipality budget (per capita)	568.03	1496.52	347.17
Mineral Production			
Real value of mineral production (US$ in 2001)	–	2,324,875	–
Copper	–	898,122	–
Zinc	–	490,013	–
Lead	–	69,880	–
Tin	–	134,851	–
Molybdenum	–	17,171	–
Silver	–	219,311	–
Gold	–	466,456	–
Iron	–	29,070	–
District Characteristics: Census 1993			
Population	12,339	10,788	22,618
% Rural population	57.76	55.32	59.08
% Children (0–15 years old)	40.68	40.58	45.14
Malnutrition rates for children	55.61	53.02	55.64
% Population without wastepipe-latrine	41.81	41.60	53.91
% Population without water	51.20	49.84	67.13
% Population without electricity	74.16	65.27	68.55
Female illiteracy rate	33.60	29.39	23.90
Altitude	2326	2720	498

Source: Authors' elaboration based on data from the Ministry of Economy and Finance and Ministry of Energy and Mines. Section III is based on 1993 Census data.

on average. These numbers do not take into account the extreme inequalities in the distribution of mining Canon transfers. For instance, whereas the 90th percentile of mineral producers receives 877 nuevos soles per capita, the 99th percentile receives 9479 nuevos soles per capita. This is evidence that although a large number of districts receive a transfer, few of them receive a significant amount.

Table 1 also presents descriptive statistics for a set of socioeconomic characteristics for districts using Census 1993 data. The evidence suggests that there are significant differences among districts regarding population size, percentage of rural population, and basic needs. This is to be expected because mineral production occurs in areas that historically have been exposed to poverty and exclusion, which is reflected in their basic needs indicators.

5 | EMPIRICAL METHODOLOGY

The empirical methodology is composed of two elements. First, we use a TWFE-DD model to study the impact of natural resource windfalls on local governments' budgets. This element was already explored in Maldonado (2020) and it is introduced here to document a non-monotonic relationship between mining Canon and local government expenditures. The second element, which is the main research question in this paper, involves the use of efficiency analysis to evaluate whether local governments in resource-rich regions are using the fiscal windfall they receive in an efficient manner.

5.1 | Testing the impact of resource windfalls on local governments' budgets

The basic specification for the TWFE-DD model is as follows:

$$e_{it} = \alpha_i + \phi_t + \beta f(MC_{it}) + X'_{it}\delta + \varepsilon_{it}, \tag{1}$$

where e_{it} is the budget outcome of interest for district i in period t, α_i and ϕ_t are district and years fixed effects, respectively, $f(MC_{it})$ is a measure of mining Canon transfers per capita allocated to district i in period t, $X'_{it}\delta$ includes district-level characteristics, and ε_{it} is an error term. The parameter of interest is β, which recovers the effect of interest. The time-fixed effects accounts for the time-series changes in our measures of fiscal revenue or expenditure. The district fixed effects controls for time-invariant characteristics at the district level and MC_{jt} accounts for changes in the dependent variable in treated districts associated with the movement of mining Canon revenues after an increase in the prices of mineral resources. Identification in this setting requires controlling for any systematic shock to fiscal revenue or expenditure in the districts benefiting from the increase in the prices of mineral resources that are potentially correlated with, but not a consequence of, the revenue shock.[18]

We specify $f(MC_{it})$ as a quadratic function. This is based on the theoretical literature about the resource curse that suggests the existence of a strong nonmonotonic pattern in the relationship between resource rents and economic and political outcomes.[19]

We perform some corrections to standard inference procedures. We cluster standard errors at the district level to control for within-group dependence. As pointed out by Moulton (1986), inference without accounting for within-group dependence can severely underestimate standard errors. This also corrects for the serial correlation common to DD models, as highlighted by Bertrand et al. (2004).[20]

5.2 | Efficiency analysis

The efficiency analysis is based on frontier analysis techniques. Typically, these techniques estimate the efficiency of a set of units by selecting the combination of inputs and outputs that reflects the optimal use.[21] Those units whose combination of inputs and outputs deviates from this optimal combination are considered inefficient. In this paper, the measure of output is sidewalks and roads constructed in urban areas (in square meters). Since Farrell (1957), two types of efficiency have been recognized: *technical inefficiency*, which is related to a situation in which a unit is using more inputs than are technically required to produce a given output, and *allocative inefficiency*, which implies a suboptimal use of inputs given current input prices and marginal productivities (Herrera & Pang, 2005). Given the lack of information regarding input prices, we focus on technical efficiency in this paper.

Several approaches have been developed to estimate the efficiency frontier. The two basic ways to classify these approaches depend on whether the frontier is parametrically or non-parametrically estimated, and whether the approach is stochastic or deterministic. We use FDH, a common nonparametric technique developed by Deprins et al. (1984) that is a variant of DEA. In this approach, the frontier is constructed as a piecewise envelopment of the data using linear programming (Kalb et al., 2012).

Technically, the FDH approach solves a linear programming problem of the following form (Geys & Moesen, 2009):

$$Min_{\{\lambda_k, z_1, z_2, \ldots, z_n\}} \lambda_k, \tag{2}$$

subject to:

$$\lambda_k C_k - \sum_{j=1}^{n} z_j C_j \geq 0. \tag{2.1}$$

$$\sum_{j=1}^{n} z_j y_{jr} \geq y_{kr} \quad with \quad r = 1, \ldots, s. \tag{2.2}$$

$$z_j \in \{0, 1\}. \tag{2.3}$$

C_k and C_j are the total inputs for municipalities k and j, respectively. The output r for these municipalities is denoted as y_{kr} and y_{jr}, respectively. The number of outputs is represented by $s$and n is the number of districts. Finally, z_j is the weight given to municipalities relative to municipality k to calculate the efficiency score λ.

An advantage of this technique is that it avoids the use of strong assumptions regarding the functional form of the relationship between inputs and outputs that are common in the deterministic frontier approach and the stochastic frontier approach.[22] In addition, this technique keeps the assumptions regarding production technology to a minimum compared with DEA and the parametric approaches (in particular, it imposes free disposability of resources). DEA with variable returns to scale (DEA-vrs) assumes that the best-practice frontier is strictly convex. However, this assumption has been questioned on empirical grounds (Cherchye et al., 2000). In any case, to recover DEA-vrs, it is sufficient to simply modify the condition in (Equation 2.3) by the following expressions:

$$\sum_{j=1}^{n} z_j = 0. \tag{2.3'}$$

$$\lambda_k, z_j \geq 0 \ for\ j = 1, ..., n. \tag{2.4}$$

For the sake of completeness, the DEA approximation for the case of constant returns to scale (DEA-crs) is composed of Equations (2), (2.1), (2.2), and (2.4). Since constant returns to scale imply that municipalities can linearly scale inputs and outputs without affecting efficiency (Geys & Moesen, 2009), it is considered that DEA-crs is too restrictive. We will not pursue this particular variant of DEA in this paper.

Despite the advantages of FDH, there are also limitations associated with this technique. In particular, the quality of the data and the presence of outliers are critical. We control for this by dropping the outliers before estimating the frontier. Specifically, we drop the percentiles 1 and 99 of our expenditure measure from the sample. As a robustness analysis, we also estimate the frontier under a DEA approach. The results are qualitatively similar.

A critical issue with this approach is accounting for exogenous or nondiscretionary variables. As pointed out by Stevens (2005), failure to account for these variables leads to an overstatement of the level of inefficiency. Two approaches have been proposed to deal with this issue. The first method involves incorporating the exogenous variables directly into the computation of the efficiency scores using a parametric approach. Typically, this implies imposing some additional structure on the error term associated with this model. The original inefficiency term of the standard parametric approach is further decomposed into a fraction explained by the nondiscretionary variables and a residual inefficiency term.[23]

The second approach is the so-called *two-stage approach*. In this approximation, the frontier is estimated without controlling for the exogenous factors. Then, a Tobit regression is implemented to assess the relationship between the estimated efficiency scores and the exogenous factors. The basic specification is as follows:

$$\hat{\lambda}_i = a + bf(MC_i) + Z_i'\gamma + v_i \geq 1, \tag{3}$$

where $\hat{\lambda}_i$ is the efficiency measure for district i estimated in the first step, $f(MC_{it})$ is a measure of mining Canon transfers per capita for district i, and Z_i is a set of control variables. Given the cross-sectional nature of this part of the empirical analysis,[24] we use a different set of control variables to remove selection bias. In addition to the traditional budget and socioeconomic controls, we take advantage of the fact that mineral production is critically dependent on geographical dimensions to provide a causal interpretation of the reduced-form results by including altitude, longitude, latitude, and distance to the provincial capital through a set of dummy variables to account for locational characteristics and region fixed effects. The identification assumption in our preferred specification is that once budgetary, socioeconomic, and geographical dimensions have been accounted for, the differences in mining Canon transfers across districts in the same region are effectively random. Finally, as is standard in these types of models, v_i is assumed to be normal with a mean of zero and constant variance.

We acknowledge that this approach is not problem free. First of all, we do not observe inputs but expenditure. One possibility is that results can be reflecting changes in prices instead a true variation in the quantity of inputs. One indirect way to address this issue is by looking at the case of nonproducer districts, where it is hard to expect that a mining boom can cause a large effect on input prices. Second, we link a measure of public good (e.g., urban roads) with

the whole budget in spending category (e.g., transport). This can induce systematic measurement error if mining Canon transfers create substitutions across type of public-good expenditures. One way to address this issue is to verify if such substitutions are actually observed in the data.[25] We address both issues in the next section.[26]

Another concern is that the main results of this strategy just pick up diminishing returns to expenditure. Recall that we are approximating efficiency using either FDH or DEA with just a single input, so it is possible that-if other inputs are fixed-the effect of mining Canon just captures diminishing returns to expenditure. Whereas this is undoubtedly a methodological limitation of the current literature about the topic, we believe it is unlikely that this issue will be empirically relevant in our setting.[27] On the one hand, we run regressions for efficiency scores constructed for 2010 on averages in mining Canon rents for 2001–2007. We do so to allow some time for expenditures to be converted into public goods, including adjustments in other fixed inputs. Therefore, whereas human capital and technical expertize are fixed in the short term, it is unlikely that these would be the Case 3 years after. On the other hand, the baseline efficiency level is pretty low in our setting (0.12). This suggests that local governments have a lot of room for improvement in terms of efficiency. Because the average local government is far away from the frontier, it is unlikely that these other fixed inputs would explain a nonmonotonic pattern for such low levels of efficiency. Under the same logic, it is improbable that the substitution across public goods within and between expenditure categories would matter at low-efficiency levels. We will address this issue in the next section.

