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Natural Resources, Redistribution and Human Capital Formation

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Abstract

How do resource booms affect human capital accumulation? We exploit time and spatial variation generated by the commodity boom across local governments in Peru to measure the effect of natural resources on human capital formation. We explore the effect of both mining production and tax revenues on test scores, finding a substantial and statistically significant effect for the latter. Transfers to local governments from mining tax revenues are linked to an increase in math test scores of around 0.23 standard deviations. We find that the hiring of permanent teachers as well as the increases in parental employment and improvements in health outcomes of adults and children are plausible mechanisms for such large effect on learning. These findings suggest that redistributive policies could facilitate the accumulation of human capital in resource abundant developing countries as a way to avoid the natural resources curse.

JEL Codes: H23, I25, O15

Key words: Resource booms, academic achievement, intergovernmental transfers.

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1. Introduction

A long-standing question in the development literature inquires about the extent to which natural resource abundance is a curse or a blessing. The recent commodities boom has brought back this discussion. While the impact of such boom on economic development has been explored elsewhere,[2] the linkages between the abundance of natural resources and human capital formation still requires deeper analysis. For instance, cross-national correlations indicate a negative relationship (Gylfason, 2001; Birdsall et al., 2001), but there is evidence that good political institutions can ameliorate this outcome (Kronenberg, 2004; Gylfason and Zoega, 2006).

As the consensus in the human capital formation literature is to move from a quantity to a quality perspective (Hanushek and Woessmann, 2009, 2010), a pending question for the natural resource abundance literature is about its implications on human capital accumulation beyond the traditional measures. Thus, the micro evidence documenting some positive but modest impacts on school attendance and attainment, as well as literacy rates (Angrist and Kugler, 2008; Litschig and Morrison, 2013), is important but incomplete, as it does not include learning outcomes. In this paper we contribute to this literature by analyzing the impact of mining activities on students' learning: reading and math skills of second graders in Peru. For this endeavor, we use a unique data set and exploit time and district-level variation to identify the impact of mining production and mining transfers to local governments on educational outcomes.

We focus on Peru, as it provides an excellent opportunity to analyze the effects of mining on human capital formation, in a setting where the institutional background is unaltered. The country has a long history of mining production that precedes colonial times (Dell, 2010), and it is one of the world's top producers of silver, tin, zinc, copper and gold (USGS, 2015). Furthermore, during the 2000s decade mineral prices quintupled and so the country's total value of mineral production. Nowadays, mining accounts for almost two-thirds of the value of exports and close to one-half of taxes in the country.

These revenues have been partially redistributed to local governments. The *Canon Minero Law* (introduced in 2001) – from here on *canon* states – that 50% of the income tax paid by mining

[2] See Aragon et al. (2015), Ross (2014), van der Ploeg (2011), Deacon (2011), Rosser (2006) and Stevens (2003), for comprehensive literature reviews.

companies to the central government should be redistributed to the regional and local governments located in the areas where the minerals are extracted. The current legal framework establishes a distribution rule that grants transfers not only to mineral producing districts but also to non-producer ones in neighboring areas. This allows us to distinguish between the impacts of a resource boom related to the increase of mining revenues, or *redistribution effect*, from the impacts related to changes in the local economy associated with increase in mineral production, or *production effect*.

We find that the production effect is positive but statistically insignificant. However, the redistribution effect shows a positive, statistical significant and non-monotonic pattern, consistent with results in the political economy literature (Caselli 2015; Maldonado 2015). For the average district receiving a transfer, we find a marginal increase in math test scores of around 23.0 percent of a standard deviation.

Our data sources also allow us to test important mechanisms. These include the hiring of permanent school-teachers as well as increases in parental income and improvements in health outcomes of children.

The existence of non-monotonic patterns reflects the fact that different magnitudes of the transfers are related to different political responses by local mayors, which in turn affect their incentives to invest in human capital accumulation. Following the recent contributions in political economy (Caselli 2015),[3] we hypothesize that resource booms affect the survival of the incumbent in a non-monotonic fashion since political competition increases as natural resource rents increase, but only up to a certain threshold. When rents become very high, incumbents have a significant amount of fiscal resources to influence electoral outcomes by buying-off citizens' electoral support. High political competition works as a discipline device creating incentives for investing in public good provision such as human capital. However, when rents are too high, mayors have fewer incentives to invest in human capital since their ability to maintain power is not challenged.

[3] Caselli (2015) shows that resource booms can have non-monotonic effects due to two potential political mechanisms. Resource booms, on the one hand, are related to more political competition but, on the other, they induce incumbency advantage. For low levels of rents, Caselli shows that the incumbency advantage effect is stronger but the opposite occurs for high levels of rents. The author shows that these two effects are related to non-monotonic effects on development outcomes such as public good provision and economic growth.

The rest of the paper is organized in seven sections, including this introduction. Section 2 briefly reviews the literature on sub-national resource booms. The specific case of the Peruvian canon law is discussed in Section 3. Sections 4 and 5, respectively, present our multiple data sources and the identification strategy. The results are presented in Section 6 including our robustness checks. Section 7 summarizes our findings concludes.

2. Sub-national resource booms: a review

A variety of countries including Indonesia, Ghana, Colombia, Brazil, Bolivia, Canada, Australia, and of course Peru, have implemented mechanisms that share some of the taxes and royalties paid by extractive companies with subnational governments. This has been associated to an important expansion of fiscal resources in resource-rich countries creating opportunities to improve living conditions (Brosio and Jimenez, 2012).

At the local level, the extra income associated with the exploitation of natural resources does not come for free as: (i) it is typically associated with conflict and violence, (ii) with increased pollution, and (iii) the local capacities for efficient spending are limited (Loayza et al., 2014; Currie et al., 2013). In this way, the potential impacts that the increased monetary resources may have attenuate substantially. Then, it comes with no surprise that the impacts of mining activity on poverty reduction have been documented to be, at best, modest (Pegg, 2006).

In Peru, local governments that were favored by the boom of mineral prices were more efficient using fiscal windfalls to provide public goods whereas those benefited with modest transfers were more inefficient (Maldonado, 2014; Ardanaz and Maldonado, 2014). Additionally, mining activity has a local impact in the surrounding areas on the demand for local inputs and real income, with the subsequent increase in prices of non-tradable goods (Aragon and Rud, 2013).

Regarding outcomes of interest for our study, some interesting impacts have been documented. In Colombia, for instance, the production of coca and diamonds has been found linked to a modest increase in school attendance among kids, besides the fact that child work also increased in the same rural areas during the same period (Angrist and Kugler, 2008). In Brazil, the commodity boom – which implied extra transfers from the federal to the state government – has been linked to gains in literacy rates and schooling attainment as well as to poverty reductions (Litschig and Morrison, 2013). Interestingly, the maritime production, which does not imply state transfers, shows different impacts (Caselli and Michaels, 2013). These last two results from Brazil also indicate some evidence of impacts on electoral outcomes (reelections) and corruption. A similar finding of an increase in corruption as a result of increases in local transfers has been documented for Peru (Maldonado, 2011). In Peru as well, there is evidence of poverty reduction and consumption increase for households in mining rural areas (Loayza et al., 2013; Zambrano et al., 2014). Interestingly, most of the impacts seem to be channeled through skilled migrants who arrive to the local economies with their labor supply, with subsequent increases in inequality (Loayza and Rigolini, 2016).

Regarding outcomes that could mediate the impacts from mining activity to human capital formation it is worth to highlight three: Pollution, Violence and Positive demand shocks:

Pollution: Mining activities produce air and soil pollutants. At low concentrations, pollutants are short-lived, but if toxic emissions are relatively large they can have negative and cumulative effects on the quality of air, soil and water (Currie et al., 2013). There is evidence that pollution can affect school and cognitive outcomes (Almond, Edlund, and Palme 2009; Lavy, Ebenstein, and Roth 2012), and increase school absenteeism (Currie et al. 2009; Gilliland et al. 2001; Park et al. 2002; Ransom and Pope III 1992).

Violence: Resource curse scholars have consistently found that resource abundance can spark civil and ethnic conflict at the local level (Ross, 2014). For example, in Colombia, the production of diamonds and coca has been found linked heightened violence, particularly in rural areas (Angrist and Kugler, 2008; Dube and Vargas, 2013). This, in turn, has implication for the school climate that directly affects learning.

Positive demand shocks: Exploitation of natural resources increase the demand of local goods and inputs, with positive effects labor outcomes, such as wages and labor supply (both at the intensive and the extensive margin). Local demand shocks also attract workers and increase the local population; in turn, population growth creates increased congestion and additional pressure on local services, such as education and health, and spillovers for surrounding localities with no crowding out effect (Black, McKinnnish, and Sanders, 2005; Marchand, 2012; Fleming and Measham, 2014; Allcott and Keniston, 2014).[4]

3. Local transfers in Peru: The Case of *Canon minero*[5]

From a fiscal perspective, local governments in Peru play a very marginal role as 97% of taxes are collected by the central government (Polastri and Rojas, 2007). Local governments' ability to establish taxes or marginal rates is very limited. Property taxes (vehicles, real estate and real estate transfer) are the main source of local tax revenues for Peruvian municipalities (90% in 2007); while production and consumption taxes play only a marginal role. Revenues from these property taxes, however, represent at most 13% of local governments' current incomes (Calvo-Gonzalez et al., 2010). Consequently, local governments are highly dependent on central government transfers (75% of local governments' budget for 2008 (Canavire-Bacarreza et al., 2012).

