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The effects of natural resource extraction on household expenditure patterns: Evidence from Mongolia*

Odmaa Narantungalag[†]

[†]School of Economics and Finance, Massey University, New Zealand

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Syed Hasan
School of Economics and Finance
Massey University
Private Bag 11222
Palmerston North 4442
NEW ZEALAND
Email: S.A.Hasan@massey.ac.nz
Phone: +64 6 356 9099 Extn 84019

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Odmaa Narantungalag†

†School of Economics and Finance, Massey University, New Zealand

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Abstract

This paper investigates the economic impacts of the mining sector on household expenditures. Employing the difference-in-differences model and the Mongolia Household Socio-Economic Survey data from 2008 to 2016, I find that the mining activities benefited local residents. Specifically, mining activities increase household expenditures on food, health, and electricity, respectively, while households reduce their expenditures on education and other non-food items. Interestingly, illness did not increase in the resource-producing region, while educational attainment improved. The findings highlight that the positive impacts of the mining sector are likely to be higher than what is determined by traditional welfare measurements of income and consumption. I provide some anecdotal evidence that the changes in household expenditure patterns can be due to increased availability of health care services and educational facilities in the mining region.

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JEL-Classification: L72, O12, O13, Q32, R11
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1. Introduction

Countries endowed with abundant subsoil resources, such as minerals, oil, and gas, may follow divergent growth and development paths. Evidence on how natural resource exploitation affects economic growth shows that there are many mechanisms through which natural resources can influence a country's development trajectory (Sachs and Warner, 2001; Van der Ploeg, 2011; Al-Ubaydli, 2012; Venables, 2016). There is, for example, clear evidence that the mining sector has backward, forward, and fiscal linkages to both national and local economies (Cust and Poelhekke, 2015; Van der Ploeg and Poelhekke, 2017). However, empirical evidence on the within-country effects of mining on household consumption patterns in a developing country remains limited and inconclusive. Using a large-scale copper-gold mine's taxes and fees as a proxy for mining activities, I investigate the local impacts of the extractive industry on household expenditures. I provide robust evidence on the positive effects of mining on household expenditures on food, health, and electricity and show how these outcomes link to a large-scale mine's development and operation.

I focus on a large-scale copper-gold mine, Oyu Tolgoi, in Mongolia for two main reasons. First, Mongolia is a lower-middle-income country heavily reliant on export commodities such as coal and copper. For example, in 2015, copper exports accounted for 49 percent of export earnings (NSO, 2019). This means, however, that the economy and the welfare of the populace are susceptible to movements in international demand and commodity prices.[1] It is therefore important to understand the outcomes of changes in economic activity, particularly at the local level, so that appropriate policy setting can be established. Oyu Tolgoi is by far the most significant mining investment in Mongolia as it attracted the largest amount of foreign direct investment (FDI) to the country just after the global financial crisis (GFC) in 2010, creating an ideal quasi-experimental setting for analyzing its local impacts.

Second, I examine the indirect impacts of mining activities on local, nearby communities. Large-scale resource extraction is capital and infrastructure intensive, so questions arise as to the direct impacts and benefits in the local economy through avenues such as job creation and demand for local goods and services. In Mongolia, the mining companies pay local fees for using land and

[1] This is one reason that several countries have established sovereign wealth funds, which serve to smooth out the impacts of demand and price movements, along with ensuring that resource exploitation results in sustainable benefits for the community.

water resources, which accrues to the subnational (provincial) government. In addition, mining companies pay local real estate and automobile taxes. These fees and taxes, separate from the resource windfalls accrued by the central government, comprise an indirect linkage to the local economy. Such a distinction between the revenue sharing mechanisms enables me to identify the effects of the mining sector's economic impacts on local communities, a matter which has received limited attention in the literature on the local impacts of natural resource extraction (Van der Ploeg, 2011; Cust and Poelhekke, 2015; Cust and Viale, 2016).

I explore the local effects of mining activities on various household consumption categories using Mongolia's nationally representative household-level socio-economic survey data. Previous studies examining the impacts of local linkages on living standards in developing countries relied on outcome variables at the district aggregate level, such as the annual conflict incidence index (Arellano-Yanguas, 2011), crime rates (Andrews and Deza, 2018), corruption (Cappelen et al., 2021), GDP per capita (Caselli and Michaels, 2013; Cust and Rusli, 2014), average per capita consumption, the poverty index (Loayza and Rigolini, 2016), gross regional domestic product (Hilmawan and Clark, 2021), and household aggregate income and consumption (Aragón and Rud, 2013). The detailed analysis of household food, non-food, medical, education, and electricity expenditures allows me to examine the natural resource sector's indirect impacts on household expenditure patterns.

The current study findings highlight that large-scale mining activity positively affects household expenditure patterns in a resource-producing region. While studies on the local impacts of mining activities mainly examine the backward and forward linkages, such as local purchases and procurement in Peru (Aragón and Rud, 2013; Orihuela and Gamarra-Echenique, 2020), job creation in Africa (Kotsadam and Tolonen, 2016; Tolonen, 2018), and spillovers and agglomeration in Australia and the United States (Black et al., 2005; Michaels, 2011; Fleming and Measham, 2015; Allcott and Keniston, 2017), institutional reforms in Colombia (Gallego et al., 2020), only a couple of studies examine the indirect links in developing countries using household-level data (Aragón and Rud, 2013; Orihuela and Gamarra-Echenique, 2020). As applied in my analysis, local taxes and fees directly linked to the large-scale mine's operation and output provide a more accurate measure of the indirect linkage.

The main challenge in estimating the causal effects of natural resource extraction is the endogeneity issue arising from confounding factors, the appropriate definition of resource dependence and abundance, and political distortions at the macroeconomic level (Van der Ploeg, 2011; James and Aadland, 2011). However, subnational level studies employing within-country data sets mitigate some of the endogeneity issues as these studies suffer less from variations in the cultural norm, institutional quality, laws, and regulations within a country (Cust and Poelhekke, 2015; Van der Ploeg and Poelhekke, 2017). In order to overcome the endogeneity issues, I exploit the empirical quasi-experimental strategy following (Aragón and Rud, 2013; Fleming and Measham, 2015). I use the difference-in-differences (DiD) model with four rounds of the Mongolia Household Socio-Economic Survey to draw a causal inference about the impacts of mining activities on household consumption. I consider three crucial characteristics of the resource-producing region for the quasi-experiment. First, the existence of large-scale mineral deposits, like Oyu Tolgoi, mainly depends on geology, making their occurrence random (Bonfatti and Poelhekke, 2017). Second, world mineral prices and demand for commodities drive the investment and development of the mine (De Haas and Poelhekke, 2019). Third, the mine has been developed and managed by non-local entities, such as foreign investors and the central government (Fleming and Measham, 2015).

This article shows that the large-scale mine's operations benefit the mining region households and influence their expenditure patterns. A 10 percent increase in collecting local taxes and fees results in a one percent increase in household per capita food expenditures. Furthermore, the same increase in mining activities leads to a 0.8 and 2.6 percent increase in household expenses on medical care and electricity, respectively. Conversely, a 10 percent increase in local taxes and fees collection reduces household non-food and education expenses by 0.9 and 2.1 percent compared to the households in the neighboring provinces. Therefore, the households in the resource-producing region increase their expenditures on basic needs such as food, medical care, and electricity by reducing their spending on other non-food items.

I consequently investigate whether increased medical and reduced education expenditures in the mining region are associated with respective health and educational outcomes. My examination confirms that individuals living in the large-scale mining region do not report illness significantly more than the control groups in neighboring regions. Furthermore, the educational attainment of individuals is significantly higher than those of the control individuals. Overall, the findings indicate that the mining activities impact local households beyond the traditional income channel but through other channels such as local taxes and fees. The results are robust to alternative models, explanatory variables, and data that I employ.

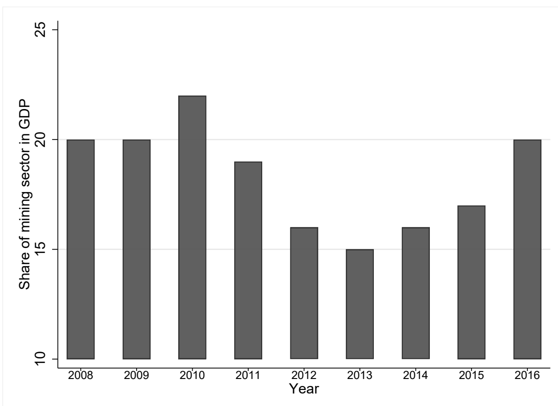
This study suggests that the application of appropriate local revenue-generating mechanisms, such as taxes and fees for the utilization of land and water by the extractive industry, is beneficial for households in the resource-producing region. Resource-rich remote regions in developing countries often lack skilled labor and market capacity that support backward and forward linkages to the mining sector (Cust and Viale, 2016). However, my investigation documents a positive impact of an alternative local linkage on household expenditure patterns, providing new empirical evidence on the local impacts of natural resource extraction. My findings lend additional support to Cust and Rusli (2014) and Hilmawan and Clark (2021) who argue that local government spending resulting from resource windfalls increases local GDP at the subnational level in Indonesia. My work also closely relates to two papers that find weak effects of fiscal linkages on local welfare. For example, Aragón and Rud (2013) find a negligible effect of revenue windfall on real incomes when examining the case of a large-scale gold mine in Peru. Similarly, Caselli and Michaels (2013) find that household incomes do not increase despite the increased oil-related revenues, but spending on schools increases in oil-rich Brazilian municipalities.

The rest of the paper proceeds as follows. Section 2 provides the background to the study, focusing on the Mongolian economy and Oyu Tolgoi mine. Section 3 discusses the empirical strategy and data. Section 4 presents the main results, robustness checks and Section 5 discusses the associated policy implications. Section 6 concludes the paper.

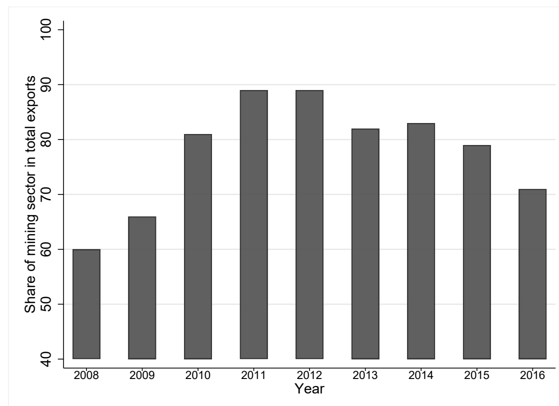
2. Background

2.1. Mongolia's dependence on minerals

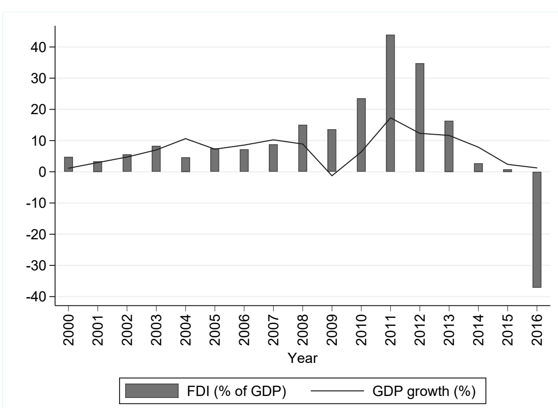
Mongolia is a fast-growing lower-middle-income country with a small, open economy, which relies on minerals, including coal, copper, gold, iron ore, and zinc. The country is a mineral dependent nation, with mining contributing around 20 percent of gross domestic product (GDP) and over 75 percent of total exports in the period 2008-2016, as shown in Panels A and B in Figure 1 (NSO, 2019).[2] Economic growth in Mongolia topped 17 percent in 2011 as foreign direct investment (FDI) poured in with the expectation of substantial returns from mineral development. The mining sector received more than 75 percent of FDI in the period 2011-2016 (Panel C in Figure 1) (NSO, 2019). Economic growth averaged 7.5 percent per annum since 2000 until the Global Financial Crisis (GFC) hit the economy with a contraction of 1.3 percent in 2009. However, China's increased demand for minerals, which underpinned a rapid increase in FDI and high commodity prices, led to a mining boom and substantial structural changes in the economy between 2010 and 2013 (Baatarzorig et al., 2018; Doojav and Luvsannyam, 2019).



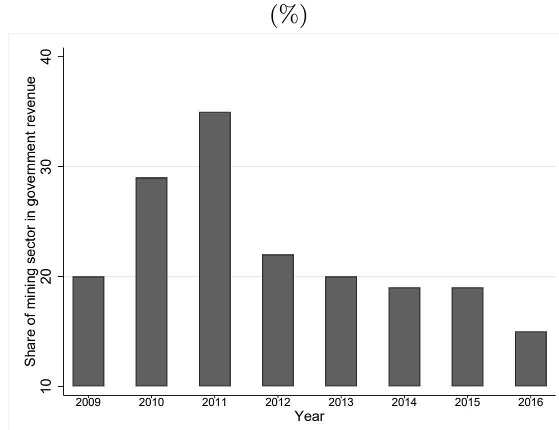
Panel A: Mining and quarrying sector share in GDP (%)



Panel B: Share of mineral exports in total exports (%)



Panel C: FDI and GDP growth



Panel D: The share of mining sector to budget revenue (%)

Figure 1: The mining sector in the Mongolian economy
Source: NSO (2019)

[2]Haglund (2011) defines a country as mineral-dependent if it generates at least 25 percent of export earnings from minerals. Based on this definition, the number of mineral-dependent low and middle-income countries, including Mongolia, stood at 61 in 2010. There are, however, other definitions of mineral dependency. For example, Auty (1993) defines a nation as mineral-dependent if it generates at least eight percent of Gross Domestic Product (GDP) and 40 percent of export earnings from minerals.

The mining sector contributed over 20 percent of central government budget revenues (Panel D in Figure 1) and accounted for four percent of total employment in 2009-2016 (NSO, 2019).[3] Several mineral deposits of economic and strategic significance comprise the majority of fiscal revenues from the mining sector. The central government invests parts of the revenues in public funds and allocates some parts to provincial governments.[4] However, whether the provinces endowed with the major mineral deposits benefit from their mineral extraction despite their significant contribution to the national economy is uncertain. Answering this question sheds some light on our understanding of the mining sector's impact on the provincial economies and motivates this paper to further examine the sector's microeconomic effects.

2.2. Oyu Tolgoi mine

The high global demand for minerals in the early 2000s made Mongolia an exciting destination for FDI and led to the discovery of the country's largest copper-gold deposit, Oyu Tolgoi, in 2001. Oyu Tolgoi, located in the Gobi desert of Southgobi province, has 31.3m tonnes of copper reserves and 3.3b tonnes of mineable copper ore reserves and is believed to be one of the top five copper-gold deposits in the world when fully operational (Oyu Tolgoi, 2018).[5] The commencement of Oyu Tolgoi's commercial production in 2013 increased Mongolia's copper concentrate exports volume to 1.4m tonnes in 2014 (Figure 2), accounting for seven percent of copper concentrates traded globally and making Mongolia the sixth-largest exporter of the mineral (WITS, 2014). The mine's annual production is projected at 0.43m tonnes of copper and 0.42m ounces of gold over the next 20 years (Rio Tinto, 2019). The Government of Mongolia established a joint venture with international investors Rio Tinto and Turquoise Hill Resources in 2009, commencing the country's

[3] Mining license holders in Mongolia need to pay a standard royalty based on the total sales value of the minerals, ranging from 2.5 percent for coal to 5.0 percent for commonly exported minerals. Additional tax categories include personal income tax, corporate income tax, value-added tax, real estate tax, water consumption tariff, land use fee, import duty, customs duty, excise tax, and taxes for foreign specialists' employment (Mineral Resources and Petroleum Authority, 2016). Either the provincial or central government collects these taxes.

[4] The government projected that in 2019 it would source 27 percent of Mongolia's consolidated total budget revenue from mining revenues, of which 10 and 36 percent would be transferred to the Stabilization Fund (SF) and the Future Heritage Fund (FHF), respectively (Vanchin, 2018). The SF and FHF, established in 2010 and 2016, respectively, act as counter-cyclical policy tools and create sustainable funds by saving parts of resource revenues (Parliament of Mongolia, 2010, 2016). The SF contributes to intra-generational equity, while the FHF underwrites inter-generational equity.

[5] In this paper, m refers to million and b refers to billion.

largest foreign-invested resource development project under Oyu Tolgoi LLC (OT). OT is the entity at the center of my analysis.[6]

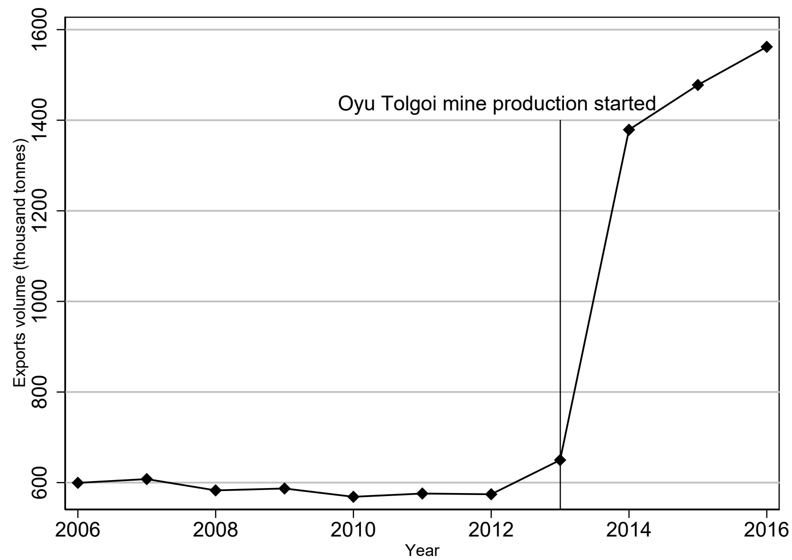


Figure 2: Exports volume of copper concentrate, 2006-2016
Source: NSO (2019)

As Mongolia's largest foreign-invested mining project, OT is believed to significantly impact the national economy and regional development. Taxes paid by OT to the central government constituted 7–13 percent of total tax revenues for 2012-2020 (Mongolian Economy, 2021). While the project's macroeconomic impacts are apparent, its local effects are not well understood. Around 20 percent of total employees come from Southgobi province (Oyu Tolgoi, 2018), while the rest of the workforce are fly-in-fly-out (FIFO) employees who travel to the remote mining site when rostered for work and return to their home location when not working (Storey, 2001; McKenzie, 2010). In addition, the majority of equipment and construction materials are not purchased locally due to the limited capacity of the local market. Therefore, the company's employment, procurement, and production have limited effects on the provincial economy because of skill shortages, limited supply of goods and materials, and absorptive capacity constraints (Cust and Poelhekke, 2015).