A final concern is related to the specification of $f(MC_{it})$. Consistent with our conceptual framework, we use a quadratic approach to capture a non-monotonic relationship. Identifying a non-monotonic relationship is tricky since it can always be confused with a convex but monotonic relationship. Fortunately, Lind and Mehlum (2010) have developed a test that provides exact necessary and sufficient conditions to distinguish between these two scenarios formally. We will implement this test in the next section.

6 | EMPIRICAL RESULTS

In this section, we present the results of two exercises. First, we study how the natural resource boom has impacted local governments' budgets. Then, we analyze whether the windfall has affected the efficiency of local government expenditure. Finally, we discuss the role of political competition and public good provision in explaining the reduced-form results.

6.1 | The impact of a resource-based windfall on local governments' budgets

Before presenting the main results of the TWFE-DD specification, we check whether the critical identification assumption, parallel trends, is valid in our setting. Figure SA.2 in the Supporting Information Appendix offers some suggestive evidence in favor of the validity of this assumption using the evolution of real income per-capita. Before 2003, both mining Canon recipient and nonrecipient municipalities showed a similar evolution. After 2003, we observe that the evolution of both type of municipalities differ. Therefore, it seems that there is no evidence against the plausibility of parallel trends in our setting.

To evaluate the impact of the fiscal windfall on local governments' budgets, we run the TWFE-DD model discussed above. The dependent variables are measured in nuevos soles based on prices in Lima in 2001 in per capita terms. The mining Canon transfers are measured in thousands of nuevos soles in per capita terms. We also include the log of the real value of mineral production to account for any potential change in district budgets directly related to mineral exploitation.

Table 2 presents the results for different types of expenditure. We found that mining Canon transfers are nonmonotonically related to most of the expenditure categories under study with the exception of "Other current expenses" and "Debt." In cases like "Payroll," "Pensions," and "Financial investment," only one of the coefficients of the quadratic relationship is statistically significant, but effects are typically weak and nonrobust. This is not unexpected since these are expenditure categories that are less sensitive to respond to political incentives. "Payroll" and "Pensions" are mostly fixed categories and it is very little what a mayor can do to modify them. "Debt" is also a minor category for local governments due to the lack of development of financial markets (which also explain the marginal role of the "Finance Investment" category) and legal restrictions imposed by the central government to limit their ability to borrow.

The most important impact is related to "Investment." This is not surprising, because local governments are required by law to use mining Canon transfers exclusively for investment. To interpret these results, it is important to consider the level of transfers allocated to a district given the estimated nonmonotonic relationship. Since the average district in the sample receives 130 nuevos soles per capita, this basically means that the effect is positive and equal to 844 nuevos soles of investment for each thousand nuevos soles of mining Canon transfers for this type of municipality. These coefficients basically imply a positive effect over the entire range of possible values (the maximum is 18,100 nuevos soles per capita), although the effect is smaller (almost 100 nuevos soles in investment expenditure for each thousand nuevos soles received). These effects represent an increase of about 300% compared with the average investment (313 nuevos soles per capita).

There is also an important effect in relation to expenditure on "Goods and services," although the effects are considerably more modest. The average district experiences an increase of 109 nuevos soles in expenditure on goods and services for each thousand nuevos soles received by way of mining Canon transfers. For the richest district, this increase is about 20 nuevos soles per thousand nuevos soles received. With the exception of Payroll, mineral production does not affect the level of expenditure.[28]

We perform a set of robustness checks of these results. We relax the parallel trends assumption by controlling for district-specific linear trends in the model in Table 2. Although this approximation is not perfect (see, for instance, Wolfers, 2006), we use it to boost the credibility of our main results. Table SA.1 in the Supporting Information Appendix shows that the basic results in Table 2 are largely unaffected by the inclusion of linear trends.

Because we lack of data to properly assess trends in efficiency given its cross-sectional nature, we also offer indirect evidence regarding trends for outcomes related to efficiency of public good provision. We focus on public good provision and living standards. We follow the same approach as above and test whether the basic results are robust to including district-specific linear trends.[29] Table SA.2 in the Supporting Information Appendix shows results for public good provision are consistent with the theoretical framework and that they are robust to controlling for district-specific linear trends. Table SA.3 in the Supporting Information Appendix shows results for household-level wellbeing indicators such as per-capita

TABLE 2 Impact of natural resource booms on local government expenditures

	Difference-in-difference estimates							
	Payroll	**Pensions**	**Goods and services**	**Other current expenses**	**Investment**	**Finance investment**	**Other capital expenditures debt**	**Debt**
Mining Canon per capita	54.217*	0.307	119.261***	−0.147	936.501***	−0.030	9.159**	−0.226
	(31.269)	(0.208)	(29.923)	(0.439)	(68.537)	(0.019)	(4.223)	(0.934)
Mining Canon per capita^2	−1.605	−0.018**	−3.009**	0.025	−26.704***	0.001	−0.455*	0.088
	(1.172)	(0.007)	(1.187)	(0.020)	(2.053)	(0.001)	(0.240)	(0.080)
Log of (1+ real value of production)	−0.551*	−0.004	−0.680	−0.073	3.775	−0.003	0.099	0.217
	(0.319)	(0.053)	(0.542)	(0.060)	(3.717)	(0.003)	(0.172)	(0.161)
Mean dependent variable	34.13	5.21	96.89	14.17	313.66	0.01	4.43	16.58
Number of observations	17,317	17,317	17,317	17,317	17,317	17,317	17,317	17,317
R^2	.101	.721	.238	.043	.488	.002	.019	.083

Note: Huber–White standard errors are clustered at the district level (in parentheses). All specifications include district and year fixed effects. The treatment variable is measured in 1000s of nuevos soles. All monetary values are in Lima prices in 2001. Real value of mineral production is measured in mineral prices in 2001. Dependent variables are measured in per capita terms.

*Significant at 10%.

**Significant at 5%.

***Significant at 1%.

consumption, per-capita income, poverty, and extreme poverty. Again, results are robust to the inclusion of district-specific linear trends.

Including mineral production as a control in Table 2 can raise concerns about of a "bad control" problem (see Angrist & Pischke, 2009). As discussed before, international prices not only affect mining Canon rents but also the investment decisions in mining companies, which can lead to an increase in mineral production.[30] This is unlikely to be the case in our setting because the project cycle in the mining sector is typically long, with processes that take at least 7 years before mineral extraction begins.[31] Given the timeline of this paper, this means that this potential change will take place at the end of our period of analysis.[32] Regardless, we re-estimate the model of Table 2 excluding producing districts from the sample. Results, reported in Table SA.4, are similar for the "Investment" category, suggesting that this concern seems to be not relevant in our setting.[33]

Another concern is the possibility that these results are driven by an increase in local prices for public goods. For instance, Aragon and Rud (2013) found that an increase of local demand driven by the operations of Yanacocha mine lead to an increase in the prices of nontradable goods. Whereas this is certainly possible, we have to take into account that Yanacocha is the largest gold mine in South America, so it might be just a matter of the scale. Large mines can create larger local effects, but it less likely that this would be the case for medium and small operations, the vast majority in our sample. To address this issue, we re-estimate the model in Table 2 dropping from the sample provinces with mines with large operations.[34] Results are reported in Table SA.5 in the Supporting Information Appendix. Our basic results are largely unaffected.

Another potential concern with our research design is the possibility that the change in the allocation rule is endogenous to the preboom efficiency levels. The national government may have wanted to favor high or low efficient municipalities at the moment of introducing the change in the allocation rule from 20% to 50% of the income tax paid by mining companies. Unfortunately, we lack of preboom efficiency data to assess whether this was the case, but we can offer some indirect evidence about whether the change in the allocation rule was designed to favor some specific set of municipalities based on socioeconomic characteristics. To address this issue, we run a regression of the change in mining Canon per-capita for alternative periods before (1996–2000) and after the change in the allocation rule (2001–2010) against pretreatment characteristics from the 1993 Census data. We also run a regression for the whole period (1996–2010). Table SA.6 in the Supporting Information Appendix shows that there is no association between changes in mining Canon per-capita and a large set of socioeconomic characteristics in 1993 in any of the periods above once standard errors have been clustered at the province levels. This is suggestive evidence against the concern raised above.[35]

It is also possible that mining Canon transfers capture endogenous responses associated with population and living standard changes induced by the boom in prices, which in turn can endogenously affect the allocated levels of mining Canon transfers in the next periods. Recall that the mining Canon allocation rule assigns transfers based on basic needs and population size for nonproducer districts, creating an endogeneity issue. To avoid this issue, we re-estimate mining Canon transfers fixing the population level, basic needs indicators, and production levels at their preboom values. In this way, only the variation in prices will play a role in explaining the variation in mining Canon. We can, therefore, predict the value of mining Canon closely following the allocation rule using a Bartik-type design. Table SA.7 in the Supporting Information Appendix shows that, although coefficients are smaller, the

non-monotonic pattern and the significance of many of the results are similar to the ones reported in Table 2.

