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EXTRACTIVE INDUSTRIES AND LOCAL DEVELOPMENT IN THE PERUVIAN HIGHLANDS[1]

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Abstract

During the last decade, the mining sector in Peru has been experiencing sustained growth. Using Census, administrative, nationally and regionally representative data we compare districts in the Peruvian Highlands with a recent mining history with suitable counterfactuals. We find that the new mining activities attract migration inflows, and have some positive effects over educational indicators. The study also shows that districts which lower level of corporate social expenditure have on average smaller impacts. However, the local potential welfare effect of the mining boom is largely untapped and the role of corporate social responsibility for its full materialization is still limited.

Key words: extractive industry, local development, Latin America, Peru, propensity score matching.

JEL Codes: L72, O12, N56, R12

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1. Introduction

Throughout its long history of mining exploitation, Peru did not manage to transform its enormous mineral wealth into a sustained process of economic and human development. In the Nineties, however, the country promoted a set of economic and institutional reforms that, in combination with a boom in commodity prices, led to a sustained expansion of mining activities and fed renewed hopes in the pro-development role of this sector. The mining sector is now one of the fastest growing sectors in Peru. This boom has occurred in an institutional context that encourages a positive interaction of mines with local populations. Despite these intentions, the mining industry has been facing a state of growing unrest and protests from local interest groups. The perceptions and expectations of different actors are a key factor for the understanding of this climate of hostility, but a starting point to interpret local populations' reactions can be provided by an evaluation of the impacts of mining activities on their living conditions.

This paper sheds some light on the impacts of the mining boom in the decade up to 2007 on populations living in mining areas of the Peruvian Highlands, a region that has received the highest mining investment inflow in the last decades. The study concentrates on new mining areas that, at the beginning of the boom, had not experienced a tradition of mining development. These areas might have been less able to capture business and labour opportunities offered by mining expansion than districts with a history of mining exploitation. However, a focus on new mining districts allows assessing the specific impact of the new institutional setting without confounding it with the long-lasting effects of mining activities which took place before the reforms of the Nineties. The paper is organized as follows. Section 2 provides a brief overview of the debate on the role of mineral resource wealth for promoting economic development. Section 3 presents the recent changes in the history of the Peruvian mining sector. Section 4 develops a simple conceptual framework showing that the impacts of mining growth on local populations are theoretically ambiguous. Section 5 presents the methodology we apply. Section 6 provides a brief description of data sources and section 7 explains the adopted classification of mining areas. Sections 8 and 9 discuss the main results and Section 10 summarizes the key findings and offers some conclusions.

2. Exploiting mining resources: a risky opportunity that cannot be renounced

The debate on the relationship between mining, growth and poverty is still open. Natural resources are regarded both as a blessing and as a curse. One of the most controversial issues is the impact on local communities. On the one hand, populations living close to mines are typically the most exposed to water, air and soil pollution of the mining industry; they are likely to compete with mines for the governance of the territory and for water and land use; they can experience economic, social and cultural repercussions from inflows of new workers and changes in local power relationships. On the other hand, local communities are also more likely to enjoy the potential benefits of the mining industry: direct job creation, infrastructure construction and local multiplier effects.

The benefits of mining development, however, do not come automatically: bad management and unfair distribution of fiscal resources, low complementarities with local firms and the low labour intensity of technology, for example, can jeopardize pro-poor and employment effects and reduce the positive spill over effects of mining investments.

This theoretical ambiguity is mirrored by the variety of empirical findings about the impact of mining on local development. Evidence is mainly anecdotal, but it already runs into decades of case studies. Part of this literature describes and stresses environmental and health impacts of mining activities on local populations and the risk that most benefits of mining exploitation are transferred outside the zone of extraction or processing (International Institute for Environment and Development [IIED] & World Business Council for Sustainable Development [WBCSD], (2002); Yelpaalaa & Ali, 2005; Bebbington & Bury, 2009; Crowson, 2009 and, above all, numerous documents provided by journalists and activist organizations[2]). Other studies, instead, emphasize the progressive role of mining operations in local development and in the control of negative externalities (McMahon & Remy, 2001; case studies described by the industry association International Council on Mining and Metals [ICMM][3]).

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[2] See, for instance, information and documents at the following websites: http://www.earthworksaction.org/;http://www.minesandcommunities.org/; http://www.nodirtygold.org/; http://www.conflictosmineros.net/.

[3] The ICMM has collected several case studies to assess the impact of large mines on the socio-economic development of host countries. See http://www.icmm.com/our-work/case-studies.

Despite these different perspectives, the debate on mining and development seems to converge on the idea that the resource curse is avoidable. The key question is not if countries should or should not renounce their mining wealth, but what policies can ensure that extractive activity contributes to economic development and poverty alleviation, provided that governments are willing to use resource endowments for the country's prosperity (Humphreys et al., 2007). Indeed, governments of resource rich countries have continued to promote extractive activities, often with the financial, technical and advisory support of several development banks. In the last twenty years, over ninety countries have rewritten mining and investment codes (Bridge, 2004) and investments in mineral exploration in developing countries have been constantly increasing (Bebbington et al. 2008; Hinojosa et al., 2010). At the same time, international organizations and financial institutions (McMahon & Remy, 2001; World Bank 2005; Ortega Girones et al., 2009; Otto et al., 2008), but also industry associations[4], research centres (IIED and WBCSD, 2002; Extractive Industries Review, 2003) and major NGOs (Herbertson, et al. 2009; Oxfam America, 2009) have made great efforts to distil toolkits and lessons for all stakeholders in order to tackle the risks of a local resource extraction and to exploit its potential benefits. This body of guidelines seems to converge in a set of general principles: promotion of an investment climate for mining development; social and environmental sustainability and fairness; transparency in dispute resolution and in managing mining revenues; long-term vision in managing price and revenue volatility; informed and capacitated participation of all stakeholders; government credibility and capacity of enforcement, supervision and regulation (Humphreys et al., 2007; World Bank, 2008; Natural Resource Charter).