Around one-third of these transfers are universally distributed among local governments through the "Fondo de Compensación Municipal" (FONCOMUN); the rest are allocated as targeted transfers. From these targeted transfers, canon (which may come from mining, oil, hydropower, forest and gas) represents a 91% of the total targeted transfers, being the mining canon the most important one (72% of all canon transfers, 29% of local governments' budgets). In some mineral-producer districts, canon can represent as much as 70% of municipal budgets (Canavire-Bacarreza et al., 2012).

The first Mining Canon Law (DS 014-92 EM) was enacted in 1992. It stated that 20% of income tax should be allocated to the areas in which the profits were generated.[6] In 2001, as part of the decentralization process, this law was modified to increase the participation of mineral rich areas. The most important law in this regard is the Law 27506 (known as "the Canon Law"), which states that the 50% of income tax paid by mining companies should be allocated to the regional and local governments located in the areas where the minerals are extracted. After several amendments to this law, it was established that this amount should be distributed between the

[4] Jacobsen and Parker (2014) find, however, that most of these effects are transitory and disappear after the boom. Later, after the end of the bonanza, there are some long-lived negative effects: lower nominal income, lower profits and earnings, and higher unemployment compensation.
[5] This section partially follows Maldonado (2015).
[6] This law has as a historical antecedent the Oil Canon, which was established in 1976 during the military government through Decree-Law 21678 after the discovery of oilfields in the Peruvian jungle.

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 exploited (40%). The remainder 5% is allocated to the public universities of the region. However, there is a gap between transfers from mining companies to the government—in the form of taxes—and the moment in which these fiscal revenues are distributed among the regional and local governments: mining companies pay taxes in March of the previous fiscal year and the mining canon is distributed in July of the year after.

By law, mining canon can be used only for investment. This means that any project to be financed with canon funds has to follow the rules of the Public Investment National System (SNIP) and obtain the approval of the Ministry of Economics and Finance. Recurring expenses, such as payroll, are prohibited by law, although there is a lot of evidence that suggests that politicians are using indirect means to avoid this restriction (Arellano-Yanguas, 2011).[7] One common practice is to hire local unskilled workers to work on infrastructure projects as an informal redistribution tool to obtain political support.[8]

4. Data and Descriptive Statistics

This paper combines several data sources to credibly estimate the effect of the mining production and canon transfers on test scores, and to identify some of the important mechanisms. The *Evaluación Censal de Estudiantes* (ECE) is the national standardized that since 2007 has been applied yearly to all second graders in Peru in math and reading (in 2006 it tested only reading in a small sample of schools nationwide). Administered by the Ministry of Education, ECE collects information about the student's performance (ranging from 0 to 800) in each test plus a small set of students' and schools' characteristics (e.g., gender, mother tongue, type of school, region and number of teachers). We merged ECE results with the *Censo Escolar* (CE) that collects information about the school in terms of infrastructure, personnel and other administrative data (e.g., share of teacher body with long-term contracts, access to electricity, water and sanitation,

[7] During the second government of Alan Garcia (2006-2011), this rule was relaxed by amendments to the annual state budget law. It was established that up to 5% of mining Canon rents can be used to finance the design of public investment projects and up to 20% of the rents can be used for maintenance of public infrastructure.
[8] Maldonado (2015) provides evidence about the use of mining canon rents to increase public employment.

etc.). We exclude the metropolitan areas from the analyses. Social dynamics triggered by mining in large urban areas substantially differ from those in rural and less populated areas (Mendéz et al., 2006; Arellano-Yanguas, 2008).

Over two million records of students' test scores (Table A1 in the Appendix) are combined with district-level data for mining production and mining canon transfers. The value of mining production is obtained from the annual reports of the Ministry of Energy and Mining. The reported volumes of copper, tin, iron, zinc, molybdenum, silver, gold, tungsten and cadmium, at the district level, are converted into U.S. dollars using the international prices of minerals at each corresponding year. Canon transfers are measured by the monetary amounts that local districts annually receive from the central government from mining taxes. These figures are compiled, computed, and reported by Ministry of Finance on the basis of the mining production of the municipalities themselves and those in their provinces. We converted all monetary figures to 2010 prices in U.S. thousand dollars per-capita.[9] Figure A1, panel a, in the Appendix, shows the average amount of canon transfers between 2007 and 2012 by district; panel b shows the average value of mining production between 2007 and 2012 by district.

Finally, in order to explore possible mechanisms at the household level, we use several years of the *Encuesta Nacional de Hogares* (ENAHO), a nationally representative household survey conducted by the Peruvian National Bureau of Statistics (INEI) aimed at measuring living standards. ENAHO allows us to measure the effect of mining production and mining canon transfers on health outcomes of children as well as adults' unemployment status, household consumption and income.

Table 1 presents summary statistics for inputs and outputs. We partition the sample into three groups: producing districts, non-producing districts in producing provinces and non-producing districts in non-producing provinces. This classification follows the division created by the Canon law. While we expect the effects of the mining production to be local (Aragon and Ruud, 2013), we do expect non-producing districts to benefit from resource windfalls.

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[9] To obtain per-capita values, we divide pecuniary values of canon transfers and production by population size estimates at the district level, which we obtained from the Peruvian National Bureau of Statistics (INEI).

Notice that average test scores in math and reading are higher in non-producing districts in producing provinces. Interestingly, scores have grown at a faster rate in non-producing districts than in producing provinces, followed by non-producing district in non-producing provinces (Table A2 in the Appendix, panel a). Regarding educational resources, mining provinces have a higher percentage of teachers with long-term contracts and with tertiary education in a school teaching program than non-producing districts in non-producing provinces; they show higher rates of schools with access to electricity, water and sanitation too. In contrast, non-producing districts in producing provinces present advantages in these indicators.

[Table 1 about here]

5. Identification Strategy

We exploit the variation across districts and time in the value of the mining activity and the canon. Our main specification is given by:

$$y_{isdt} = \alpha + g(m_{dt}) + f(c_{dt}) + \delta_1 X_{isdt} + \delta_2 S_{sdt} + \gamma_d + \theta_t + \varepsilon_{isdt} \qquad (1)$$

where y_{isdt} is the test score for the student i, enrolled in school s, located in district d in year t, m_{dt} is the value of mining production in district d in year t and c_{dt} is the amount of canon transferred to district d in year t, both in thousands of dollars per-capita at constant prices of 2010. X is a vector of socio-demographic characteristics of the student including gender and mother tongue; S is a vector of schools characteristics varying by time and space (e.g., school day, school administration, type, and percentage of girls). γ and θ denote district and year fixed effects respectively and ε_{istd} is an idiosyncratic error term. Standard errors are robust to unknown forms of heteroskedasticity and clustered at the district level.[10] Notice we do not control for lags of canon or mining production in our specification. In the case of mining canon, it has been pointed out that Mayors react to the transfers that they receive in any given year because not doing so will lead to higher political competition and higher likelihood that the central government will reduce transferences due to low budget execution (e.g., Maldonado, 2015; Ardanaz and Maldonado,

[10] Peru is currently divided in 1,867 districts, but at the end of the period of analysis, only 1,838 existed and were part of the sample.

2014). In the case of mining production, we expect the effects on market outcomes to be contemporaneous (Jacobsen and Parker, 2014).

Following our discussion in Section 2, several models about the political economy of natural resources predict non-linear relationships. Thus, we explore such predictions by allowing functions *g(.)* and *f(.)* to follow a polynomial of order two or more.

Changes in mining production could be correlated with unobserved variables that affect test scores. For example, if mines are disproportionally located in poorer districts then, provided the changes in poverty that the areas have also seen during the period of analysis, it will not be possible to separate the impact of mining from the effect of poverty on test scores. In that case, our estimates of $g(m_{dt})$ could be biased. We circumvent this problem by focusing on the within-district variation on the value of production. Therefore, our identification comes from year-to-year changes in the value of production in the same district, including districts that become producers during the period of analysis.[11] Also, the inclusion of time-fixed effects allows us to control for the possibility that unobserved factors alter test scores and mining production (and transfers) over time.

It is possible, however, that local governments may influence production decisions by investing in ways that attract mining companies. As before, if the traits influencing investment decisions are time-invariant our district fixed-effect model will account for such characteristics. Also, the fact that starting a new exploitation requires seven years on average reduces the possibility that our findings are driven by such traits: a new exploitation started as a consequence of the price boom would appear only at the end or beyond our period of analysis. Furthermore, by law, local governments play no role in the process of granting mining rights.