A final concern is that, given the mining Canon allocation rule, outcomes across districts in the same region are correlated. This would be also the case for districts in the same province. This would lead to an underestimation of the standard errors due this form of clustering. Table SA.8 in the Supporting Information Appendix shows that the inference of our results are unaffected by clustering our standard errors at the level of the region and the province.

Table 3 presents the results of the impact of fiscal windfalls on functional expenditure. We consider the nine most important functions of local government in Peru and find a pattern consistent with the nonmonotonic relationship suggested by the theoretical literature. All the coefficients for the level and the square of mining Canon transfers are strongly statistically significant for almost all the expenditure categories studied, with the exception of "Health and sanitation," in which case the coefficient for the square is not statistically significant.

The type of expenditure most affected by mining Canon transfers is "Transport," which is again consistent with the current legal framework that favors investment in infrastructure. This type of expenditure also has other economic and political properties that make it one of the most attractive applications of mining Canon revenue. It is usually associated with the construction and maintenance of roads and sidewalks, which is highly intensive in terms of low-skilled labor, and a common method politicians use to obtain political support from citizens. It also has the advantage of serving as an indicator to citizens of the quality of politicians.[36]

To examine the net effect of mining Canon transfers on transport expenditure, we proceed in the same way as above. The average municipality experienced an increase of about 250 nuevos soles in transport expenditure for each thousand nuevos soles of mining Canon transfers. The net effect for a mineral resource-rich district is more modest, and even becomes negative for a few of the richest ones.

"Transport," "Planning," and "Agriculture" are the expenditure categories that benefited the most from the resource windfall. According to Arellano (2011b), the increase in Agriculture can be explained by local politicians' interest in compensating citizens from rural areas for the potentially negative effects of mining activity. This usually takes the form of irrigation projects, seed distribution, or similar programs.

We also evaluate the robustness of these results to violations of parallel trends. As above, we do so by controlling by district-specific linear trends. Table SA.9 in the Supporting Information Appendix shows that the main results in Table 3 are robust to relaxing the parallel trends assumption.

To summarize, we found a strong positive relationship between mining Canon transfers and local government expenditure. These results are robust to a set of robustness checks. In the next section, we explore whether local governments have used these increases in their budgets in an efficient manner.

6.2 | Efficiency of local public spending

We first derive the efficiency frontier using the FDH approach. We focus on four sectors: transport, infrastructure, education, and health. Because of space constraints, we discuss the results for transport, although the basic results are mostly the same for the other sectors (the results are presented in the Supporting Information Appendix). We focus on transport because, as discussed above, this is the expenditure category that experienced the most dramatic

TABLE 3 Impact of natural resource booms on local government expenditures

	Difference-in-difference estimates								
	Planning	**Agriculture**	**Social assistance**	**Education and culture**	**Energy and natural resources**	**Industry, trade and services**	**Health and sanitation**	**Transport**	**Housing and urban development**
Mining Canon per capita	269.258***	172.590***	34.600***	178.123***	14.972***	26.074***	108.534***	279.371***	38.571***
	(51.112)	(29.931)	(3.623)	(15.997)	(2.310)	(4.732)	(20.848)	(58.986)	(5.432)
Mining Canon per capita^2	−7.611***	−4.757***	−0.410**	−6.152***	−0.556***	−1.011***	−1.872	−9.952***	−1.348***
	(1.964)	(0.987)	(0.171)	(0.879)	(0.089)	(0.153)	(1.649)	(1.810)	(0.239)
Log of (1+ real value of production)	−1.287	0.310	0.167	2.048	−0.349	−0.151	1.175	−0.529	0.329
	(0.962)	(0.824)	(0.353)	(1.673)	(0.303)	(0.293)	(1.175)	(1.386)	(0.352)
Mean dependent variable	164.89	38.46	42.95	57.99	13.80	9.25	66.66	68.29	20.24
Number of observations	17,317	17,317	17,317	17,317	17,317	17,317	17,317	17,317	17,317
R^2	.296	.144	.116	.259	.032	.058	.232	.219	.051

Note: Huber–White standard errors are clustered at the district level (in parentheses). All specifications include district and year fixed effects. The treatment variable is measured in 1000s of nuevos soles. All monetary values are in Lima prices in 2001. Real value of mineral production is measured in mineral prices in 2001. Dependent variables are measured in per capita terms.

*Significant at 10%.

**Significant at 5%.

***Significant at 1%.

increase as a result of the resource-based windfall. Following Herrera and Francke (2007), we use one main outcome for the analysis: sidewalks and roads constructed in urban areas (in square meters). We focus on urban roads because public goods in urban settings are more salient for political authorities and they can use them to signal competence and obtain electoral support. This is true, even in the case of producer districts that are mainly rural but always have urban cores. Figure 4 presents a histogram with the distribution of efficiency scores. These results suggest that local governments in Peru are very inefficient (mean score of 0.12). Figure 5 presents the efficiency frontier for the case of urban roads using the FDH approach.

Table 4 presents the results of the Tobit model for efficiency scores. All the transfers and budgetary and production variables represent averages for the period 2001–2007. The efficiency scores were constructed for 2010 to allow time for expenditure to be converted into public goods.

Column 1 presents the results of the simplest specification in which the level and square of mining Canon transfers are included. The relationship between the level of mining Canon transfers and the efficiency score is negative (coefficient of −0.391 and standard error 0.041), and strongly statistically significant. The square is also strongly significant (coefficient of 0.191 and standard error 0.051). Since the average mining Canon transfer per capita for the period is 67 nuevos soles, this implies that the efficiency score for the average municipality is negatively associated with mining Canon transfers. The net effect is only positive for those municipalities in the top 1% of mining Canon transfers.

This is illustrated in Figure 6, which presents the marginal effects for the previous specification.[37] For local governments with mining Canon transfers close to the mean, the effect of mining Canon transfers on efficiency is negative (marginal effect of −0.36,808). This marginal effect becomes positive for districts with average mining Canon transfers above 1000 nuevos soles. The economic significance of these coefficients is important. Since the average value for the efficiency score is 0.12, the impact of mining Canon transfers on efficiency has an effect size of 3 for a district with an average level of mining Canon transfers.

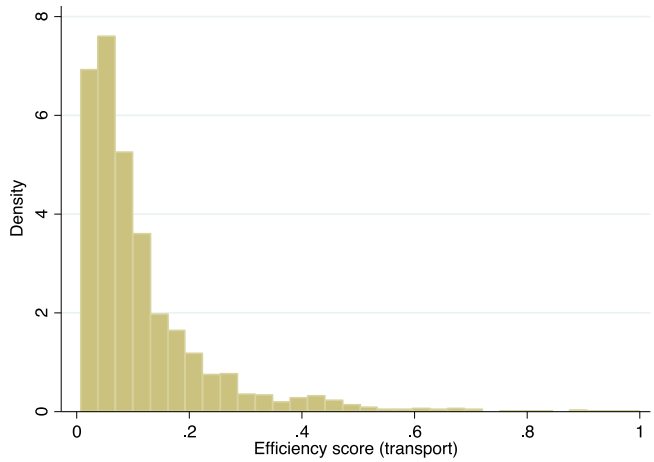


FIGURE 4 Histogram of efficiency scores for the transport sector. *Source*: Authors' elaboration based on an input-oriented Free Disposal Hull model. The input is the average expenditure on transport for the period 2001–2007. The output is square meters of urban roads per capita in 2010.

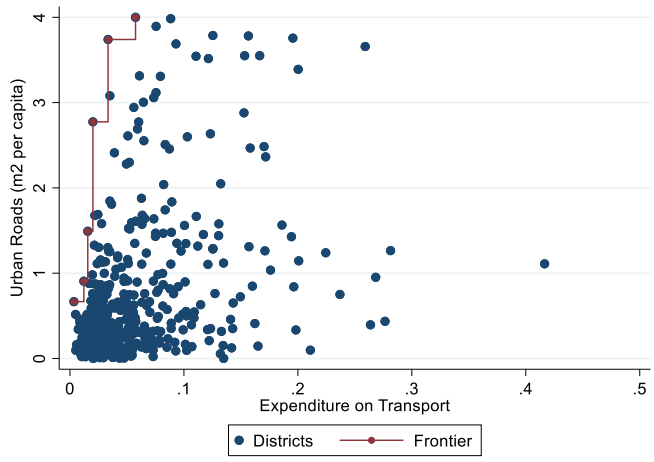


FIGURE 5 Efficiency frontier for transport. *Source*: Authors' elaboration. The input is the average expenditure on transport for the period 2001–2007. The outcome is square meters of urban roads per capita in 2010.

Column 2 adds average real production (measured in logs) to the previous specification. We found a negative association between efficiency scores and mineral production (coefficient of −0.002 and standard error 0.000). This implies that resource-rich districts are less efficient than non-producer districts after controlling for natural resource rents. This is not surprising, because mining companies in many mineral-producing districts have assumed a more direct involvement in the provision of public goods such as health facilities, schools, and roads, or even the funding of social and economic projects to obtain the support of citizens (the so-called "social license") to develop their operations and reduce social conflict.[38] This may have introduced some level of inefficiency on the part of local governments because the citizens' attention is now focused on what mining companies can directly provide for them.

Column 3 adds new fiscal variables to the previous specification. We add the average executed budget and the most important transfers from the central government, the municipal compensation fund (FONCOMUN). In both cases, the coefficients are negative and statistically significant, although these coefficients are smaller than those estimated for mining Canon.

Column 4, 5, and 6 add a set of control variables. Column 4 includes controls for pre-boom socioeconomic characteristics using Census data for 1993. These characteristics include population size, percentage of the rural population, and indicators of basic needs. Column 5 adds geographical characteristics including altitude, latitude, longitude, a dummy variable for capitals of provinces, a dummy for districts located on the coast, and the distance to the provincial capital. Column 6 adds region fixed effects.

