Mining, Natural Disasters, Schooling, Cognition and Child Marriage: Evidence in Peru

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Abstract

The paper analyzes the causal effects of mining production and natural disasters on the well-being of children in Peru, with a particular focus on education enrollment, child labor, serious injury, access to safe drinking water and electricity, cognition, child marriage and child fertility. Using copper demand from Asia as instruments, the results indicate that the expansion of copper mining in Peru has led to negative consequences for child welfare, including lower education enrollment, increased child labor and injury, and reduced access to safe drinking water and electricity. Meanwhile, negative shocks in agriculture, such as flooding, drought, crop failure, and pests, cause a reduction in household wealth but an increase in education enrolment and hours spent in school. Finally, I use exogenous variation in schooling induced by agriculture shock to examine the causal effect of schooling on cognition, child marriage, and child fertility. I find that enrolment induced by agriculture shocks increases math abilities for both boys and girls, with the treatment effect on girls doubling that of boys. Further, educational enrolment significantly reduced child marriage and fertility among boys.

Keywords: International trade, copper mining, education, natural disaster, schooling, child labor

JEL: O13, I15, J13, Q34

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1 Introduction

The mining industry has played a vital role in Peru's economic development, particularly in copper mining, where Peru is the world's second-largest producer. The expansion of copper mining in Peru has raised concerns about its impact on the well-being of the population, with a rapid expansion in large-scale mining activity during recent years generating a host of protests in Peru as rural populations attempt to defend their livelihood and environment often with violent results (Taylor and Bonner, 2017; Taylor, 2011). Local communities are reported to suffer from negative externalities of mining while revenues do not translate into local welfare due to weak institution and corruption. The Peruvian Ombudsman's office registered 217 separate conflicts in June 2011 alone (Economist, 2011); the average number of conflicts by region increased from 1.02 in 2005 to 6.91 in 2010.

Children in Peru are subjected to the worst forms of child labor, including in mining and commercial sexual exploitation. The government estimated that 1,251,400 children, ages 5 to 17, were engaged in hazardous child labor and that 58.4 percent of these children worked in agriculture, fishing, or mining [1].

This paper investigates the causal effects of copper mining production and natural disaster on these outcomes in Peru, combing household panel data from Young Lives survey, mining production data from Central Reserve Bank of Peru, and trade data from The United Nations Comtrade database. Instrumental variable is constructed by using copper import from China, Japan and South Korea, three main partners in copper trade with Peru.

As a result, this paper first finds that mining growth has not necessarily translated into improvements in the well-being of the population. The expansion of copper mining in Peru causes lower education enrolment, increased child labor and child injury, and reduced access to safe drinking water and electricity.

This paper investigates the causal effects of copper mining production and natural disasters, such as droughts, floods, pest infestations on crops, crop failure, and death of livestock,

[1] see Child Labor and Forced Labor Report on Peru by US Department of Labor.

on various outcomes in Peru. The study combines household panel data from the Young Lives survey, mining production data from the Central Reserve Bank of Peru, and trade data from The United Nations Comtrade database. An instrumental variable is constructed using copper import from China, Japan, and South Korea, three main partners in copper trade with Peru.

As a result, this paper first finds that mining growth has not necessarily translated into improvements in the well-being of the population. The expansion of copper mining in Peru causes lower education enrollment, increased child labor and child injury, and reduced access to safe drinking water and electricity.

In addition to mining growth, the paper also examines the impact of natural disasters on socio-economic outcomes. The results indicate that various agriculture shocks reduce household wealth but have positive impact on education enrolment and hours spent in school (conditional on enrolment). When controlling for income effects, the enrollment coefficients remain significant.

The findings of this paper have significant policy implications for Peru's mining industry. The expansion of copper mining in Peru has generated protests and conflicts, and this paper demonstrates that this growth has not necessarily translated into improvements in the well-being of the population. Policymakers should prioritize the reduction of negative externalities from mining activities, particularly those related to education, child labor, and access to safe drinking water and electricity. Furthermore, the government should address weak institutions and corruption that prevent revenues from translating into local welfare. It is critical to develop policies that promote sustainable mining practices that benefit local communities and the environment while generating economic growth. Ultimately, policymakers must ensure that the benefits of mining activities are equitably distributed and that mining activities do not come at the expense of the well-being of local communities.