Despite these efforts, in many parts of the world the expansion of mining operations is still accompanied by protests and social conflicts. Some practitioners and scholars suggest that these tensions are ascribable to a mismatch and friction between the continual pressure for mining expansion and the need to ensure ex-ante institutional and governance conditions (Bebbington et al., 2008; Pegg, 2006). Others take this line of reasoning further arguing that power and capacity asymmetries between the stakeholders (Arellano-Yanguas, 2008) or the priority given to mining investment promotion as opposed to socio-

[4] See website of ICMM (http://www.icmm.com).

environmental regulation and monitoring might (Campbell, 2009) have created the effect of feeding conflicts and reducing the institutional capacity of host countries.

Against this background, a closer look at those countries, such as Peru, that have done their best to apply the prescriptions of the today consensus on sustainable mining development, can provide useful insights for interpreting the continuous climate of tension surrounding mining operations.

3. The Peruvian 21st century mining boom and the country's response to international initiatives

From the early Nineties, Peru has made substantial progress in following the policy agenda recommended by international organizations and NGOs. In the Nineties, the government passed several legislative measures to reduce obstacles to foreign capital inflows towards the mining industry, to promote privatization and to ensure a favourable fiscal regime and a stable and clear legal framework. In the late 1990s, these new investment conditions, economic stabilization of the Peruvian economy, and the recovery of the international economic cycle led to a surge in mining investment and production. Between 1996 and 2009, annual mining investments increased from 387 to 2,771 Million US$ (Ministry of Energy and Mines [MINEM], 2004 and 2009). From 1995 to 2005, mining GDP grew at yearly average rates of 8.2 percent compared to a total GDP growth of 3.2 percent. In the following years, mining growth slowed down due to the international crisis, but in 2008 the sector registered a growth of 9.8 percent. In this period, Peru enhanced its position as metallic producer and in 2008, it was the first and second world producer of, respectively, silver and zinc, and the third world producer of copper, tin and bismuth.

The decade of the mining boom also witnessed a strengthening of the role of the State in environmental regulation and monitoring. Furthermore, since 2000-2002, Peru has promoted fiscal and political decentralization and the current fiscal legislation provides for redistributive mechanisms that should prioritize those areas more exposed to potential negative effects of mining operations.These new rules and the surge in mining production led to a rapid increase of transfers to regional governments that in 2007 reached a level 38 times higher than in 2002. Revenues generated by the mining sectors now account for a large share of total transfers to regional (60 percent) and local governments (39 percent)[5].

At the same time, Peru has fostered public-private partnership and consultative mechanisms, such as dialogue roundtables, in managing community-mine relationships (Arellano-Yangua, 2008). Some multinational corporations started to invest in development projects. In 2000 mining companies spent US$ 30.5 million on infrastructure and social programs (Hoyos Ordonez, 2002). By 2009, this figure had already doubled and the mining industry's expenditure on social development (US$ 56 million) had surpassed that for infrastructure (US$ 7.5 million) (Instituto de Ingenieros de Minas del Perú Minería Peruana [IIMP], 2010).

Despite this notable progress in the legal and institutional setting, the local struggles against mining firms have mushroomed. The mining boom resulted in a large expansion of mining operations also in unexplored areas occupied by agro pastoral communities. The number of concessions for mining exploration and exploitation rose from 1525 in 1994 to 2100 in 2007 (Datamart de Minéria). This rapid extension of the territorial influence of mining has increased the contacts as well as the conflicts between enterprises and local communities. At the same time, mining activities increasingly compete against other human and productive water uses. In 2009, about 24 percent of 21 major populated watersheds were subject to mining concessions (elaborated from Bebbington & Bury, 2009). Between 2004 and 2007, Peruvian Ombudsman's office recorded 23 mining conflicts (Defensoría del Pueblo, 2007). In 2009, it recorded 129 socio-environmental conflicts and about 65 percent of them (83) were mining-related disputes. Most mining conflicts are, primarily, struggles for use and contamination of water resources (60 percent) and for land acquisition and access (15 percent) (Glave & Kuramoto, 2007).

In spite of some different opinions, local populations and their organizations[6], overall, agree that the mining companies, so far, have not produced a sizable positive impact on their living conditions. They claim that labour opportunities in mines are very limited and not stable, while fiscal revenues distributed at local level are lower than expected. In some cases, rural organizations have

[5] 2008 data reported by IIMP (2010).

[6] For this information we refer to several sources: De Echave and Torres (2005), De Echave et al. (2009), De Echave, Hoetmer & Palacios (2010), Glave and Kuramoto (2002), Zarate and Durand (2005).

denounced lack of transparency and unfair land transactions with mines or damage to health, soil and water resources.

This snapshot of mining and local human and economic development in Peru is far from being clear. Case studies of the last fifteen years disclose light and shade in the interactions between mines and local communities and local economy, but emblematic examples do not always fully reflect general patterns and trends. Only a few studies have tried to evaluate the overall impacts of the recent mining boom on local economies, reaching mixed conclusions. De Echave and Torres (2005) found a negative correlation between human development indicators and mining GDP at departmental level between 1991 and 2001. Zegarra et al. (2007) found a positive effect of the mining boom on per capita urban income, but a non significant effect on per capita rural income and expenditure and on urban household expenditure. Finally, using census data, Arellano Yanguas (2011) concludes that mining revenues did not significantly improve socioeconomic indicators at municipal level.