Overall, the coefficients for the level and the square of mining Canon transfers retain their signs and levels of statistical significance after adding control variables. As expected, the size of these coefficients is reduced as a result of including the control variables, but they are very robust. The economic significance of these estimates is important, even for the last specification. The same robustness is observed in the case of mineral production and the average executed budget. The coefficient of FONCOMUN is no longer significant after controlling for preboom socioeconomic characteristics.

TABLE 4 Determinants of local government efficiency (urban transport using an input-oriented FDH model)

	Tobit model					
	(1)	(2)	(3)	(4)	(5)	(6)
Average mining Canon per-capita	−0.391***	−0.378***	−0.244***	−0.207***	−0.199***	−0.132***
	(0.041)	(0.038)	(0.040)	(0.040)	(0.043)	(0.041)
Average mining Canon per-capita^2	0.191***	0.188***	0.166***	0.153***	0.141***	0.087***
	(0.051)	(0.046)	(0.044)	(0.040)	(0.037)	(0.020)
Log of (1+ real value of production)		−0.002***	−0.002***	−0.002***	−0.002***	−0.002***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Average FONCOMUN per-capita			−0.054**	−0.033	−0.008	−0.047
			(0.025)	(0.026)	(0.030)	(0.032)
Average budget per-capita			−0.079***	−0.086***	−0.082***	−0.065***
			(0.016)	(0.017)	(0.019)	(0.018)
t-Statistic for Lind and Mehlun's (2010) test for U-shape relationships	2.54	2.85	3.11	3.26	3.18	3.25
(H0: Monotone or inverse U-shape)	(0.006)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Socioeconomic controls	No	No	No	Yes	Yes	Yes
Geographical controls	No	No	No	No	Yes	Yes
Region fixed effects	No	No	No	No	No	Yes
Number of observations	1793	1793	1793	1755	1386	1386

Note: Huber–White robust standard errors (in parentheses). The mining Canon variable and its square are measured in 1000s of nuevos soles. All monetary values are in Lima prices in 2001. Real value of mineral production is measured in mineral prices in 2001. All independent variables are averages for the period 2001–2007. The efficiency score variable is measured for the period 2001–2007. The variable used for its construction is urban roads (square meters per capita) using expenditure on transport. The technique used was input-oriented Free Disposal Hull. Socioeconomic controls include population in 1993, percentage of rural population in 1993, population living in houses with inadequate physical characteristics in 1993, population living in households with children that were not enrolled in school in 1993, population living in overcrowded houses in 1993, population living in houses without wastepipes in 1993, and population living in houses with high economic dependency in 1993. Geographical controls include altitude, longitude, latitude, dummy for being a provincial capital, dummy for being a coastal district, and distance to the provincial capital

*Significant at 10%.

**Significant at 5%.

***Significant at 1%.

One concern of these results is that they may be reflecting a convex but monotonic relationship instead a true nonmonotonic one. We use the test proposed by Lind and Mehlum (2010) and formally test whether the relationship is nonmonotonic. Give the sign of the coefficients, the estimated empirical relationship is U-shaped. Table 4 report the *t*-statistics and the *p*-values for this test for each specification. We reject the null hypothesis that the relationship is monotone for all the specifications. In all the cases, the estimated *t*-statistics are

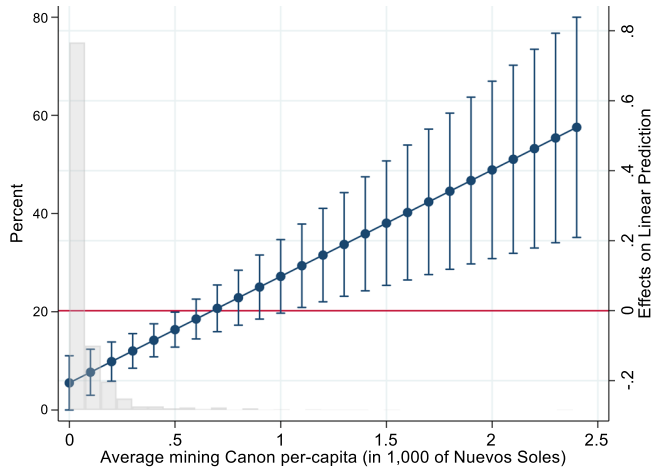


FIGURE 6 Marginal effects of the impact of mining Canon on local government efficiency

well beyond the usual levels of statistical significance. We conclude that the empirical relationship between efficiency scores and mining Canon rents is truly nonmonotonic.

Another concern with this approximation is the fact that efficiency scores were estimated in a previous step. Accounting for this requires to address the fact that standard errors are no longer valid in this case. We address this issue by estimating standard errors using bootstrap with 1000 repetitions, following a commonly accepted approach. Results reported in Table SA.10 shows that this alternative inference strategy does not affect the main results in Table 4.

Table 5 presents the results using a DEA approach under variable returns to scale. The estimated coefficients are similar to those obtained using the FDH technique. In addition, the relationship is truly nonmonotonic based on the Lind and Mehlum's (2010) test. However, it is important to emphasize that similarity among coefficients is neither always expected nor always relevant to the validity of our results. In fact, efficiency scores estimated under FDH assumptions are typically higher than those estimated using DEA (see, for instance, Geys & Moesen, 2009). As highlighted, more relevant is that the explanatory variables are robust to the chosen technique, which is the case in our setting. In addition, there is some consensus that what matters is the relative performance of local governments rather than their specific efficiency scores.

We provide additional evidence in this regard for other measures of public goods in education, health, and infrastructure using both approaches in the Supporting Information Appendix. In particular, we consider the total literacy rate (Tables SA.11 and SA.12) for the case of education, health clinics per-capita (Tables SA.13 and SA.14) for health, and sanitation coverage (Tables SA.15 and SA.16) for infrastructure. The results are consistent with those discussed above. In particular, the nonmonotonic pattern in terms of the role of mining Canon in explaining the efficiency scores is consistent with the empirical evidence. In some cases, we have found that the specific estimated coefficients differ between the FDH and DEA approaches, but as discussed earlier, this is not relevant to the validity of the analysis.

It is worth noticing that, the fact that these results are consistent for other public goods, helps to reduce the concerns regarding the presence of systematic measurement error. Rather than favoring certain types of public goods and substituting across them, mining Canon

TABLE 5 Determinants of local government efficiency (urban transport using an input-oriented DEA model)

	Tobit model					
	(1)	(2)	(3)	(4)	(5)	(6)
Average mining Canon per-capita	−0.388***	−0.375***	−0.271***	−0.233***	−0.249***	−0.157**
	(0.041)	(0.038)	(0.051)	(0.052)	(0.060)	(0.063)
Average mining Canon per-capita^2	0.185***	0.182***	0.159***	0.145***	0.142***	0.080***
	(0.049)	(0.044)	(0.041)	(0.036)	(0.036)	(0.020)
Log of (1+ real value of production)		−0.002***	−0.002***	−0.002***	−0.002***	−0.002***
		(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Average FONCOMUN per-capita			−0.100***	−0.082**	−0.073	−0.100**
			(0.037)	(0.039)	(0.047)	(0.051)
Average budget per-capita			−0.054*	−0.063**	−0.052	−0.038
			(0.028)	(0.030)	(0.035)	(0.036)
t-Statistic for Lind and Mehlun's (2010) test for U-shape relationships	2.53	2.82	2.97	3.20	3.03	2.51
(H0: Monotone or inverse U-shape)	(0.006)	(0.002)	(0.002)	(0.001)	(0.001)	(0.006)
Socioeconomic controls	No	No	No	Yes	Yes	Yes
Geographical controls	No	No	No	No	Yes	Yes
Region fixed effects	No	No	No	No	No	Yes
Number of observations	1793	1793	1793	1755	1386	1386

Note: Huber–White robust standard errors (in parentheses). The mining Canon variable and its square are measured in 1000s of nuevos soles. All monetary values are in Lima prices in 2001. Real value of mineral production is measured in mineral prices in 2001. All independent variables are averages for the period 2001–2007. The efficiency score variable is measured for the period 2001–2007. The variable used for its construction is urban roads (square meters per capita) using expenditure on transport. The technique used was input-oriented data envelopment analysis. Socioeconomic controls include population in 1993, percentage of rural population in 1993, population living in houses with inadequate physical characteristics in 1993, population living in households with children that were not enrolled in school in 1993, population living in overcrowded houses in 1993, population living in houses without wastepipes in 1993, and population living in houses with high economic dependency in 1993. Geographical controls include altitude, longitude, latitude, dummy for being a provincial capital, dummy for being a coastal district, and distance to the provincial capital

Abbreviation: DEA, data envelopment analysis.

*Significant at 10%.

**Significant at 5%.

***Significant at 1%.

transfers are nonmonotonically related to public goods in the same fashion. Therefore, it is unlikely that this form of measurement error is relevant in our setting.

A final concern is that this measurement error is caused by reallocations across public goods investment within the same expenditure category. However, it is important to notice that this theoretical possibility would be empirical relevant in contexts where local governments are relatively efficient and are closer to the frontier. In that scenario, substitution across public

goods would be possible because local governments maximize a payoff function. But, if local governments are highly inefficient and then receive a large windfall of fiscal resources, it is improbable that substitutions across public goods take place. In our setting, the average level of efficiency is pretty low (0.12 for transport expenditures). Therefore, we find this possibility unlikely.

Although we cannot explore substitution effects across outputs based on a single-expenditure category for the case of transport, we do have two outputs (health clinics per-capita and sanitation coverage rate) and a single-expenditure category for the case of health and sanitation. Tables SA.13 and SA.15 in the Supporting Information Appendix present the results for both outputs based on this single expenditure category for the FDH model (Tables SA.14 and SA.16 present results for the DEA model). We find the same nonmonotonic pattern in both outputs, even with similar coefficients. In our view, this finding is inconsistent with the idea of substitution across public goods within a single expenditure category. We interpret this result as suggestive evidence that, in a low-efficiency environment, local governments affected by a fiscal windfall have plenty of room to affect efficiency without creating substitution effects across public goods within the same expenditure category. Therefore, we believe that the nonmonotonic pattern found between mining Canon and efficiency score is unlikely to be explained by substitution effects within the same expenditure category.