The mining and quarrying sector requires a substantial amount of resources such as water and land, large-scale infrastructure to operate (De Haas and Poelhekke, 2019). For a large-scale

[6] Oyu Tolgoi attracted $6.2b (50 percent of GDP) in FDI in 2010; the second stage of underground mine development, underway since 2016, required a further $5.3b of FDI (Rio Tinto, 2019; Li et al., 2017). The Government of Mongolia owns 34 percent, and Turquoise Hill Resources owns 66 percent.

mine like OT, the amount of land and water required is substantial. The provincial governments in Mongolia apply various taxes for the use of land and water, along with additional imposts, including real estate tax, automobile taxes, and royalty fees for mineral resources. Therefore, local fees and taxes paid by mining companies can comprise a significant share of revenue base of the provincial government. The taxes and fees paid by OT were US$0.3m and accounted for around two percent of provincial government revenue in 2008. They increased substantially in the subsequent years and accounted for 18 and 23 percent of provincial government revenues in 2014 and 2016, respectively, after the mine commenced copper production in 2013 (Oyu Tolgoi, 2019; NSO, 2019). I exploit these exogenous changes in local taxes and fees created by the development of the large-scale copper-gold mine to examine the local economic impacts of the mine on household expenditure patterns.

3. Methodology and data

3.1. Empirical approach

I examine whether a large-scale mine's taxes and fees to the local economy has a discernible impact on the consumption of goods and services by residents in the resource-producing region using a quasi-experimental setting. Employing ordinary least squares (OLS) can produce biased or inconsistent estimates in the presence of endogeneity that may arise due to the omission of relevant variables in the model (Wooldridge, 2015). The difference-in-differences (DiD) model can be employed to overcome (Parmeter and Pope, 2013) and is, therefore, used in the analysis. The empirical specification closely follows the DiD model used by Aragón and Rud (2013) and takes the following form:

$$y_i = \delta + \beta(M_t \times D_s) + \eta_t + \alpha_s + X_i\Theta + \varepsilon_{ist}, \quad (1)$$

where, depending on the analysis, y_i is the (natural logarithm of) monthly per capita income or expenditure (or specific categories of expenditure in separate analyses) of household i ($i = 1, \dots n$); X_i is a set of household/individual-level control variables (described in Subsection 3.2), η_t is the year fixed effects and α_s is the province fixed effects. I consider 2008 as the control period as local fees and taxes in the large-scale mining region were similar to those of the neighboring provinces

(EITIM, 2020). The analysis excludes 2010 as it is the year when the investment agreement between the international investor and the government came into effect: I do not expect any immediate impact in 2010. The DiD estimate (β) captures the economic impact of mining activities on household expenditures in Southgobi province. The exposure variable M_t, a continuous variable, is the (natural logarithm of) annual local taxes and fees collected by the provincial government for the use of land, water and real estate, and automobile taxes. In the model, I expect local taxes and fees to impact the households in Southgobi positively. Note that some of the effects may occur due to the wages paid to employees, local purchases made from the market, and the company's social investment in the local economy.[7] Households in the neighboring regions might benefit from the mine's various spillover effects, but not directly from local taxes, which are used to support the health and education sectors and infrastructure development.

My analysis, therefore, focuses on the Southgobi province (gray shaded area in Figure 3) and considers Southgobi households as the treatment group. Households from the four neighboring provinces, Bayankhongor, Uvurkhangai, Dundgobi, and Dornogobi, are the control households (diagonal line shaded area in Figure 3).[8] The neighboring provinces are similar to Southgobi and also possess a wealth of mineral resources such as gold, coal, iron, and wolfram. However, they do not have mines comparable to Oyu Tolgoi. Thus D_s in the model is an indicator variable taking the value of one for households living in Southgobi and zero for those in the neighboring provinces.[9]

The identifying assumption for the DiD model is that the difference in the outcome variable between the treatment and control households would have remained the same in the absence of Oyu Tolgoi's investment agreement, which came into effect in 2010, following exogenous shocks in the global demand for minerals in the early 2000s. While I cannot test the assumption directly, I validate it by graphically showing overtime income and expenditure patterns for both the treatment and control groups as discussed in Subsection 4.2.

[7] Southgobi province transfers more than half of the resource revenues to the central government. Local taxes from the mining sector, including real estate, water, land use, and automobile taxes, are paid to the provincial government every year, in addition to royalties and donations. These taxes rose substantially from \$0.3m in 2008 to \$7.9m in 2016, following the commencement of OT's open-pit mine operation in mid-2013 (Oyu Tolgoi, 2019).

[8] Comparing the expenditures of households in Southgobi against those in neighboring provinces is a more reliable measure than the distance from the mine. The reason is that local tax revenues do not have to be spent in the vicinity of the mine.

[9] It is essential to note that mining licenses are issued across Mongolia and mining operations take place in the neighboring provinces. However, the amount of mineral resources, the scale of operation, and the FDIs these mines attracted are not comparable to the Oyu Tolgoi mine, which significantly impact the national economy and central government revenue collection.

Figure 3: Map of Mongolia

3.2. Data

I use data from four rounds of the Mongolia Household Socio-Economic Survey, a nationally representative cross-sectional survey conducted by the National Statistics Office (NSO) every two years. The survey uses a stratified two-stage sample design based on population figures obtained from the administrative records of local governments. The first stage stratifies the capital city, Ulaanbaatar, and the 21 provinces. The second stage divides the 21 provinces into two substrata: urban – provincial capitals, and rural – small towns and the countryside (NSO, 2019).[10]

The four HSES rounds that I employ in my study – 2008, 2012, 2014, and 2016 – comprised of an initial sample of 56,608 households with 138,584 individuals. I retained a total of 10,400 households located in Southgobi and its neighboring provinces – Bayankhongor, Uvurkhangai, Dundgobi, and Dornogobi, and omitted 47 households that did not report any monetary income. Consequently, the final sample consists of 36,704 individuals in 10,353 households, of which 1,901 belong to 2008, 2,131 belong to 2012, 3,115 belong to 2014, and 3,206 belong to the 2016 survey. I considered 611 individuals without any formal schooling as these individuals had missing data for education. In addition, I considered 1,438 individuals as not being ill as they did not report their illness status.

[10]The HSES questionnaires and the primary datasets are publicly available from the NSO Census and Survey data catalog and can be obtained using the following link: http://web.nso.mn/nada.

The missing data could be due to errors in collecting and reporting the data and individuals not being comfortable reporting their education or illness.

The survey collects detailed data on various sources of income and all household consumption/expenditure categories. In my estimation, I employ various household expenditure categories to analyze the large-scale mine's local impacts. Following previous studies such as those of Banks et al. (1997), Blundell et al. (2007) and Hasan (2016), I categorize household expenditures to food, non-food, health, education, electricity, and other non-food expenditures and use them as the dependent variables to estimate Equation 1.[11]

Table 1 reports the summary statistics for the dependent variables for treatment and control households in each survey round. Panel A reports the variables used for the household-level analysis. The monthly household income was higher for the treatment households in the base year 2008, while both groups increased their incomes steadily in all years, except for the treatment group in 2016. The decline in incomes in 2016 is attributable to a sudden decrease in FDI in 2014, a sharp drop in commodity prices in 2015, and risks and uncertainties that affected the mining sector at that time (Doojav and Luvsannyam, 2019).[12] In contrast, the treatment households' food consumption was similar to that of the control group in 2008. Although both groups increased their food consumption over time, the treatment households' food expenditure was higher in 2012-2016, indicating that they positively benefited from increased mining activities.

While non-food expenditures were higher for the treatment group in 2008, they changed over time in a pattern similar to income. Other non-food expenditures, including transportation, services, communication, clothing, and others, were higher for the treatment households in 2008 and grew similarly to income and non-food expenditure. On the other hand, both groups' expenditures on medical services and electricity increased over time, except that medical expenditures declined for the treatment group in 2016. Interestingly, treatment households' expenditure on education declined over time, whereas the control group had relatively stable expenditure on education.

[11] In constructing the variable consumption, I exclude some of the lumpy non-consumption items, such as spending on weddings and religious activities, from household expenditure. However, throughout the analysis, I use consumption and expenditure interchangeably.

[12] At the same time, the national poverty rate increased to 29.6 percent in 2016 from its lowest level of 21.6 percent in 2014 (NSO, 2019).

Table 1: **Summary statistics of dependent variables**

	2008		2012		2014		2016	
Variable	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
Panel A: Household-level variables								
Per capita income	130	94	223	164	292	191	274	222
	(129)	(91)	(172)	(143)	(262)	(150)	(179)	(159)
Per capita food expenditures	44	45	70	59	87	65	71	53
	(33)	(27)	(53)	(41)	(52)	(38)	(42)	(33)
Per capita non-food expenditures	106	61	157	87	187	122	146	121
	(131)	(76)	(179)	(95)	(188)	(112)	(116)	(105)
Per capita medical expenditures	2	1	3	3	11	3	6	5
	(3)	(4)	(7)	(7)	(101)	(8)	(14)	(16)
Per capita education expenditures	7	6	6	5	4	6	4	6
	(16)	(12)	(15)	(12)	(13)	(13)	(11)	(17)
Per capita electricity expenditures	1	1	2	2	2	2	4	3
	(2)	(2)	(2)	(3)	(3)	(3)	(4)	(3)
Per capita other non-food expenditures	96	52	145	77	169	110	132	107
	(126)	(72)	(177)	(91)	(149)	(109)	(110)	(97)
Number of households	304	1,597	312	1,819	622	2,493	624	2,582
Panel B: Individual-level variables								
Ill in the past month	0.08	0.05	0.09	0.05	0.08	0.06	0.06	0.05
	(0.3)	(0.2)	(0.3)	(0.2)	(0.3)	(0.2)	(0.2)	(0.2)
Number of individuals	1,201	6,407	985	6,527	1,961	8,917	1,894	8,812
Individual's education (years)	7.68	7.39	8.72	8.42	8.66	8.50	9.48	8.56
	(4.6)	(4.7)	(5.1)	(5.2)	(5.6)	(5.3)	(5.3)	(5.1)
Number of individuals	1,102	5,864	887	5,820	1,716	7,847	1,616	7,700

Note: Panel A reports the dependent variables for the analyses conducted at household level. All values are on per capita monthly basis. Means are reported in thousand Tugrik (MNT) and adjusted for 2010 price level. The exchange rate was US$1 ≈ 1,257 MNT at the end of 2010. Panel B reports the illness rate for all individuals whereas individual's education is years of schooling for only those aged 6 and above from the HSES. Standard deviations are reported in the parentheses.

Panel B in Table 1 presents the summary statistics for the dependent variables, the incidence of illness, and education years, which are used for the individual-level analysis. Eight percent of the treatment individuals reported that they were ill in 2008, compared to the five percent of control group individuals. Their illness rate increased in 2012 and declined in 2014-2016. On the other hand, the illness rate of control individuals did not change in all years, except 2014. I also use schooling years for individuals aged six and above as a dependent variable in my analysis. The treatment individuals had slightly higher years of education than the control group in 2008. The educational attainments of both groups increased in subsequent years, except that it was lower for the treatment individuals in 2014 than in 2012.

Before estimating the empirical model, I conducted t-tests to check the significance of the differences in (the natural logarithms of) income, various categories of expenditures, illness rate, and educational attainment between the treatment and control groups (Table 2). Panel A presents the differences in dependent variables between treatment and control households over the years. Income, expenditures on non-food consumption, health, and other non-food items were significantly higher for the treatment households in 2008, as indicated by the significance from the t-test. The differences in these items, except medical expenditures, declined over time, indicating that the treatment households increased them less than the control group.

The expenditures on food, education, and electricity also provide interesting patterns. For example, treatment households' food expenditure was significantly lower than the control group's in 2008. It increased substantially in subsequent years, and the difference in food expenditure was significantly higher in 2012-2016. On the other hand, the treatment group's education expenditure was slightly higher than that of the control group in 2008, although the difference was insignificant. Over time, however, the pattern of expenditures changed, with treatment households spending less on education. Expenditure on electricity was higher for treatment households in the base year without a significant difference between both groups in the initial period. Treatment households increased their electricity expenditure over time, except in 2012, and the difference was significant in 2016.

Table 2: **Differences income and expenditures between treatment and control groups**

Variable name	2008	2012	2014	2016
Panel A: Household-level variables				
Ln(per capita income)	0.304***	0.349***	0.398***	0.235***
	(0.050)	(0.041)	(0.028)	(0.029)
Ln(per capita food expenditures)	-0.075**	0.129***	0.287***	0.291***
	(0.032)	(0.034)	(0.023)	(0.023)
Ln(per capita non-food expenditures)	0.548***	0.588***	0.391***	0.195***
	(0.051)	(0.045)	(0.031)	(0.031)
Ln(per capita medical expenditures)	0.242***	0.277***	0.466***	0.252***
	(0.092)	(0.085)	(0.060)	(0.062)
Ln(per capita education expenditures)	0.156	-0.761***	-0.794***	-0.385**
	(0.239)	(0.229)	(0.175)	(0.177)
Ln(per capita electricity expenditures)	0.022	-0.970***	0.109	0.439***
	(0.229)	(0.213)	(0.164)	(0.156)
ln(per capita other non-food expenditures)	0.592***	0.631***	0.419***	0.214***
	(0.052)	(0.046)	(0.033)	(0.031)
Number of households	1,901	2,131	3,115	3,206
Panel B: Individual-level variables				
Ill in the past month	0.026***	0.045***	0.024***	0.015***
	(0.007)	(0.008)	(0.006)	(0.006)
Number of individuals	7,608	7,512	10,878	10,706
Individual's education (years)	0.135	0.194	-0.025	0.678***
	(0.154)	(0.188)	(0.144)	(0.141)
Number of individuals	6,966	6,707	9,563	9,316

Note: Mean of differences between households/individuals in treatment and control regions are reported for each year. Panel A reports the dependent variables for the analyses conducted at household level. All values are in their natural logarithm. Panel B reports the illness rate for all individuals whereas individual's education is years of schooling for only those aged 6 and above from the HSES. Standards errors are recorded in the parentheses. * p <0.10, ** p <0.05, *** p <0.01.

I also examine the difference in individual-level dependent variables, which are shown in Panel B of Table 2. The treatment individuals reported a significantly higher incidence of illness than their control counterparts in 2008. The difference in reporting illness increased in 2012 but declined afterward. On the other hand, educational attainment for the treatment individuals was higher in the base year, with the difference increasing in 2012 and significantly so in 2016. Overall, the t-test results indicate that treatment households adjusted their food and non-food expenditures, while the increased mining activities in Southgobi province did not negatively impact their health and educational outcomes.

The HSES also collects information on each household member's age, gender, education, employment status, whether a person was ill in the month before the survey, and residential property type and urban/rural status (NSO, 2019). Since these characteristics can affect income and consumption at the household level, I control these factors in the model when estimating the impacts of large-scale mining activities. Specifically, the household-specific control variables are the household head's age, gender, marital status, years of education, and household size. The household's urban/rural status and dwelling type are also included in the model to account for differences in living conditions.

Table 3 presents the summary statistics for the independent variables. Panel A presents the main variable of interest: taxes paid by the mine to the provincial government, including fees for land and water use, real estate, and automobile taxes. I use local taxes and fees to proxy mining activities for the local economy. The taxes and fees paid were US$0.3m and accounted for around two percent of provincial government revenue in 2008 and they increased substantially in the subsequent years, accounting for over 15 percent of revenues in 2014-2016 (Oyu Tolgoi, 2019; NSO, 2019). The taxes and fees are nil for the control households as the mine does not pay any local taxes or fees to the neighboring provinces. However, it pays taxes to the central government, which then manages and redistributes mining revenues across the country.[13]

Panel B presents the household-level control variables. The age of household heads declined for the treatment households, while it increased for the control households. The shift in age may happen due to the migration of younger people into the mining regions, which may offer them better job opportunities.[14] For both groups, the proportion of male-headed households decreased. Although treatment household heads had slightly lower years of schooling in 2008, their education was higher than that of the control group in 2014 and 2016. The proportion of households living in apartments and houses increased for the treatment group over time, except in 2014, whereas there is no clear pattern for the control households. The share of treatment households living in rural areas remained stable while it declined for the control households. Internal migration from rural

[13] Mining operations take place on five percent of country's territory (EITIM, 2020). Therefore, most provinces collect local mining taxes and fees from the mining companies. But they are not as high as that of OT's because of the scale of the mining activities.

[14] Traditionally in Mongolia, following a divorce or the death of a husband, the oldest son becomes household head. The number of divorces in Southgobi during 2008-2016 increased by 285 percent, compared to 110 percent for the entire country (NSO, 2019). The relatively higher divorce rates in Southgobi may partly explain the younger age of households as the proportion of married couples decreased for both the control and treatment groups.