This study integrates earlier works based on a nationally representative data with Census data in order to evaluate the effects of mining activities between 1993 and 2007 on a set of welfare indicators at district level. We adopt a methodology which is similar to that applied by Arellano Yanguas (2011), but, we delve into the analysis of impact heterogeneity across rural and urban areas and the corporate social responsibility strategies of mining firms.

4. The expected impacts of mining development on local economies

This section briefly schematizes the expected microeconomic and social impacts of mining activities drawing on the above discussed empirical and theoretical literature. The expansion of existing mining activities or the opening of new mining operations can produce a range of interconnected local effects.

(a) *Public goods and access to public services:* Mining industry can lead to an increase in public goods and services through different channels (Ticci, 2007):

- Increase in demand for public goods and services, rise in political opportunity for their provision and reduction in their financial cost due to changes in size, income and geographical distribution of population;
- Loosening of government budget constraint due to a rise in inflows of mining revenues;

- Increase in private investment in construction and maintenance of infrastructure;
- Promotion of local development projects by mining firms.

The international emphasis on the issue of resource revenues transparency (as emblematically represented by the case of EITI) suggests that financing of public expenditure is one of the main pro-developmental roles of mining industry in resource rich countries[7]. In Peru, this potential benefits do not need to translate into actual positive effects, especially on local populations. Some authors suggest that, in Peru, management and distribution of mining taxes and royalties tend to be problematic (Barrantes, 2005; Zárate & Durand, 2005; Arellano Yanguas, 2008) and also direct investment by mines in social development and infrastructures is highly concentrated: in 2008, two companies alone (Yanacocha Mining and Activos Mineros) financed 36 percent of all funds allocated in that year (IIMP, 2010).

(b) *Financial, physical and human capital:* Enlargement of mining concessions require land acquisitions from local communities and households. The corresponding compensation constitutes a form of financial capital for local people. Moreover, to the extent that the mining sector represents an 'engine of growth' for local economy, it stimulates private investment in physical and human capital.

(c) *Migration flows and urbanization:*

- Environment and land-related movements: farm households that have lost their lands or have been negatively affected by environmental externalities of mining may move to other districts or to urban areas.
- Labour-related migrations: mining areas usually attract immigration flows of people who seek jobs in the mining industry or in other sectors with upstream or downstream linkages.

(d) *Farming activities:* Mining operations often require an intensive use of water resources, are land demanding and can create heavy environmental externalities. The consequent effects can damage farming activities. On the other hand, mines can produce positive effects on farming to the extent that

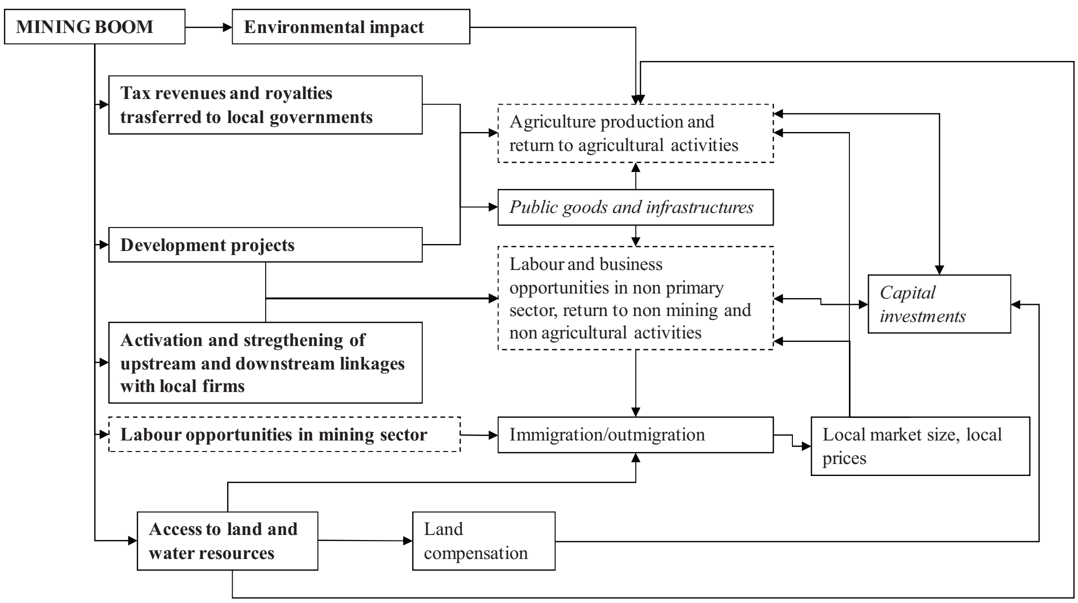
[7] One of the main reports of World Bank on Extractive Industries and Sustainable Development, for instance, states that '[f]rom a country development perspective, the most important component of the economic benefits from extractive industries is usually the flow of revenues that can be used for growth-promoting public expenditures' (Liebenthal, Michelitsch, & Tarazona 2005, p. 80).

mining enterprises promote agricultural and rural development projects. In addition, if mines attract new workers and their families, local food markets might grow resulting in increased returns to agriculture. Aragón and Rud (2009), for instance, found that Yanacocha Mine, in Cajamarca region, has produced a positive impact on households' income by stimulating the demand of local goods, agricultural products included.