Additionally, canon transfers depend on the value of taxes paid by mining companies, which in turn depend on the value of production. Furthermore, Barrantes et al. (2010) show that changes in the mining Canon law were the product of circumstantial alliances between congressmen from mineral rich regions and not the result of pressure from regional and local actors or the executive power. Thus, our goal is to estimate whether, conditional on the value of mining production, year-

[11] Only few districts become producers during the period of analysis. Eliminating them from our sample does not change our results (results available upon request).

to-year variation in the amount of transfers received by the same district correlates with test scores of students. Once the transfer is received, its effectiveness on the formation of human capital will depend on the investment capacity of the local governments.[12]

6. Results

6.1. Effect of mining production

We start by considering the link between production of minerals and student academic achievement ignoring, for the moment, the role of the canon. In Table 2 we show estimates of Equation (1) for math (panel A) and reading (panel B). We first consider a linear specification. For math, column (1), we find no significant association between production and student learning. The parameter is near zero both practically and statistically. When exploring higher order polynomials (column 2) and the inclusion of school and children characteristics (columns 3 and 4) the results remain unchanged. The absence of a statistically significant effect is also present when we studying the effect on reading outcomes (panel B).

[Table 2 about here]

In tables A3 and A4 in the Appendix we consider four different types of schools: urban, rural, public and private. As shown in these tables, we find no association between mining production and student achievement in those subsamples either, except for the case of reading scores for private schools (Table A3) and math and reading scores for rural schools (Table A4). For rural schools, we find a negative and statistically significant effect (at 5%). This effect does not disappear when considering higher order polynomials and when including schools' and students' characteristics. Mining production also has a weak effect on math scores for urban schools, but this effect disappears after controlling for polynomials and socio-economic characteristics.

Since these specifications do not control for the role of mining royalties, these coefficients are picking out part of the variation on test scores related to natural resource rents. Thus, they cannot

[12] Maldonado (2015) estimates that only 14% of local governments had urban planning plans and 20% had local development plans. Only 29% had cadastral information systems. Along the same lines, most local governments in the country lack of stable and qualified public servants. Only 21% of the local public servants have permanent contracts whereas 50% have temporary ones. More importantly, only 19% of local public servants have professional degrees.

be interpreted causally and must be taken with a grain of salt. In the next section, we will analyze the role of canon and evaluate whether the negative effect of mining production persists after controlling for mining rents.

6.2. Effect of canon

We now consider the effect of the mining canon, after controlling for the value of mining production. Our estimates are displayed in Table 3. As in the previous subsection we explore two student learning outcomes: mathematics (panel A) and reading (panel B). In both cases, we find no association when considering a lineal model (column 1). However, a quadratic functional form suggests a nonlinear link for math but not for reading (column 2). This pattern, at least for math, is consistent with the non-monotonic effects of resource booms highlighted by the political economy literature described earlier.

Adding controls for the value of mining production (column 3) and student and school controls (column 4) does not alter our findings: there is a positive, statistically significant but with decreasing marginal effects for math. Notice that the coefficient for mining production is not significant after controlling for canon and its square. This suggests that the results of the previous section were biased.

[Table 3 about here]

Considering column 4, the impact-maximizing amount of canon is about US$ 5,500 per capita per year. For this sample, the 99-percentile value of canon transfers is US$ 1,313. Thus, for nearly all districts receiving canon, our findings suggest a positive effect of canon transfers on math test scores. Moreover, given that the average transfer per-capita during the period of our analysis for the sample of districts that received strictly positive transfers is US$ 107, our estimates suggest an increase in around 23 percent of a standard deviation in math scores.

To put our estimates in perspective, the average impact of the canon on test scores is higher than 83 percent of the studies reported by Kremer, Brannen and Glannerster (2013) who analyze primary school interventions evaluated with randomized control trials. For example, based on the authors' review, our effect is larger than all the studies where "business as usual inputs" are provided (e.g., textbook, class size, flipcharts) and all but two of the pedagogical innovations. The latter is relevant because one of the studies on pedagogical innovation is the one that provides contracts to teachers (Duflo et al., 2012). As we will show below, one of the mechanisms that explain our findings is the increase in the share of teachers with long-term contracts.

6.3. Heterogeneous effects

In Table 4 we report regressions exploring heterogeneous effects regarding the public-private and urban-rural divides.[13] In column (1) we reproduce the results for the entire sample to ease comparisons. The quadratic relationship is present in all but private schools. This result is consistent with the fact that mining production has very limited impact on local economic conditions and provides additional support to the hypothesis that the main driver factor is political since Peruvian mayors seem to use mining canon funds to improve learning conditions in public schools. We will provide additional evidence on this regard in the next section.

[Table 4 about here]

6.4. Mechanisms

We now explore several mechanisms. For example, transfers to local governments could improve test scores by improving school infrastructure and the quality of teachers (e.g., by hiring teachers with long-term contracts). This is shown in Table 5. Using data from the Censo Escolar we test whether year-to-year variation in the canon transfers relates to percentage of teachers with long-term contracts (column 1), percentage of teachers with college degrees in education (columns 2 and 3) and basic infrastructure services in the school: electricity (column 4), water (column 5) and sanitation (column 6). We find that the canon is positively and statistically significantly associated with long-term contracts for teachers as well as improving the access to electricity and sanitation. As shown in Appendix Table A5 and A6, these effects are concentrated on rural and public schools.[14]

[Table 5 about here]

[13] Note that we do not control for schools or students' observable characteristics. Nonetheless, these results hold when controlling for all observable characteristics (available upon request).

[14] Consistent with our previous results, we find no impact on enrollment for the case of public schools. However, we do find a non-monotonic effect in enrollment for the case of private schools.

We also explore whether these transfers affect household-level outcomes. In Table 6 we link several household surveys (from 2007 and 2012) to the canon and mining datasets. In column (1) we show that there is decline in unemployment status of adults (aged between 14 and 65) when transfers increase.[15] In column 2 we find that this employment surge seems to occur due to an increase in public employment, although the relationship is non-monotonic, a result consistent with the idea that politicians use public employment as an instrument to obtain political support.[16] Tables A7 shows the previous results are driven by rural areas. Note we do not find a statistically significant effect on per capita consumption or income (columns 4 and 5, respectively).

[Table 6 about here]

Finally, also using the ENAHO, we test whether the canon improves health conditions of citizens and children (6-10). In Table 7 we consider three (self-reported) indicators: having health complications in the last four weeks, felt sick in the last four weeks and the number of days an individual between 15 and 64 years of age could not work due to sickness. Our results indicate that canon transfers are associated with declines in the probability of experiencing health complications for adults and children and also with a decline in the probability of being sick recently (but for adults only). Results are essentially the same for urban and rural areas (Table A8).

[Table 7 about here]

6.5. Robustness checks

6.5.1. Relaxing the parametric quadratic specification.

So far, we have documented the existence of non-monotonic effects of mining canon on learning outcomes. These results are consistent with a story of political economy but it strongly relies on the use a quadratic parametric approximation. To evaluate whether this approach is

[15] In ENAHO, employment is defined for individuals 14 years of age or older.

[16] Robinson, Torvik and Verdier (2006) have highlighted this mechanism from a theoretical point of view. Maldonado (2015) provides evidence on this regard for the Peruvian case for a different period than the one covered in this paper.

consistent with the data, we extend the empirical model to include other polynomials and check whether they offer a better fit.

Table 8 presents the results of the analysis. Columns 1 to 3 replicate the results for the basic specification. We added to the basic specification cubic and quartic terms for mining canon in columns 4 and 5. We find that all the coefficients of the empirical model are no longer significant, providing evidence that alternative specifications to the quadratic one do not offer a better fit to the data.

We formally test this using an F-test for nested models. As a benchmark, we first test whether the coefficients for the quadratic approximation are both equal to zero. We confidently reject the null hypothesis that both coefficients are equal to zero (F-statistic of 3.67 with a p-value of 0.03) for the case of math scores (Panel A, Table 8). For the case of the cubic and quadratic approximations, we implement a test for nested models in which the null hypothesis assumes that the quadratic approximation offers a better fit with the data with respect to alternative specifications. In both cases, we fail to reject the null (F-statistic of 0.73 with a p-value of 0.39 for the cubic specification and F-statistic of 0.59 with a p-value of 0.56 for the quartic one). Therefore, the evidence suggest that the quadratic approximation offer the best fit to the data.

[Table 8 about here]

6.5.2. Alternative samples of districts according to mining production

One concern is that endogenous production responses may play a role even after controlling by mining production in the econometric specifications. To address this issue, we take advantage of the fact that the mining Canon law establishes that non-producer districts located in the same province and region as the producer ones also receive a fraction of the rent generated by mining exploitation in a producer region. This allow us to test the impact of natural resource rents in settings where production externalities and production endogenous responses are not expected to play a role.