6.2.1 | Explaining the basic results: The role of political competition and public good provision

We have estimated a nonmonotonic relationship between mining Canon transfers and the level of efficiency of local governments' expenditure. Based on the conceptual framework in Section 3, we hypothesized that the dynamics of political competition is relevant in explaining the impact of mining Canon rents on the efficiency of local governments' expenditure. Maldonado (2020) formally test this relationship between mining Canon rents and political competition using longitudinal data and find evidence consistent with a nonmonotonic relationship. We refer the reader to that paper for a detailed discussion on the matter.[39] Table SA.17 in the Supporting Information Appendix provides similar results using an alternative measure of royalties based only on mining Canon transfers.[40]

This evidence is consistent with the theoretical framework outlined above, yet it does not provide a direct link with efficiency. The standard approach in this context is running a regression like Equation (3) with an interaction between the treatment variable and the mediator, in this case our measure of political competition. However, this exercise is not straightforward when the design is based on a quadratic model as the used here because the interactions are hard to interpret. To avoid this issue, we split the sample based on political competition levels and run regressions for municipalities with high and low levels of political competition.

Table SA.18 in the Supporting Information Appendix reports the results for the suggested exercise. We split the sample between high- and low-political competition levels according to the median of this variable. Panel A presents results for the municipalities with high levels of political competition and Panel B does the same for those municipalities with low levels. The first column shows that the coefficient for the level of the average mining Canon per-capita is higher for municipalities with low levels of political competition. This is consistent with our theoretical framework: municipalities with low levels of political competition are more

inefficient. Because most municipalities receive very small amounts of mining Canon, we already know that for the large majority of them the net effect of mining Canon on efficiency is negative. The results from Table SA.18 suggests that, when political competition is low, this negative effect is even larger.

Political competition seems to serve as a device that forces politicians to increase their levels of efficiency in terms of spending public resources. To offer an additional robustness check on whether this relationship is in fact positive, we use the methods developed by Cattaneo et al. (2021) to construct a binned scatterplot of that relationship. Figure SA.3 in the Supporting Information Appendix presents the results. There is a clear positive relationship between efficiency scores and our measure of political competition.

Although it is tempting to conclude that this increase in political competition is good for citizens, the fact that the level of expenditure also shows a nonmonotonic relationship with mining Canon transfers casts doubts on this apparently beneficial effect. Since more political competition is also associated with shorter political horizons for incumbent politicians, it is possible that mayors are merely increasing rents, and the joint reduction in expenditure and public good provision is consistent with an increase in efficiency since the input (expenditure) can be adjusted faster than the output (public good provision).

An alternative explanation is that politicians use mining Canon to cut local taxes or to reduce debts instead of investing in public goods. This is unlikely to be the case in our setting because some legal and institutional restrictions.[41] To see that, we explore how mining Canon is related to different sources of local governments' incomes. In Table SA.19 in the Supporting Information Appendix, we show that there is nonmonotonic relationship between mining Canon and local taxes with a negative coefficient for the level (−3.54) and positive for the square (0.13), both significant at the usual levels. However, although the net effect is negative for all the relevant support of the mining Canon variable, these coefficients are pretty small in magnitude. For each thousand soles of mining Canon per-capita, the reduction in local taxes per-capita collected is at most 3.54 soles. This magnitude is so small that cannot explain an alternative use of mining Canon funds as to explain the reduction in public provision. This also applies for the case of debts.[42]

Of course, the evidence in this regard should be taken with care. On the one hand, the econometric identification of a mechanism is challenging. Imai et al. (2010) have shown that, even when the treatment and the mechanism have been randomly allocated, a causal parameter for the mechanism cannot be identified without additional assumptions. Due to the nature of our research problem, we are very far from that scenario because of the nonrandom variation in political competition and mining Canon transfers. The relationship between political competition and efficiency is then open to future research and is beyond the goal of this paper. On the other hand, due to the cross-section nature of our data, it is very little what it can be done to properly explore this link and rule out alternative explanations.[43]

We turn now to a discussion of the role of public good provision. Here, we evaluate whether mining Canon revenues are nonmonotonically related to the per-capita provision of urban roads. We estimate a cross-sectional least squares specification similar to the one used in the Tobit analysis. Standard errors are clustered at the district level. The results are presented in Table 6.

We find strong evidence of the nonmonotonic pattern previously suggested. The coefficients for the level of mining Canon and its square are strongly significant and have the expected signs. In terms of mining Canon transfers, the net impact for the average district in the sample is 2.895, which represents an effect size of 3.91 (a mean of 0.74 square meters of urban roads per

TABLE 6 Public good provision (urban transport: Urban roads (m^2 per capita)

	Cross-Sectional Ordinary Least Squares Model					
	(1)	(2)	(3)	(4)	(5)	(6)
Average mining Canon per capita	3.152***	2.976***	1.957**	2.166**	1.654	4.391**
	(0.812)	(0.845)	(0.852)	(0.900)	(1.135)	(1.930)
Average mining Canon per capita^2	−2.140**	−1.993**	−1.857**	−2.106**	−1.458	−3.514**
	(0.876)	(0.895)	(0.824)	(0.885)	(1.087)	(1.680)
Log of (1+ real value of production)		0.013	0.011	0.011	0.009	0.000
		(0.013)	(0.011)	(0.012)	(0.014)	(0.013)
Average FONCOMUN per capita			1.505*	1.129	3.593***	3.096**
			(0.817)	(0.870)	(1.272)	(1.444)
Average budget per capita			0.652***	0.616***	0.368	0.476**
			(0.227)	(0.221)	(0.228)	(0.214)
Socioeconomic controls	No	No	No	Yes	Yes	Yes
Geographical controls	No	No	No	No	Yes	Yes
Region fixed effects	No	No	No	No	No	Yes
Number of observations	438	438	438	430	303	303

Note: Huber–White standard errors clustered at the district level (in parentheses). The mining Canon variable and its square are measured in 1000s of nuevos soles. All monetary values are in Lima prices in 2001. Real value of mineral production is measured in mineral prices in 2001. All independent variables are averages for the period 2001–2007. Socioeconomic controls include population in 1993, percentage of rural population in 1993, population living in houses with inadequate physical characteristics in 1993, population living in households with children that were not enrolled in school in 1993, population living in overcrowded houses in 1993, population living in houses without wastepipes in 1993, and population living in houses with high economic dependency in 1993. Geographical controls include altitude, longitude, latitude, dummy for being a provincial capital, dummy for being a coastal district, and distance to the provincial capital.

*Significant at 10%.

**Significant at 5%.

***Significant at 1%.

capita). On the other hand, a district located in the 99th percentile experiences a net impact of −0.272 (negative effect size of 0.368). Except for the case of Column 5, the results are robust to the inclusion of budgetary, socioeconomic, and geographical/regional controls. In our preferred specification (Column 6), the effects are larger. The net impact for the average district is 3.96 (effect size of 5.36).

In summary, the evidence is consistent with the theoretical framework. The link between mining Canon rents and public good provision follows an inverse U-shaped pattern whereas the relationship between efficiency scores and mining Canon rents goes in the opposite direction. We interpret this as evidence of incumbents' strategic behavior. For high levels of mining Canon rents, a negative relationship of mining Canon rents with public good provision along with a positive relationship with efficiency scores suggests a scenario where the reduction in inputs is faster than an adjustment in outputs as a consequence of higher political competition and lower chances of keeping office. Thus, the increase in efficiency is, paradoxically, related to a lower public good provision. The opposite should be also true in places with low

TABLE 7 Determinants of local government efficiency (urban transport using an input-oriented FDH model)

	Censored Quantile Regression Model (Powell, 1986)				
	(1)	(2)	(3)	(4)	(5)
Average mining Canon per capita	−0.038	−0.055*	−0.107**	−0.143**	−0.303**
	(0.030)	(0.033)	(0.044)	(0.059)	(0.130)
Average mining Canon per capita^2	0.032*	0.054**	0.076**	0.103**	0.206
	(0.021)	(0.028)	(0.034)	(0.050)	(0.129)
Log of (1+ real value of production)	−0.001**	−0.001*	0.000	−0.001**	−0.002*
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Average FONCOMUN per capita	−0.012	0.006	−0.016	−0.036	−0.095
	(0.020)	(0.015)	(0.023)	(0.027)	(0.074)
Average budget per capita	−0.040***	−0.055***	0.041**	−0.054***	−0.041
	(0.013)	(0.011)	(0.017)	(0.017)	(0.034)
Socioeconomic controls	Yes	Yes	Yes	Yes	Yes
Geographical controls	Yes	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes
Quantile (τ)	0.10	0.30	0.50	0.70	0.90
Number of observations	1386	1386	1386	1386	1386

Notes: Bilias et al.'s (2000) standard errors (in parentheses). The mining Canon variable and its square are measured in 1000s of nuevos soles. All monetary values are in Lima prices in 2001. Real value of mineral production is measured in mineral prices in 2001. All independent variables are averages for the period 2001–2007. The efficiency score variable is measured for the period 2001–2007. The variable used for its construction is urban roads (square meters per capita) using expenditure on transport. The technique used was input-oriented Free Disposal Hull. Socioeconomic controls include population in 1993, percentage of rural population in 1993, population living in houses with inadequate physical characteristics in 1993, population living in households with children that were not enrolled in school in 1993, population living in overcrowded houses in 1993, population living in houses without wastepipes in 1993, and population living in houses with high economic dependency in 1993. Geographical controls include altitude, longitude, latitude, dummy for being a provincial capital, dummy for being a coastal district, and distance to the provincial capital.