The structure of the paper is as follows. Section 2 documents related literature. Section 3 explains data and methods. Section 4 presents the main results. Finally, Section 5 concludes.

2 Related Literature

Over the years, impacts on water quality and quantity have been a contentious issue surrounding mining projects in Peru (Bebbington and Williams, 2008). Extraction poses threats to local communities have historically exercised in order to access and control water resources and to govern the territory in which they reside (Bebbington et al., 2010). For example, the operations of the large mining company Yanacocha in Cajamarca (Peru) provoke and require a fundamental reshuffling of how rights to water are allocated, resulting in changes in the distribution of the benefits and burdens of accessing water (Sosa and Zwarteveen, 2012). In response, communities and grassroots networks have increasingly expressed concern about the environmental damage caused by mining operations.

The expansion in large-scale mining activity during recent years generating a host of protests in Peru as rural populations attempt to defend their livelihood and environment often with violent results (Taylor and Bonner, 2017; Taylor, 2011). The Peruvian Ombudsman's office registered 217 separate conflicts in June 2011 alone (Economist, 2011); the average number of conflicts by region increased from 1.02 in 2005 to 6.91 in 2010.

Furthermore, children in Peru are subjected to the worst forms of child labor, including in mining and commercial sexual exploitation Report. The government estimated that 1,251,400 children, ages 5 to 17, were engaged in hazardous child labor and that 58.4 percent of these children worked in agriculture, fishing, or mining. The government also identified 70,500 children, ages 10 to 17, who were at risk of forced labor.

Peru has made progress in eliminating the worst forms of child labor by creating a National Forced Labor Observatory and approving the Municipal Model for the Detection and Eradication of Child Labor. Despite these efforts, children in Peru are still subjected to hazardous labor, including mining and commercial sexual exploitation. There is a need for stronger legal frameworks and law enforcement to protect children from these dangers. The country's informal and small-scale mining sector exposes children to hazardous working conditions, while communities near illegal mining operations face an increased risk of child trafficking and sexual exploitation.

Most working children are at home, helping their family by assisting in the family business or farm and with domestic work (Edmonds and Pavcnik, 2005). Bhalotra and Heady (2003) finds that girls' hour of work are increasing in farm size signals imperfections in land and labor markets. Girls in households with larger farms are less likely to attend school.

Levine and Rothman (2006) use gravity model of trade to examine how openness to trade affects children and conclude little harm from trade, and potential benefits largely through slightly faster GDP growth. Edmonds and Pavcnik (2005) documents that child labor remains a prevalent issue in many countries, particularly in developing nations where poverty rates are high and education is not widely accessible. Child labor is associated with lower wages for adult workers, indicating that the use of child labor can have a negative impact on the entire economy. Policy interventions aimed at addressing child labor should focus on increasing access to education and enforcing laws that protect children from exploitation.

3 Data and method

3.1 Young Lives Survey

The Young Lives Peru dataset is a longitudinal dataset that has been collected in five rounds of data collection: 2002, 2006, 2009, 2013, and 2016. It includes various measures of children's well-being and development, such as physical health, cognitive development, educational attainment, social and emotional well-being. The dataset also includes information on children's time use, such as time spent on education, work, leisure, and household chores. Additionally, the dataset captures information on children's families, including parental education, income, occupation, and household characteristics, as well as community-level data such as access to basic services, infrastructure, and social programs. the Young Lives study in Peru collects data from 20 sites, selected to be representative of the diversity of the Peruvian population in terms of geographic location, ethnicity, and level of economic development. The 20 sites include both rural and urban areas, coastal, highland and jungle regions, and different levels of economic development. The selection of these sites ensures that the Young Lives study in Peru provides a comprehensive and representative sample of children's development and well-being in the country. The 20 sites in Peru where the Young Lives study is conducted are: Amazonas, Ancash, Apurimac, Arequipa, Ayacucho, Cajamarca, Callao, Cusco, Huancavelica, Huanuco, Ica, Junin, Lambayeque, Lima, Loreto, Madre de Dios, Pasco, Piura, Puno, and San Martin, as shown in Figure 1.