For this purpose, we perform the same regressions for non-producing districts in producing provinces (that is, where there exists at least one producer). Table 9 presents the results. The coefficients are strongly statistically significant and larger than those reported in Table 3 for the basic specification for math scores (Panel A). This result is robust to controlling for student and school characteristic (column 3). Also, there is no strong evidence for the case of reading scores (Panel B) – consistent with previous results.

We perform the same regressions for non-producing districts in non-producer provinces, but no evidence of impacts is found for this case (Table A9). This is not surprising because these districts typically receive very small levels of mining Canon transfers which are not expected to play a role in terms of explaining learning outcomes.[17]

6.5.3. Permutation tests

To further check the validity of our design, we implement a permutation test to further evaluate the significance of our basic results. We computed 10000 random permutations by districts of the temporal series of mining canon. For each permutation, the linear and squared coefficients of the main regressions in Table 3 (controlling by production) are estimated. The empirical distributions of such coefficients are shown in Figure 1. As it can be seen the linear and quadratic coefficients of our main result are at the extremes of their corresponding distributions. This provides further evidence suggesting that our results are not due to pure chance. These results hold even if we restrict the permutations to be performed within the same province and region.

7. Concluding remarks

We studied in this paper how booms of natural resources affect human capital accumulation exploiting a natural experiment in the mining sector in Peru. This task is not easy since resource booms are typically associated to complex changes in economic and political conditions that can affect human capital accumulation in several ways. Changes in mining production can improve labor market opportunities, making possible for households to invest more in education, but it can also affect student's performance if they generate negative environmental and health-related externalities. On the other hand, resource booms are linked to increases in natural resource rents to local governments, implying an increasing access to fiscal resources that politicians can use to build schools, hire better teachers and distribute school inputs.

[17] The distribution of mining canon transfers is highly unequal. Whereas very few districts receive extraordinary high levels of mining rents, most of them receive some positive amounts even though their size is insignificant. According to some estimates, the Gini coefficient for mining canon rents is close to 0.8 (see Maldonado 2015 for a discussion).

We found non-monotonic effects of mining rents on math scores, but no effect for the case of reading. The former effect is positive and large: 23% of a standard deviation for the average municipality, implying that the mining boom in Peru has been beneficial for students in almost all recipient municipalities. Only for extremely canon-rich municipalities (top 1% in terms of mining canon distribution), the net effect is negative. These results are in line with recent scholarship documenting non-monotonic and perverse effects for natural resource rich regions. This evidence is consistent with a political economy story where mayors invest in public goods when they expect to keep power, but underinvest when they face less political competition. In fact, we find that these effects are mainly driven by public schools and by changes in school-level conditions such as infrastructure and better labor conditions for teachers. These are ways in which politicians can invest mining canon transfers.

We did not find impacts of mining production on learning outcomes. This result is important, since it helps to identify the causal mechanism as a political one. The resource boom had a limited impact on improving households' economic conditions with a weak impact on reducing unemployment and no effects in terms of increasing income and consumption per-capita. Interestingly, only public employment reacted to the boom, but again the story seems to be political as incumbents use public employment as a clientelistic tool to obtain political support. The non-monotonic effect found for public employment is consistent in this regard.

In addition, we also found non-monotonic effects for the case of health variables. This results can be interpreted as a result of improvements in the quality and access to health facilities, something that has been documented in other studies (Ardanaz and Maldonado 2014; Maldonado 2015).

The evidence presented in this paper put into question some beliefs in the literature about the role of natural resources in development. Recent scholarship have emphasized that natural resources can be a blessing only when good institutions are available. However, we have shown that a natural resource boom can led to an increase of human capital accumulation in a context of poor institutions when mechanisms of distribution of natural resource windfalls are in place. Moreover, we find that only extremely canon-rich municipalities experience negative effects of a resource boom. This may explain the anecdotal evidence of the resource curse literature, which is typically motivated by highlighting the economic and political distortions experienced by extremely natural wealth in the Middle East or Africa. Thus, natural resource can lead to a curse only for extremely natural-resource-rich societies, and it can potentially be a blessing for the rest.

Undoubtedly the effect of natural resource booms on academic achievement deserves further research, in particular under different institutional set-ups and windfalls-redistribution schemes. Focusing on the Peruvian case, perhaps one important question that remains open for discussion is: What are the long-term effects of mining production on the social outcomes here analyzed once the boom ends? Jacobsen and Parker (2014) find long-lived negative effects in the labor markets after the end the of the gas and oil bonanza of the 70s in the United States. However, we have not seen evidence documenting the long-run effects on human capital formation after the bust. Another question that remains open to consideration is: What is behind the heterogeneous impact of canon on different test subjects? As documented we observe an impact of canon transfers on math test scores, but not on reading scores. Up to this point we have not been able to identify the mechanisms behind this conundrum, and it deserves further research.

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Table 1. Descriptive statistics. Averages 2007-2012

	Producing districts	Non-producing districts in producing provinces	Non-producing districts in non-producing provinces
A. Learnings, as measured by "Evaluación Censal de Estudiantes"			
Average scores in mathematics	517.06	534.04	509.17
Average scores in reading	514.73	532.49	508.46
Number of students	*110868*	*409626*	*1565804*
B. Schools' characteristics, as measured by "Censo Escolar", %			
Teachers with long-term contract	28.56	31.23	27.79
Teachers with a tertiary education degree in a school teaching program	97.44	97.08	94.54
Schools with access to electricity	71.24	74.96	60.48
Schools with access to water	65.86	68.97	54.96
Schools with access to sanitation	74.83	76.46	72.12
Number of schools	*5794*	*22771*	*83361*
C. Districts' characteristics			
Mining production per-capita†	15513	0.00	0.00
Canon transfers per-capita†	0.37	0.19	0.04
Number of districts	128	554	1156

† Thousands of USD at constant prices of 2010, divided by total population at the district level. The total number of habitants for each district and year is obtained from Peru's National Bureau of Statistics (INEI).
Source: Authors' calculations based on data from ESCALE, UMC, Peru's Ministry of Finance, Peru's Ministry of Energy and Mines, and INEI.

Table 2. Effects of mining production on academic achievement

	Dependent variable: Test scores			
	(1)	**(2)**	**(3)**	**(4)**
	Panel A. Math scores			
Mining production	0.0000	0.0001	0.0001	0.0001
	(0.0001)	(0.0002)	(0.0002)	(0.0002)

Mining production squared		-0.0000	-0.0000	-0.0000
		(0.0000)	(0.0000)	(0.0000)
R-squared	0.0062	0.0062	0.0146	0.0171
Number of students	2,072,339	2,072,339	2,016,774	2,012,798
		Panel B. Reading scores		
Mining production	-0.0001	0.0001	0.0001	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Mining production squared		-0.0000**	-0.0000*	-0.0000**
		(0.0000)	(0.0000)	(0.0000)
R-squared	0.0266	0.0266	0.0509	0.0638
Number of students	2,068,271	2,068,271	2,011,922	2,008,941
Student controls	N	N	Y	Y
School controls	N	N	N	Y

Note: Standard errors clustered at the district level in parentheses. * Significant at ten percent; ** significant at five percent; *** significant at one percent. Mining corresponds to the value of mining production per-capita, in thousands of USD at constant prices of 2010. School characteristics include: school day; school administration type (public/private), and school type (one-teacher school/full grade). Student characteristics include: gender and mother language (Spanish/other) of the children.

Source: Authors' calculations based data from ESCALE, UMC, INEI, and data from Peru's Ministry of Finance and Peru's Ministry of Mines and Energy.

Table 3. Effects of canon on academic achievement

	Dependent variable: Test scores			
	(1)	**(2)**	**(3)**	**(4)**
		Panel A. Math scores		
Canon	6.9139	21.6714**	21.7054**	24.0105**
	(4.6448)	(9.5905)	(9.6360)	(9.4667)
Canon squared		-1.9654**	-1.9679**	-2.1754***
		(0.8429)	(0.8453)	(0.8285)
Mining production			-0.0000	-0.0000
			(0.0001)	(0.0001)
R-squared	0.0062	0.0062	0.0062	0.0172
Number of students	2,072,339	2,072,339	2,072,339	2,012,798
		Panel B. Reading scores		
Canon	-0.6112	-2.6721	-2.5545	-2.8542
	(1.7751)	(4.3260)	(4.3682)	(4.5153)
Canon squared		0.2743	0.2656	0.2731
		(0.3728)	(0.3743)	(0.3848)
Mining production			-0.0001	-0.0001
			(0.0001)	(0.0001)
R-squared	0.0266	0.0266	0.0266	0.0638
Number of students	2,068,271	2,068,271	2,068,271	2,007,595
Student controls	N	N	N	Y
School controls	N	N	N	Y

Note: Standard errors clustered at the district level in parentheses. * Significant at ten percent; ** significant at five percent; *** significant at one percent. Mining and canon correspond to the value of mining production per-capita and canon per-capita, in thousands of USD at constant prices of 2010. School characteristics include: school day; school administration type (public/private), and school type (one-teacher school/full grade). Student characteristics include: gender and mother language (Spanish/other) of the children.