Abbreviation: FDH, Free Disposal Hull.

*Significant at 10%.

**Significant at 5%.

***Significant at 1%.

levels of mining Canon rents. We offer additional robustness checks of our main results in the next section.

6.3 | Additional robustness checks

Here, we provide additional evidence regarding the robustness of our results. The Supporting Information Appendix presents additional evidence with respect to the nonmonotonic relationship between mining Canon rents and efficiency scores for other public goods. In this

section, we relax the strong distributive assumptions associated with Tobit models by using the quantile regression model for censored data (QRC) suggested by Powell (1986).[44] Another advantage of using QRC is that its results are robust to outliers, which also helps to alleviate concerns that our results are just driven by few municipalities.[45] Inference was conducted using the resampling approach suggested by Bilias et al. (2000).

Table 7 presents the results of the empirical exercise. We consider an input-oriented FDH model for the case of urban transport as a benchmark using our preferred specification with region-fixed effects and controls for budgetary, socioeconomic, and geographical variables. We follow the current practice of using quantile regression models to estimate results for different conditional quantiles. In particular, we use quantiles 0.1, 0.3, 0.5, 0.7, and 0.9 in the analysis.

The evidence suggests a pattern consistent with the nonmonotonic case previously discussed. Although some of the coefficients are estimated with less precision in the cases of the extreme quantiles (0.1 and 0.9), the qualitative results are essentially the same. Interestingly, the results suggest that, conditional on the set of control variables discussed above, the impacts of mining Canon transfers are larger in the most efficient municipalities. For instance, the net effect is negative (−0.276) for the municipalities at the ninth decile of the conditional efficiency distribution, assuming an average mining Canon transfer of 67 nuevos soles for the period 2001–2007. This represents a 250% decrease in the average level of efficiency in the sample (0.11). Conversely, municipalities at the first decile have a net effect of −0.034, which represents a 30% reduction with respect to the average level of efficiency in the sample.

It is notable that the results using standard quantile regression are similar (see Figure SA.4 in the Supporting Information Appendix). This is not surprising if we take into account the fact that very few observations are close to the upper value of 1. Therefore, censoring does not seem to be a significant problem in the sample. At the same time, treating municipalities with high levels of mining Canon rents as outliers, does not change the quantitative and qualitative reading of our results.

To summarize, the evidence presented in this paper seems to be robust with regard to relaxing the distributive assumptions associated with Tobit models. The results in this section also provide evidence regarding the heterogeneous effects of mining Canon transfers.

7 | CONCLUDING REMARKS

This paper analyzes how fiscal windfalls related to natural resource booms affect the efficiency of local government expenditure. Consistent with a basic theoretical framework that highlights the nonmonotonic responses associated with resource booms, we estimate a negative impact of natural resource rents on efficiency for districts with an average level of mining Canon transfers, but positive effects in the case of extremely resource-rich districts. These effects are explained by the strategic behavior of local politicians in the face of a resource boom, which in turn affects the provision of public goods and as a result the level of efficiency in the use of local government budgets.

The results presented in this paper call for a more nuanced view regarding the effects of resource booms on efficiency and public good provision. Whereas most of the existing evidence has suggested very modest impacts of resource booms on public good provision and increases in inefficiency, some new scholarship and the evidence presented in this paper suggest that these effects are not necessarily monotonic. Given the magnitude of the shock in natural resource rents, it might be the case that previous studies are only capturing part of the phenomenon.

However, the increase in efficiency in extremely mineral-rich regions does not necessarily represent good news because it is related to reductions in public good provision. We believe this is an issue that requires more research.

Despite these results, it is important to emphasize that this perverse increase in the impact of political competition on efficiency is only valid for a few districts with extraordinarily high levels of mining rents. For most of the local governments in the sample, the increase in mining rents seems to be related to higher levels of inefficiency, a finding consistent with the existing literature. One key contribution of this paper is showing that the relationship between natural resource rents and efficiency is quite complex. We also emphasize the role of political competition in this regard. We believe that scholars interested in understanding the determinants of local government efficiency would be better off incorporating political factors into their analysis in innovative ways. We hope our paper is seen as an example of that approach.

ACKNOWLEDGEMENTS

We would like to thank the Editor and two anonymous referees for their comments and suggestions.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ORCID

Stanislao Maldonado http://orcid.org/0000-0002-8408-9422

ENDNOTES

[1]For instance, Indonesia, Ghana, Colombia, Brazil, Bolivia, Canada, and Australia, to mention just a few countries, have implemented mechanisms that share some of the taxes and royalties paid by extractive companies with subnational governments (see Brosio and Jimenez (2012) for an overview).

[2]We use the term "efficiency" to describe a relationship between the use of inputs and outputs in a production process, following a large and old literature on the matter in economics and productivity analysis (Farrell, 1957). This should not be confused with other definitions of efficiency in economics like Pareto efficiency.

[3]See, for instance, Caselli and Micheals (2013) and Ferraz and Monteiro (2012) for evidence from Brazil. Hunt (2007) and Maldonado (2011) offer evidence from Peru on the corruption of public officials.

[4]We will use the term "district" to refer to the lower administrative unit in the Peruvian state and the terms "municipality" and "local government" to refer to the institutional–political structure that manages a district. Because in most instances these terms are closely related, we will use them interchangeably.

[5]"Canon" is a Spanish word used to refer to a tax related to a specific activity. The current use refers to a rule whereby a portion of the revenues collected by the central government is allocated to subnational governments.

[6]This common view has been challenged by new studies suggesting that the effect of a resource boom can be beneficial (Aragon & Rud, 2013) or that there is a nonmonotonic pattern in terms of public good provision (Maldonado, 2020).

[7]Currently, Peru is the second-largest producer of copper and silver, the third-largest producer of zinc and tin, the fourth-largest producer of lead and molybdenum, and the sixth-largest producer of gold (see Ministry of Energy and Mines (2012) for details).

[8]This section follows Maldonado (2020).

[9]There are about 1645 local governments, 1840 if the provincial governments that also play the role of local governments in the provincial capitals are included.

[10]At the end of Fujimori's last term, several changes were introduced that reduced municipalities' financial autonomy (see Barr and Dietz (2006) for a detailed discussion) that may potentially affect efficiency and public good provision. Since these changes were not designed to affect a particular set of district, we address this issue by including time-fixed effects in our empirical design. We discuss this issue in a robustness check about the change of the mining Canon allocation during the government of president Paniagua.

[11]During the period 2001–2010, canon transfers represented 31% of the total budgets in mineral-producing districts.

[12]The exchange rate for the period under analysis was 2.85 nuevos soles per US dollar.

[13]For instance, the Gini coefficient for the distribution of rents for the period is 0.8.

[14]Maldonado (2020) finds strong evidence of a nonmonotonic relationship between mineral rents and political competition, re-election outcomes, public good provision, public employment, local government expenditure, and living standard measures. These nonmonotonic effects are mainly driven by extremely rich municipalities in terms of mining rents.

[15]We refer the reader to the discussion in Maldonado (2020) for more details.

[16]The intuition here is somewhat similar to the Shapiro–Stiglitz efficiency wage model, although a bit more complex. In that model, unemployment works as a discipline device because workers do not exert effort when there is full employment. Then, employers use salaries above the market-clearing level to induce scarcity and obtain higher effort. Here, the idea is that a windfall of fiscal resources makes the incumbent politicians less sensitive to scarcity, reducing their levels of effort in the provision of public goods. Therefore, they become less efficient in the use of the public budget. The extra fiscal resources are not large enough for incumbents to worry about the entry of potential competitors, leaving them room for becoming inefficient.

[17]Besley et al. (2010) also propose a model that includes the possibility of nonmonotonic effects, but their outcomes of interest are not related to efficiency.

[18]Formally, this is known as the common trends assumption. In terms of counterfactuals, this implies an additive structure for the potential outcomes for the untreated districts. For a discussion, see Angrist and Pischke (2009, chapter 6).

[19]Maldonado (2020) follows this approach. He also shows that the parametric quadratic specification is robust compared with alternative nonparametric approaches.

[20]Our identification strategy differs of other approaches exploited in related literature. One approximation is the use of Bartik-type instruments as in Dube and Vargas (2013). We do not follow that approach in the main text of this paper because it only works when natural resource rents are only allocated to resource-rich municipalities. In our setting, only 104 municipalities (out of 1840) are producers, but 1776 are mining Canon recipients. We include a robustness check with a similar exercise replicating the allocation rule and fixing production and socioeconomic characteristics (associated with the allocation rule for nonproducer districts) to their pretreatment levels in the Supporting Information Appendix (Table A.7).

[21]The modern literature on efficiency measurement dates back to Farrell (1957). For a review of the literature with an emphasis on local government performance, see Worthington and Dollery (2000).

[22]These two econometric approaches are used to estimate frontier production functions in which a theoretical production function represents an ideal against which empirical functions are evaluated to construct measures of inefficiency. When the difference between this ideal and the empirical observations for a set of units is associated solely with the inefficiency of the unit, we call this a *deterministic frontier function*. When this difference is related to inefficiency and a set of random factors such as luck or unexpected shocks, we call it a stochastic frontier production function. See Greene (2008) for an in-depth treatment of both approaches.

[23]See Kalb et al. (2012) for an application of this approach.

[24] Recall that the estimation of efficiency scores requires the accumulation of several years of expenditure data to allow time for the public goods to be delivered/constructed. Therefore, we typically accumulate the expenditure between 2001 and 2006 (or 2007) for public goods in 2007 (or 2010). This aggregation converts our original panel dataset into a cross-section of municipalities.