(e) *Relative and absolute local prices, wages, employment and sector composition of local economy*: a mining boom can be associated with changes in population size and in composition of population by age, income, occupation and education. Mines and surrounding economic activities can increase labour demand. All these factors are likely to shape the level and structure of both labour demand and supply and to induce economic diversification of household income sources out of the farming sector.

All these potential effects of mining growth are likely to manifest themselves as an impact on level and distribution of household economic wealth and expenditure. The final effect, however, is ambiguous. Figure 1 illustrates the main mechanisms at stake, but, as the above discussion shows, not all channels are always activated in all mining areas, and neither do the effects always have the same signs. Political and institutional contextual settings, mines' attitudes, initial household asset endowments and ex-ante specialization and tradition of local economy conditions, indeed, can mediate or feed the various interlinks.

Figure 1: Main channels of mining impacts on local economies



The effects of the recent mining boom on Peruvian local economies are therefore not theoretically predictable. The empirical analyses of the next sections and their interpretations based on the proposed conceptual framework will attempt to shed some lights on the impacts on the ground.

5. Estimation methodology

We estimate the effects of the mining boom on a set of outcomes by combining a difference-in-difference (DD) estimation with propensity score matching (PSM), a technique developed in the literature as an instrument for evaluating social programs. In this study, districts located in the Highlands constitute our units of analysis and the exposure to the 1993-2007 mining boom represents the 'treatment'. The usage of differences matching estimators in non-experimental settings has been extensively reviewed (Smith & Todd, 2005) showing that they have better performance than the cross sectional estimators.

The simple comparison between mean outcomes of treated and untreated units might be misleading if some factors influence both the outcome and the probability of participating in the treatment. We need, instead, to use 'comparable' districts, namely districts that, in absence of a mining boom, would have shown similar outcome indicators. Therefore, we resort propensity score matching technique to balance for observable characteristics and create groups that are as similar as possible in terms of confounding variables. Let Y_i^1 be the outcome value of district *i* if *i* is treated (i.e. is a mining district) and Y_i^0 the outcome value of district *i* if *i* is not treated (i.e. is a non mining district). We also define *D(Z)* as the observed participation status, with *D=1* in case of treatment, *D=0* otherwise, and *Z* indicating the set of variables which determine treatment group membership (i.e. exposure to the mining boom).

PSM assumes that there are no other unobservable variables which are linked to the exposure to the mining boom and which also affect expected impacts *Y*. If this condition is not met, the matching method will generate biased estimates of impacts. However, if the unobservable variables that have these features are permanent, the bias may be eliminated coupling PSM with difference-in-difference estimates (Heckman et al. 1998). For example, this method controls for the bias arising from a change in the economic environment – a macroeconomic change or a weather shock such as El Niño – that involves all districts and that might affect both outcome variables and mining operations. Moreover, by focusing the analysis on the Highlands region the assumption of homogenous impacts across districts appears more plausible.

PSM-DD estimator of the 'Average Treatment Effect on Treated' (ATT) is constructed by comparing the before and after mining boom mean change in outcome measures for the mining districts with those for the matched non mining districts:

(8) $$ATT = E_{p(Z/D_i=1)}\left\{\left[E(Y_i^{1,t+1} - Y_i^{1,t} / D_i = 1, p(Z_i)) - E(Y_i^{0,t+1} - Y_i^{0,t} / D_i = 1, p(Z_i))\right] / D_i = 1\right\}$$

This study calculates propensity scores using a logit regression and applies nonparametric kernel matching. The PSM estimator for ATT can be analytically expressed as (Guo & Fraser, 2010):

(9) $$ATT = \frac{1}{n_1} \sum_{i \in I_1 \cap S_p} \{(Y_i^{1,t+1} - Y_i^{1,t}) - \sum_{j \in I_0 \cap S_p} W(i)(Y_j^{0,t+1} - Y_j^{0,t})\}$$

where n_1 is the number of mining districts, $i \in I_1$ are mining districts, $j \in I_0$ are non mining districts, *Sp* is the common support region, and $W(i,j)$ is the weight given to the *j*-th non mining district in making a comparison with the *i*-th mining district. Weights are assigned according to a kernel function of the predicted propensity score following Heckman et al. (1997). Standard errors, instead, are estimated using the bootstrapping method.

In order to ensure robust findings, we exclude districts with a history of mining exploitation. This is an important choice, since our data suggest that the characteristics of the non mining districts are very different from the characteristics of old mining districts so the former will not constitute an appropriate counterfactual for the later. We chose to restrict the analysis comparing non mining areas and areas where mining activities have grown after 1993 (hereafter referred as 'new mining districts'). Specialization in mining sector, indeed, is likely to affect both the participation to the mining boom and its effect. First, firms usually react to an improvement in returns to mining activities by increasing the exploitation of productive capacity already in place. Second, a mining tradition can positively affect the probability to attract further mining investments. New investors might prefer acquiring existing mining firms than financing green field investments in new areas in order to save time and to reduce risks and costs. Moreover, in old mining areas, new companies are more likely to find complementary services and infrastructures as well as specialised labour force. At the same time, negative impacts on agricultural activities might be more severe in districts with a mining tradition since host old mining firms could use more polluting techniques than new companies that usually adopt modern technologies. In addition, old mining districts can be affected by previous and long-lasting environmental problems. Finally, old mining districts might be better equipped to exploit labour and business opportunities offered by the mining expansion. A focus on new mining areas, therefore, allows us to avoid the risk of confounding past effects of mining development with those triggered by the recent mining boom.