Source: Authors' calculations based data from ESCALE, UMC, INEI, and data from Peru's Ministry of Finance and Peru's Ministry of Mines and Energy.

Table 4. Heterogeneous effects of canon on academic achievement

	Sample				
	All	**Urban**	**Rural**	**Private**	**Public**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
			Panel A. Math scores		
Canon	21.7054**	24.9423**	18.3271*	-4.3996	23.6142***
	(9.6360)	(11.3530)	(10.1226)	(16.7949)	(8.9815)
Canon squared	-1.9679**	-2.2199**	-1.9329**	-0.1085	-2.0959**
	(0.8453)	(0.9878)	(0.8927)	(1.2641)	(0.8443)
Mining production	-0.0000	0.0002	0.0001	0.0001	0.0001
	(0.0001)	(0.0001)	(0.0003)	(0.0003)	(0.0003)
R-squared	0.0062	0.0092	0.0115	0.0103	0.0060
Number of students	2,072,339	1,392,151	660,949	300,937	1,724,326
			Panel B. Reading scores		
Canon	-2.5545	2.1926	0.0053	-24.0071**	0.1903
	(4.3682)	(4.4891)	(7.5531)	(10.7773)	(4.4472)
Canon squared	0.2656	-0.1924	0.0219	2.0173**	-0.0410
	(0.3743)	(0.3871)	(0.6655)	(0.8042)	(0.3982)
Mining production	-0.0001	0.0000	-0.0001	-0.0001	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
R-squared	0.0266	0.0273	0.0254	0.0228	0.0277
Number of students	2,068,271	1,389,725	659,342	300,799	1,720,622

Note: Standard errors clustered at the district level in parentheses. * Significant at ten percent; ** significant at five percent; *** significant at one percent. None of the regressions include student or school characteristics. Mining and canon correspond to the value of mining production per-capita and canon per-capita, in thousands of USD at constant prices of 2010.
Source: Authors' calculations based data from UMC, INEI, and data from Peru's Ministry of Finance and Peru's Ministry of Mines and Energy.

Table 5. Mechanisms: School characteristics

	Dependent Variables					
	Enrollment	Percentage of teachers with long-term contract (at the school level)	Percentage of teachers with a tertiary education degree in a school teaching program	School has access to electricity	School has access to water	School has access to sanitation
Canon	0.0188	0.1556***	0.0101	0.2032**	0.0220	0.2909***
	(0.0159)	(0.0501)	(0.0130)	(0.0841)	(0.0561)	(0.1104)
Canon squared	0.0070	-0.0942***	0.0077	-0.0707*	-0.0158	-0.1766**
	(0.0099)	(0.0247)	(0.0061)	(0.0395)	(0.0306)	(0.0782)
Mining production	-0.0011	-0.0016	-0.0016**	0.0077**	0.0066	0.0056
	(0.0009)	(0.0033)	(0.0008)	(0.0037)	(0.0042)	(0.0068)
R-squared	0.0011	0.0060	0.0013	0.0387	0.0235	0.1941
Number of schools	284867	142318	142318	234074	234072	234035

Note: Standard errors clustered at the district level in parentheses. * Significant at ten percent; ** significant at five percent; *** significant at one percent. None of the regressions include school characteristics. Mining and canon correspond to the value of mining production per-capita and canon per-capita, in thousands of USD at constant prices of 2010.
Source: Authors' calculations based data from ESCALE, UMC, INEI, and data from Peru's Ministry of Finance and Peru's Ministry of Mines and Energy.

Table 6. Mechanisms: Role of economic conditions

	Dependent Variables				
	Unemployment (14 – 65 years of age)	**Employed in the public sector (14 – 65 years of age)**	**Spending on education per-student in household**	**Consumption per-capita**	**Income per-capita**
Canon	-0.0536*	0.1042*	0.0757	-0.0654	-0.0024
	(0.0291)	(0.0610)	(0.1450)	(0.0716)	(0.0965)
Canon squared	0.0166	-0.0537**	-0.1425**	-0.0121	-0.0187
	(0.0123)	(0.0253)	(0.0685)	(0.0283)	(0.0678)
Mining production	0.0014	-0.0085**	0.0087	0.0046	0.0043
	(0.0029)	(0.0039)	(0.0086)	(0.0088)	(0.0053)
R-squared	0.0004	0.0034	0.0267	0.0263	0.0214
Number of people	574,210	117,443	78,236	136,855	136,849

Note: Standard errors clustered at the district level in parentheses. * Significant at ten percent; ** significant at five percent; *** significant at one percent. None of the regressions include sociodemographic characteristics. Mining and canon correspond to the value of mining production per-capita and canon per-capita, in thousands of USD at constant prices of 2010.
Source: Authors' calculations based on ENAHO household survey data and data from Peru's Ministry of Finance and Peru's Ministry of Mines and Energy.

Table 7. Mechanisms: Role of health factors

	Dependent variable				
	Individual experienced health complications in the past 4 weeks		Individual was sick in the past 4 weeks		Number of days individual couldn't work due to sickness in the past 4 weeks
	(All individuals)	(6 to 10 years of age)	(All individuals)	(6 to 10 years of age)	(14 - 65 years of age)
Canon	-0.2372***	-0.3575***	-0.1730***	-0.1104	-0.0261
	(0.0646)	(0.0946)	(0.0525)	(0.0930)	(0.0882)
Canon squared	0.1248***	0.2701***	0.0528**	0.0364	-0.0212
	(0.0226)	(0.0480)	(0.0218)	(0.0464)	(0.0323)
Mining production	0.0029	0.0073	0.0070**	0.0057	0.0008
	(0.0040)	(0.0063)	(0.0030)	(0.0046)	(0.0043)
R-squared	0.0299	0.0019	0.0023	0.0019	0.0013
Number of people	528064	56349	528064	56349	434325

Note: Standard errors clustered at the district level in parentheses. * Significant at ten percent; ** significant at five percent; *** significant at one percent. None of the regressions include sociodemographic characteristics. Mining and canon correspond to the value of mining production per-capita and canon per-capita, in thousands of USD at constant prices of 2010.
Source: Authors' calculations based on ENAHO household survey data and data from Peru's Ministry of Finance and Peru's Ministry of Mines and Energy.

Table 8. Robustness check: Evaluating parametric specification

Dependent Variable: Test scores					
	(1)	(2)	(3)	(4)	(5)
			Panel A. Math scores		
Canon	3.5246	17.3868*	17.5242*	12.7588	6.5527
	(4.6428)	(10.5255)	(10.5110)	(15.1555)	(19.6666)
Squared canon		-1.7345*	-1.7567**	1.0082	8.3454
		(0.8924)	(0.8943)	(3.9760)	(10.3484)
Mining production			-0.0001	-0.0001	-0.0001
			(0.0001)	(0.0001)	(0.0001)
Cubic canon				-0.2372	-1.8782
				(0.2774)	(1.7670)
Quartic canon					0.1000
					(0.0930)
F-test for quadratic specification			3.67		
			[0.0257]		
F-test for nested models comparison:				0.73	
Quadratic versus Cubic model				[0.3926]	
F-test for nested models comparison:					0.59
Quadratic versus Quartic model					[0.5561]
Number of students	2,325,127	2,325,127	2,325,127	2,325,127	2,325,127
			Panel B. Reading scores		
Canon	-2.6821	-7.7145	-7.5401	-9.8779	-12.1412
	(2.5335)	(6.4772)	(6.4192)	(9.1283)	(12.1078)
Squared canon		0.6291	0.6011	1.9570	4.6371
		(0.5438)	(0.5438)	(2.4986)	(6.9097)
Mining production			-0.0002**	-0.0002*	-0.0002
			(0.0001)	(0.0001)	(0.0001)
Cubic canon				-0.1164	-0.7153
				(0.1794)	(1.2059)
Quartic canon					0.0365
					(0.0638)
F-test for quadratic specification			0.72		
			[0.4872]		
F-test for nested models comparison:				0.42	
Quadratic versus Cubic model				[0.5167]	
F-test for nested models comparison:					0.22
Quadratic versus Quartic model					[0.8063]
Number of students	2,322,741	2,322,741	2,322,741	2,322,741	2,322,741

Note: Standard errors clustered at the district level in parentheses. * Significant at ten percent; ** significant at five percent; *** significant at one percent. None of the regressions include student or school characteristics. Mining and canon correspond to the value of mining production per-capita and canon per-capita, in thousands of USD at constant prices of 2010.
Source: Authors' calculations based on ENAHO household survey data and data from Peru's Ministry of Finance and Peru's Ministry of Mines and Energy.