Table 3: **Summary statistics of independent variables**

Variable	2008 Treatment	2008 Control	2012 Treatment	2012 Control	2014 Treatment	2014 Control	2016 Treatment	2016 Control
Panel A: Regional-level variable								
Local taxes from mining (million US$)	0.31	0	1.36	0	10.15	0	12.96	0
Panel B: Household-level variables								
Household head's age (years)	46.50	44.51	46.30	44.98	44.78	45.80	43.35	46.26
	(15.06)	(14.39)	(15.57)	(14.51)	(15.00)	(14.26)	(14.63)	(15.05)
Household head is married	0.63	0.69	0.47	0.67	0.51	0.63	0.47	0.59
	(0.48)	(0.46)	(0.50)	(0.47)	(0.50)	(0.48)	(0.50)	(0.49)
Household head is male	0.74	0.82	0.71	0.80	0.73	0.77	0.71	0.75
	(0.44)	(0.39)	(0.45)	(0.40)	(0.44)	(0.42)	(0.45)	(0.43)
Household head's education (years)	8.79	8.82	9.52	9.57	10.34	10.12	12.10	10.30
	(4.22)	(4.15)	(4.30)	(4.35)	(4.91)	(4.50)	(4.40)	(4.79)
Ln(per capita income)	11.45	11.15	12.11	11.77	12.35	11.95	12.34	12.10
	(0.79)	(0.79)	(0.62)	(0.68)	(0.67)	(0.63)	(0.61)	(0.65)
Lives in apartment/house	0.07	0.11	0.08	0.07	0.06	0.10	0.10	0.11
	(0.26)	(0.31)	(0.27)	(0.26)	(0.24)	(0.29)	(0.30)	(0.32)
Lives in rural area	0.61	0.70	0.62	0.74	0.61	0.61	0.62	0.63
	(0.49)	(0.46)	(0.49)	(0.44)	(0.49)	(0.49)	(0.49)	(0.48)
Number of households	304	1,597	312	1,819	622	2,493	624	2,582
Panel C: Individual-level variables								
Individual's age (years)	28.16	27.33	30.10	28.55	28.51	28.60	27.82	28.99
	(19.11)	(18.15)	(19.99)	(18.95)	(19.30)	(19.31)	(19.35)	(19.98)
Individual is male	0.48	0.49	0.47	0.49	0.48	0.49	0.50	0.49
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Individual's education (years)	6.90	6.76	7.76	7.51	7.42	7.48	7.89	7.48
	(4.93)	(4.92)	(5.49)	(5.59)	(5.98)	(5.72)	(5.97)	(5.55)
Ln(per capita wage income)	5.16	4.37	5.80	5.49	6.28	5.92	7.50	6.25
	(5.42)	(5.32)	(5.77)	(5.65)	(5.90)	(5.69)	(5.67)	(5.65)
Lives in apartment/house	0.08	0.10	0.07	0.07	0.06	0.09	0.10	0.11
	(0.27)	(0.31)	(0.25)	(0.25)	(0.23)	(0.29)	(0.30)	(0.32)
Lives in rural area	0.59	0.69	0.62	0.75	0.62	0.63	0.62	0.62
	(0.49)	(0.46)	(0.49)	(0.44)	(0.49)	(0.48)	(0.48)	(0.48)
Number of individuals	1,201	6,407	985	6,527	1,961	8,917	1,894	8,812

Note: Panel A reports local taxes and fees paid by the mining company. The control group does not receive any fees from the large-scale mining company. Panel B and C reports the independent variables for the household- and individual-level analysis, respectively. Dummy variables indicating male, married, living in apartment/house and rural areas show their sample proportions. Standard deviations are reported in the parentheses.

areas to urban areas, including the capital city, rose in the 2010-2016 period due to people's search for better economic opportunities and access to markets and services. Southgobi is the only province with more people settling in than those emigrating (IAM, 2018). However, these factors are believed to be minor to affect my analysis setting.

Finally, Panel C provides individual-specific control variables. Individuals' age, the proportion of males in the community, and education in years are similar and stable over time for both groups. The log of wage income remains higher for the treatment individuals. There is no clear pattern in the share of households living in apartments/houses and rural areas for both groups. The independent variables indicate that the treatment and control households/individuals are not systematically different.

4. Results

I start this section with a brief descriptive macroeconomic analysis. Before estimating the primary model in Subsection 3.1, I examine the mining sector's impact on provincial macroeconomic indicators to understand whether the extractive industry has an overall effect on the local economy. I estimate an unrestricted three-variable vector autoregressive (VAR) model, employing Mongolia's provincial data, and use the Cholesky decomposition to estimate impulse response functions, thereby analyzing the mining sector's impact (ΔM) on provincial GDP (ΔY) and government revenue (ΔG).[15]

The results of the VAR model and impulse response functions shown in Figure 4 suggest that provinces with significant mineral resources are those that most benefit from mining activities, reinforcing my preference to study the large-scale mine's impact at the household level. I find that a shock to mining sector production has, in the short run, a significantly positive effect on provincial GDP and a positive though insignificant effect on government revenue in those provinces with large mineral deposits (Panel (a) in Figure 4). The effect is not significant in provinces without considerable mineral deposits (Panel (b) in Figure 4) (see Appendix A for the entire model).

[15] The Cholesky decomposition constrains the VAR system such that the shock from the least exogenous series has no direct contemporaneous effect on the most exogenous series (Sims, 1980; Enders, 2010). In the exercise, I rank the variables in terms of their contemporaneous exogeneity as mining production, GDP, and government revenue per capita.

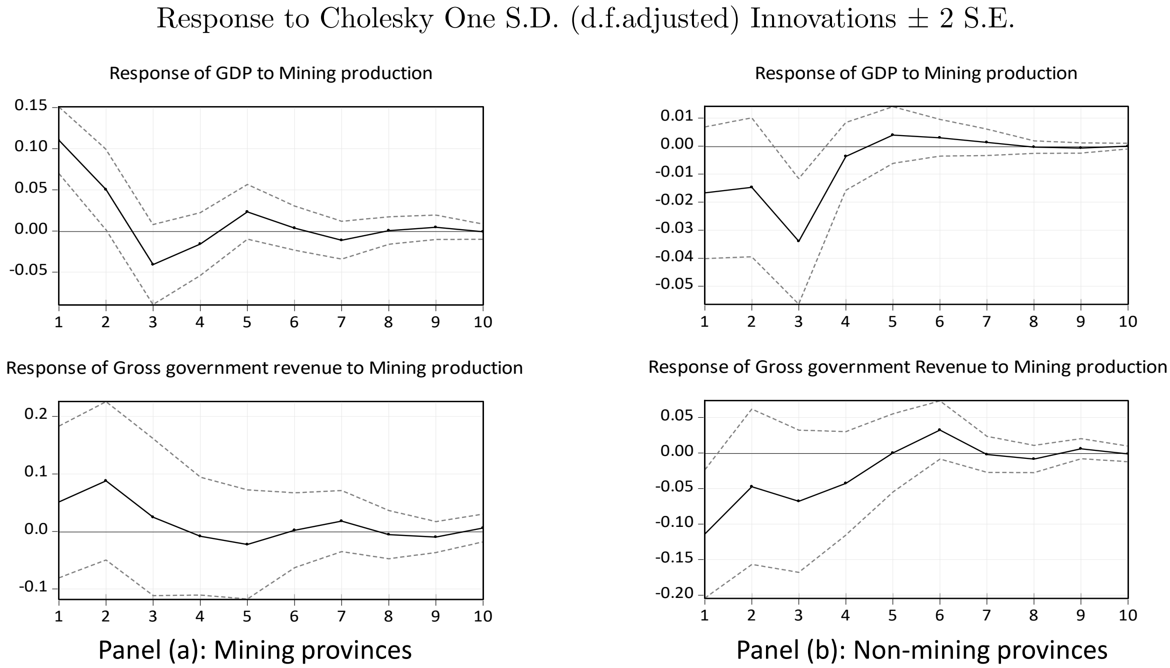


Figure 4: Impulse response functions for provinces

In investigating the causal effect of the mining activity on household expenditures, I estimate the DiD model in three stages. In the baseline model, I regress the dependent variables on the exposure variable (i.e., $M_t \times D_s$) with survey year and province fixed effects. I then add the household-specific control variables to the model. I include (log of) household per capita income in the final stage to estimate the preferred model. Sample weights are used, and robust standard errors are clustered at the HSES survey cluster-level to account for differences in the model within households.[16] All tests are conducted at the conventional five percent significance level.[17]

4.1. Main results

4.1.1. Effect on income, food and non-food expenditures

Table 4 reports the estimates of Model 1. The DiD estimate on household per capita income is statistically insignificant in column 1, indicating no difference in income between the treatment and control groups. The year fixed effects show the significant growth in the incomes of control households during 2012-2016. The addition of household-specific control variables does not affect

[16] For individual level analysis, robust standard errors are clustered at the household level.
[17] Results that are not presented here are available from the author upon request.

Table 4: **Regression results of DiD models of the mining impact on income, food and non-food expenditures**

	ln(income)		ln(food)			ln(non-food)		
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(local taxes) × mining	0.005	0.002	0.105***	0.105***	0.104***	-0.074***	-0.087***	-0.088***
	(0.020)	(0.018)	(0.017)	(0.016)	(0.014)	(0.021)	(0.019)	(0.014)
2012	0.627***	0.609***	0.245***	0.241***	0.000	0.510***	0.488***	0.068**
	(0.034)	(0.033)	(0.027)	(0.027)	(0.023)	(0.043)	(0.039)	(0.033)
2014	0.799***	0.768***	0.341***	0.334***	0.031	0.804***	0.769***	0.240***
	(0.034)	(0.032)	(0.025)	(0.024)	(0.022)	(0.040)	(0.036)	(0.032)
2016	0.923***	0.856***	0.117***	0.095***	-0.244***	0.787***	0.718***	0.128***
	(0.034)	(0.032)	(0.027)	(0.027)	(0.023)	(0.040)	(0.036)	(0.031)
Household head's age (years)		0.011***		0.006***	0.001***		0.006***	-0.002***
		(0.001)		(0.000)	(0.000)		(0.001)	(0.000)
Household head is male		0.186***		0.157***	0.083***		0.140***	0.011
		(0.022)		(0.019)	(0.016)		(0.023)	(0.018)
Household head's education (years)		0.027***		0.003*	-0.008***		0.038***	0.019***
		(0.002)		(0.001)	(0.001)		(0.002)	(0.002)
Household head is married		-0.209***		-0.297***	-0.214***		-0.070***	0.074***
		(0.021)		(0.017)	(0.014)		(0.022)	(0.017)
Ln(per capita income)					0.395***			0.689***
					(0.011)			(0.016)
Lives in apartment/house		0.362***		0.095***	-0.048**		0.341***	0.091***
		(0.034)		(0.022)	(0.021)		(0.034)	(0.024)
Lives in rural area		0.012		0.146***	0.141***		-0.087***	-0.096***
		(0.021)		(0.019)	(0.016)		(0.026)	(0.021)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.24	0.33	0.13	0.20	0.41	0.20	0.28	0.58
Number of households	10,353	10,353	10,353	10,353	10,353	10,353	10,353	10,353

Note: All dependent variables are in per capita level. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1, 3 and 6 run the basic models with province and year fixed effects. Columns 2, 4 and 7 add household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Columns 5 and 8 add log of household per capita income in the model.

the results, as shown in column 2. Therefore, I do not find evidence that local taxes and fees from the large-scale mine significantly increase household incomes. However, income is a more volatile and sensitive measure than consumption/expenditure because accurate income measurement requires survey respondents to understand their assets, returns, profits, and income (Deaton, 1997). In addition, income does not provide us with detailed information about how households make consumption choices as local economic activity increases. Consequently, I focus on household expenditures, which is considered a better and more reliable indicator of living standards at the household level (Deaton and Zaidi, 2002).[18]

The DiD estimate in the baseline model in column 3 for household per capita food expenditure is positive and significant, providing evidence that a 10 percent increase in local taxes from the large-scale mine increases food expenditure by the treatment households by one percent in Southgobi. The control households increased their food consumption significantly over time, as indicated by the year fixed effects.

The results remain similar when I add the household-specific control variables in column 4. The coefficients of the control variables reported in column 4 are mostly meaningful. As expected, households with male, older, and more educated heads living in apartments/houses spend significantly more food than younger, female, and single-headed households living in traditional gers.[19] In addition, rural households spend significantly more on food in comparison to their urban counterparts because of higher food prices, which are attributable to mainly transportation costs (Li, 2021). On the other hand, households with married heads spend significantly less on food per person than those households with a single head, possibly because they can take advantage of economies of scale, cook more at home, and spend less on food outside the home (Gerrior et al., 1995; Roos et al., 1998). Educational attainment, along with the marital and socio-economic status of household heads, therefore, affect food choices and expenditures (Fraser et al., 2000; Venn et al., 2018).

[18] Consumption has smaller seasonal fluctuations than income, especially in developing countries where households finance their consumption from their assets or credits to smooth their consumption even when there is little or no income (Deaton and Zaidi, 2002).

[19] A ger is a traditional Mongolian house that is built by assembling a wooden framework and covering it with traditional felt. It is the most portable and suitable dwelling for nomads. People live in gers in both rural and urban areas in Mongolia. In 2016, 40 percent of the total Mongolian population lived in gers, 36 percent in detached houses, and 24 percent in apartments (NSO, 2019).

I include income to estimate the preferred model and report the results in column 5. Although income significantly affects food expenditures, it does not alter the main finding. The positive and significant DiD estimate in column 5 indicates that mining activities may positively affect food consumption beyond the conventional income channel. Including income in the model reverses the household head's education and residential property signs; i.e., the coefficients become negative. These variables are highly correlated with income, and without the income variable, they have the expected signs, indicating that I could be over-controlling. Notably, the DiD estimate remains similar to columns 3 and 4. The adjusted R-squared of 0.41 in the preferred model in column 5 explains the variations in household food consumption reasonably well.

I next examine the impact of mining activities on household non-food expenditure as I have no *a prior* expectations about households' preferences for non-food items when local economic activities increase. The results presented in Columns 6, 7, and 8 of Table 4, indicate that mining taxes lead to a reduction in non-food expenditure. Specifically, a 10 percent increase in the collection of local taxes results in around a one percent reduction in non-food expenditure (Column 8). Although we previously observed that the absolute value of household non-food expenditure increased over time for the treatment households, it increased to a lesser extent than that of the control counterparts. While the elasticity of non-food expenditure is usually higher than that for food, the opposite may occur in low-income countries where the budget share for food may increase as income rises (Almås, 2012). My results indicate that the treatment households spend more on food and less on non-food items. For example, Bhalotra and Attfield (1998) report that low-income households in rural Pakistan spent nearly all of their additional income on food, indicating a higher elasticity for food expenditure than for non-food spending. Similarly, Hasan (2016) find that households in Bangladesh, a low-income country, initially increased their budget share for food when their incomes rose.

The results reported in this study provide additional evidence on the economic benefits realized by local communities when large-scale mining occurs. Overall, the results in Table 4 highlight that the treatment households modify their consumption patterns when local economic activities increase as large-scale mining development commences. The findings align with other studies that examine the effect of mining on welfare. For example, mining appears to have a positive impact on household consumption around a large-scale gold mine and to reduce poverty in mining districts in Peru (Aragón and Rud, 2013; Loayza and Rigolini, 2016). Bazillier and Girard (2020) also find that a 1.2 percent increase in household consumption near artisanal and small-scale gold mines in Burkina Faso is associated with a 10 percent increase in gold prices. Similarly, in developed country context, a coal seam gas discovery increased median household incomes in Southern Queensland, Australia, and oil and gas endowments resulted in real wage increases in U.S counties (Fleming and Measham, 2015; Allcott and Keniston, 2017).

4.1.2. EFFECT ON HEALTH AND EDUCATIONAL OUTCOMES

The health and education outcomes of the local population are primary pillars of sustainable economic growth and development in mining regions in developing countries. Public and private investments resulting from mining activities can improve local health and education outcomes, which benefit the population in the long run (Stijns, 2006; Mousavi and Clark, 2021). Therefore, I examine whether large-scale mining activities affect household health and educational outcomes and report the analysis of household medical expenditure in Table 5. The DiD estimate in column 1 is positive but statistically insignificant. However, as soon as I include the household-specific control variables in column 2, the results are significant at the conventional level, indicating that a 10 percent rise in local taxes increases medical expenditure by 0.8 percent. The result remains similar with the inclusion of household income in the model.

The results in Table 5 provide evidence that the treatment households increase their medical expenditure, which could result from two possibilities. First, increased health care expenses could mean that local people living nearby the mine experience more frequent or severe illnesses than their counterparts. Studies in other countries sometimes reported such an outcome. For example, the incidence of anemia among women and stunting in children in 44 resource-rich developing countries were higher for those who live in the proximity of mines that release lead contamination than those who live further away (von der Goltz and Barnwal, 2019). Similarly, pollution from gold mines appears to reduce productivity in rural areas in Ghana (Aragón and Rud, 2013) and individuals living within five kilometers of a mine have a higher likelihood of reporting illness in Mongolia (Narantungalag et al., 2021).

Therefore, I examine whether the likelihood of reporting illness increases with mining activities in Southgobi. I estimate Equation 1 for individuals using the linear probability, probit and logit

Table 5: **Regression results of DiD models of the mining impact on medical expenditure**

Variable	(1)	(2)	(3)
Ln(local taxes) × mining	0.053	0.080**	0.079**
	(0.036)	(0.033)	(0.031)
2012	0.585***	0.546***	0.217***
	(0.070)	(0.068)	(0.070)
2014	0.900***	0.835***	0.420***
	(0.065)	(0.065)	(0.069)
2016	1.236***	1.110***	0.648***
	(0.064)	(0.063)	(0.067)
Household head's age (years)		0.032***	0.026***
		(0.001)	(0.001)
Household head is male		0.092**	-0.008
		(0.045)	(0.043)
Household head's education (years)		0.023***	0.008**
		(0.003)	(0.003)
Household head is married		-0.252***	-0.139***
		(0.040)	(0.038)
Ln(per capita income)			0.540***
			(0.024)
Lives in apartment/house		0.361***	0.166***
		(0.058)	(0.056)
Lives in rural area		-0.232***	-0.239***
		(0.046)	(0.045)
Province fixed effects	Yes	Yes	Yes
Adjusted R^2	0.15	0.27	0.33
Number of households	10,353	10,353	10,353

Note: All dependent variables are in per capita basis. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Column 1 runs the basic model with province and year fixed effects. Column 2 adds household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Column 3 adds log of household per capita income in the model.

models. In this setting, the dependent variable is a dummy variable taking the value of one for individuals who were ill in the month prior to the survey and zero otherwise. I include individual-specific control variables in the preferred specification and report the results in Table 6. The results from all three models without and with the control variables indicate that the probability of reporting illness does not increase significantly in Southgobi province. Since the results provide no evidence that mining is causing adverse health impacts on residents in Southgobi, I associate the positive health expenditure elasticity with higher income and access to health care services created by the mining industry.