6. Data sources

Our empirical analysis is based on the combination of various data sources. Data on socio-demographic characteristics and labour indicators at district level come from the Population and Housing Census of 1993 and 2007. The Mining Directory of the Ministry of Energy and Mines provided the list of all mining units in activity in the Peruvian territory. For additional mining information, we rely on Datamart system of the Ministry of Energy and Mines. Data on agricultural production and agricultural producer prices are drawn from SISAGRI, the source for aggregated data of Ministry of Agriculture, while other information on agricultural and farming stocks comes from 1994 Peru National Agricultural Census (CENAGRO 1994). This information is also linked to other data on geographical characteristics that are gathered by National Statistical Office.

7. Classification of mining areas

The first step to investigating the welfare and distributive impacts of mines at local level is the creation of a dummy variable which identifies those areas that have been exposed to the influence of the recent mining boom. We define mining areas those districts mining where the number of mining workers in 2007 was above the average within the group of districts with at least one mining worker (108) *or* where there is at least one medium-large operative mining unit. All remaining districts are defined *non mining or untreated (UD)*. We include the condition on job employment in addition to that on operative mining operations, in order to avoid the risk some districts to be classified as non mining even if there are companies operating in the territory but with headquarters in a close district. Mining districts, in turn, are divided according to the following classification: new mining districts (NMD) and old mining districts (OMD) are mining districts where the number of mining workers in 1993 was, respectively, below and above the average. Finally, we denote mining districts with high (or low) social corporate spending all mining districts where average per capita spending for social projects in 2007 was above (below) the average within districts with positive companies' social spending (195 soles).

There is evidence that this classification reflects the exposure of district territory to an intense mining activity as well as to the related environmental risks. As shown on Table 1, the average amount of land under mining concessions for each type of operation – exploitation, exploration, inactive and abandoned mines – and the average amount of mining tailings are much greater in mining than non mining districts.

Table 1: Average mining tailings in 2004-2008 (tons) and hectares under metallic mining concession in 2007

District classification	*Average mining tailings in 2004-2008 (tons)*	*Average district surface under concessions for mining exploitation, hectares*	*Average district surface under concessions for exploration operations, hectares*	*Average district surface under concessions for all types of mining activity*, hectares*
Non mining districts (UD)	15	23	1,792	4,055
New mining districts (NMD)	2,700	702	3,239	15,463
Old mining districts (OMD)	2,388	1,097	3,094	11,238
All	260	96	2,145	5,082

Source: author's elaboration based on MINEM. **Note:** the top 2 percent of districts is cut. **Note**: *exploration, exploitation, inactive and abandoned mines.

Also the incidence of mining canon on the main public transfers to local governments is higher among mining than non mining districts, but in this case the gap is less marked. Indeed, in line with the legislation, mining canon also reaches non mining districts. But the main feature of mining canon distribution is its temporal and geographical concentration. Mining canon transferred to local governments have accelerated only in recent years (see Table 2) and is concentrated on a limited number of districts: the top 20 districts (about 1.7 percent of all Highlands districts considered in the analysis) account for 34 percent of total mining canon received to local governments in 1996-2005 period.

Table 2: Mining canon as a share of the main transfers to local governments (percentage)

	Period of reference	
District classification	*1996-2005*	*2003-2005*
Non mining districts (UD)	9	16
New mining districts (NMD)	16	27
Old mining districts (OMD)	18	30
All	10	17

Note: Main transfers to local governments include Canons, Vaso de Leche Program, and Foncomun. The top 2 percent of districts is cut.

8. Constructing the counterfactual

In order to create a comparable control group for mining districts and to estimate the propensity scores, we evaluate a set of potentially relevant control Z variables that are exogenous and might affect both changes in outcome variables and the likelihood of participating in the mining boom:

a. ***Known metallic deposits in 1997***: investors are likely to firstly target areas where the presence of metallic deposits is documented and risks of unsuccessful and expensive operations of explorations are lower.

b. ***Land utilization and presence of farm activities prior to mining boom.*** Mining investments might be discouraged in districts where land disputes with local populations are more likely, namely in districts with greater utilization of lands for productive uses and higher return to farm activities before the mining boom. At the same time, farming specialization and potentialities of agricultural activities might affect both exposure of the local economy to mining risks and its capacity to capture mining benefits. The analysis uses a set of proxies of these factors drawn from 1994 CENAGRO: agriculture land as share of total district area, average share of farmers' land used for farming or breeding in the district, average share of farmers' non-irrigated agricultural area in the district, share of non-formally titled plots of land.

c. ***Average district altitude:*** the presence of metal resources is more likely in districts at high altitudes (Bebbington and Bury, 2009), but these areas can also be less accessible and less endowed with public services because costs for public service provision are higher than in other areas. This, in turn, might influence return to economic activities and migration decisions. Moreover, altitude tends to correlate with climate conditions that affect types and productivity of farming activities.

d. ***Mining exploration operations and exploitation activities in the surrounding districts prior to mining boom:*** existence of these operations can prefigure successive activities of mining exploitation in the district. At the same time, exploration activities can also produce environmental damage and land disputes or transactions, while local populations can change their investment and migration choices or political claims and requests as they anticipate a future mining expansion. Among possible confounding variables, we therefore include a dummy that indicates whether in the district there was at least one concession for mining exploration in 1994-1997 and a dummy that takes value 1 if the district belongs to a province where another district had at least one mining exploitation concession in 1994-1997.

e. ***Protected areas in the district*** can prevent mining investments and influence other economic activities, infrastructural development and distribution of human settlements.

f. ***Regional dummies*** are used to control for historical and political factors which can affect district economic performances, the structure of local economies and incentives to mining investment. Regional dummies also help to control for differences in rock composition, in distribution of mineral deposits and availability of water resources which are important inputs for both mining and energy industry.

g. ***Human capital at household level prior to mining boom***. Some household initial characteristics could correlate with the probability of living in mining or non mining areas but also with affordability in meeting private costs associated with access to public services (private costs of connection, preparation of home facilities etc) and with changes in overall social and economic welfare status. In order to control for these effects, we introduce variables that can influence outcomes but not are affected by them: average education level of household heads in 1993 and share of household heads whose mother tongue was a native language in 1993.

h. ***Change in welfare index in the earlier period***: in order to assess the presence of correlation between unobservables and the probability of receiving the treatment, we include the *growth rate* of welfare index, a key and representative outcome variable, before the mining boom.