Figure 1: Young Lives 20 sites in Peru

Table 1 shows around half of children in Young Lives are girls. Furthermore, education enrolment peaks at age 9 and then start to decline afterwards. Child labor increases alongside children's age.

Table 2 shows the key characteristics of boys and girls in Peru, based on data from Young Lives Peru round 4 when children are aged 13. Girls spend more time on household chores than boys. Additionally, boys spend more time in paid work than girls, while girls spend

Table 1: Summary statistics of Young Lives in Peru

	(1) 2002	(2) 2006	(3) 2009	(4) 2013	(5) 2016
Age	2.31	6.64	9.27	13.18	16.22
Female	0.49	0.49	0.49	0.49	0.49
Child's weight (kg)	12.89	23.23	31.12	45.06	53.19
Child's height (cm)	83.59	113.81	128.79	146.79	156.63
Child is currently enrolled	0.24	0.26	0.97	0.88	0.83
Serious injury	.	0.08	0.10	0.11	0.13
Hours/day spend in household chores	.	0.94	1.04	1.28	1.38
Hours/day spent in domestic tasks	.	0.30	0.39	0.57	0.53
Hours/day spent in paid work	.	0.07	0.13	0.83	1.17
Household characteristics					
Rural residence	0.30	0.29	0.27	0.24	0.22
Access to safe drinking water	0.51	0.62	0.81	0.81	0.83
Access to electricity	0.67	0.77	0.87	0.95	0.96
Mother's age	28.63	32.96	35.82	39.64	42.30
Household size	5.70	5.52	5.41	5.10	5.01
Father's age	32.65	36.83	39.66	43.64	46.25
Observations	2766	2648	2617	2537	2468

Notes: Source: The Young Lives datasets (UK Data Archives), Standard errors in parentheses* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

more time in domestic tasks. Finally, there is a significant difference in the prevalence of serious injury between boys and girls, with boys having a higher incidence of serious injury. Overall, the data suggest that gender differences exist in the burden of child labor and the risk of injury among children in Peru.

3.2 Mining and trade

In Peru, a department (departamento in Spanish) refers to an administrative region similar to a state or province. There are 25 departments in Peru, each with its own government and capital city. Departments are further divided into provinces, districts, and other administrative units. Mining production measure is at the department level. The data on the primary value of copper mining by departments in Peru is sourced from the Central Reserve Bank of Peru (Banco Central de Reserva del Peru). This data provides information

Table 2: Difference between boys and girls in round 4 in Young Lives in Peru

	Boys		Girls		Difference
	mean	sd	mean	sd	b
Age	13.251	3.091	13.103	3.005	0.149
Child's weight (kg)	45.705	14.056	44.390	11.419	1.316*
Child's height (cm)	147.369	12.454	146.179	19.076	1.190
Child is currently enrolled	0.888	0.315	0.881	0.323	0.007
Serious injury	0.133	0.340	0.078	0.268	0.055***
Hours/day spend in household chores	1.119	0.852	1.456	1.106	-0.337***
Hours/day spent in domestic tasks	0.609	1.300	0.526	1.228	0.083
Hours/day spent in paid work	1.075	2.866	0.570	2.147	0.505***
Rural residence	0.232	0.422	0.252	0.434	-0.020
Access to safe drinking water	0.811	0.392	0.813	0.390	-0.002
Access to electricity	0.948	0.222	0.950	0.217	-0.002
Household size	5.102	1.922	5.090	1.898	0.012
Observations	1298		1239		2537

Notes: Source: The Young Lives datasets (UK Data Archives), T statistics in parentheses. Unequal two-sided t-test * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

on the production value of mining activities in each department (or region) of Peru. The data on the international trade of copper is sourced from the UN Comtrade database. As an instrument for mining expansion, I construct international copper demand from partner countries. China, Korea and Japan are the three main countries importing cropper from Peru (Ministry of Energy and Mines, Peru). Therefore, I use their import from all countries, excluding Peru, as a proxy for international demand for copper.