Table 6: **Regression results of DiD models of the mining impact on the likelihood of reporting illness**

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Ln(local taxes) × mining	-0.004	-0.003	-0.003	-0.001	-0.003	-0.001
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
2012		-0.006		-0.007		-0.006
		(0.004)		(0.004)		(0.004)
2014		0.003		0.002		0.002
		(0.004)		(0.004)		(0.004)
2016		-0.007*		-0.008*		-0.007*
		(0.004)		(0.004)		(0.004)
Individual's age (years)		0.001***		0.001***		0.001***
		(0.000)		(0.000)		(0.000)
Individual is male		-0.015***		-0.013***		-0.013***
		(0.002)		(0.002)		(0.002)
Individual's education (years)		-0.002***		-0.001***		-0.001***
		(0.000)		(0.000)		(0.000)
Ln(per capita wage income)		-0.000		0.000		-0.000
		(0.000)		(0.000)		(0.000)
Lives in apartment/house		0.015**		0.013***		0.011**
		(0.006)		(0.005)		(0.004)
Lives in rural area		-0.031***		-0.027***		-0.025***
		(0.004)		(0.003)		(0.003)
Model	LPM	LPM	Probit	Probit	Logit	Logit
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2/Psedu R^2	0.00	0.02	0.01	0.05	0.01	0.05
Number of individuals	36,704	36,704	36,704	36,704	36,704	36,704

Note: Robust standard errors, clustered at the household level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1, 3 and 5 run the basic models with province and year fixed effects. Columns 2, 4 and 6 add individual-specific controls to the specification. The reference groups is female, living in traditional gers and urban areas.

The other reason for the increased medical expenditure of households in Southgobi is the availability of improved health care services and facilities. The provincial government capital investment in the health sector in Southgobi increased from less than one percent of total provincial government expenditures in 2009. However, it increased to four and five percent in 2011 and 2014, respectively, marking the highest level of capital investment during 2008-2016 (NSO, 2019; SHD, 2020).[20] Such an increase in the health sector investment in Southgobi also reflects the overall impact of the mining industry in 2010-2014, when the country experienced its highest economic growth rates. In addition, OT provided training and scholarships for doctors and nurses on medical waste management, first aid and supplied hospital equipment to various towns within the province between 2012-2013 (Oyu Tolgoi, 2018). Hence, the increased public investment in the health sector and the

[20] At the same time the percentage of health expenditure to total central government budget expenditures dropped to seven percent in 2016 from nine percent in 2008 (NSO, 2019).

additional support from the mining company can strengthen the capacity, quality, and accessibility of health care services in Southgobi. Such improvements allow people to spend more on their health care by relaxing the supply constraints on medical services.[21]

The findings on medical expenditure and health outcomes in Southgobi province align with the population health statistics. For example, the monthly under-five mortality rate per 1,000 live births was below the national median, dropping to 16 in 2016 from 23 in 2009. In contrast, other provinces made slower progress. Although the new cases of cancer reported per 10,000 population rose by 4-9 percent annually on average across the provinces in the study, the growth in mortality rate from cancer per 10,000 population remained similar across Southgobi and two of the control provinces, Dundgovi and Uvurkhangai (NSO, 2019). The increased number of new cases of cancers can also be linked to better health services as people are more likely to be diagnosed with such illnesses when health services are improved. Therefore, my results point out that local communities increase their medical expenditure because of improved and more accessible health care services.

I now investigate the effects of mining activities on household education expenditure in Table 7. The DiD estimate in the baseline model is negative and only marginally significant at the 10 percent level. However, the results with additional control variables in columns 2 and 3 are negative and significant, indicating that a 10 percent rise in the collection of mining taxes leads to a decline of 2.1 percent in per capita education expenditure (column 3). Furthermore, an increase in income reduces education expenses, as indicated by the model's log of per capita income variable. This shows that households in Southgobi do not increase their education expenditure even if their incomes rise.

I associate this pattern of education expenditure with two potential mechanisms: young people seeking higher incomes in the mining sector and improved access to schools, vocational education, and scholarships provided by OT at no cost. First, the lower expenditure on education could mean that younger people may substitute their additional years of education for higher incomes when the mining sector is booming. Some previous studies find that natural resource extraction negatively affects educational attainment, and reduces test scores and college enrolment levels (e.g., Douglas and Walker, 2017; Santos, 2018; Ahlerup et al., 2020; Mejía, 2020). Conversely, oil windfall revenues led to an increase in the number of teachers and classrooms in Brazilian municipalities (Caselli and

[21] Note that such programs proved to be useful for health promotion. For example, infant mortality declined in African localities. Large-scale gold-mining spurred local economic growth and improved access to health care information, contributing to the effective treatment of child diarrhea (Tolonen, 2018).

Michaels, 2013). Hence, I examine whether mining activities affect educational outcomes negatively in Southgobi.

Table 7: **Regression results of DiD models of the mining impact on education expenditure**

Variable	(1)	(2)	(3)
Ln(local taxes) × mining	-0.133*	-0.213***	-0.210***
	(0.077)	(0.067)	(0.069)
2012	-0.394***	-0.326***	0.541***
	(0.141)	(0.125)	(0.132)
2014	-0.428***	-0.340***	0.752***
	(0.140)	(0.128)	(0.139)
2016	-0.757***	-0.524***	0.693***
	(0.136)	(0.125)	(0.140)
Household head's age (years)		-0.085***	-0.069***
		(0.003)	(0.003)
Household head is male		-1.796***	-1.530***
		(0.136)	(0.127)
Household head's education (years)		0.054***	0.093***
		(0.009)	(0.009)
Household head is married		3.097***	2.800***
		(0.113)	(0.106)
Ln(per capita income)			-1.422***
			(0.062)
Lives in apartment/house		-0.393***	0.122
		(0.139)	(0.137)
Lives in rural area		-0.413***	-0.396***
		(0.087)	(0.088)
Province fixed effects	Yes	Yes	Yes
Adjusted R^2	0.01	0.23	0.28
Number of households	10,353	10,353	10,353

Note: All dependent variables are in per capita basis. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Column 1 runs the basic model with province and year fixed effects. Column 2 adds household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Column 3 adds log of household per capita income in the model.

I estimate Equation 1 for individuals using the OLS and ordered logit models. The outcome variable is each household member's years of schooling above six, and I add individual-specific control variables in the preferred specifications. The results in Table 8 from both models are positive and significant. It implies that the increase in educational attainment in Southgobi is significantly higher than those of the control group over the period. Thus, I reject the hypothesis that school enrollment is low and conclude that mining activities positively impact educational outcomes for Southgobi residents while allowing them to spend less on education services than their control counterparts.[22] The reduction in education expenditure may be attributable to the availability of new schools, kindergartens, vocational education centers, and tertiary scholarships provided by OT through its corporate social responsibility investments (Oyu Tolgoi, 2018). This allows households to spend less on education while achieving better educational outcomes.

Table 8: **Regression results of DiD models of the mining impact on educational attainment**

	OLS		Ordered-logit	
Variable	(1)	(2)	(3)	(4)
Ln(local taxes) × mining	0.122**	0.147***	0.067***	0.070***
	(0.058)	(0.054)	(0.021)	(0.020)
2012	0.882***	0.164	0.194***	-0.077**
	(0.108)	(0.104)	(0.037)	(0.039)
2014	0.864***	0.065	0.171***	-0.105***
	(0.097)	(0.102)	(0.033)	(0.037)
2016	1.094***	0.051	0.334***	-0.041
	(0.095)	(0.100)	(0.033)	(0.037)
Individual's age (years)		0.079***		0.030***
		(0.002)		(0.001)
Individual is male		-0.711***		-0.283***
		(0.050)		(0.018)
Ln(per capita income)		0.822***		0.313***
		(0.052)		(0.020)
Lives in apartment/house		1.482***		0.674***
		(0.113)		(0.046)
Lives in rural area		-1.019***		-0.418***
		(0.069)		(0.026)
Province fixed effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.02	0.15		
Pseudo R^2			0.00	0.03
Number of individuals	32,552	32,552	32,552	32,552

Note: Robust standard errors, clustered at the household level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1 and 3 run the basic models with province and year fixed effects. Columns 2 and 4 add individual-specific controls to the specification. The reference groups is female, living in traditional gers and urban areas.

The results from Tables 5–8 confirm that the residents in Southgobi are better off with the large-scale copper-gold mine development in their localities. I observe that the treatment households increase their medical expenditure, but they do not report illness more than their control counterparts. Although they reduce their educational expenses, their educational attainments are

[22]For example, the number of full-time students enrolled in the general education schools in Southgobi remained at 10.5 thousand during 2009-2011, and declined slightly to 10.4 thousand in 2012-2013 and then increased to 11.4 thousand in 2016. On the other hand, the number of students in the three other neighboring provinces was in decline, while it increased slightly in one of the control provinces in the same period (NSO, 2019).

significantly higher than those in the neighboring provinces. Together these findings highlight that examining household expenditure patterns at a disaggregated level provides useful information about the potential social benefits of large-scale mining activities, complementing the findings of previous studies such as Douglas and Walker (2017); Tolonen (2018) and Mejía (2020).

4.1.3. EFFECT ON ELECTRICITY AND OTHER NON-FOOD EXPENDITURES

My final investigation looks at whether the large-scale mining activities have a discernible impact on expenditures on electricity and other non-food items, including clothing, transportation, and communication services. Resource extraction and utilization require large-scale infrastructure development such as power plants, roads, and rail networks for operating mines and transporting commodities (Michaels, 2011; Collier and Laroche, 2015; Bonfatti and Poelhekke, 2017; De Haas and Poelhekke, 2019). I investigate whether the OT mining region households benefit from such infrastructure development.

The results from the analysis of expenditure on electricity and other non-food items are presented in Table 9. The DiD estimate in column 3 shows that electricity expenditure increases by 2.6 percent when there is a 10 percent increase in the collection of mining taxes and fees. The higher expenditures relate to the increased generation and supply of electricity in the mining region, with the central government and the mining company jointly supporting the development of power supply infrastructure. The central government built a power transmission line and substation connected to the central grid system in 2013 in Southgobi, which ensured permanent access to electricity for households in Southgobi (Ministry of Energy, 2013). In addition, OT connected two Southgobi towns, which had intermittent electricity supply, to the central electric grid (Oyu Tolgoi, 2018). Therefore, households have a permanent electricity supply due to increased public and private investment, raising household consumption and expenditure on power.

The final outcome variable I examine is household expenditures on other non-food items. The DiD estimates for all models in columns 4-6 in Table 9 are negative and significant. The results from the preferred model indicate that a 10 percent increase in the collection of local mining taxes and fees reduces expenditures on other non-food items by 0.8 percent (column 6). As expected, these results are similar to the findings in Table 4 and confirm that the treatment households increased their expenditures on non-food items, excluding medical services and electricity, to a lesser extent than the control households in the neighboring provinces.

Table 9: **Regression results of DiD models of the mining impact on electricity and other non-food expenditures**

	ln(electricity)			ln(other non-food)		
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Ln(local taxes) × mining	0.322*	0.259**	0.258**	-0.081***	-0.095***	-0.096***
	(0.186)	(0.122)	(0.121)	(0.022)	(0.020)	(0.015)
2012	1.049***	0.723***	0.588***	0.564***	0.545***	0.101***
	(0.276)	(0.191)	(0.193)	(0.043)	(0.040)	(0.033)
2014	0.665**	0.283	0.114	0.868***	0.838***	0.279***
	(0.319)	(0.204)	(0.209)	(0.041)	(0.037)	(0.032)
2016	1.658***	1.002***	0.813***	0.833***	0.771***	0.149***
	(0.301)	(0.199)	(0.200)	(0.040)	(0.037)	(0.032)
Household head's age (years)		0.021***	0.018***		0.005***	-0.004***
		(0.003)	(0.003)		(0.001)	(0.000)
Household head is male		-0.592***	-0.633***		0.162***	0.027
		(0.100)	(0.101)		(0.025)	(0.019)
Household head's education (years)		0.243***	0.237***		0.035***	0.015***
		(0.008)	(0.009)		(0.002)	(0.002)
Household head is married		-0.220**	-0.174*		-0.087***	0.065***
		(0.091)	(0.092)		(0.023)	(0.017)
Ln(per capita income)			0.221***			0.728***
			(0.062)			(0.016)
Lives in apartment/house		0.583***	0.503***		0.345***	0.081***
		(0.126)	(0.132)		(0.036)	(0.025)
Lives in rural area		-3.063***	-3.066***		-0.067**	-0.076***
		(0.116)	(0.116)		(0.027)	(0.021)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.08	0.39	0.39	0.21	0.27	0.58
Number of households	10,353	10,353	10,353	10,353	10,353	10,353

Note: All dependent variables are in per capita level. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1, 3 and 5 run the basic models with province and year fixed effects. Columns 2, 4 and 6 add household-specific controls to the specification. The reference groups is female, never married, separated or widowed, living in traditional gers and urban areas.

The observed changes in non-food consumption expenditures may come about for the following reasons. First, it appears that households are increasing their food consumption by significantly reducing their expenditures on non-food items. Second, the treatment households may have more varieties of non-food goods offered at more competitive prices in the local markets than the control households. For example, De Haas and Poelhekke (2019) find that mining activities have a positive impact on firms in non-tradable sectors within the immediate vicinity of the mines and positive overall spending effects on firms further away. Therefore, households may face more competitive prices and consumption opportunities because more goods and services become locally available following increased economic activities resulting from mining activity (Papageorgiou and Thisse, 1985).

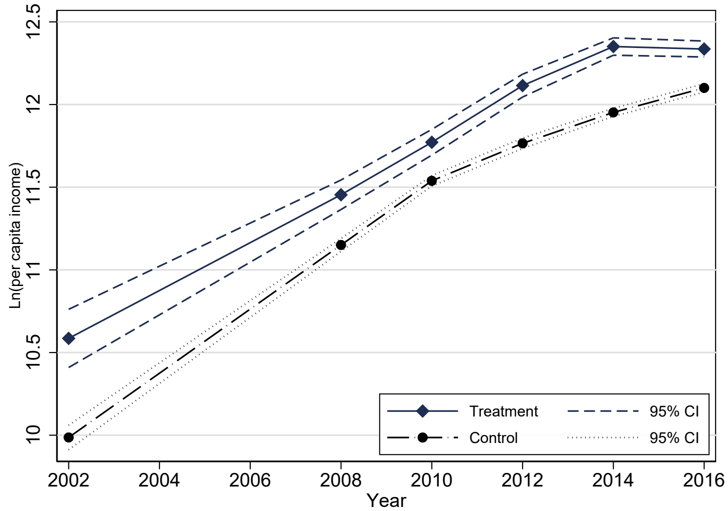
4.2. Common trend

The validity of DiD model relies on the common trend assumption as discussed previously. The earliest HSES round that I have available to examine the common trend is the 2002 round, the first HSES Mongolia conducted using the internationally applied methodology for the household survey. However, the 2002 round lacks data for the critical control variables used in my empirical specifications. Therefore, I examine the common trend assumption visually, using the key dependent variables such as income, food, and non-food expenditures in Figure 5.

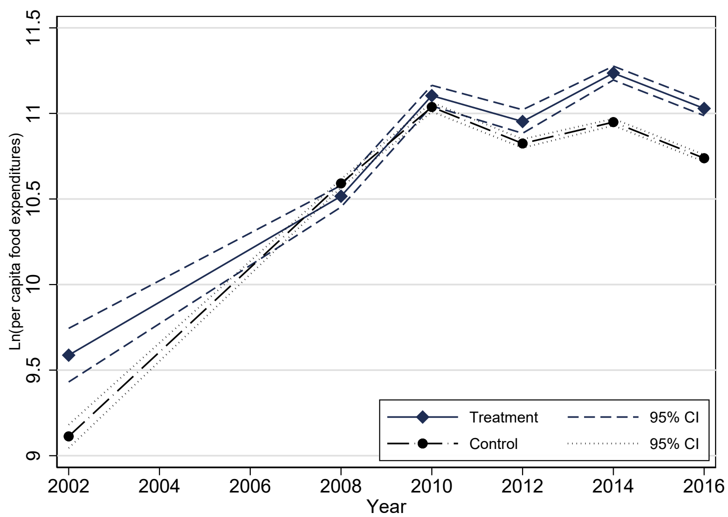
Panel A plots the log of monthly per capita real income and shows that the incomes of treatment and control households had similar patterns until 2010. Although there was a slight increase in the incomes of the treatment households over the period 2012-2016, an apparent divergence between both groups did not occur, suggesting that the impact of mining activities on income is negligible. Panel B shows that although the treatment households had higher food expenditures in 2002, both groups had similar food expenses, which grew in parallel in 2008-2010. After 2012, the difference in food expenditure between the treatment and control households increased, with the treatment households increasing their food expenditure at a higher rate than the control households. The common trend observed in food expenditure confirms the validity of the DiD model. The picture is less clear for the non-food expenditures in Panel C as the expenditures of both groups seem to follow similar patterns. The reason is that the non-food expenditures comprise expenses for many different types of goods and services consumed by households. However, the disaggregated expenditures on health, education, and electricity items analyzed empirically show significant differences between the two groups. Overall, the common trend assumption is likely to be valid.