Table 3 shows the logit estimations. In order to estimate a population-level treatment effect, we estimate the propensity scores using weighted logit regression[8]. Weights are calculated according to the reference population of each outcome variables and old mining districts are excluded.

Table 3: Estimation of the propensity scores of participation to mining boom, logit model

	Coef.	Std.	
Metallic deposits	1.181	0.451	**
Share of agricultural district land	0.058	1.408	
Average share of non irrigated land	-0.197	0.851	
Average share of farmers' agricultural land	-0.739	1.203	
Share of untitled plots	0.722	0.727	
Mining exploration in 1994-97	1.117	0.483	*
Average education level of household heads	2.887	0.824	**
District average altitude	0.001	0.000	**
Protected areas	-0.740	0.551	
Mining operations in districts of the same province in 1994-97	0.840	0.401	*
Mother tongue of household heads (Share of native)	-1.661	0.724	*
Central-Southern Sierra	1.092	0.869	
South-Eastern Sierra	0.344	0.717	
Central-Northern Sierra	1.277	0.573	*
Change in welfare index 1981-1993	-6.525	12.611	
Constant	-11.769	2.135	**
R-squared=0.3032			
Number of obs = 1015			

Note: * significant at 5% level; ** significant at 1% level. Stata module used to estimate propensity scores is pscore by Becker and Ichino (2002). The balancing test is satisfied. In order to improve quality of the matches, the balancing test is restricted to the common support, namely it is performed only on the observations whose propensity score belongs to the intersection of the supports of the propensity score of treated and controls. This restriction is particularly important in Kernel matching since it uses nearly all observations in the control group and therefore this matching algorithm might include observations that are bad matches (Caliendo & Kopeinig, 2008). The dataset excludes old mining districts.

The presence of known metallic deposits and of exploration operations in the mid-Nineties increases the probability of participating in the mining boom. Altitude has also a positive – albeit small – effect. Higher human capital stock at

[8] To perform propensity score matching, we used the Stata module *pscore* elaborated by Becker and Ichino (2002)

district level is associated with a higher probability of participating to the mining boom. A possible explanation of this link is that the fear of facing language barriers or a hostile environment might have negatively influenced incentives to invest in mining operations. Finally, the regional dummy for Central Northern Sierra is positive and significant reflecting the fact that these areas experienced a great proliferation of new mining activities compared to other areas with a longer mining tradition. The coefficient of welfare change between 1981 and 1993 is no significant. Prior to (that is in absence of) treatment, non mining and mining districts did not experienced a systematic different growth rate in this outcome variable and this result is consistent with the nonexistence of unobservables that are correlated with the treatment and the change in outcome variable.

9. Average treatment effects

We assess impacts of the mining boom on a set of outcome variables that cover various dimensions of local development: demographic trends, access to public goods, housing conditions, employment and diversification of local economy. Each mining district is matched with a weighted average of a share of non mining districts in the control group on common support. This share is determined by the choice of bandwidth. We show the results when the bandwidth is set at 0.06 but estimates are replicated for four bandwidths, 0.01, 0.08 and 0.5 (available upon request). Larger bandwidths allow us to increase the number of districts in the control group that are comparable to the mining district. However by increasing the bandwith we may gain some efficiency at the expense of introducing a potential bias. Tables 4a and 4b present the mean average changes in the outcome variables across NMDs and UMDs within the common support and the PS-DD estimates of average impacts experienced, overall, by NMDs and by new mining districts with low corporate social spending.

- New mining areas saw a significantly faster growth of total and urban population than non mining areas probably reflecting their capacity to attract migration flow or contain outmigration. While, on average, non mining districts experienced a decrease in immigrant population, new mining areas received migrants from other districts. These differences, however, are smaller or not significant when the analysis focuses on districts with lower corporate social spending.

- Overall, Highlands's districts experienced a generalized reduction in labour share of farming activities and this pattern was more marked in rural mining areas where the mining boom led to a stronger change in district economic structure out of agriculture. Mining growth has also produced a positive effect on the share of labour force employed in mining sector both in urban areas and, to a greater extent, in rural areas but it seems to have blocked economic diversification towards non primary sector. Our results, indeed, indicate that the proliferation of new mining operations has had a large and negative impact on the share of population working in non mining and non agricultural activities which remained almost unchanged between 1993 and 2007 in new mining districts compared to a growth by 3-5 percentage points in non mining rural and urban areas of the common support. When we restrict the analysis to the districts with a low level of corporate social spending, the effect on mining and agriculture labour share is still significant but smaller, while the impact on the remaining sectors is unchanged. These outcomes indirectly suggest that those areas that enjoyed higher participation of mining companies to development and assistance projects might be more able to exploit labour opportunities in mining, but corporate social responsibility seems to not have helped to trigger multiplicative effects on other sectors.
- In rural areas of new mining districts, we found significant positive impacts on adults' involvement in economic activities. In the considered period, the share of rural population above 15 years and engaged in productive activities grew more (by about 7 percentage points) in new mining than in non mining districts. However, we do not find an effect on rural unemployment rate. In urban areas, the role of mining boom in vitalizing labour market was even less evident.
- We cannot unequivocally state that the mining boom caused a deterioration of the agriculture sector nor we can deduce whether push or pull forces out of farming occupation prevail. In fact, the data do not allow us to conclude whether the reduction in agriculture labour share is explained by the arrival of new workers employed in mining-related activities or by a negative effect of mining on access or quality of land and water resources. Mining districts tend to be more exposed to environmental risks than other areas, but our estimates do not highlight an impact of the mining boom on crop producer prices and on district value of agriculture production.