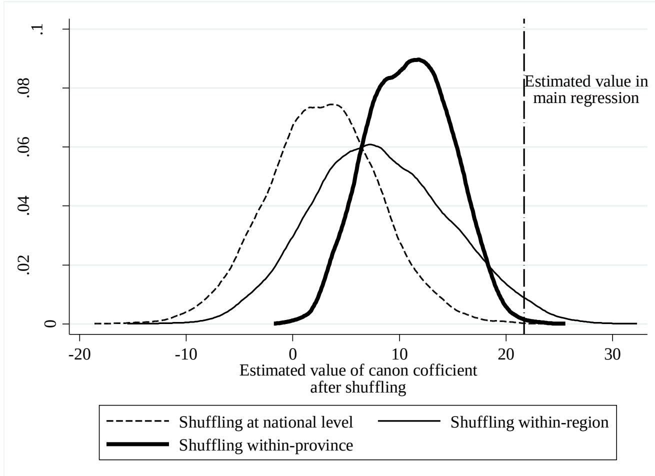
Table 9. Robustness check: Non-producing districts

Non-producing districts in producing provinces				
	Dependent Variable: Scores			
	(1)	(2)	(3)	(4)
	Panel A. Math Scores			
Canon	15.3272**	42.9592***	42.9592***	44.0927***
	(7.2185)	(9.2665)	(9.2665)	(9.2499)
Canon squared		-4.0120***	-4.0120***	-4.1620***
		(0.8158)	(0.8158)	(0.8099)
R-squared	0.0062	0.0067	0.0067	0.0204
Number of students	407870	407870	407870	400466
	Panel B. Reading Scores			
Canon	-3.8087	-5.3912	-5.3912	-4.5662
	(2.4266)	(5.6013)	(5.6013)	(5.6375)
Canon squared		0.2281	0.2281	0.0850
		(0.4882)	(0.4882)	(0.4810)
R-squared	0.0210	0.0210	0.0210	0.0597
Number of students	407261	407261	407261	399885
Student controls	N	N	Y	Y
School controls	N	N	N	Y

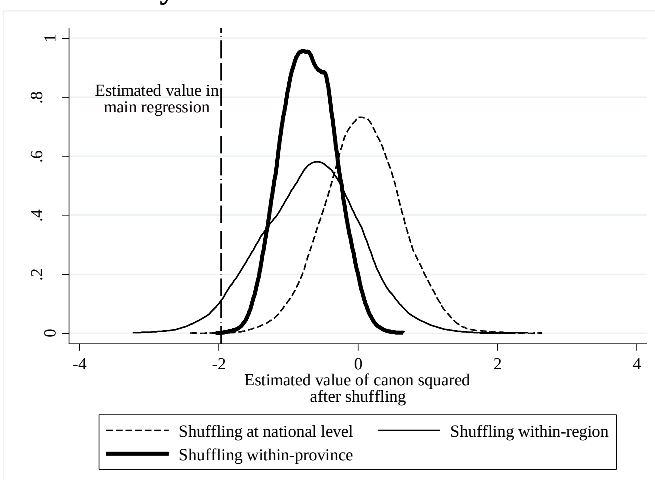
Note: Standard errors clustered at the district level in parentheses. * Significant at ten percent; ** significant at five percent; *** significant at one percent. School characteristics include: school day; school administration type (public/private), and school type (one-teacher school/full grade). Student characteristics include: gender and mother language (Spanish/other) of the children. Canon corresponds to the value of canon per-capita, in thousands of USD at constant prices of 2010.
Source: Authors’ calculations based on ECE, CE, data from Peru’s Ministry of Finance and Peru’s Ministry of Mines and Energy.

Figure 1. Mining canon transfer randomizations

a. Kernel density estimate for the coefficient of canon



b. Kernel density estimate for the coefficient of canon squared



Bandwidth: 0.2

Note: In our regressions, mining and canon correspond to the value of mining production per-capita and canon per-capita, in thousands of USD at constant prices of 2010. The regressions do not include school characteristics or student characteristics.

Source: Authors' calculations based on data from Peru's Ministry of Finance and Peru's Ministry of Energy and Mines.

Appendix

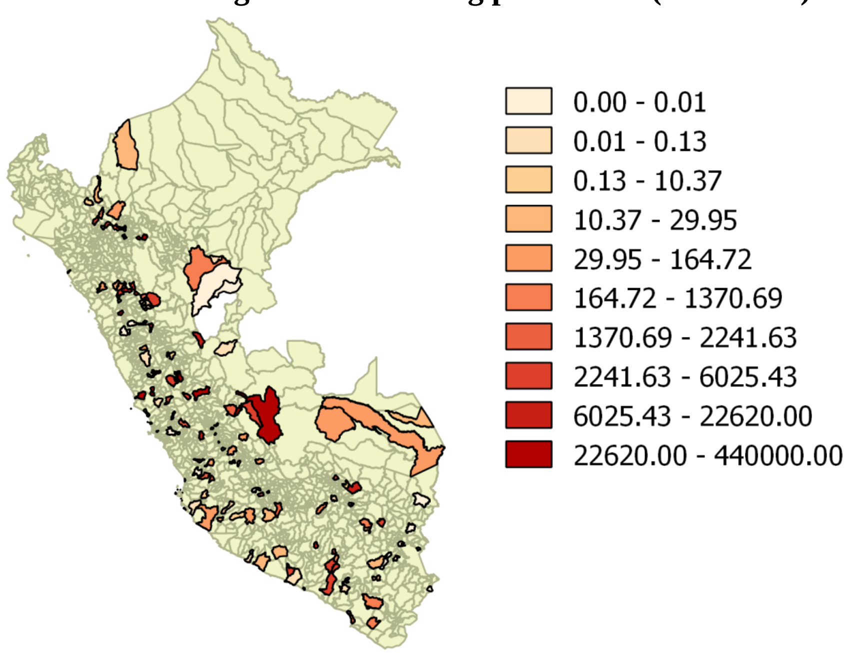
Table A1. Sample size

Year	Number of schools assessed	Number of students assessed
2007	19,520	368,150
2008	18,731	322,000
2009	17,932	327,087
2010	17,856	344,799
2011	17,526	343,213
2012	20,344	381,049
Total	111,909	2,086,298

Source: Authors' compilations based on ECE and CE data.

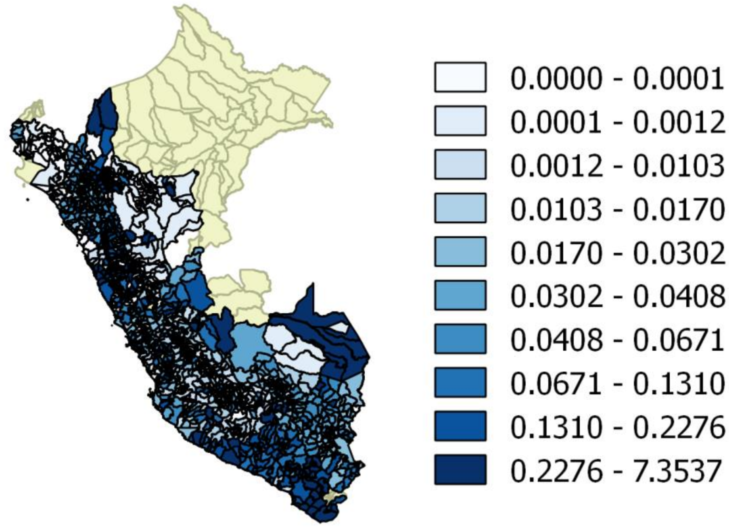
Figure A1. Mining production and canon transfers by district

a. Average value of mining production (2007-2012)



(*Continues on the next page*)

b. Average value of canon transfers (2007-2012)



Note: The value of mining corresponds to the sum of the value of production (price × volume) of copper, tin, iron, zinc, molybdenum, silver, gold, tungsten and cadmium produced by each legal established mine. Mining and canon correspond to the value of mining production per-capita and canon per-capita, in thousands of USD at constant prices of 2010.
Source: Authors' calculations based on data from Peru's Ministry of Finance and Peru's Ministry of Energy and Mines.

Table A2. Descriptive Statistics

a. Academic outcomes by year and district type

	Academic outcomes	
Year	**Average score in math**	**Average score in communication**
	Producing districts	
2007	508.49	497.88
2008	527.17	502.24
2009	526.66	519.99
2010	517.98	523.25
2011	503.74	507.85
2012	518.34	526.59
	Non-producing districts in producing provinces	
2007	512.94	505.72
2008	536.30	517.11
2009	547.09	537.01
2010	537.99	539.44
2011	535.93	544.21
2012	530.90	543.31
	Non-producing districts in non-producing provinces	
2007	494.76	486.86
2008	514.70	490.27
2009	515.82	514.91
2010	515.29	520.90
2011	506.41	515.61
2012	510.15	522.54