4.3. Robustness checks

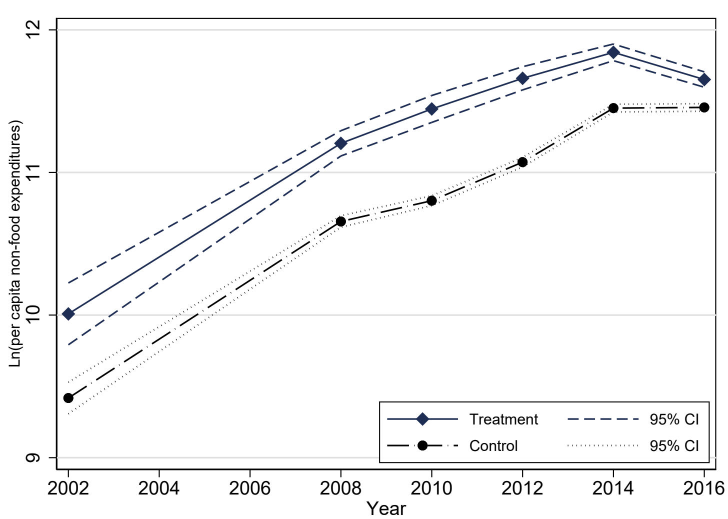
I perform additional robustness checks to confirm that the main results are consistent with data, model, and methods modifications. First, I employ a traditional DiD model that uses dummy variables to show that the choice of my independent variable, local mining taxes and fees, does not



Panel A: Household income



Panel B: Household food expenditure



Panel C: Household non-food expenditure

Figure 5: Monthly income, food and non-food consumption, 2002-2016
Source: NSO (2019)

drive the results. In this model, the base year is 2008, and *After* is an indicator variable taking the value of one for the years after 2012.[23] The interaction term between Southgobi and *After* is the DiD estimate–the variable of interest. I estimate the DiD models with the household-specific controls on all outcome variables from Tables 4, 5, 7 and 9. The DiD estimates presented in Table B.1 are in line with my main findings, providing evidence that large-scale mining activities have a significant impact on household expenditures. Although the effects on household medical and electricity expenditures are statistically insignificant, the coefficient estimates are high and economically significant.

In the main analysis, I used local taxes and fees paid to the provincial government to measure mining activities. Mining taxes and fees are preferred because they indirectly link to the local economy when the backward and forward linkages are limited because of local market constraints. The subnational government spends these mining-related revenues to provide public services and invest in infrastructure and health and education sectors. However, there are other direct and indirect linkages to the local economy, which can affect household expenditures.

Thus, I next examine two competing variables that can capture the impact of mining activities on household expenditures. They are wages paid to employees (proxied by taxes paid for employee social security and medical insurance) and corporate social responsibility (CSR) investment made by the mining company. In modeling household expenditures, health, and education outcome variables, I use wages paid by the company to its employees as a proxy for mining activities and repeat Tables 4–9. The results indicate that mining wages also have a significant impact on household consumption and health and educational outcomes in the mining region (Tables C.1 – C.6). Note that the coefficient magnitudes are likely to be underestimated because the wages in the neighboring regions can also increase due to the high economic growth experienced in the country during the period of my analysis, leading to a smaller effect of mining wages on the components of household expenditures.

Third, I use CSR investment as a proxy for mining activities, and the results also indicate that there are similar significant effects on household expenditures (Tables C.7 – C.12). I observe that

[23] I estimate the following conventional DD model: $y_i = \delta + \gamma D_s + \beta_t(\eta_t \times D_s) + \eta_t + \alpha_s + X_i\Theta + \varepsilon_i$, where, in addition to the previous notations, η_t is a dummy taking the value of one for the years after 2012, and zero otherwise. The results also remain robust when I use a flexible DiD model with the interaction of Southgobi with each year, instead of $After$.

the effects of both mining wages and CSR investment on medical and electricity expenditures are positive but statistically insignificant. These outcomes could result because local taxes and fees already capture some of their effects.

Fourth, I undertake the analyses on a household rather than per capita basis. In this case, I employ household-level outcome variables and include household size in all models. Again, the DiD estimates with the household-level variables support the main findings (Tables D.1 – D.6). Although the estimates for educational expenditures are only marginally significant at the 10 percent level, they are consistent with the main results.

Finally, I examine whether variables in per capita terms affect my results. I explore this because there are economies of scale in household consumption, while demographic factors may also affect consumption levels. Income and consumption analyses widely utilize equivalence scales to address those issues (Bishop et al., 2014). Two well-known equivalence scales – the square root of family size (SRFS) and OECD equivalence scale are used (Schwarze, 2003; Breunig et al., 2019). The former takes the square root of the number of family members to adjust the household size. The latter assigns one to the first adult and adds 0.5 for an additional adult and 0.3 for an extra child in the household. The models using the equivalized variables, the SRFS (Tables E.1 – E.6) and OECD scale (Tables F.1 – F.6), produce qualitatively similar results, supporting my main findings.

The overall results of this study highlight that large-scale mining activities significantly affect household consumption patterns in nearby communities. The treatment households increase their food consumption more than those who are not directly affected by large-scale mining activities. They also display a greater increase in their medical and electricity expenditures than their counterparts, although their educational expenditures are lower. While increased mining activities do not adversely affect the health of residents, educational outcomes improve in the mining region. Hence, my findings indicate that large-scale mining activities positively affect local residents' living standards.

5. Discussion and policy implications

This study documents some local economic benefits of early-stage large-scale mining activities on household expenditure patterns. I associate the significant changes in household food and non-food expenditures with increased local economic activities resulting from the investment in and development of a large-scale copper-gold mine. In particular, I use local taxes and fees paid by the large-scale mining company as a proxy for mining activities to arrive at three main findings.

First, the households living in the mining region increase their food expenditure relative to those living in the neighboring provinces. This positive outcome in food consumption highlights that households living in remote rural regions in developing countries have unmet food demands. Increased spending by the local government, financed by mining tax revenues, and lower transportation costs enabled by mining-related infrastructure development can increase the supply and variety of food and local produce in the market. Previous studies such as Aragón and Rud (2013), Lippert (2014) and Loayza and Rigolini (2016) find that real incomes and consumption increased in mining areas. My study establishes the causal link between mining activities and household food consumption.

Second, I observe that households also increase their expenditure on health care and services more than those not affected by large-scale mining. Consequently, I examine whether the higher medical expenditure is due to either increased illness or the availability of health care services. I find that individuals in the large-scale mining province do not report illness significantly more than their control counterparts. Thus, I associate higher spending on medical services with the increased availability of health care enabled by provincial government capital investment in the health sector. This finding to some extent, aligns with Tolonen (2018) who report that local industrial shocks such as mining activities spurred economic growth and created jobs, which reduced infant mortality. However, my results contrast with Aragón and Rud (2015) and von der Goltz and Barnwal (2019) who find that pollution from mining activities increases morbidity in resource-rich developing countries.

Third, the educational expenditures of the households in the mining region decline despite their increased incomes. My subsequent investigation of mining activities' effect on educational outcomes confirms that individuals' years of schooling increased significantly more than in the control group in the neighboring provinces. Earlier studies on the effects of natural resource extraction on human capital find that school drop-outs increase, and test scores and college enrolments decline in the presence of mining activities (Douglas and Walker, 2017; Zuo et al., 2019; Mejía, 2020; Ahlerup et al., 2020). However, I argue that the positive impact on educational outcomes is driven by CSR, which supports increased availability of schools, training centers, and additional financial support for tertiary education, as argued in other studies such as Stijns (2006, 2009) and Mousavi and Clark (2021).

I also find that households increase their electricity expenditure in the mining region as a result of increased investment in the energy sector and improved availability of electricity. Households reduce their expenditures on other non-food goods and services by increasing their expenses on food, medical care, and electricity. The increased spending on food and health care will benefit residents over time in the province with the large-scale mine. A higher level of nutrition and better access to health care will improve people's quality of life and increase their life-expectancy. In addition, higher educational outcomes, coupled with better health, will raise productivity, which is essential to sustainable growth and development of the mining region, including when mining operations cease in the future (Cust and Poelhekke, 2015; Venables, 2016).

The results of this study highlight that the mining sector's indirect channels such as local taxes for real estate and automobile use, along with fees on the use of land and water paid by mining companies, positively affect household consumption patterns. My investigation of disaggregated expenditures points out that households make their spending decisions based on their unmet food demands and increased availability of health and education services. These findings show that households prioritize the consumption of essential items such as food and expenditures that positively impact their future well-being, such as those on health and electricity, over other non-food goods and services. Importantly, reducing expenditure on education without reducing their service intake was possible due to the support of the mining company and local governments on that sector. The same is likely to be true for expenditure on other non-food items. Therefore, in addition to managing windfall revenues from the mining sector, resource-rich developing countries should ensure that some taxes and fees accrue to the local governments, which have a better understanding of local development needs. My findings also indicate that using household aggregate income or consumption may not indicate the magnitude of the positive impact when people enjoy a higher share of public benefit.

It is important to note two potential issues with this study. First, I investigated the impacts of a foreign-invested mega-mining project, Oyu Tolgoi, which has significantly higher capacity, scale, and resource use needs than mines smaller in size. While the results reported in this study are important, there remain some unresolved issues related to the investment agreement for Oyu Tolgoi, which may affect the positive outcomes in the local community in the future. Second, the study only focused on the short-run gains from mining as I only examined the effects occurring in the mine's early development and operational periods. Although I can infer that the short-run improvement in health, education, and food availability will provide long-run benefits, future research should examine the *ex-post* gains, focusing on the intermediate/outcome welfare indicators.

6. Conclusion

The current study finds that large-scale extractive industries can positively affect residents in developing countries by employing the difference-in-differences models with several rounds of recent household survey data from Mongolia. I provide robust evidence that increases in mining-related local taxes and fees result in increased household spending on food, health care, and electricity in the mining region. At the same time, households reduce their expenditures on education and other non-food items. These outcomes result from a large-scale mine's investment and development in the resource-producing region.

Three findings of the study are of particular importance. First, households in the mining region increase their food consumption relative to those in neighboring provinces. Second, household expenditure on health care in the mining area increases, but individuals in the area do not report illness more than their control counterparts. Third, households spend less on education, but their schooling years are significantly higher than the control group. Thus, my study highlights that households in the mining region prioritize their spending decisions based on unmet demands for basic needs such as food, electricity, and health care by reducing their expenses on education and other non-food items. Importantly, local government and mining companies support on education allowed people to reduce expenditure on that category without reducing their educational attainment. The increased food consumption and positive health and educational outcomes will assist in sustainable growth and development in the mining region now and in the future.

My investigation extends the literature on the effect of the mining sector's indirect linkages on the local economy by providing a detailed analysis of household expenditure patterns. Specifically, this study emphasizes that using household aggregate income or consumption may not indicate the extent of the positive impact of mining activities, as shown in this paper. The findings emphasize the importance of appropriate policy settings where local governments collect taxes for the use of local resources such as land and water by the extractive industries and use the proceeds for the benefit of local communities who might otherwise be negatively affected.

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A. Impact of mining: sub-national differences

Both large and small-scale mining activities take place across Mongolia. The mining sector's production comprises at least 40 percent of the provincial GDP in provinces where large-scale mining occurs. In contrast, mining activities make up less than five percent of provincial GDP in other provinces without large-scale mines (NSO, 2019). Therefore, examining the mining sector's impact at the sub-national level is useful to analyze and understand outcomes at the micro-level subsequently. Following the definition of Auty (1993) for a resource-rich country, I categorize nine provinces as resource-rich, mining provinces as at least eight percent of their annual provincial GDP comes from the mining sector for the period 2010-2018.[24] The remaining 12 are non-mining provinces. Table A.1 presents the list of provinces with the categorization.

I examine sub-national effects, reflecting the importance of mining to provincial economies, through VAR analyses of macroeconomic variables. I investigate the following three-variable autoregressive process, separately for mining and non-mining provinces:

$$Y_{i,t} = A + B \times Y_{i,t-1} + e_{it} \tag{2}$$

where,

$$Y_{i,t} = \begin{bmatrix} Y_{i,t}^1 \\ Y_{i,t}^2 \\ Y_{i,t}^3 \end{bmatrix}, \quad A = \begin{bmatrix} a_{10} \\ a_{20} \\ a_{30} \end{bmatrix}, \quad B = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}, \quad e_{it} = \begin{bmatrix} \varepsilon_{i,t}^1 \\ \varepsilon_{i,t}^2 \\ \varepsilon_{i,t}^3 \end{bmatrix},$$

and $Y_{i,t}^1, Y_{i,t}^2, Y_{i,t}^3, a_{m0}, a_{mn}$, and ε^m indicates the natural logarithm of mining sector's production, GDP and government revenue, intercepts, coefficients, and error terms, respectively. All three macroeconomic variables are on per capita basis. I use provincial level macroeconomic panel data available for the period 2010-2018.

I use the Cholesky decomposition to create the impulse response functions from the VAR system to analyze the impact of the mining sector on the provincial economy. The Cholesky decomposition constrains the VAR system such that the shock ($\epsilon_{i,t}^3$) from the least exogenous series ($Y_{i,t}^3$) has no

[24] I excluded the capital city Ulaanbaatar from the analysis because it is a separate urban area that is different from all provinces in terms of market size, population, and economic structure.

direct effect on the most exogenous series ($Y_{i,t}^1$), while forcing a significant asymmetry on the system (Sims, 1980; Enders, 2010). Changes in provincial GDP per capita are likely to influence the government revenue collection due to tax implications. However, it is unlikely that changes in revenue collected by the provincial government have an instantaneous effect on the GDP per capita. All series are in their natural logarithms and first differenced to satisfy the stationary condition.[25] I divided the panel into mining and non-mining provinces based on the criteria mentioned above.

Figure 4 shows the impulse response functions for mining sector production, GDP, and government revenue, to a one standard deviation shock in the mining sector production. Panel (a) relates to the mining provinces. The top graph shows the response of the mining sector production to its one standard deviation shock. The mining sector production increases by 0.45 percent in the same year, then declines up to year four, increases up to year six, and reaches long-term stability after year eight. GDP increases by a little more than 0.1 percent in year one to a one standard deviation shock in the mining sector production in the following graph. GDP grows in the second year, and then the response is insignificant. Although the mining sector production shock increases the provincial government revenue up to year four, the effect is not significantly different from zero. Overall, a shock in mining sector production has positive effects on GDP and government revenue in the mining provinces in the short-run.

[Figure 4]

Panel (b) in Figure 4 shows the impulse response functions for non-mining provinces. A one standard deviation shock in the mining sector production causes itself to increase by 0.8 percent in the same year in the top graph. The non-mining provinces' response is higher than that of mining provinces because of the mining sector's volatility in non-mining provinces. After year two, the mining sector production response remains negative until year four and becomes insignificant after that. However, provincial GDP and government revenue drop by less than 0.02 percent and more than 0.1 percent, respectively, in year one and stay around zero. Overall, the impulse response functions for non-mining provinces reveal that mining sector production does not significantly affect GDP and government revenue in these provinces. The results of VAR model indicate that the mining provinces predominantly realize the benefits of mining activities.

[25] I performed panel unit root tests for serial correlation. The Johansen test results, available from the author upon request, confirm that the three variables are not cointegrated and meet the VAR model requirement.

Table A.1: **Categorization of mining and non-mining provinces in Mongolia**

Province	Mining production	Government revenue	GDP	% of Mining in GDP	Mining
Arkhangai	13.40	489.25	3,513.74	0.31	Non-mining
Bayankhongor	316.01	542.09	3,451.97	7.50	Non-mining
Bayan-Ulgii	59.13	491.55	2,666.06	2.07	Non-mining
Bulgan	56.06	632.71	4,232.63	1.23	Non-mining
Darkhan-Uul	354.25	395.50	3,291.44	10.57	Mining
Dornod	3,741.44	509.94	6,674.69	51.42	Mining
Dornogovi	515.53	578.41	4,019.90	13.49	Mining
Dundgovi	34.04	653.75	4,448.71	0.73	Non-mining
Govi-Altai	242.63	680.51	3,458.76	5.40	Non-mining
Govisumber	1,039.53	715.17	4,062.97	25.98	Mining
Khentii	18.95	560.50	3,942.83	0.51	Non-mining
Khovd	84.66	521.77	3,144.19	2.29	Non-mining
Khuvsgul	273.52	485.65	3,242.44	6.93	Non-mining
Orkhon	9,714.98	782.80	13,251.47	75.53	Mining
Selenge	1,279.24	483.35	5,042.28	27.11	Mining
Southgobi	2,682.00	1,783.80	6,671.04	40.00	Mining
Sukhbaatar	1,734.61	624.14	5,343.96	32.83	Mining
Tuv	456.65	547.02	4,557.51	8.08	Mining
Uvs	223.98	556.64	3,278.32	5.66	Non-mining
Uvurkhangai	103.92	461.30	2,951.84	3.12	Non-mining
Zavkhan	62.39	605.09	3,656.78	1.48	Non-mining

Note: All variables are in thousand Mongolian Tugrik (MNT) and on per capita basis. The figures are an average of annual data for the period 2010-2018. Provinces are defined as mining provinces if at least 8 percent of the provincial GDP comes from the mining sector, following Auty (1993).