3.3 Estimation strategy

where C_{dt} is the mining primary value of department d at year t, and Y_{it} is the outcome of interest, such as whether child i is currently enrolled at year t. This specification includes year-fixed effects and department-fixed effects. However, there might be time-varying omitted variables as confounding if they influence both outcome variables and mining expansion. This would cause bias as the effect of the omitted variable would be attributed to the impact of mining. Therefore, I employ an instrumental variable strategy. Therefore, equation (1) represents the second-stage equation. The instrument variable is computed as the cropper import of China, South Korea, and Japan, excluding those from Peru. This measure reflects the domestic demand for cropper in these three countries, instead of supply factors in Peru.

4 Results

4.1 The impact of mining expansion

Table 3 presents the results on enrolment, child labor and serious injury. The table is divided into three pairs of columns, each representing one of the outcomes. Within each pair, the first column (OLS) shows the results from an ordinary least squares regression, while the second column (IV) presents the results from an instrumental variable regression. A negative relationship is observed between log copper production and education enrollment in both OLS and IV regressions, indicating that an increase in copper production is associated with lower education enrollment. This could imply that as copper production increases, there may be a decrease in the number of children attending school. The OLS regression shows no statistically significant relationship between log copper production and child labor. However, the IV regression indicates a positive and statistically significant relationship, with a coefficient of $0.0754 (p < 0.001)$. Both OLS and IV regressions show a positive relationship between log copper production and serious injury. This implies that as copper production increases, there might be an increase in the number of serious injuries, potentially due to increased labor force participation in the copper industry or related industries. The regressions also include year-fixed effects and department-fixed effects, which control for time-invariant factors and regional differences that may affect the outcomes.

As shown in Table 4, a negative relationship is observed between log copper production and access to safe drinking water in both OLS and IV regressions. The coefficients are $-0.02633 (p < 0.001)$ and $-0.02080 (p < 0.001)$ respectively, indicating that an increase in copper production is associated with a decrease in access to safe drinking water. This could

Table 3: The effect of copper expansion on education and child labor

	(1)	(2)	(3)	(4)	(5)	(6)
	Education enrolment		Child labor		Serious injury	
	OLS	IV	OLS	IV	OLS	IV
Log copper production	-0.0086**	-0.0013***	0.0102	0.0754***	0.0084**	0.0003***
	(0.0036)	(0.0001)	(0.0238)	(0.0008)	(0.0029)	(0.0001)
Constant	0.2521***	0.2556***	0.9294***	0.9251***	0.0674***	0.0654***
	(0.0110)	(0.0115)	(0.1562)	(0.1330)	(0.0181)	(0.0189)
year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
department fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12270	12270	9656	9656	9671	9671

Notes: Enrolment is a binary indicator if the child is currently enrolled. Child labor is a sum over hours per day spent in household chores, domestic tasks including farming, and family business, and spent in paid activities. Serious injury is a binary indicator if the child has had serious injury since last interview. Source: The Young Lives datasets (UK Data Archives), The Central Reserve Bank of Peru, and The United Nations Comtrade database. Standard errors in parentheses clustered at department level.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

imply that as copper production increases, there may be detrimental effects on water quality and availability for local communities.

Both OLS and IV regressions show a negative relationship between log copper production and access to electricity. This suggests that as copper production increases, there might be a decrease in access to electricity for local communities, potentially due to increased resource consumption or infrastructure disruption caused by mining operations.

The qualitative argument provided discusses the contentious issue of water quality and quantity surrounding mining projects in Peru. The negative relationship observed between copper production and access to safe drinking water in the table aligns with the concerns raised in the qualitative argument. As copper production increases, the allocation of water rights and access to water resources may be reshuffled, leading to changes in the distribution of benefits and burdens for local communities.