[25] This solution would not work if there are multiple outputs that can be produced with a single sector-specific budget. For instance, the expenditure in education can be used for different outputs (hiring teachers, training teachers, building schools, etc.). Therefore, it is possible that some budget reallocation across outputs can be observed. In this scenario, estimating efficiency scores in one output would be conditional to the other (unobserved) outputs. If the education budget increase all outputs, then the increase in the observed output would lower than the case if which we keep the other outputs constant. The problem is that this would look like a decrease in efficiency: the observed output would seem to have increase much less than expected. Unfortunately, we cannot offer evidence against this possibility due to data constraints. We acknowledge this limitation here.

[26] We thank one referee for pointing out these issues.

[27] This is a limitation of the existing literature about technical efficiency, which is mainly based on the use of a single input variable. For instance, in their review of the local government's efficiency literature, Narbon-Perpina (2018) show that almost all reviewed papers use a measure of expenditure as the single input variable as we do in this paper. Therefore, we acknowledge this limitation here.

[28] Perhaps it is worth clarifying why effects are found in categories like "Goods and Services" and "Other Capital Expenditures," which are not uses of mining Canon transfers according to the law. We just interpret this as evidence of substitution effects: before the boom, local governments were constrained in their ability to invest. After the boom, those fiscal resources originally used for investment can be reallocated due to a large influx of mining Canon rents.

[29] Ideally, we would like to regress different public good outcomes on the interaction between mining Canon and year fixed effects. Unfortunately, we only have two preboom years (2001 and 2002). Therefore, a test as the proposed one is unfeasible in this setting. For that reason, rather than testing whether parallel trends in valid in our setting, we assume it is not by introducing district-specific linear trends. If results are robust, we can conclude that our results are robust to potential violations of the parallel trends assumption.

[30] Alternatively, the inclusion of mineral production as a control variable can be justified as a conditional mean assumption in panel data settings (see, for instance, Stock & Watson, 2010). In this scenario, the control variable is allowed to be correlated with unobservables but its inclusion is justified as long as it helps to remove bias in the relationship between the treatment variable and the unobservables. In our setting, we expect that the inclusion of mineral production as a control variable helps to remove variation in a budget outcome that can be attributed to changes in production instead of changes in mining Canon rents.

[31] A typical mining project typically has five phases: exploration, evaluation, construction, production, and closure. Assuming that a rise of prices lead to mining companies to expand exploration in new potential sites, it is expected that this phase takes 3–5 years on average. According to the Centre for Energy, Petroleum and Mineral Law and Policy of the University of Dundee, an "... *exploration programme implemented with serious intent might take 3–5 years depending on many factors. The desired outcome is a published resource*" (see https://www.extractiveshub.org/topic/view/id/21/chapterId/268). The evaluation phase typically takes 2–3 years before starting the construction and implies fulfilling all government regulations, including the approval of the environmental assessment study and obtaining the social license. For instance, Antamina, one of the largest mines in the country, took 3 years to complete about 200 authorizations (see https://santabarbaraconsultants.com/content/uploads/2014/02/Antamina-Permitting-2003.pdf). The construction phase takes, on average, 3 years, but it could take more. According to the Extractive Hub, for "... *a large mine, a construction period of three years, under ideal conditions, may be regarded as impressive. In countries with infrastructural constraints, it could be much longer*". Taking all these elements, on average, it could take about 8–11 years for a new mine to complete this process before starting production.

[32] See Figure SA.1 in the Supporting Information Appendix for evidence in favor of this argument. After the rise in prices, no large change in mineral production is observed for the four most important minerals exported by the country.

[33] Coefficients have the expected signs, although in some cases, due to the sample size reduction, some of them are no longer significant. However, the results on "Investment" category are unaffected.

[34] We drop operations with sales higher than 1200 (US millions) in 2010. These include the following mines: Antamina (Ancash), Antapaccay (Cusco), Cerro Verde (Arequipa), Toquepala (Tacna), and Yanacocha (Cajamarca).

[35] Institutional and historical knowledge also points out against this possibility. The transition government led by president Paniagua was in power for only 8 months after the end of the Fujimori's regime in November 2000. As acknowledged by several political scientists, the government was mainly in charge of making sure that the April 2001 elections were fair and free. Paniagua and his party were not relevant contenders in that election, otherwise he would not have been chosen by the Congress as the president for the transition period. The government did not implement significant economic and political reforms during its term, except some initial steps towards a more decentralized country, a demand that was majoritarian in that historical moment. The change in the allocation rule was precisely thought as a way to fund the decentralization process. Because the different types of Canon were among the few transfers that favored subnational governments outside Lima, they were chosen because most regions are entitled to them. Therefore, it is unlikely that the change in the allocation rule was driven by prereform efficiency levels. If the reform goal would have been implemented to favor places with relative levels of prereform efficiency, then we should have observed that the change of rule should have favored municipalities in the capital city and in the modern cities of the north coast and the modern south like Arequipa. That did not happen.

[36] There is ample evidence of the use of these mechanisms in mineral-rich districts. See, for instance, Gil (2009) and Salas (2010) regarding the districts in the area influenced by the Antamina mine in Ancash, and Arellano (2011b) for mineral-rich districts in Pasco and Moquegua.

[37] Notice that in Figure 6 we are plotting the marginal effect and not the observed empirical relationship between mining Canon and the efficiency scores. Whereas the former is linear, the later has a U-shape form.

[38] See Arellano (2011b) for a discussion.

[39] Ideally, we would like to have a panel data of efficiency measures in annual terms. In that scenario, we could have incorporated our measures of mining Canon transfers and interact them with the indicator of political competition to test for the role of political competition as a mechanism. As previously discussed, that it is not feasible in this setting because of the cross-sectional nature of our empirical approach.

[40] We found that, for a district with a level of per capita mining Canon transfers similar to the average (109 nuevos soles per year), the total marginal effect is −0.94. In relation to the average of the measure of political competition, the size of the effect is very small, about 1%. The impact of mining Canon is negative for most of the districts, except those with very high levels of per capita mining rents. These districts are in the top 1% of the mining rents distribution (see Table SA.7 for details).

[41] First of all, local governments cannot create or change taxes (Legislative Decree 776). The Congress is the only power able to create new taxes. Local governments can control contributions and fees, but they play a marginal role in the total budget. Second, local governments have no autonomous capacity for taking debts. According to the Fiscal Transparency Law, local governments can take debts only if the National government plays the role of guarantor. Even in that case, local governments can take obligations only up to 100% of their fiscal revenues. The large majority of municipalities comply with the law. For instance, in 2018, 93% of local governments complied with these budgetary rules. Therefore, it is unlikely that these factors would play a significant role in our setting.

[42] We explore this issue in Columns 6 and 7 in Table SA.18 in the Supporting Information Appendix. These two variables capture access to internal and external credit. In the first case, there is no relationship except for the square. Even if both coefficients were statistically significant, the coefficients are very small as above, so they

are empirically irrelevant to put into question our main results. Regarding the second case, both coefficients are close to zero and nonsignificant. Therefore, debts is not a competing explanation for our main argument.

[43] From a strict epistemological point of view, hypothesis testing requires falsification (Popper, 1959). Lack of rejection of the null hypothesis implies a situation in which data is consistent with this hypothesis, but that does not rule out alternative explanations. Therefore, we claim that our results are consistent with a role for political competition, but that does not mean that political competition is the only factor that explains this relationship. The isolation of a single factor is not possible from an epistemological (due to the so-called induction problem) and econometric (without additional assumptions) points of view.

[44] This approach also has the advantage of allowing covariates to shift location, scale, and the entire shape of the distribution Chernozhukov and Hong (2002), which permits us to analyze heterogeneous effects. One drawback of Powell's (1986) original approach is that the objective function is not convex, creating computational problems that have severely limited its practical use. This issue is addressed using the algorithm developed by Fitzenberger (1996).

[45] Another advantage of using a quantile regression model for censored data model is that it helps to address the serial correlation of the estimated efficiency scores, which call into question the standard inference procedures (Simar & Wilson, 2007). In addition, the input C and the output y are correlated with MC and Z by construction, which implies that v is correlated with MC and Z. Although both problems disappear asymptotically, they do so at a low convergence rate. Simar and Wilson (2007) suggest implementing an alternative bootstrap algorithm to address these issues. However, recent work by Johnson and Kuosmanen (2012) suggests that these concerns might be overstated and that the standard two-stage estimators are consistent even when correlation between inputs and contextual variables is allowed.

REFERENCES

Acemoglu, D., & Robinson, J. (2006). Economic backwardness in political perspective. *American Political Science Review*, *100*, 115–131.

Afonso, A., & Fernandes, S. (2008). Assessing and explaining the relative efficiency of local government. *Journal of Socio-Economics*, *37*, 1946–1979.

Angrist, J., & Kluger, A. (2008). Resource windfall or a new resource curse? Coca, income and civil conflict in Colombia. *Review of Economics and Statistics*, *90*, 191–215.

Angrist, J., & Pischke, J. (2009). *Mostly harmless econometrics: An empiricist's companion*. Princeton University Press.

Aragon, F., & Rud, J. (2013). Natural resources and local communities: Evidence from a Peruvian gold mine. *American Economic Journal: Economic Policy*, *5*, 1–25.

Ardanaz, M. (2014). Fiscal windfalls, transparency, and the efficiency of public good provision: evidence from Brazilian local governments. In Transparent Governance in an Age of Abundance: Experiences from the Extractive Industries in Latin America and the Caribbean. Inter-American Development Bank.

Arellano, J. (2011a). Aggravating the resource curse: Decentralization, mining and conflict in Peru. *Journal of Development Studies*, *47*, 617–638.

Arellano, J. (2011b). *¿Minería sin fronteras? Conflicto y desarrollo en regiones mineras del Peru*. Instituto de Estudios Peruanos.

Ashworth, J., Geys, B., Heyndels, B., & Wille, F. (2014). Competition in the political arena and local government performance. *Applied Economics*, *46*, 2264–2276.