- We do not find significant impacts on access to public services that can be attributed to new mining operations. We observe that in the period 1993-2007, Highlands's rural areas saw considerable advances in access to water, electricity and, albeit to a lower extent, to sanitation services, but the mining boom in the decade up to 2007 did not accelerate this progress. Moreover, our results suggest that, so far, corporate social responsibility has not helped to overcome bottlenecks in materializing these potential benefits: there is no sign of impact on access to basic services, not only when the analysis focuses on districts with low levels of corporate social expenditure, but also in the overall sample. These findings are in line with widespread concerns regarding total amount (which has grown only recently), management and geographical concentration of mining revenues.
- The mining boom that began in the mid-1990s, however, seems to have contributed to the improvement of educational outcomes that many Highlands districts have achieved since the mid-Nineties. We found a negative impact (albeit small) on child labour and a positive effect on primary and secondary school attendance in rural areas. It is not easy to conclude whether this link is explained by changes in demographic composition of district population due to migration inflows, by greater financial resources for educational services and facilities or by higher expected returns to education in the local labour market, but it is worth observing that corporate social responsibility might have enhanced the effect on primary and secondary school attendance since this impact, respectively, decreases or becomes non statically significant in the sample restricted to districts with low corporate social spending.
- Finally, we estimated the mean impact of the mining boom on changes in poverty rates and on welfare ratio[9] which is a proxy of the real per capita expenditure. PS-DD estimates of ATT are not significant in all samples we considered. Therefore, the arrival of new mining firms did not lessen nor exacerbate the growth in poverty rates experienced by Highland districts between 1993 and 2007.

[9] The welfare ratio is obtained by dividing the per-capita expenditure by the region-specific time-specific poverty line.

Table 4a: Double difference estimates

All sample: non mining districts (UD) and new mining districts (NMD)							
			Mean change in outcome indicators[1]		**PS-DD estimates of ATT**		
			UD	NMD	ATT	std error	
Access to basic service and housing quality	***Change in share of rural population...***	*with access to electricity*	0.28	0.26	-0.05	0.04	
		with improved water services	0.24	0.28	-0.05	0.04	
		improved sanitation services	0.09	0.10	0.00	0.01	
		who live in households with safe walls	0.01	0.03	0.01	0.01	
	Change in share of urban population ...	*with access to electricity*	0.32	0.28	0.04	0.05	
		with improved water services	-0.06	-0.03	0.05	0.06	
		improved sanitation services	0.28	0.24	-0.01	0.03	
		who live in households with safe walls	0.07	0.12	0.02	0.01	
Migration and demographic trends	***Change in share of...***	*recent migrants in rural areas*	-0.01	-0.03	0.02	0.02	
		recent migrants in urban areas	-0.03	-0.02	0.03	0.01	**
		recent migrants	-0.02	-0.02	0.03	0.01	**
	Relative change[2] in...	*rural population*	-3.77	-7.69	-1.32	12.33	
		urban population	45.31	64.65	55.47	20.78	***
		total population	8.17	26.42	18.29	5.50	***
Labour market and occupational distribution	***Change in share of rural...***	*population 15+ engaged in ec. activities*	0.05	0.14	0.07	0.02	***
		labor force that is unemployed	0.01	0.00	-0.01	0.01	
		labour in mining activities	0.00	0.09	0.17	0.02	***
		labour in agricultural activities	-0.04	-0.11	-0.12	0.02	***
		labour in other sectors	0.03	0.02	-0.06	0.02	***
	Change in share of urban...	*population 15+ engaged in ec. activities*	0.07	0.10	-0.01	0.01	
		labor force that is unemployed	0.01	-0.01	0.00	0.01	
		labour in mining activities	0.01	0.06	0.10	0.02	***
		labour in agricultural activities	-0.06	-0.06	-0.03	0.02	
		labour in other sectors	0.05	0.01	-0.07	0.02	***
Poverty and welfare status	***Change in...***	*welfare index*	-0.02	-0.01	0.00	0.00	
		poverty rate	0.12	0.08	-0.01	0.02	
Agricultural indicators	***Change in...***	*agricultural price index*	0.01	-0.05	0.01	0.04	
		agricultural production index	0.23	0.27	-0.07	0.10	
Education and child labour	***Change in share of child workers...***	*in rural areas*	0.000	0.003	-0.01	0.004	**
		in urban areas	0.004	0.002	-0.002	0.004	
	Primary school attendance	*in rural areas*	0.18	0.19	0.04	0.01	***
		in urban areas	0.14	0.13	0.02	0.01	
	Secondary school attendance	*in rural areas*	0.14	0.13	0.04	0.01	***
		in urban areas	0.10	0.08	0.00	0.02	

Table 4b: Double difference estimates.