Moreover, the expansion of large-scale mining activity has led to numerous protests and conflicts, as rural populations attempt to defend their livelihoods and environment. The observed negative relationship between copper production and access to electricity in the

Table 4: The effect of copper expansion on living conditions

	(1)	(2)	(3)	(4)
	Access to safe drinking water		Access to electricity	
	OLS	IV	OLS	IV
Log copper production	-0.02633***	-0.02080***	-0.03800***	-0.01442***
	(0.00728)	(0.00013)	(0.00894)	(0.00010)
Constant	0.58666***	0.58930***	0.77736***	0.78859***
	(0.02822)	(0.02705)	(0.03954)	(0.03931)
year fixed effect	Yes	Yes	Yes	Yes
department fixed effect	Yes	Yes	Yes	Yes
Observations	12292	12292	12291	12291

Notes: Acess is a binary indicator if the household have access to safe drinking water or to electricity. Source: The Young Lives datasets (UK Data Archives), The Central Reserve Bank of Peru, and The United Nations Comtrade database. Standard errors in parentheses clustered at department level.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

table could reflect these challenges faced by local communities, further underscoring the detrimental effects of mining on essential resources and infrastructure.

In conclusion, the table's findings support the qualitative argument that the expansion in copper production has negative consequences for local communities in terms of access to safe drinking water and electricity.

4.2 The impact of natural disaster on schooling

The results indicate that various shocks negatively affect wealth but can lead to an increase in hours spent in school and enrollment rates, as shown in Table 5.

Droughts appear to have a negative impact on the household wealth index. However, droughts have a positive impact on hours spent in school and enrollment rates, with coefficients of 0.248 and 0.038, respectively, both at a significance level of $p < 0.01$. When controlling for income effect, the coefficient for enrollment increases to 0.043, still significant at $p < 0.01$. In the case of floods, the results show a significant negative effect on wealth, with a coefficient of -0.033 and a significance level of $p < 0.01$. The impact on hours spent in school is not statistically significant (0.148), but the coefficient on enrollment rates is

Table 5: The effect of natural disasters on schooling

	(1) wealth	(2) hours in school	(3) enrolment	(4) enrolment
Panel A: Shock - Drought				
shock-drought	-0.044***	0.248***	0.038***	0.043***
	(0.005)	(0.075)	(0.011)	(0.011)
wealth				0.111***
				(0.036)
year fixed effect	Yes	Yes	Yes	Yes
department fixed effect	Yes	Yes	Yes	Yes
N	10068	10093	10118	10068
Panel B: Shock - Flood				
shock-flooding	-0.033***	0.148	0.031*	0.034**
	(0.008)	(0.119)	(0.015)	(0.015)
wealth				0.110***
				(0.037)
year fixed effect	Yes	Yes	Yes	Yes
department fixed effect	Yes	Yes	Yes	Yes
N	10068	10093	10118	10068
Panel C: Shock - Pests on crops				
shock-pests on crops	-0.039***	0.313**	0.039***	0.043***
	(0.011)	(0.118)	(0.012)	(0.012)
wealth				0.111***
				(0.037)
year fixed effect	Yes	Yes	Yes	Yes
department fixed effect	Yes	Yes	Yes	Yes
N	10068	10093	10118	10068
Panel D: Shock - Crop failure				
shock-crop failure	-0.035***	0.181	0.087***	0.092***
	(0.009)	(0.133)	(0.017)	(0.017)
wealth				0.133***
				(0.030)
year fixed effect	Yes	Yes	Yes	Yes
department fixed effect	Yes	Yes	Yes	Yes
N	12786	12122	12781	12721
Panel E: Shock - Death of livestock				
shock-death of livestock	-0.045***	0.447***	0.136***	0.142***
	(0.011)	(0.127)	(0.023)	(0.023)
wealth				0.133***
				(0.030)
year fixed effect	Yes	Yes	Yes	Yes
department fixed effect	Yes	Yes	Yes	Yes
N	12786	12122	12781	12721

Notes: Access is a binary indicator if the household have access to safe drinking water or to electricity. Source: The Young Lives datasets (UK Data Archives), The Central Reserve Bank of Peru, and The United Nations Comtrade database. Standard errors in parentheses, clustered at department level.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

positive and significant at $p < 0.1$, with a value of 0.031. When controlling for wealth, the coefficient for enrollment increases to 0.034, significant at $p < 0.05$.