(*Continues on the next page*)

b. Characteristics of schools by year and district type

	School characteristics				
Year	**Percentage of teachers with long-term contract**	**Percentage of teachers with a tertiary education degree in a school teaching program**	**Percentage of schools with access to electricity**	**Percentage of schools with access to water**	**Percentage of schools with access to sanitation**
	Producing districts				
2007	24.29	97.18	58.86	52.2	45.66
2008	27.54	98.11	69.36	61.03	43.76
2009	32.24	97.98	70.51	67.48	87.06
2010	29.73	98.02	71.36	70.89	86.7
2011	25.97	96.50	75.72	70.44	90.31
2012	30.34	97.04	79.13	72.14	91.54
	Non-producing districts in producing provinces				
2007	25.49	96.36	60.17	52.86	51.59
2008	32.34	97.35	70.62	64.73	52.11
2009	33.37	97.30	76.42	73.99	88.52
2010	31.55	97.91	77.20	72.48	88.78
2011	32.41	96.22	83.07	75.94	92.91
2012	31.53	97.30	84.97	76.63	93.79
	Non-producing districts in non-producing provinces				
2007	28.99	93.62	47.54	45.7	52.58
2008	31.64	94.06	53.89	49.51	43.24
2009	30.51	94.33	61.02	60.28	82.38
2010	26.07	95.34	65.61	58.94	86.98
2011	22.22	94.69	70.54	59.76	89.57
2012	26.82	96.11	87.87	76.22	94.86

(*Continues on the next page*)

c. Descriptive statistics of Production and Canon

	Mining Production (In thousands US per-capita)				Canon (In thousands US per-capita)			
Year	**Mean**	**p25**	**p50**	**p75**	**Mean**	**p25**	**p50**	**p75**
	Producing districts							
2007	14,115	5	37	5,837	0.42	0.02	0.12	0.32
2008	20,315	8	52	5,572	0.45	0.03	0.15	0.37
2009	13,244	1	26	3,443	0.31	0.04	0.13	0.18
2010	12,690	2	36	3,543	0.26	0.03	0.12	0.23
2011	17,486	1	31	2,467	0.38	0.06	0.14	0.28
2012	15,502	2	27	2,256	0.43	0.09	0.20	0.37
	Non-producing districts in producing provinces							
2007	0	0	0	0	0.24	0.01	0.04	0.17
2008	0	0	0	0	0.21	0.02	0.07	0.18
2009	0	0	0	0	0.16	0.01	0.07	0.17
2010	0	0	0	0	0.14	0.01	0.07	0.15
2011	0	0	0	0	0.17	0.02	0.09	0.18
2012	0	0	0	0	0.21	0.02	0.12	0.22
	Non-producing districts in non-producing provinces							
2007	0	0	0	0	0.06	0.00	0.01	0.04
2008	0	0	0	0	0.05	0.00	0.01	0.03
2009	0	0	0	0	0.03	0.00	0.01	0.03
2010	0	0	0	0	0.03	0.00	0.01	0.03
2011	0	0	0	0	0.04	0.00	0.01	0.04
2012	0	0	0	0	0.04	0.00	0.01	0.06

d. Descriptive Statistics by district type

Descriptive Statistics by district type											
Producing districts				Non-producing districts in producing provinces				Non-producing districts in non-producing provinces			
Average value of production and canon											
Mining Production (In US per-capita)		Canon (In US per-capita)		Mining Production (In US per-capita)		Canon (In US per-capita)		Mining Production (In US per-capita)		Canon (In US per-capita)	
15512.69		0.00		0.00		0.37		0.19		0.04	
Average scores											
Rural	Urban	Private	Public	Rural	Urban	Private	Public	Rural	Urban	Private	Public
Average score in math											
494.15	531.05	550.48	513.28	493.37	549.49	569.22	524.57	481.77	523.14	548.95	502.97
Average score in communication											
479.42	535.42	569.33	508.11	476.72	553.69	587.73	517.60	465.47	530.02	574.58	502.77
Average number of students and schools											
Average number of students											
280.68	391.42	231.60	370.74	188.83	406.18	499.40	289.67	357.50	633.48	413.47	550.56
Average number of schools											
9.33	3.06	4.21	6.30	7.07	4.06	8.38	5.10	11.05	4.38	6.25	8.23

Source: Authors' compilations based on ECE, CE and data from Peru's Ministry of Finance and Peru's Ministry of Energy and Mines.

Table A3. Effects of mining production on academic achievement by type of school

	Dependent variable: Test scores							
	Private				Public			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	Panel A. Math Scores							
Mining production	0.0001	-0.0011	-0.0011	-0.0011	0.0000	0.0002	0.0001	0.0001
	(0.0002)	(0.0008)	(0.0009)	(0.0009)	(0.0001)	(0.0002)	(0.0002)	(0.0002)
Mining production squared		0.0000	0.0000	0.0000		-0.0000	-0.0000	-0.0000
		(0.0000)	(0.0000)	(0.0000)		(0.0000)	(0.0000)	(0.0000)
R-squared	0.0103	0.0103	0.0145	0.0173	0.0059	0.0059	0.0121	0.0148
Number of students	300,937	300,937	299,270	298,757	1,724,326	1,724,326	1,716,158	1,712,695
	Panel B. Reading Scores							
Mining production	-0.0002***	-0.0003	-0.0003	-0.0003	-0.0000	0.0001	0.0001	0.0001
	(0.0001)	(0.0005)	(0.0006)	(0.0006)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Mining production squared		0.0000	0.0000	0.0000		-0.0000**	-0.0000**	-0.0000**
		(0.0000)	(0.0000)	(0.0000)		(0.0000)	(0.0000)	(0.0000)
R-squared	0.0227	0.0227	0.0301	0.0337	0.0277	0.0277	0.0475	0.0520
Number of students	300,799	300,799	299,123	298,610	1,720,622	1,720,622	1,712,453	1,708,985
Student controls	N	N	Y	Y	N	N	Y	Y
School controls	N	N	N	Y	N	N	N	Y

Note: Standard errors clustered at the district level in parentheses. * Significant at ten percent; ** significant at five percent; *** significant at one percent. Mining corresponds to the value of mining production per-capita, in thousands of USD at constant prices of 2010. School characteristics include: school day; school type (one-teacher school/full grade), and percentage of girls in the school. Student characteristics include: gender and mother language (Spanish/other) of the children.
Source: Authors' compilations based on ECE, CE and data from Peru's Ministry of Finance and Peru's Ministry of Mines and Energy

Table A4. Effects of mining production on academic achievement by area

	Dependent variable: Test scores							
	Urban				Rural			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	Panel A. Math Scores							
Mining production	0.0002*	0.0004	0.0004	0.0004	-0.0003***	-0.0004*	-0.0005**	-0.0004*
	(0.0001)	(0.0003)	(0.0003)	(0.0003)	(0.0001)	(0.0002)	(0.0002)	(0.0002)
Mining production squared		-0.0000	-0.0000	-0.0000		0.0000	0.0000	0.0000
		(0.0000)	(0.0000)	(0.0000)		(0.0000)	(0.0000)	(0.0000)
R-squared	0.0091	0.0091	0.0145	0.0167	0.0114	0.0114	0.0119	0.0141
Number of students	1,392,151	1,392,151	1,355,691	1,352,959	660,949	660,949	654,235	653,001
	Panel B. Reading Scores							
Mining production	0.0000	0.0002	0.0002	0.0002	-0.0003***	-0.0003*	-0.0003**	-0.0003**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0001)
Mining production squared		-0.0000	-0.0000	-0.0000		0.0000	0.0000	0.0000
		(0.0000)	(0.0000)	(0.0000)		(0.0000)	(0.0000)	(0.0000)
R-squared	0.0273	0.0273	0.0532	0.0568	0.0254	0.0254	0.0289	0.0319
Number of students	1,389,725	1,389,725	1,353,416	1,350,682	659,342	659,342	652,668	651,431
Student controls	N	N	Y	Y	N	N	Y	Y
School controls	N	N	N	Y	N	N	N	Y

Note: Standard errors clustered at the district level in parentheses. * Significant at ten percent; ** significant at five percent; *** significant at one percent. Mining and canon correspond to the value of mining production per-capita and canon per-capita, in thousands of USD at constant prices of 2010. School characteristics include: school day; school administration type (public/private); school type (one-teacher school/full grade), and percentage of girls in the school. Student characteristics include: gender and mother language (Spanish/other) of the children.
Source: Authors' compilations based on ECE, CE and data from Peru's Ministry of Finance and Peru's Ministry of Mines and Energy

Table A5. Mechanisms based on school characteristics by type of school

	Dependent Variables					
	Enrollment	**Percentage of teachers with long-term contract (at the school level)**	**Percentage of teachers with a tertiary education degree in a school teaching program**	**School has access to electricity**	**School has access to water**	**School has access to sanitation**
			Panel A. Private			
Canon	-0.0203**	-0.0829	-0.0280	0.3077**	0.1542	0.0258
	(0.0100)	(0.1009)	(0.0460)	(0.1299)	(0.1399)	(0.1903)
Canon squared	0.0353***	-0.0745**	0.0860***	-0.0777	-0.0707	-0.0023
	(0.0044)	(0.0371)	(0.0164)	(0.0487)	(0.0765)	(0.0550)
Mining Production	0.0001	-0.0125	-0.0091	-0.0480	-0.0328	0.0320
	(0.0002)	(0.0079)	(0.0078)	(0.0459)	(0.0307)	(0.0382)
R-squared	0.0011	0.0033	0.0045	0.0374	0.0288	0.0412
Number of schools	69,878	35,004	35,004	32,620	32,621	32,607
			Panel B. Public			
Canon	0.0189	0.2282***	-0.0004	0.1957**	0.0029	0.3669***
	(0.0178)	(0.0553)	(0.0130)	(0.0831)	(0.0524)	(0.1023)
Canon squared	0.0063	-0.1172***	0.0071	-0.0644*	-0.0028	-0.1952***
	(0.0113)	(0.0307)	(0.0054)	(0.0373)	(0.0267)	(0.0719)
Mining Production	-0.0013	-0.0013	-0.0008	0.0074**	0.0072**	0.0052
	(0.0010)	(0.0028)	(0.0006)	(0.0038)	(0.0036)	(0.0057)
R-squared	0.0015	0.0150	0.0011	0.0444	0.0290	0.2281
Number of schools	214,989	107,314	107,314	201,454	201,451	201,428

Note: Standard errors clustered at the district level in parentheses. * Significant at ten percent; ** significant at five percent; *** significant at one percent. Mining and canon correspond to the value of mining production per-capita and canon per-capita, in thousands of USD at constant prices of 2010. None of the regressions include school characteristics.
Source: Authors' compilations based on CE and data from Peru's Ministry of Finance and Peru's Ministry of Mines and Energy.