B. Alternative DiD approach

Table B.1: **The effect of mining on household income and expenditures: an alternative DiD approach**

Variable	ln(income) (1)	ln(food) (2)	ln(non-food) (3)	ln(medical) (4)	ln(education) (5)	ln(electricity) (6)	ln(other non-food) (7)
Southgobi	0.228***	-0.318***	0.351***	-0.134	0.339	-1.257***	0.407***
	(0.072)	(0.050)	(0.050)	(0.123)	(0.267)	(0.411)	(0.052)
2012	0.605***	-0.025	0.084**	0.205***	0.606***	0.591***	0.119***
	(0.036)	(0.023)	(0.035)	(0.075)	(0.139)	(0.204)	(0.035)
2014	0.764***	0.042**	0.225***	0.436***	0.744***	0.207	0.264***
	(0.033)	(0.021)	(0.033)	(0.070)	(0.141)	(0.209)	(0.033)
2016	0.852***	-0.227***	0.109***	0.667***	0.674***	0.918***	0.129***
	(0.032)	(0.022)	(0.032)	(0.068)	(0.140)	(0.197)	(0.033)
Southgobi × After	0.032	0.296***	-0.213***	0.175	-0.693***	0.290	-0.239***
	(0.070)	(0.052)	(0.053)	(0.126)	(0.267)	(0.400)	(0.055)
Household head's age (years)	0.012***	0.001***	-0.002***	0.026***	-0.069***	0.018***	-0.004***
	(0.001)	(0.000)	(0.000)	(0.001)	(0.003)	(0.003)	(0.000)
Household head is male	0.186***	0.084***	0.011	-0.007	-1.530***	-0.627***	0.026
	(0.022)	(0.016)	(0.018)	(0.043)	(0.127)	(0.101)	(0.019)
Household head's education (years)	0.027***	-0.007***	0.019***	0.009**	0.092***	0.239***	0.015***
	(0.002)	(0.001)	(0.002)	(0.003)	(0.009)	(0.009)	(0.002)
Household head is married	-0.208***	-0.214***	0.074***	-0.140***	2.797***	-0.181*	0.065***
	(0.021)	(0.014)	(0.017)	(0.038)	(0.106)	(0.092)	(0.017)
Ln(per capita income)		0.395***	0.689***	0.540***	-1.421***	0.221***	0.728***
		(0.011)	(0.016)	(0.024)	(0.062)	(0.062)	(0.017)
Lives in apartment/house	0.362***	-0.050**	0.093***	0.164***	0.127	0.498***	0.083***
	(0.034)	(0.022)	(0.025)	(0.057)	(0.137)	(0.131)	(0.025)
Lives in rural area	0.012	0.142***	-0.097***	-0.238***	-0.397***	-3.061***	-0.076***
	(0.021)	(0.016)	(0.020)	(0.045)	(0.088)	(0.117)	(0.021)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.33	0.41	0.57	0.33	0.28	0.39	0.58
Number of households	10,353	10,353	10,353	10,353	10,353	10,353	10,353

Note: All dependent variables are in per capita level. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. All columns run the preferred models with province and year fixed effects and household-specific controls. The reference groups is female, never married, separated or widowed, living in traditional gers and urban areas.

C. The impact of mining wages and CSR investment on household expenditures

Table C.1: **Regression results of DiD models of mining wages on income, food and non-food expenditures**

	ln(income)		ln(food)			ln(non-food)		
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(mine wages) × mining	0.002	0.001	0.014***	0.013***	0.012***	-0.007*	-0.008***	-0.009***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.004)	(0.003)	(0.002)
2012	0.620***	0.605***	0.215***	0.214***	-0.025	0.520***	0.501***	0.084**
	(0.037)	(0.036)	(0.027)	(0.028)	(0.023)	(0.046)	(0.042)	(0.035)
2014	0.793***	0.764***	0.349***	0.344***	0.042**	0.787***	0.751***	0.225***
	(0.034)	(0.033)	(0.024)	(0.023)	(0.021)	(0.041)	(0.036)	(0.033)
2016	0.918***	0.852***	0.129***	0.109***	-0.227***	0.767***	0.696***	0.109***
	(0.034)	(0.032)	(0.026)	(0.026)	(0.022)	(0.040)	(0.037)	(0.032)
Household head's age (years)		0.012***		0.006***	0.001***		0.006***	-0.002***
		(0.001)		(0.000)	(0.000)		(0.001)	(0.000)
Household head is male		0.186***		0.157***	0.084***		0.139***	0.011
		(0.022)		(0.019)	(0.016)		(0.023)	(0.018)
Household head's education (years)		0.027***		0.003**	-0.007***		0.038***	0.019***
		(0.002)		(0.001)	(0.001)		(0.002)	(0.002)
Household head is married		-0.208***		-0.296***	-0.214***		-0.069***	0.074***
		(0.021)		(0.017)	(0.014)		(0.022)	(0.017)
Ln(per capita income)					0.395***			0.689***
					(0.011)			(0.016)
Lives in apartment/house		0.362***		0.093***	-0.050**		0.342***	0.093***
		(0.034)		(0.022)	(0.022)		(0.035)	(0.025)
Lives in rural area		0.012		0.147***	0.142***		-0.088***	-0.097***
		(0.021)		(0.019)	(0.016)		(0.026)	(0.020)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.24	0.33	0.12	0.20	0.41	0.19	0.28	0.57
Number of households	10,353	10,353	10,353	10,353	10,353	10,353	10,353	10,353

Note: All dependent variables are in per capita level. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1, 3 and 6 run the basic models with province and year fixed effects. Columns 2, 4 and 7 add household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Columns 5 and 8 add log of household per capita income in the model.

Table C.2: **Regression results of DiD models of mining wages on medical expenditure**

Variable	(1)	(2)	(3)
Ln(mine wages) × mining	0.006	0.008	0.007
	(0.006)	(0.006)	(0.005)
2012	0.573***	0.532***	0.205***
	(0.075)	(0.073)	(0.075)
2014	0.907***	0.849***	0.436***
	(0.066)	(0.066)	(0.070)
2016	1.245***	1.128***	0.668***
	(0.064)	(0.064)	(0.068)
Household head's age (years)		0.032***	0.026***
		(0.001)	(0.001)
Household head is male		0.093**	-0.007
		(0.045)	(0.043)
Household head's education (years)		0.023***	0.009**
		(0.003)	(0.003)
Household head is married		-0.252***	-0.140***
		(0.040)	(0.038)
Ln(per capita income)			0.540***
			(0.024)
Lives in apartment/house		0.360***	0.164***
		(0.058)	(0.057)
Lives in rural area		-0.231***	-0.238***
		(0.046)	(0.045)
Province fixed effects	Yes	Yes	Yes
Adjusted R^2	0.15	0.27	0.33
Number of households	10,353	10,353	10,353

Note: All dependent variables are in per capita basis. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Column 1 runs the basic model with province and year fixed effects. Column 2 adds household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Column 3 adds log of household per capita income in the model.

Table C.3: **Regression results of DiD models of mining on the likelihood of reporting illness**

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Ln(mine wages) × mining	0.000	0.000	0.000	0.000	0.000	0.000
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2012		-0.007*		-0.008*		-0.007*
		(0.004)		(0.004)		(0.004)
2014		0.001		0.000		0.000
		(0.004)		(0.004)		(0.004)
2016		-0.009**		-0.010**		-0.009**
		(0.004)		(0.004)		(0.004)
Individual's age (years)		0.001***		0.001***		0.001***
		(0.000)		(0.000)		(0.000)
Individual is male		-0.015***		-0.013***		-0.013***
		(0.002)		(0.002)		(0.002)
Individual's education (years)		-0.002***		-0.002***		-0.001***
		(0.000)		(0.000)		(0.000)
Ln(per capita wage income)		-0.000		0.000		-0.000
		(0.000)		(0.000)		(0.000)
Lives in apartment/house		0.015**		0.013***		0.011**
		(0.006)		(0.005)		(0.004)
Lives in rural area		-0.032***		-0.027***		-0.025***
		(0.004)		(0.003)		(0.003)
Model	LPM	LPM	Probit	Probit	Logit	Logit
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2/Psedu R^2	0.00	0.02	0.01	0.05	0.01	0.05
Number of individuals	36,704	36,704	36,704	36,704	36,704	36,704

Note: Robust standard errors, clustered at the household level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1, 3 and 5 run the basic models with province and year fixed effects. Columns 2, 4 and 6 add individual-specific controls to the specification. The reference groups is female, living in traditional gers and urban areas.

Table C.4: **Regression results of DiD models of mining wages on education expenditure**

Variable	(1)	(2)	(3)
Ln(mine wages) × mining	-0.031***	-0.031***	-0.029***
	(0.012)	(0.011)	(0.011)
2012	-0.307**	-0.254*	0.606***
	(0.149)	(0.131)	(0.140)
2014	-0.389***	-0.343***	0.743***
	(0.142)	(0.130)	(0.141)
2016	-0.723***	-0.538***	0.674***
	(0.136)	(0.125)	(0.140)
Household head's age (years)		-0.085***	-0.069***
		(0.003)	(0.003)
Household head is male		-1.794***	-1.530***
		(0.136)	(0.127)
Household head's education (years)		0.054***	0.092***
		(0.009)	(0.009)
Household head is married		3.094***	2.797***
		(0.113)	(0.106)
Ln(per capita income)			-1.421***
			(0.062)
Lives in apartment/house		-0.388***	0.127
		(0.139)	(0.137)
Lives in rural area		-0.414***	-0.397***
		(0.087)	(0.088)
Province fixed effects	Yes	Yes	Yes
Adjusted R^2	0.01	0.23	0.28
Number of households	10,353	10,353	10,353

Note: All dependent variables are in per capita basis. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Column 1 runs the basic model with province and year fixed effects. Column 2 adds household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Column 3 adds log of household per capita income in the model.

Table C.5: **Regression results of DiD models of mining wages on educational attainment**

	OLS		Ordered-logit	
Variable	(1)	(2)	(3)	(4)
Ln(mine wages) × mining	0.015*	0.016*	0.008**	0.008**
	(0.009)	(0.008)	(0.003)	(0.003)
2012	0.853***	0.139	0.181***	-0.090**
	(0.112)	(0.108)	(0.039)	(0.040)
2014	0.875***	0.087	0.179***	-0.095***
	(0.098)	(0.102)	(0.033)	(0.037)
2016	1.110***	0.079	0.345***	-0.029
	(0.094)	(0.100)	(0.033)	(0.036)
Individual's age (years)		0.079***		0.030***
		(0.002)		(0.001)
Individual is male		-0.711***		-0.283***
		(0.050)		(0.018)
Ln(per capita income)		0.822***		0.313***
		(0.052)		(0.020)
Lives in apartment/house		1.482***		0.673***
		(0.113)		(0.046)
Lives in rural area		-1.019***		-0.418***
		(0.069)		(0.026)
Province fixed effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.02	0.15		
Pseudo R^2			0.00	0.03
Number of households	32,552	32,552	32,552	32,552

Note: Robust standard errors, clustered at the household level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1 and 3 run the basic models with province and year fixed effects. Columns 2 and 4 add individual-specific controls to the specification. The reference groups is female, living in traditional gers and urban areas.

Table C.6: **Regression results of DiD models of mining wages on electricity and other non-food expenditures**

	ln(electricity)			ln(other non-food		
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Ln(mine wages) × mining	0.018	0.012	0.012	-0.007**	-0.009***	-0.010***
	(0.027)	(0.017)	(0.017)	(0.004)	(0.003)	(0.002)
2012	1.043***	0.725***	0.592***	0.576***	0.560***	0.119***
	(0.281)	(0.203)	(0.204)	(0.046)	(0.043)	(0.035)
2014	0.773**	0.376*	0.208	0.851***	0.820***	0.264***
	(0.307)	(0.204)	(0.209)	(0.041)	(0.037)	(0.033)
2016	1.782***	1.107***	0.919***	0.812***	0.749***	0.129***
	(0.282)	(0.196)	(0.197)	(0.040)	(0.038)	(0.033)
Household head's age (years)		0.021***	0.018***		0.005***	-0.004***
		(0.003)	(0.003)		(0.001)	(0.000)
Household head is male		-0.586***	-0.627***		0.161***	0.026
		(0.100)	(0.101)		(0.025)	(0.019)
Household head's education (years)		0.245***	0.239***		0.035***	0.015***
		(0.008)	(0.009)		(0.002)	(0.002)
Household head is married		-0.227**	-0.181*		-0.087***	0.065***
		(0.091)	(0.092)		(0.023)	(0.017)
Ln(per capita income)			0.221***			0.728***
			(0.062)			(0.017)
Lives in apartment/house		0.578***	0.498***		0.347***	0.083***
		(0.126)	(0.131)		(0.037)	(0.025)
Lives in rural area		-3.059***	-3.061***		-0.068**	-0.076***
		(0.117)	(0.117)		(0.027)	(0.021)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.08	0.39	0.39	0.20	0.27	0.58
Number of households	10,353	10,353	10,353	10,353	10,353	10,353

Note: All dependent variables are in per capita level. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1 and 4 run the basic models with province and year fixed effects. Columns 2 and 5 add household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Columns 3 and 6 add log of household per capita income in the model.

Table C.7: **Regression results of DiD models of mining CSR investment on income, food and non-food expenditures**

	ln(income)		ln(food)			ln(non-food)		
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(mining CSR) × mining	-0.003	-0.013	0.086***	0.080***	0.085***	-0.059**	-0.075***	-0.066***
	(0.024)	(0.021)	(0.021)	(0.019)	(0.017)	(0.026)	(0.023)	(0.017)
2012	0.630***	0.616***	0.223***	0.221***	-0.023	0.526***	0.508***	0.084**
	(0.037)	(0.036)	(0.027)	(0.028)	(0.023)	(0.046)	(0.042)	(0.035)
2014	0.802***	0.773***	0.371***	0.365***	0.059***	0.782***	0.746***	0.214***
	(0.033)	(0.031)	(0.024)	(0.023)	(0.021)	(0.039)	(0.035)	(0.031)
2016	0.928***	0.864***	0.133***	0.113***	-0.229***	0.775***	0.706***	0.112***
	(0.034)	(0.032)	(0.027)	(0.027)	(0.023)	(0.041)	(0.037)	(0.032)
Household head's age (years)		0.011***		0.006***	0.001***		0.006***	-0.002***
		(0.001)		(0.000)	(0.000)		(0.001)	(0.000)
Household head is male		0.187***		0.158***	0.084***		0.139***	0.011
		(0.022)		(0.019)	(0.016)		(0.023)	(0.018)
Household head's education (years)		0.027***		0.003**	-0.008***		0.038***	0.019***
		(0.002)		(0.001)	(0.001)		(0.002)	(0.002)
Household head is married		-0.210***		-0.297***	-0.214***		-0.070***	0.074***
		(0.021)		(0.017)	(0.014)		(0.022)	(0.017)
Ln(per capita income)					0.396***			0.688***
					(0.011)			(0.016)
Lives in apartment/house		0.362***		0.092***	-0.051**		0.343***	0.094***
		(0.034)		(0.022)	(0.022)		(0.034)	(0.024)
Lives in rural area		0.013		0.147***	0.142***		-0.088***	-0.097***
		(0.021)		(0.019)	(0.016)		(0.026)	(0.020)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.24	0.33	0.12	0.20	0.41	0.20	0.28	0.57
Number of households	10,353	10,353	10,353	10,353	10,353	10,353	10,353	10,353

Note: All dependent variables are in per capita level. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1, 3 and 6 run the basic models with province and year fixed effects. Columns 2, 4 and 7 add household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Columns 5 and 8 add log of household per capita income in the model.

Table C.8: **Regression results of DiD models of mining CSR investment on medical expenditure**

Variable	(1)	(2)	(3)
Ln(mining CSR) × mining	0.002	0.016	0.023
	(0.045)	(0.041)	(0.038)
2012	0.593***	0.552***	0.219***
	(0.075)	(0.073)	(0.075)
2014	0.928***	0.872***	0.454***
	(0.064)	(0.063)	(0.067)
2016	1.266***	1.148***	0.681***
	(0.064)	(0.065)	(0.069)
Household head's age (years)		0.032***	0.026***
		(0.001)	(0.001)
Household head is male		0.095**	-0.006
		(0.045)	(0.043)
Household head's education (years)		0.024***	0.009**
		(0.003)	(0.003)
Household head is married		-0.255***	-0.142***
		(0.040)	(0.038)
Ln(per capita income)			0.540***
			(0.024)
Lives in apartment/house		0.360***	0.164***
		(0.058)	(0.057)
Lives in rural area		-0.231***	-0.238***
		(0.046)	(0.045)
Province fixed effects	Yes	Yes	Yes
Adjusted R^2	0.15	0.27	0.33
Number of households	10,353	10,353	10,353

Note: All dependent variables are in per capita basis. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Column 1 runs the basic model with province and year fixed effects. Column 2 adds household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Column 3 adds log of household per capita income in the model.

Table C.9: **Regression results of DiD models of mining CSR investment on the likelihood of reporting illness**

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Ln(mining CSR) × mining	0.001	0.001	0.001	0.002	0.001	0.002
	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.002)
2012		-0.008*		-0.008*		-0.008*
		(0.004)		(0.004)		(0.004)
2014		0.001		0.000		0.000
		(0.004)		(0.004)		(0.004)
2016		-0.010**		-0.010**		-0.010**
		(0.004)		(0.004)		(0.004)
Individual's age (years)		0.001***		0.001***		0.001***
		(0.000)		(0.000)		(0.000)
Individual is male		-0.015***		-0.013***		-0.013***
		(0.002)		(0.002)		(0.002)
Individual's education (years)		-0.002***		-0.002***		-0.001***
		(0.000)		(0.000)		(0.000)
Ln(per capita wage income)		-0.000		0.000		-0.000
		(0.000)		(0.000)		(0.000)
Lives in apartment/house		0.015**		0.013***		0.011**
		(0.006)		(0.005)		(0.004)
Lives in rural area		-0.032***		-0.027***		-0.025***
		(0.004)		(0.003)		(0.003)
Model	LPM	LPM	Probit	Probit	Logit	Logit
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2/Psedu R^2	0.00	0.02	0.01	0.05	0.01	0.05
Number of individuals	36,704	36,704	36,704	36,704	36,704	36,704

Note: Robust standard errors, clustered at the household level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1, 3 and 5 run the basic models with province and year fixed effects. Columns 2, 4 and 6 add individual-specific controls to the specification. The reference groups is female, living in traditional gers and urban areas.