Subsample: non mining districts (UD) and new mining districts (NMD) with low social expenditure							
			Mean change in outcome indicators		**PS-DD estimates of ATT**		
			UD	NMD	ATT	std error	
Access to basic service and housing quality	***Change in share of rural population...***	*with access to electricity*	0.28	0.26	-0.07	0.04	
		with improved water services	0.24	0.29	-0.05	0.04	
		improved sanitation services	0.09	0.10	0.00	0.01	
		who live in households with safe walls	0.01	0.04	0.01	0.01	
	Change in share of urban population ...	*with access to electricity*	0.32	0.26	0.02	0.05	
		with improved water services	-0.06	-0.02	0.08	0.06	
		improved sanitation services	0.28	0.24	0.00	0.03	
		who live in households with safe walls	0.07	0.12	0.02	0.02	
Migration and demographic trends	***Change in share of...***	*recent migrants in rural areas*	-0.01	-0.04	0.02	0.02	
		recent migrants in urban areas	-0.03	-0.03	0.02	0.01	
		recent migrants	-0.02	-0.02	0.02	0.01	
	Relative change[2] in...	*rural population*	-3.74	-8.57	-2.87	12.33	
		urban population	45.10	63.00	56.25	32.18	*
		total population	8.40	26.60	17.75	7.50	**
Labour market and occupational distribution	***Change in share of rural...***	*population 15+ engaged in ec. activities*	0.05	0.10	0.06	0.02	**
		labour force that is unemployed	0.01	0.00	-0.01	0.01	
		labour in mining activities	0.00	0.10	0.15	0.03	***
		labour in agricultural activities	-0.04	-0.10	-0.10	0.03	***
		labour in other sectors	0.03	0.00	-0.06	0.02	***
	Change in share of urban...	*population 15+ engaged in ec. activities*	0.07	0.10	-0.01	0.02	
		labour force that is unemployed	0.01	0.00	0.01	0.01	
		labour in mining activities	0.01	0.00	0.08	0.02	***
		labour in agricultural activities	-0.06	-0.10	-0.02	0.02	
		labour in other sectors	0.05	0.00	-0.07	0.03	**
Poverty and welfare status	***Change in...***	*welfare index*	-0.02	-0.01	0.00	0.00	
		poverty rate	0.12	0.08	-0.01	0.02	
Agricultural indicators	***Change in...***	*agricultural price index*	0.00	-0.09	-0.03	0.04	
		agricultural production index	0.26	0.24	-0.13	0.13	
Education and child labour	***Change in share of child workers..***	*in rural areas*	0.001	0.003	-0.010	0.004	***
		in urban areas	0.004	0.002	-0.002	0.003	
	Primary school attendance	*in rural areas*	0.18	0.19	0.04	0.01	***
		in urban areas	0.14	0.13	0.01	0.01	
	Secondary school attendance	*in rural areas*	0.14	0.13	0.03	0.02	
		in urban areas	0.10	0.08	-0.02	0.01	

*Notes: i) [1] Mean changes in outcome indicators between 1993 and 2007 are restricted to only those districts determined by PSM; ii) [2]ATT estimates of relative changes are calculated without combining propensity score matching with difference-in-difference; iii) *, ** and *** indicate significance levels of 10%, 5%, 1% respectively, when testing the null hypothesis of equality of mean changes between UD and NMD; iv) PS kernel matched standard errors are obtained by bootstrapping (100 repetitions). ATT estimates in the overall sample are based on a number of observations ranging from 1005 and 959 observations (873/917 comparison and 86 NMD). ATT estimates in the subsample are based on a number of observations ranging from 975 and 895 observations (827/917 comparison and 68 NMD)); v) Estimates for agriculture indicators which are relates to the 1999-2007 period.*

10. Conclusions

The main impacts that the mining boom brought in new mining areas are those related to demographic trends and to occupational distribution. Mining expansion has positivity affected immigration inflows and has fostered a change in labour sectoral composition towards mining activities while producing a negative impact on labour share of agriculture and non primary sectors. Therefore, the opening of new mining operations can have a propulsive role for local economies but the main risk is to fall into a trap of mining specialization with little links with other industries. In fact, also the local (or intra-district) employment effect of mining growth, at least so far, has been negligible. The impact of the mining boom on the proportion of the adult population engaged in economic activities is positive in rural areas, but it is not significant in urban areas. Nor we do detect evidence of significant impact on the reduction in unemployment rates in new mining districts, especially in urban areas where unemployment is more prevalent.

A possible explanation of the lack of employment effects is that the impact of mining development on employment opportunities in economic activities are still incipient in new mining districts, but it is also worth reminding that we consider a rather protracted period and that descriptive evidence on districts with a long tradition of mining development are not encouraging: during the entire period of mining growth (1993-2007) labour share of non primary activities in old mining districts was higher than in the remaining districts, but it declined over time.

Our findings indicate that greater corporate social responsibility may play a role in increasing opportunities for mining employment and in attracting a larger inflow of migrants, but it has largely failed to support local populations in taking advantage of business and labour opportunities that mining growth and its indirect effects could have opened in non primary sectors. The results suggest that higher corporate social expenditure is also associated with a slightly increase in the positive impact of the mining boom on progress of primary and secondary school attendance in rural areas.

However, it is clear that the main findings of this study relate to the impacts that do not emerge. Some of the most expected impacts are, indeed, 'missing': we found no sign of impacts on improvement in access to basic services and on some of the principal welfare indicators such housing conditions, poverty rate and per capita real expenditure. This is the pending chore for the mining industry and the national and regional governments in Peru if an environmentally sustainable mining can be developed side by side with a sustained increase of the wellbeing of the mining communities in Peru.

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