Balaguer-Coll, T., & Prior, D. (2009). Short and long-term evaluation of efficiency and quality. An application to Spanish municipalities. *Applied Economics*, *41*, 2991–3002.

Benito, B., Bastida, F., & Garcia, J. (2010). Explaining differences in efficiency: An application to Spanish municipalities. *Applied Economics*, *42*, 515–528.

Bertrand, M., Duflo, E., & Mullainathan, S. (2004). How much should we trust differences-in-differences estimates? *Quarterly Journal of Economics*, *119*, 249–275.

Besley, T., Persson, T., & Sturm, D. (2010). Political competition, policy and growth: Theory and evidence from the US. *Review of Economic Studies*, *77*, 1329–1352.

Bilias, Y., Chen, S., & Ying, Z. (2000). Simple resampling methods for censored regression quantiles. *Journal of Econometrics*, *99*(2), 373–386.

Borge, L., Falch, T., & Tovmo, P. (2008). Public sector efficiency: The roles of political and budgetary institutions, fiscal capacity and democratic participation. *Public Choice*, *136*, 475–495.

Brollo, F., Nannicini, T., Perotti, R., & Tabellini, G. (2013). The political resource curse. *American Economic Review*, *103*, 1759–1796.

Brosio, G., & Jimenez, J. (2012). *The intergovernmental assignment of revenues from natural resources: A difficult balance between centripetal and centrifugal tendencies* [Unpublished manuscript]. ECLAC.

Carrion, J. F. (2006). Fujimori and the mayors of Lima, 1990-2001: The impact and legacy of neopopulist rule. In R. Barr, & H. Dietz (Eds.), *The Fujimori legacy: The rise of electoral authoritarianism in Peru* (pp. 61–80). Pennsylvania State University Press.

Caselli, F. (2005). *Power struggles and the natural-resource curse*. Mimeo, London School of Economics.

Caselli, F. (2006). *Power struggles and the natural resource curse*. Mimeo, London School of Economics.

Caselli, F., & Cunningham, T. (2009). Leader behavior and the natural resource curse. *Oxford Economic Papers*, *61*, 628–650.

Caselli, F., & Micheals, G. (2013). Do oil windfalls improve living standards? Evidence from Brazil. *American Economic Journal: Applied Economics*, *5*, 208–238.

Cattaneo, M., Crump, R., Farrell, M., & Feng, Y. (2021). On Binscatter. Mimeo. Princeton University.

Cherchye, L., Kuosmanen, T., & Post, T. (2000). What is the economic meaning of FDH? A reply to Thrall. *Journal of Productivity Analysis*, *13*, 263–267.

Chernozhukov, V., & Hong, H. (2002). Three-step censored quantile regression and extramarital affairs. *Journal of the American Statistical Association*, *97*, 872–882.

Conceicao, M., & Stosic, B. (2005). Technical efficiency of the Brazilian municipalities: Correcting nonparametric frontier measurements for outliers. *Journal of Productivity Analysis*, *24*, 157–181.

De Borger, B., & Kerstens, K. (1996). Cost efficiency of Belgian local governments: A comparative analysis of FDH, DEA, and econometric approaches. *Regional Science and Urban Economics*, *26*, 145–170.

De Borger, B., Kerstens, K., Moesen, W., & Vanneste, J. (1994). Explaining differences in productive efficiency: An application to Belgian municipalities. *Public Choice*, *80*, 339–358.

Deprins, D., Simarahd, L., Tulkens., H., Marchand, M., Pestieau, P., & Tulkens, H. (1984). Measuring labour efficiency in post offices, *The performance of public enterprises: Concepts and measurements*. North-Holland.

Dube, O., & Vargas, J. (2013). Commodity price shocks and civil conflict: Evidence from Colombia. *Review of Economic Studies*, *80*, 1384–1421.

Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society*, *120*, 253–289.

Fitzenberger, B. (1996). A guide to censored quantile regressions. In C. Rao, & G. Maddala (Eds.), *Handbook of Statistics*. North-Holland.

Geys, B., & Moesen, W. (2009). Exploring sources of local government technical inefficiency: Evidence from Flemish municipalities. *Public Finance and Management*, *1*, 1–29.

Gil, V. (2009). *Aterrizaje minero. Cultura, conflicto, negociaciones y lecciones para el desarrollo desde la minería de Ancash*. Instituto de Estudios Peruanos.

Gimenez, V., & Prior, D. (2007). Long and short-term cost efficiency frontier evaluation: Evidence from Spanish local governments. *Fiscal Studies*, *28*, 121–139.

Greene, W. (2008). *The econometric approach to efficiency analysis* [Unpublished manuscript]. New York University.

Herrera, P., & Francke, P. (2007). *Análisis de la eficiencia del gasto municipal y de sus determinantes*. PUCP-CIES.

Herrera, S., & Pang, G. (2005). *Efficiency of public spending in developing countries: An efficiency frontier approach*. World Bank Policy Research Working 3645.

Hunt, J. (2007). How corruption hits people when they are down. *Journal of Development Economics*, *84*(2), 574–589.

Imai, K., Luke, K., & Yaman, T. (2010). Identification, inference and sensitivity analysis for causal mediation effects. *Statistical Science*, *25*(1), 51–71.

Johnson, A., & Kuosmanen, T. (2012). One-stage and two-stage DEA estimation of the effects of contextual variables. *European Journal of Operational Research*, *220*, 559–570.

Kalb, A., Geys, B., & Heinemann, F. (2012). Value for money? German local government efficiency in comparative perspective. *Applied Economics*, *44*, 201–218.

Karl, T. (1997). *The paradox of plenty: Oil booms and petro states*. University of California Press.

Lind, J., & Mehlum, H. (2010). With or without U? The appropriate test for a U-shaped relationship. *Oxford Bulletin of Economics and Statistics*, *72*(1), 109–118.

Lizzeri, A., & Persico, N. (2005). A drawback of electoral competition. *Journal of the European Economic Association*, *3*, 1318–1348.

Loayza, N., Miery Teran, A., & Rigolini, J. (2013). Poverty, inequality, and the local natural resource curse [Unpublished manuscript]. The World Bank.

Maldonado, S. (2011). *Resource windfall and corruption: Evidence from Peru* [Unpublished manuscript]. UC Berkeley.

Maldonado, S. (2012). *Resource curse, political support and democratic consolidation: Evidence from Peru* [Unpublished manuscript]. UC Berkeley.

Maldonado, S. (2020). *The non-monotonic political effects of resource booms* [Unpublished manuscript]. Universidad del Rosario.

Ministry of Energy and Mines. (2012). Informe de Produccion Minera Anual 2001-2010. Mimeo.

Ferraz, C., & Monteiro, J. (2012). Does oil make leaders unaccountable? Evidence from Brazil's offshore oil boom [Unpublished manuscript]. PUC-Rio.

Moulton, B. (1986). Random group effects and the precision of regression estimates. *Journal of Econometrics*, *32*, 385–397.

Narbon-Perpina, I. (2018). Local government' efficiency: a systematic literature review-Part 1. *International Transactions in Operational Research*, *25*, 431–468.

Polastri, R., & Rojas, F. (2007). Decentralization. In M. M. Giugale, V. Fretes-Cibils, & J. Newman (Eds.), *An opportunity for a different Peru: Prosperous, equitable and governable*. The World Bank.

Polo, M. (1998). *Electoral competition and political rents* [Unpublished manuscript]. Bocconi University.

Popper, K. (1959). *The logic of scientific discovery*. Routledge.

Powell, J. (1986). Censored regression quantiles. *Journal of Econometrics*, *32*, 143–155.

Revelli, F., & Tovmo, P. (2007). Revealed yardstick competition: Local government efficiency patterns in Norway. *Journal of Urban Economics*, *62*, 121–134.

Ross, M. (1999). The political economy of the resource curse. *World Politics*, *53*, 325–361.

Sachs, J., & Warner, A. (1995). *Natural resource abundance and economic growth* [Unpublished manuscript]. Harvard University.

Salas, G. (2010). La embriaguez del Canon minero. La política distrital en San Marcos a doce años de la presencia de Antamina. *Anthropologica*, *28*, 111–138.

Simar, L., & Wilson, P. (2007). Estimation and inference in two-stage, semiparametric models of production processes. *Journal of Econometrics*, *136*, 31–64.

Skilling, D., & Zeckhauser, R. (2002). Political competition and debt trajectories in Japan and the OECD. *Japan and the World Economy*, *14*, 121–135.

Stevens, P. (2005). Assessing the performance of local government. *National Institute Economic Review*, *193*, 90–101.

Stigler, G. (1972). Economic competition and political competition. *Public Choice*, *13*, 31–64.

Stock, J., & Watson, M. (2010). *Introduction to Econometrics*. Pearson.

Svensson, J. (1998). *Controlling spending: Electoral competition, polarization and endogenous platforms* [Unpublished manuscript]. Stockholm University.

Vicente, P. (2010). Does oil corrupt? Evidence from a natural experiment in West Africa. *Journal of Development Economics*, *92*, 28–38.

Wittman, D. (1989). Why democracies produce efficient results. *Journal of Political Economy*, *97*, 1395–1424.

Wolfers, J. (2006). Did unilateral divorce laws raise divorce rates? A reconciliation and new results. *American Economic Review*, *96*(5), 1802–1820.

Worthington, A. (2000). Cost efficiency in Australian local government: A comparative analysis of mathematical programming and econometric approaches. *Financial Accountability and Management*, *16*, 201–223.

Worthington, A., & Dollery, B. (2000). An empirical survey of frontier efficiency measurement techniques in local government. *Local Government Studies*, *26*, 23–52.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Maldonado, S., & Ardanaz, M. (2022). Natural resource windfalls and efficiency in local government expenditure: Evidence from Peru. *Economics & Politics*, 1–37. https://doi.org/10.1111/ecpo.12209