Table C.10: **Regression results of DiD models of mining CSR investment on education expenditure**

Variable	(1)	(2)	(3)
Ln(mining CSR) × mining	-0.161*	-0.174**	-0.193**
	(0.087)	(0.080)	(0.083)
2012	-0.340**	-0.280**	0.598***
	(0.149)	(0.131)	(0.139)
2014	-0.450***	-0.399***	0.701***
	(0.137)	(0.124)	(0.136)
2016	-0.750***	-0.556***	0.674***
	(0.137)	(0.126)	(0.141)
Household head's age (years)		-0.085***	-0.069***
		(0.003)	(0.003)
Household head is male		-1.797***	-1.531***
		(0.136)	(0.127)
Household head's education (years)		0.054***	0.093***
		(0.009)	(0.009)
Household head is married		3.097***	2.798***
		(0.113)	(0.106)
Ln(per capita income)			-1.424***
			(0.062)
Lives in apartment/house		-0.388***	0.128
		(0.139)	(0.137)
Lives in rural area		-0.415***	-0.397***
		(0.088)	(0.088)
Province fixed effects	Yes	Yes	Yes
Adjusted R^2	0.01	0.23	0.28
Number of households	10,353	10,353	10,353

Note: All dependent variables are in per capita basis. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Column 1 runs the basic model with province and year fixed effects. Column 2 adds household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Column 3 adds log of household per capita income in the model.

Table C.11: **Regression results of DiD models of mining CSR investment on educational attainment**

	OLS		Ordered-logit	
Variable	(1)	(2)	(3)	(4)
Ln(mining CSR) × mining	0.159**	0.176***	0.076***	0.083***
	(0.067)	(0.064)	(0.024)	(0.024)
2012	0.830***	0.109	0.171***	-0.103**
	(0.112)	(0.108)	(0.039)	(0.040)
2014	0.878***	0.085	0.180***	-0.096***
	(0.095)	(0.100)	(0.032)	(0.036)
2016	1.082***	0.042	0.333***	-0.045
	(0.095)	(0.101)	(0.033)	(0.037)
Individual's age (years)		0.079***		0.030***
		(0.002)		(0.001)
Individual is male		-0.711***		-0.283***
		(0.050)		(0.018)
Ln(per capita income)		0.823***		0.314***
		(0.052)		(0.020)
Lives in apartment/house		1.480***		0.672***
		(0.113)		(0.046)
Lives in rural area		-1.019***		-0.419***
		(0.069)		(0.026)
Province fixed effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.02	0.15		
Pseudo R^2			0.00	0.03
Number of households	32,552	32,552	32,552	32,552

Note: Robust standard errors, clustered at the household level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1 and 3 run the basic models with province and year fixed effects. Columns 2 and 4 add individual-specific controls to the specification. The reference groups is female, living in traditional gers and urban areas.

Table C.12: **Regression results of DiD models of mining CSR investment on electricity and other non-food expenditures**

	ln(electricity)			ln(other non-food)		
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Ln(mining CSR) × mining	0.090	0.013	0.016	-0.066**	-0.082***	-0.073***
	(0.190)	(0.125)	(0.124)	(0.027)	(0.024)	(0.017)
2012	1.064***	0.762***	0.626***	0.582***	0.567***	0.120***
	(0.277)	(0.202)	(0.204)	(0.046)	(0.043)	(0.035)
2014	0.810***	0.415**	0.245	0.845***	0.813***	0.251***
	(0.295)	(0.196)	(0.201)	(0.039)	(0.036)	(0.032)
2016	1.799***	1.143***	0.952***	0.820***	0.760***	0.132***
	(0.279)	(0.198)	(0.199)	(0.041)	(0.038)	(0.033)
Household head's age (years)		0.021***	0.018***		0.005***	-0.004***
		(0.003)	(0.003)		(0.001)	(0.000)
Household head is male		-0.582***	-0.624***		0.162***	0.026
		(0.101)	(0.102)		(0.025)	(0.019)
Household head's education (years)		0.245***	0.239***		0.035***	0.015***
		(0.008)	(0.009)		(0.002)	(0.002)
Household head is married		-0.232**	-0.185**		-0.087***	0.065***
		(0.091)	(0.093)		(0.023)	(0.017)
Ln(per capita income)			0.221***			0.727***
			(0.062)			(0.016)
Lives in apartment/house		0.579***	0.499***		0.347***	0.084***
		(0.126)	(0.132)		(0.037)	(0.025)
Lives in rural area		-3.057***	-3.060***		-0.067**	-0.076***
		(0.117)	(0.117)		(0.027)	(0.021)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.08	0.39	0.39	0.20	0.27	0.58
Number of households	10,353	10,353	10,353	10,353	10,353	10,353

Note: All dependent variables are in per capita level. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1 and 4 run the basic models with province and year fixed effects. Columns 2 and 5 add household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Columns 3 and 6 add log of household per capita income in the model.

D. Household level analysis

Table D.1: **Regression results of DiD models of the mining impact on income, food and non-food expenditures**

	ln(income)		ln(food)			ln(non-food)		
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(local taxes) × mining	-0.022	-0.019	0.077***	0.084***	0.089***	-0.102***	-0.106***	-0.093***
	(0.019)	(0.017)	(0.016)	(0.015)	(0.013)	(0.021)	(0.018)	(0.014)
2012	0.483***	0.536***	0.101***	0.168***	0.027	0.367***	0.425***	0.068**
	(0.036)	(0.033)	(0.027)	(0.026)	(0.023)	(0.047)	(0.039)	(0.033)
2014	0.674***	0.702***	0.217***	0.268***	0.083***	0.680***	0.711***	0.243***
	(0.034)	(0.032)	(0.024)	(0.022)	(0.021)	(0.043)	(0.036)	(0.032)
2016	0.731***	0.770***	-0.075***	0.009	-0.194***	0.595***	0.643***	0.129***
	(0.033)	(0.031)	(0.025)	(0.025)	(0.022)	(0.042)	(0.036)	(0.031)
Household head's age (years)		0.006***		0.000	-0.001***		0.001	-0.003***
		(0.000)		(0.000)	(0.000)		(0.001)	(0.000)
Household head is male		0.073***		0.044***	0.025*		0.034	-0.015
		(0.021)		(0.015)	(0.013)		(0.024)	(0.019)
Household head's education (years)		0.029***		0.004***	-0.003***		0.039***	0.020***
		(0.002)		(0.001)	(0.001)		(0.002)	(0.002)
Household head is married		0.258***		0.169***	0.101***		0.354***	0.181***
		(0.020)		(0.014)	(0.012)		(0.023)	(0.018)
Household size		0.109***		0.110***	0.081***		0.136***	0.063***
		(0.004)		(0.004)	(0.003)		(0.005)	(0.005)
Ln(household income)					0.263***			0.667***
					(0.011)			(0.018)
Lives in apartment/house		0.319***		0.052**	-0.032		0.305***	0.092***
		(0.032)		(0.020)	(0.020)		(0.033)	(0.024)
Lives in rural area		-0.009		0.125***	0.127***		-0.107***	-0.101***
		(0.020)		(0.017)	(0.015)		(0.026)	(0.021)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.17	0.37	0.10	0.34	0.43	0.12	0.38	0.60
Number of households	10,353	10,353	10,353	10,353	10,353	10,353	10,353	10,353

Note: All dependent variables are in per capita level. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1, 3 and 6 run the basic models with province and year fixed effects. Columns 2, 4 and 7 add household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Columns 5 and 8 add log of household per capita income in the model.

Table D.2: **Regression results of DiD models of the mining impact on medical expenditure**

Variable	(1)	(2)	(3)
Ln(local taxes) × mining	0.025	0.056*	0.064**
	(0.036)	(0.033)	(0.031)
2012	0.442***	0.461***	0.227***
	(0.071)	(0.067)	(0.070)
2014	0.776***	0.761***	0.454***
	(0.064)	(0.063)	(0.068)
2016	1.045***	1.013***	0.677***
	(0.064)	(0.063)	(0.067)
Household head's age (years)		0.026***	0.024***
		(0.001)	(0.001)
Household head is male		-0.030	-0.062
		(0.045)	(0.043)
Household head's education (years)		0.024***	0.012***
		(0.003)	(0.003)
Household head is married		0.265***	0.152***
		(0.043)	(0.042)
Household size		0.079***	0.031***
		(0.011)	(0.011)
Ln(household income)			0.437***
			(0.027)
Lives in apartment/house		0.311***	0.172***
		(0.058)	(0.057)
Lives in rural area		-0.256***	-0.252***
		(0.045)	(0.044)
Province fixed effects	Yes	Yes	Yes
Adjusted R^2	0.13	0.23	0.26
Number of households	10,353	10,353	10,353

Note: All dependent variables are in per capita basis. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Column 1 runs the basic model with province and year fixed effects. Column 2 adds household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Column 3 adds log of household per capita income in the model.

Table D.3: **Regression results of DiD models of the mining impact on the likelihood of reporting illness**

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Ln(local taxes) × mining	-0.004	-0.003	-0.003	-0.002	-0.003	-0.002
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
2012		-0.008*		-0.008**		-0.008**
		(0.004)		(0.004)		(0.004)
2014		0.002		0.001		0.001
		(0.004)		(0.004)		(0.004)
2016		-0.009**		-0.009**		-0.009**
		(0.004)		(0.004)		(0.004)
Individual's age (years)		0.001***		0.001***		0.001***
		(0.000)		(0.000)		(0.000)
Individual is male		-0.015***		-0.013***		-0.013***
		(0.002)		(0.002)		(0.002)
Individual's education (years)		-0.002***		-0.001***		-0.001***
		(0.000)		(0.000)		(0.000)
Household size		-0.004***		-0.003***		-0.003***
		(0.001)		(0.001)		(0.001)
Ln(household wage income)		-0.000		0.000		0.000
		(0.000)		(0.000)		(0.000)
Lives in apartment/house		0.014**		0.012**		0.010**
		(0.006)		(0.005)		(0.004)
Lives in rural area		-0.031***		-0.027***		-0.025***
		(0.004)		(0.003)		(0.003)
Model	LPM	LPM	Probit	Probit	Logit	Logit
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2/Psedu R^2	0.00	0.02	0.01	0.05	0.01	0.05
Number of individuals	36,704	36,704	36,704	36,704	36,704	36,704

Note: Robust standard errors, clustered at the household level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1, 3 and 5 run the basic models with province and year fixed effects. Columns 2, 4 and 6 add individual-specific controls to the specification. The reference groups is female, living in traditional gers and urban areas.

Table D.4: **Regression results of DiD models of the mining impact on education expenditure**

Variable	(1)	(2)	(3)
Ln(local taxes) × mining	-0.154*	-0.100*	-0.096*
	(0.090)	(0.057)	(0.056)
2012	-0.489***	0.326***	0.201*
	(0.164)	(0.120)	(0.121)
2014	-0.508***	0.138	-0.026
	(0.163)	(0.123)	(0.130)
2016	-0.916***	0.094	-0.086
	(0.157)	(0.123)	(0.131)
Household head's age (years)		-0.071***	-0.072***
		(0.003)	(0.003)
Household head is male		-1.544***	-1.561***
		(0.106)	(0.106)
Household head's education (years)		0.055***	0.048***
		(0.008)	(0.008)
Household head is married		0.910***	0.850***
		(0.105)	(0.107)
Household size		1.733***	1.707***
		(0.032)	(0.033)
Ln(household income)			0.233***
			(0.059)
Lives in apartment/house		-0.049	-0.124
		(0.134)	(0.135)
Lives in rural area		-0.348***	-0.346***
		(0.085)	(0.085)
Province fixed effects	Yes	Yes	Yes
Adjusted R^2	0.01	0.53	0.54
Number of households	10,353	10,353	10,353

Note: All dependent variables are in per capita basis. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Column 1 runs the basic model with province and year fixed effects. Column 2 adds household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Column 3 adds log of household per capita income in the model.

Table D.5: **Regression results of DiD models of the mining impact on educational attainment**

	OLS		Ordered-logit	
Variable	(1)	(2)	(3)	(4)
Ln(local taxes) × mining	0.122**	0.164***	0.067***	0.076***
	(0.058)	(0.055)	(0.021)	(0.021)
2012	0.882***	0.059	0.194***	-0.112***
	(0.108)	(0.104)	(0.037)	(0.039)
2014	0.864***	-0.102	0.171***	-0.163***
	(0.097)	(0.101)	(0.033)	(0.037)
2016	1.094***	-0.102	0.334***	-0.094**
	(0.095)	(0.100)	(0.033)	(0.037)
Individual's age (years)		0.084***		0.032***
		(0.002)		(0.001)
Individual is male		-0.705***		-0.281***
		(0.050)		(0.018)
Household size		-0.092***		-0.038***
		(0.023)		(0.009)
Ln(household income)		1.106***		0.413***
		(0.055)		(0.021)
Lives in apartment/house		1.394***		0.647***
		(0.114)		(0.047)
Lives in rural area		-0.997***		-0.413***
		(0.069)		(0.026)
Province fixed effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.02	0.15		
Pseudo R^2			0.00	0.03
Number of households	32,552	32,552	32,552	32,552

Note: Robust standard errors, clustered at the household level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1 and 3 run the basic models with province and year fixed effects. Columns 2 and 4 add individual-specific controls to the specification. The reference groups is female, living in traditional gers and urban areas.

Table D.6: **Regression results of DiD models of the mining impact on electricity and other non-food expenditures**

	ln(electricity)			ln(other non-food)		
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Ln(local taxes) × mining	0.346	0.277**	0.281**	-0.109***	-0.115***	-0.102***
	(0.213)	(0.140)	(0.140)	(0.021)	(0.019)	(0.015)
2012	1.073***	0.752***	0.649***	0.421***	0.472***	0.105***
	(0.319)	(0.226)	(0.226)	(0.046)	(0.040)	(0.033)
2014	0.626*	0.235	0.100	0.743***	0.773***	0.292***
	(0.370)	(0.240)	(0.245)	(0.043)	(0.037)	(0.033)
2016	1.699***	1.031***	0.882***	0.640***	0.687***	0.159***
	(0.349)	(0.231)	(0.234)	(0.041)	(0.037)	(0.032)
Household head's age (years)		0.019***	0.018***		-0.001*	-0.005***
		(0.003)	(0.003)		(0.001)	(0.000)
Household head is male		-0.683***	-0.697***		0.050**	-0.000
		(0.111)	(0.111)		(0.024)	(0.019)
Household head's education (years)		0.276***	0.270***		0.036***	0.017***
		(0.010)	(0.010)		(0.002)	(0.002)
Household head is married		0.006	-0.044		0.375***	0.198***
		(0.108)	(0.110)		(0.023)	(0.018)
Household size		0.084***	0.063**		0.112***	0.037***
		(0.027)	(0.028)		(0.005)	(0.004)
Ln(household income)			0.193**			0.686***
			(0.081)			(0.018)
Lives in apartment/house		0.587***	0.525***		0.303***	0.084***
		(0.146)	(0.153)		(0.034)	(0.024)
Lives in rural area		-3.532***	-3.530***		-0.087***	-0.081***
		(0.134)	(0.134)		(0.027)	(0.021)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.07	0.38	0.38	0.13	0.36	0.59
Number of households	10,353	10,353	10,353	10,353	10,353	10,353

Note: All dependent variables are in per capita level. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1 and 4 run the basic models with province and year fixed effects. Columns 2 and 5 add household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Columns 3 and 6 add log of household per capita income in the model.

E. Square root of household size

Table E.1: **Regression results of DiD models of the mining impact on income, food and non-food expenditures**

	ln(income)		ln(food)			ln(non-food)		
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(local taxes) × mining	-0.008	-0.016	0.091***	0.090***	0.093***	-0.088***	-0.102***	-0.094***
	(0.019)	(0.017)	(0.015)	(0.015)	(0.013)	(0.021)	(0.018)	(0.014)
2012	0.555***	0.534***	0.173***	0.182***	0.038*	0.439***	0.428***	0.070**
	(0.034)	(0.033)	(0.025)	(0.026)	(0.023)	(0.044)	(0.039)	(0.033)
2014	0.736***	0.707***	0.279***	0.284***	0.097***	0.742***	0.719***	0.251***
	(0.033)	(0.031)	(0.023)	(0.022)	(0.021)	(0.041)	(0.036)	(0.032)
2016	0.827***	0.775***	0.021	0.029	-0.177***	0.691***	0.652***	0.137***
	(0.032)	(0.031)	(0.025)	(0.025)	(0.022)	(0.040)	(0.036)	(0.031)
Household head's age (years)		0.007***		0.002***	0.000		0.002***	-0.003***
		(0.000)		(0.000)	(0.000)		(0.001)	(0.000)
Household head is male		0.104***		0.085***	0.055***		0.068***	-0.007
		(0.020)		(0.014)	(0.013)		(0.023)	(0.019)
Household head's education (years)		0.028***		0.004***	-0.004***		0.039***	0.020***
		(0.002)		(0.001)	(0.001)		(0.002)	(0.002)
Household head is married		0.176***		0.026**	-0.004		0.253***	0.179***
		(0.020)		(0.013)	(0.011)		(0.021)	(0.017)
Ln(adjusted income)					0.260***			0.652***
					(0.011)			(0.018)
Lives in apartment/house		0.316***		0.059***	-0.026		0.305***	0.092***
		(0.032)		(0.020)	(0.020)		(0.033)	(0.024)
Lives in rural area		-0.004		0.132***	0.132***		-0.102***	-0.101***
		(0.020)		(0.017)	(0.016)		(0.025)	(0.021)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.24	0.33	0.15	0.18	0.29	0.17	0.30	0.54
Number of households	10,353	10,353	10,353	10,353	10,353	10,353	10,353	10,353

Note: All dependent variables are in per capita level. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1, 3 and 6 run the basic models with province and year fixed effects. Columns 2, 4 and 7 add household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Columns 5 and 8 add log of household per capita income in the model.