Table A6. Mechanisms based on school characteristics by area

	Dependent Variables					
	Enrollment	**Percentage of teachers with long-term contract**	**Percentage of teachers with a tertiary education degree in a school teaching program**	**School has access to electricity**	**School has access to water**	**School has access to sanitation**
			Panel A. Urban			
Canon	0.0476	-0.0532	0.0199	0.0577	-0.0926	0.0589
	(0.0514)	(0.0808)	(0.0229)	(0.0514)	(0.0783)	(0.0849)
Canon squared	0.0078	0.0323	-0.0078	0.0032	0.0240	-0.0222
	(0.0375)	(0.0481)	(0.0082)	(0.0211)	(0.0291)	(0.0452)
Mining Production	-0.0076	0.0032	-0.0076	0.0027	0.0024	0.0107**
	(0.0055)	(0.0094)	(0.0047)	(0.0031)	(0.0069)	(0.0052)
R-squared	0.0016	0.0019	0.0018	0.0325	0.0213	0.0653
Number of schools	64,684	32,299	32,299	44,803	44,804	44,789
			Panel B. Rural			
Canon	0.0034	0.3131***	0.0356	0.2251*	0.0905	0.4593***
	(0.0132)	(0.0887)	(0.0246)	(0.1176)	(0.0748)	(0.1274)
Canon squared	-0.0070	-0.2378***	-0.0010	-0.1141**	-0.0429	-0.2530***
	(0.0067)	(0.0416)	(0.0110)	(0.0526)	(0.0470)	(0.0760)
Mining Production	0.0007	-0.0011	-0.0019*	0.0043	0.0128**	0.0049
	(0.0008)	(0.0046)	(0.0011)	(0.0052)	(0.0056)	(0.0056)
R-squared	0.0011	0.0162	0.0013	0.0587	0.0354	0.2920
Number of schools	77,460	38,726	38,726	72,053	72,054	72,047

Note: Standard errors clustered at the district level in parentheses. * Significant at ten percent; ** significant at five percent; *** significant at one percent. Mining and canon correspond to the value of mining production per-capita and canon per-capita, in thousands of USD at constant prices of 2010. None of the regressions include school characteristics.
Source: Authors' calculations based data from ESCALE, UMC, INEI, and data from Peru's Ministry of Finance and Peru's Ministry of Mines and Energy.

Table A7. Mechanisms based on economic conditions by area

	Dependent Variables				
	Unemployed (14 years of age or older)	**Employed in the public sector (14 years of age or older)**	**Spending on education per-student in the household**	**Monthly consumption per-capita**	**Monthly income per-capita**
			Panel A. Urban		
Canon	-0.0340	0.0189	0.0097	-0.0995	-0.0771
	(0.0417)	(0.0770)	(0.1936)	(0.0867)	(0.1104)
Canon squared	-0.0011	-0.0056	-0.0428	0.0440*	0.0716**
	(0.0176)	(0.0207)	(0.0977)	(0.0236)	(0.0331)
Mining Production	0.0021	-0.0030	-0.0093	-0.0008	0.0040
	(0.0049)	(0.0030)	(0.0084)	(0.0115)	(0.0085)
R-squared	0.0004	0.0009	0.0256	0.0284	0.0229
Number of people	343629	84713	49864	83190	83184
			Panel B. Rural		
Canon	-0.0677*	0.3150***	0.1160	-0.0805	0.0601
	(0.0371)	(0.0893)	(0.2062)	(0.1044)	(0.1300)
Canon squared	0.0292*	-0.1211**	-0.1839*	-0.0509	-0.1048
	(0.0152)	(0.0503)	(0.1040)	(0.0423)	(0.0650)
Mining Production	0.0011	-0.0100***	0.0205*	0.0066	0.0015
	(0.0029)	(0.0037)	(0.0116)	(0.0078)	(0.0050)
R-squared	0.0005	0.0164	0.0579	0.0612	0.0437
Number of people	230581	32730	28372	53665	53665

Note: Standard errors clustered at the district level in parentheses. * Significant at ten percent; ** significant at five percent; *** significant at one percent. Mining corresponds to the value of mining production per-capita, in thousands of USD at constant prices of 2010. None of the regressions include school characteristics.
Source: Authors' compilations based on ENAHO household survey data and data from Peru's Ministry of Finance and Peru's Ministry of Mines and Energy.

Table A8. Mechanisms based on health factors by area

	Dependent variable				
	Individual experienced health complications in the past 4 weeks		Individual was sick in the past 4 weeks		Number of days individual couldn't work due to sickness in the past 4 weeks
	(All individuals)	(6 to 10 years of age)	(All individuals)	(6 to 10 years of age)	(14 - 65 years of age)
			Panel A. Urban		
Canon	-0.2431**	-0.3742***	-0.1686**	-0.1559	0.0019
	(0.0989)	(0.1355)	(0.0787)	(0.1256)	(0.1320)
Canon squared	0.1342***	0.3308***	0.0394*	0.1381***	0.0052
	(0.0354)	(0.0633)	(0.0235)	(0.0476)	(0.0480)
Mining Production	0.0056**	0.0219*	0.0050	0.0111	-0.0053**
	(0.0023)	(0.0114)	(0.0058)	(0.0112)	(0.0025)
R-squared	0.0204	0.0028	0.0046	0.0021	0.0006
Number of people	318120	29473	318120	29473	260974
			Panel B. Rural		
Canon	-0.2519***	-0.3466***	-0.1638**	-0.0597	-0.0463
	(0.0778)	(0.1291)	(0.0660)	(0.1374)	(0.1230)
Canon squared	0.1218***	0.2380***	0.0612**	-0.0145	-0.0326
	(0.0261)	(0.0624)	(0.0288)	(0.0840)	(0.0452)
Mining Production	0.0010	-0.0015	0.0077**	0.0020	0.0045
	(0.0059)	(0.0062)	(0.0036)	(0.0059)	(0.0062)
R-squared	0.0560	0.0020	0.0010	0.0024	0.0029
Number of people	209944	26876	209944	26876	173351

Note: Standard errors clustered at the district level in parentheses. * Significant at ten percent; ** significant at five percent; *** significant at one percent. Mining and canon correspond to the value of mining production per-capita and canon per-capita, in thousands of USD at constant prices of 2010. None of the regressions include sociodemographic characteristics.
Source: Authors' calculations based on ENAHO household survey data and data from Peru's Ministry of Finance and Peru's Ministry of Mines and Energy.

Table A9. Robustness check: Non-producing districts

Non-producing districts in non-producing provinces			
	Dependent Variable: Scores		
	(1)	**(2)**	**(4)**
		Panel A. Math Scores	
Canon	3.0216	11.3721	14.4347
	(7.0492)	(20.0901)	(20.2367)
Canon squared		-0.9788	-1.2158
		(1.7309)	(1.7321)
R-squared	0.0055	0.0055	0.0163
Number of students	840,920	840,920	817,235
		Panel B. Reading Scores	
Canon	2.6782	4.2645	3.4589
	(1.9732)	(6.4470)	(7.2205)
Canon Squared		-0.1866	-0.0914
		(0.5473)	(0.6094)
R-squared	0.0242	0.0242	0.0600
Number of students	839,965	839,965	816,281
Student controls	N	N	Y
School controls	N	N	Y

Note: Standard errors clustered at the district level in parentheses. * Significant at ten percent; ** significant at five percent; *** significant at one percent. Canon corresponds to the value of canon per-capita, in thousands of USD at constant prices of 2010. School characteristics include: school day; school administration type (public/private), and school type (one-teacher school/full grade). Student characteristics include: gender and mother language (Spanish/other) of the children.
Source: Authors' calculations based on ECE, CE, data from Peru's Ministry of Finance and Peru's Ministry of Mines and Energy.