Pest infestations on crops, crop failure, and death of livestock all have negative impacts on wealth but show positive effects on education outcomes. Pest infestations lead to a decrease in wealth (coefficient: -0.039, $p < 0.01$), an increase in hours spent in school (coefficient: 0.313, $p < 0.05$), and higher enrollment rates (coefficient: 0.039, $p < 0.01$). Crop failure results in reduced wealth (coefficient: -0.035, $p < 0.01$), no significant effect on hours in school, and increased enrollment rates (coefficient: 0.087, $p < 0.01$). Death of livestock negatively affects wealth (coefficient: -0.045, $p < 0.01$), while positively impacting hours spent in school (coefficient: 0.447, $p < 0.01$) and enrollment rates (coefficient: 0.136, $p < 0.01$). When controlling for income effects, the enrollment coefficients remain significant across all three cases.

4.3 The causal effect of schooling on child cognition, marriage and fertility

Now, we can use exogenous variation in schooling induced by agriculture shock to examine the educational impact on cognition, child marriage and child fertility. Table 6 shows the estimates using two-stage least square estimation. Education enrolment induced by agriculture shock increased math for both boys and girls. The treatment effect on girls is doubled than boys. Further, educational enrolment significantly reduced child marriage and fertility among boys.

Table 6: The causal effect of schooling on child cognition, child marriage and child fertility

	(1) math	(2) ppvt	(3) read	(4) marriage	(5) fertility
Panel A: Boys					
L.enrolment	223.017**	-0.538	0.023	-0.613***	-0.621**
	(99.379)	(1.093)	(1.633)	(0.236)	(0.242)
year fixed effect	Yes	Yes	Yes	Yes	Yes
department fixed effect	Yes	Yes	Yes	Yes	Yes
N	3440	2848	2171	605	604
Panel B: Girls					
L.enrolment	410.463***	-0.161	-5.657	0.324	0.139
	(149.444)	(1.425)	(17.125)	(0.330)	(0.228)
year fixed effect	Yes	Yes	Yes	Yes	Yes
department fixed effect	Yes	Yes	Yes	Yes	Yes
N	3309	2779	2106	553	554

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Cognitive measures are the item response theory (IRT) standardised math scores, IRT standardised Peabody Picture Vocabulary Test (PPVT), and IRT standardised reading score. Marriage and fertility have smaller observations because they are only measured in the last two round of the survey. Source: The Young Lives datasets (UK Data Archives), The Central Reserve Bank of Peru, and The United Nations Comtrade database. Standard errors in parentheses, clustered at department level.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5 Conclusion

This paper reveals significant relationships between increased copper production and various socio-economic and environmental outcomes in Peru, especially on children. The results indicate that as copper production increases, there is a decrease in education enrollment, an increase in child labor and serious injuries as well as worsen living conditions. These findings align with the qualitative arguments that mining projects, particularly copper production, can have negative consequences for local communities in terms of access to essential resources, environmental degradation, and public health.

Additionally, the results show that agricultural shocks, such as drought, flooding, pest infestations, crop failure, and death of livestock, negatively impact wealth but have positive effects on education outcomes. Furthermore, the induced education enrolment has increased math ability for children, particularly girls. It also reduced child marriage and fertility among boys. This highlights the complex interplay between environmental factors and socio-economic outcomes in rural communities.

Furthermore, the observed impacts emphasize the importance of sustainable and responsible mining practices. Policymakers, mining companies, and communities must work together to develop strategies that address the adverse effects of mining on local populations and the environment, ensuring equitable distribution of benefits and mitigating potential social and ecological harm.

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