Table E.2: **Regression results of DiD models of the mining impact on medical expenditure**

Variable	(1)	(2)	(3)
Ln(local taxes) × mining	0.039	0.065**	0.070**
	(0.036)	(0.032)	(0.031)
2012	0.514***	0.487***	0.253***
	(0.070)	(0.067)	(0.070)
2014	0.838***	0.786***	0.480***
	(0.064)	(0.064)	(0.068)
2016	1.140***	1.046***	0.709***
	(0.063)	(0.063)	(0.067)
Household head's age (years)		0.029***	0.025***
		(0.001)	(0.001)
Household head is male		0.020	-0.028
		(0.044)	(0.043)
Household head's education (years)		0.024***	0.012***
		(0.003)	(0.003)
Household head is married		0.071*	0.022
		(0.040)	(0.039)
Ln(adjusted income)			0.426***
			(0.027)
Lives in apartment/house		0.326***	0.187***
		(0.057)	(0.056)
Lives in rural area		-0.247***	-0.246***
		(0.045)	(0.044)
Province fixed effects	Yes	Yes	Yes
Adjusted R^2	0.14	0.24	0.28
Number of households	10,353	10,353	10,353

Note: All dependent variables are in per capita basis. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Column 1 runs the basic model with province and year fixed effects. Column 2 adds household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Column 3 adds log of household per capita income in the model.

Table E.3: **Regression results of DiD models of the mining impact on the likelihood of reporting illness**

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Ln(local taxes) × mining	-0.004	-0.003	-0.003	-0.001	-0.003	-0.001
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
2012		-0.006		-0.007		-0.006
		(0.004)		(0.004)		(0.004)
2014		0.003		0.002		0.002
		(0.004)		(0.004)		(0.004)
2016		-0.007*		-0.008*		-0.007*
		(0.004)		(0.004)		(0.004)
Individual's age (years)		0.001***		0.001***		0.001***
		(0.000)		(0.000)		(0.000)
Individual is male		-0.015***		-0.013***		-0.013***
		(0.002)		(0.002)		(0.002)
Individual's education (years)		-0.002***		-0.001***		-0.001***
		(0.000)		(0.000)		(0.000)
Ln(adjusted wage income)		-0.000		0.000		-0.000
		(0.000)		(0.000)		(0.000)
Lives in apartment/house		0.015**		0.013***		0.011**
		(0.006)		(0.005)		(0.004)
Lives in rural area		-0.031***		-0.027***		-0.025***
		(0.004)		(0.003)		(0.003)
Model	LPM	LPM	Probit	Probit	Logit	Logit
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2/Psedu R^2	0.00	0.02	0.01	0.05	0.01	0.05
Number of individuals	36,704	36,704	36,704	36,704	36,704	36,704

Note: Robust standard errors, clustered at the household level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1, 3 and 5 run the basic models with province and year fixed effects. Columns 2, 4 and 6 add individual-specific controls to the specification. The reference groups is female, living in traditional gers and urban areas.

Table E.4: **Regression results of DiD models of the mining impact on education expenditure**

Variable	(1)	(2)	(3)
Ln(local taxes) × mining	-0.143*	-0.229***	-0.233***
	(0.083)	(0.073)	(0.074)
2012	-0.441***	-0.362***	-0.177
	(0.152)	(0.135)	(0.138)
2014	-0.468***	-0.366***	-0.124
	(0.151)	(0.137)	(0.147)
2016	-0.837***	-0.570***	-0.304**
	(0.146)	(0.135)	(0.148)
Household head's age (years)		-0.093***	-0.090***
		(0.003)	(0.003)
Household head is male		-1.910***	-1.871***
		(0.147)	(0.147)
Household head's education (years)		0.055***	0.064***
		(0.010)	(0.010)
Household head is married		3.418***	3.456***
		(0.123)	(0.123)
Ln(adjusted income)			-0.336***
			(0.070)
Lives in apartment/house		-0.449***	-0.339**
		(0.149)	(0.149)
Lives in rural area		-0.440***	-0.440***
		(0.094)	(0.094)
Province fixed effects	Yes	Yes	Yes
Adjusted R^2	0.01	0.23	0.23
Number of households	10,353	10,353	10,353

Note: All dependent variables are in per capita basis. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Column 1 runs the basic model with province and year fixed effects. Column 2 adds household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Column 3 adds log of household per capita income in the model.

Table E.5: **Regression results of DiD models of the mining impact on educational attainment**

	OLS		Ordered-logit	
Variable	(1)	(2)	(3)	(4)
Ln(local taxes) × mining	0.122**	0.158***	0.067***	0.074***
	(0.058)	(0.055)	(0.021)	(0.021)
2012	0.882***	0.082	0.194***	-0.103***
	(0.108)	(0.103)	(0.037)	(0.039)
2014	0.864***	-0.065	0.171***	-0.149***
	(0.097)	(0.101)	(0.033)	(0.037)
2016	1.094***	-0.071	0.334***	-0.082**
	(0.095)	(0.100)	(0.033)	(0.037)
Individual's age (years)		0.082***		0.031***
		(0.002)		(0.001)
Individual is male		-0.708***		-0.282***
		(0.050)		(0.018)
Ln(adjusted income)		1.039***		0.389***
		(0.056)		(0.021)
Lives in apartment/house		1.418***		0.655***
		(0.114)		(0.046)
Lives in rural area		-1.003***		-0.414***
		(0.069)		(0.026)
Province fixed effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.02	0.15		
Pseudo R^2			0.00	0.03
Number of households	32,552	32,552	32,552	32,552

Note: Robust standard errors, clustered at the household level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1 and 3 run the basic models with province and year fixed effects. Columns 2 and 4 add individual-specific controls to the specification. The reference groups is female, living in traditional gers and urban areas.

Table E.6: **Regression results of DiD models of the mining impact on electricity and other non-food expenditures**

	ln(electricity)			ln(other non-food)		
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Ln(local taxes) × mining	0.334*	0.264**	0.266**	-0.095***	-0.110***	-0.101***
	(0.200)	(0.131)	(0.130)	(0.021)	(0.019)	(0.015)
2012	1.061***	0.720***	0.633***	0.492***	0.485***	0.113***
	(0.297)	(0.208)	(0.209)	(0.044)	(0.040)	(0.033)
2014	0.645*	0.246	0.132	0.805***	0.788***	0.302***
	(0.345)	(0.222)	(0.227)	(0.041)	(0.036)	(0.033)
2016	1.679***	0.999***	0.874***	0.737***	0.706***	0.171***
	(0.325)	(0.215)	(0.217)	(0.040)	(0.037)	(0.032)
Household head's age (years)		0.019***	0.018***		0.001	-0.004***
		(0.003)	(0.003)		(0.001)	(0.000)
Household head is male		-0.649***	-0.667***		0.090***	0.013
		(0.105)	(0.105)		(0.023)	(0.019)
Household head's education (years)		0.259***	0.255***		0.036***	0.017***
		(0.009)	(0.009)		(0.002)	(0.002)
Household head is married		-0.038	-0.056		0.236***	0.158***
		(0.096)	(0.096)		(0.021)	(0.017)
Ln(adjusted income)			0.158**			0.677***
			(0.075)			(0.018)
Lives in apartment/house		0.574***	0.522***		0.309***	0.088***
		(0.136)	(0.142)		(0.034)	(0.025)
Lives in rural area		-3.300***	-3.300***		-0.081***	-0.080***
		(0.125)	(0.125)		(0.026)	(0.021)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.08	0.38	0.39	0.19	0.29	0.54
Number of households	10,353	10,353	10,353	10,353	10,353	10,353

Note: All dependent variables are in per capita level. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1 and 4 run the basic models with province and year fixed effects. Columns 2 and 5 add household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Columns 3 and 6 add log of household per capita income in the model.

F. OECD equivalence scale

Table F.1: **Regression results of DiD models of the mining impact on income, food and non-food expenditures**

	ln(income)		ln(food)			ln(non-food)		
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(local taxes) × mining	-0.003	-0.016	0.096***	0.087***	0.097***	-0.083***	-0.103***	-0.092***
	(0.019)	(0.017)	(0.016)	(0.015)	(0.013)	(0.020)	(0.018)	(0.014)
2012	0.573***	0.533***	0.191***	0.165***	0.037	0.457***	0.422***	0.077**
	(0.033)	(0.032)	(0.025)	(0.026)	(0.023)	(0.043)	(0.038)	(0.033)
2014	0.750***	0.707***	0.293***	0.274***	0.090***	0.755***	0.717***	0.258***
	(0.032)	(0.031)	(0.023)	(0.022)	(0.021)	(0.040)	(0.035)	(0.032)
2016	0.851***	0.779***	0.045*	0.018	-0.180***	0.715***	0.652***	0.147***
	(0.032)	(0.031)	(0.025)	(0.024)	(0.023)	(0.039)	(0.036)	(0.031)
Household head's age (years)		0.005***		-0.001**	-0.001***		-0.000	-0.003***
		(0.000)		(0.000)	(0.000)		(0.001)	(0.000)
Household head is male		0.064***		0.035**	0.032**		0.025	-0.016
		(0.019)		(0.014)	(0.014)		(0.023)	(0.018)
Household head's education (years)		0.027***		0.002*	-0.005***		0.037***	0.020***
		(0.002)		(0.001)	(0.001)		(0.002)	(0.002)
Household head is married		0.188***		0.099***	-0.047***		0.283***	0.159***
		(0.019)		(0.013)	(0.012)		(0.022)	(0.017)
Ln(adjusted income)					0.284***			0.649***
					(0.011)			(0.018)
Lives in apartment/house		0.315***		0.048**	-0.026		0.301***	0.097***
		(0.032)		(0.021)	(0.020)		(0.033)	(0.024)
Lives in rural area		-0.004		0.129***	0.134***		-0.102***	-0.099***
		(0.020)		(0.017)	(0.016)		(0.025)	(0.021)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.25	0.34	0.15	0.23	0.29	0.18	0.30	0.54
Number of households	10,353	10,353	10,353	10,353	10,353	10,353	10,353	10,353

Note: All dependent variables are in per capita level. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1, 3 and 6 run the basic models with province and year fixed effects. Columns 2, 4 and 7 add household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Columns 5 and 8 add log of household per capita income in the model.

Table F.2: **Regression results of DiD models of the mining impact on medical expenditure**

Variable	(1)	(2)	(3)
Ln(local taxes) × mining	0.044	0.059*	0.072**
	(0.036)	(0.032)	(0.031)
2012	0.532***	0.458***	0.253***
	(0.070)	(0.067)	(0.070)
2014	0.852***	0.766***	0.475***
	(0.064)	(0.063)	(0.068)
2016	1.165***	1.023***	0.707***
	(0.063)	(0.062)	(0.067)
Household head's age (years)		0.025***	0.024***
		(0.001)	(0.001)
Household head is male		-0.039	-0.047
		(0.044)	(0.043)
Household head's education (years)		0.022***	0.010***
		(0.003)	(0.003)
Household head is married		0.194***	-0.011
		(0.042)	(0.038)
Ln(adjusted income)			0.444***
			(0.027)
Lives in apartment/house		0.307***	0.187***
		(0.058)	(0.056)
Lives in rural area		-0.251***	-0.244***
		(0.045)	(0.044)
Province fixed effects	Yes	Yes	Yes
Adjusted R^2	0.15	0.25	0.27
Number of households	10,353	10,353	10,353

Note: All dependent variables are in per capita basis. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Column 1 runs the basic model with province and year fixed effects. Column 2 adds household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Column 3 adds log of household per capita income in the model.

Table F.3: **Regression results of DiD models of the mining impact on the likelihood of reporting illness**

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Ln(local taxes) × mining	-0.004	-0.003	-0.003	-0.001	-0.003	-0.001
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
2012		-0.006		-0.007		-0.006
		(0.004)		(0.004)		(0.004)
2014		0.003		0.002		0.002
		(0.004)		(0.004)		(0.004)
2016		-0.007*		-0.008*		-0.007*
		(0.004)		(0.004)		(0.004)
Individual's age (years)		0.001***		0.001***		0.001***
		(0.000)		(0.000)		(0.000)
Individual is male		-0.015***		-0.013***		-0.013***
		(0.002)		(0.002)		(0.002)
Individual's education (years)		-0.002***		-0.002***		-0.001***
		(0.000)		(0.000)		(0.000)
Ln(adjusted wage income)		-0.000		0.000		-0.000
		(0.000)		(0.000)		(0.000)
Lives in apartment/house		0.015**		0.013***		0.011**
		(0.006)		(0.005)		(0.004)
Lives in rural area		-0.031***		-0.027***		-0.025***
		(0.004)		(0.003)		(0.003)
Model	LPM	LPM	Probit	Probit	Logit	Logit
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2/Psedu R^2	0.00	0.02	0.01	0.05	0.01	0.05
Number of individuals	36,704	36,704	36,704	36,704	36,704	36,704

Note: Robust standard errors, clustered at the household level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1, 3 and 5 run the basic models with province and year fixed effects. Columns 2, 4 and 6 add individual-specific controls to the specification. The reference groups is female, living in traditional gers and urban areas.

Table F.4: **Regression results of DiD models of the mining impact on education expenditure**

Variable	(1)	(2)	(3)
Ln(local taxes) × mining	-0.140*	-0.100*	-0.231***
	(0.082)	(0.054)	(0.073)
2012	-0.423***	0.288**	-0.025
	(0.150)	(0.113)	(0.138)
2014	-0.453***	0.111	0.062
	(0.150)	(0.116)	(0.147)
2016	-0.810***	0.073	-0.089
	(0.145)	(0.116)	(0.147)
Household head's age (years)		-0.068***	-0.090***
		(0.002)	(0.003)
Household head is male		-1.509***	-1.880***
		(0.101)	(0.144)
Household head's education (years)		0.053***	0.069***
		(0.007)	(0.010)
Household head is married		0.893***	3.394***
		(0.100)	(0.120)
Ln(adjusted income)			-0.564***
			(0.070)
Lives in apartment/house		-0.037	-0.246*
		(0.127)	(0.147)
Lives in rural area		-0.331***	-0.434***
		(0.080)	(0.093)
Province fixed effects	Yes	Yes	Yes
Adjusted R^2	0.01	0.50	0.24
Number of households	10,353	10,353	10,353

Note: All dependent variables are in per capita basis. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Column 1 runs the basic model with province and year fixed effects. Column 2 adds household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Column 3 adds log of household per capita income in the model.

Table F.5: **Regression results of DiD models of the mining impact on educational attainment**

	OLS		Ordered-logit	
Variable	(1)	(2)	(3)	(4)
Ln(local taxes) × mining	0.122**	0.153***	0.067***	0.072***
	(0.058)	(0.055)	(0.021)	(0.021)
2012	0.882***	0.066	0.194***	-0.109***
	(0.108)	(0.104)	(0.037)	(0.039)
2014	0.864***	-0.072	0.171***	-0.154***
	(0.097)	(0.102)	(0.033)	(0.037)
2016	1.094***	-0.090	0.334***	-0.090**
	(0.095)	(0.101)	(0.033)	(0.037)
Individual's age (years)		0.082***		0.032***
		(0.002)		(0.001)
Individual is male		-0.703***		-0.281***
		(0.050)		(0.018)
Ln(adjusted income)		1.025***		0.386***
		(0.055)		(0.021)
Lives in apartment/house		1.412***		0.652***
		(0.113)		(0.046)
Lives in rural area		-1.010***		-0.416***
		(0.069)		(0.026)
Province fixed effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.02	0.15		
Pseudo R^2			0.00	0.03
Number of households	32,552	32,552	32,552	32,552

Note: Robust standard errors, clustered at the household level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1 and 3 run the basic models with province and year fixed effects. Columns 2 and 4 add individual-specific controls to the specification. The reference groups is female, living in traditional gers and urban areas.

Table F.6: **Regression results of DiD models of the mining impact on electricity and other non-food expenditures**

	ln(electricity)			ln(other non-food)		
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Ln(local taxes) × mining	0.336*	0.262**	0.268**	-0.089***	-0.112***	-0.100***
	(0.197)	(0.130)	(0.129)	(0.021)	(0.019)	(0.015)
2012	1.065***	0.708***	0.623***	0.511***	0.470***	0.115***
	(0.294)	(0.206)	(0.207)	(0.043)	(0.039)	(0.033)
2014	0.653*	0.244	0.125	0.819***	0.778***	0.302***
	(0.340)	(0.219)	(0.224)	(0.040)	(0.036)	(0.033)
2016	1.683***	0.991***	0.861***	0.760***	0.696***	0.173***
	(0.321)	(0.213)	(0.215)	(0.039)	(0.036)	(0.032)
Household head's age (years)		0.017***	0.017***		-0.002***	-0.005***
		(0.003)	(0.003)		(0.001)	(0.000)
Household head is male		-0.683***	-0.687***		0.041*	0.003
		(0.105)	(0.105)		(0.023)	(0.019)
Household head's education (years)		0.256***	0.252***		0.034***	0.016***
		(0.009)	(0.009)		(0.002)	(0.002)
Household head is married		-0.003	-0.082		0.304***	0.139***
		(0.101)	(0.095)		(0.022)	(0.017)
Ln(adjusted income)			0.181**			0.683***
			(0.073)			(0.018)
Lives in apartment/house		0.567***	0.517***		0.299***	0.089***
		(0.135)	(0.141)		(0.034)	(0.025)
Lives in rural area		-3.265***	-3.262***		-0.083***	-0.079***
		(0.124)	(0.123)		(0.026)	(0.021)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.08	0.39	0.39	0.19	0.31	0.54
Number of households	10,353	10,353	10,353	10,353	10,353	10,353

Note: All dependent variables are in per capita level. Robust standard errors, clustered at the HSES cluster level, are reported in parentheses. * p <0.10, ** p <0.05, *** p <0.01. Columns 1 and 4 run the basic models with province and year fixed effects. Columns 2 and 5 add household-specific controls to the specification. The reference group is female, never married, separated or widowed, living in traditional gers and urban areas. Columns 3 and 6 add log of household per capita income in the model.