Large-scale mining and local development: Evidence from Mongolia[☆]

Odmaa Narantungalag[a]

[a]*School of Economics and Finance, Massey University, Palmerston North, New Zealand*

Abstract

This paper investigates the impacts of large-scale mining activities on consumption of households located in mining regions. Employing a flexible difference-in-differences model and five rounds of cross-sectional household socio-economic surveys from Mongolia to compare households in mining regions againts those in non-mining regions, we find that large-scale mining has significant negative impact on household consumption in mining-areas. Examination of different components of consumption, such as food, non-food and energy consumption, suggests that households are better off in mining-regions, where mining companies spend more on supporting the development of local economy. Our results indicate that the impacts of large-scale mining can be greater in the presence of more corporate social responsibility activties and public policies aimed at ensuring inclusive regional development.

JEL-Classification: D12, O13, Q32, Q33

Keywords: Resources and development, Dutch disease, Difference-in-differences estimation

[☆]I thank Syed Hasan, Rukmani Gounder, Martin Berka, Derrin Davis, Garry Barret, Nazmun Ratna, Evzen Kocenda and Dean Hyslop for their comments and feedback on an earlier draft.

Email address: O.Narantungalag@massey.ac.nz (Odmaa Narantungalag)

1. Introduction

The number of mineral-dependent low and middle-income countries increased from 46 to 61 between 1996 and 2010 by a measure of resource dependence that attributes at least 25 percent of export earnings to minerals (Haglund, 2011).[1] According to Rees (1992), the value of mineral abundance is determined by the level of the country's production and processing, and if these levels are significant then so too will be the improvement in human welfare. Clearly, resource-rich developing nations have the potential and opportunity to turn their natural resources into productive human and physical capital to foster their growth and development, but this is not guaranteed.

Resource-rich developing countries often lack the domestic financial resources to develop their mineral deposits so they rely heavily on foreign direct investment (FDI) but the effective management of revenues from resource exploitation depends on the country's macroeconomic policy choices, institutions and governance (Venables, 2016). When the benefits of natural resource exploitation are questioned, the fiscal linkage becomes an important attribute of revenue management because resource rents are often appropriated by governments to improve public services and infrastructure (Auty, 2001). However, it is not the only way to benefit from resource exploitation. For example, copper mines in Zambia have weak fiscal linkages but strong backward linkages to the local market that were found to have positive impacts on real household expenditure, housing conditions and ownership of consumer durables (Lippert, 2014). Similarly, a large-scale gold mine in Peru was found to have a positive impact on local incomes because of the mine's backward linkages (Aragón and Rud, 2013). However, the demand and productive linkages can be limited in resource-rich developing countries because the mining sector usually relies much more on capital investments than labour inputs (Auty and Kiiski, 2001).[2] Therefore, whether any benefit

[1] An economy is considered mineral dependent if at least eight percent of Gross Domestic Product (GDP) and 40 percent of export earnings are generated from minerals (Auty, 1993).

[2] Auty and Kiiski (2001) refer to demand linkages as the mining sector's domestic spending on labour and capital, and productive linkages as inputs required for the production and the processing of minerals.

from resource exploitation is channelled to the socio-economic development of communities nearby to mineral deposits is an important policy question worth investigating empirically.

The aim of the research reported in this paper is to examine whether large-scale mining, which attracted substantial FDI, has had any significant impact on the welfare of households in mining regions. We contribute to the existing literature by examining the local impacts - those that occur in areas where mining is undertaken - of copper, iron ore and zinc production in Mongolia, a lower-middle income and small open economy. In the period 1990-2004, the agriculture sector accounted for more than 25 percent of GDP, while the mining sector represented only 11 percent. In the period 2010-2016, the country's exports were mainly driven by the minerals sector, which contributed over 70 percent of total value of exports. The mining sector contributed 18 percent of GDP, 19 percent of government budget revenue and employed 3-5 percent in 2016 (NSO, 2015, 2016b).

We find that large-scale mining has significant negative impacts on household consumption in mining regions. However, the analyses of food and non-food consumption show that such negative impact is desirable, as a result of wider development of the mining regions that enable households to spend more on food and electricity, and less on non-food items. The findings suggest that encouraging more active corporate social responsibility of mining companies and devising policies to ensure inclusive regional development in mining regions can enhance the impacts of large-scale mining in low and lower-middle income, resource-rich countries. The paper is organized as follows. We discuss the relevant literature in Section 2, followed by Section 3 where the identification of mining provinces, empirical strategy and the data are introduced. We present our results in Section 4 and provide conclusions as well as policy implications in Section 5.

2. Literature review

Although it is commonly believed that resource-rich countries should outperform their resource-poor counterparts, there is some evidence that resource exploitation can be harmful to growth. This is the phenomenon defined as the "resource curse" by Gelb (1988) and Sachs and Warner (1995, 1999, 2001). The mere abundance of resources is not the only explanation

for the resource curse, however. Other factors such as the implementation of the rule of law, openness to trade, corruption, economic freedom and institutional strength also determine the country's growth trajectory (Gounder, 2002; Halvor et al., 2006; Farhadi et al., 2015).

Mineral dependent developing countries, such as Chile and Botswana, created favourable investment and taxation environments and followed strict fiscal rules to manage the windfall revenues effectively (Korinek, 2013, 2014). Conversely, other nations such as Venezuela, Nigeria and Algeria have experienced negative growth rates in recent decades and have been unsuccessful in using oil resources as a catalyst for development (Van der Ploeg, 2011). Moreover, when natural resource exploitation dominates economic activity there can be negative impacts on growth enhancing factors such as human and public capital accumulation and genuine savings, which in turn lower the overall growth rate (Sachs and Warner, 1999; Atkinson and Hamilton, 2003; Bhattacharyya and Collier, 2014). Gylfason (2001) further argued that the existence of the natural resource is not the problem; rather, it is how the authorities manage the resource rents through policies, incentives and institutions.

Natural resource exploitation can foster regional development. Hajkowicz et al. (2011) found that improved income, housing affordability, educational attainment and employment are positively correlated with mining activity in remote Australian locations. Moreover, mining regions in Australia have lower income inequality than the national average in comparison to non-metropolitan, non-mining regions (Fleming and Measham, 2015a). This arises from the fact that new mining jobs create jobs in other sectors through local multiplier effects in countries such as Australia and Canada (Marchand, 2012; Fleming and Measham, 2015b).

However, evidence from developing countries suggest different outcomes. Aragón and Rud (2013, 2015) used household income and expenditure data to examine the effect of large gold mines in Peru and Ghana. While the gold mine in Peru had positive effects on household income and the non-traded sector because of the mine's backward linkage to the local economy. Conversely, the pollution from the gold mine in Ghana reduced the productivity of agricultural workers and increased rural poverty in the locality of the mine. Similarly, the living standards in oil-rich municipalities in Brazil did not improve despite increased investment from oil companies on infrastructure, education and health facilities

because of rent-seeking behaviour by officials (Caselli and Michaels, 2013). Against this background, this paper aims to provide a further evidence from resource-rich low income countries by using data from Mongolia.

3. Methodology and data

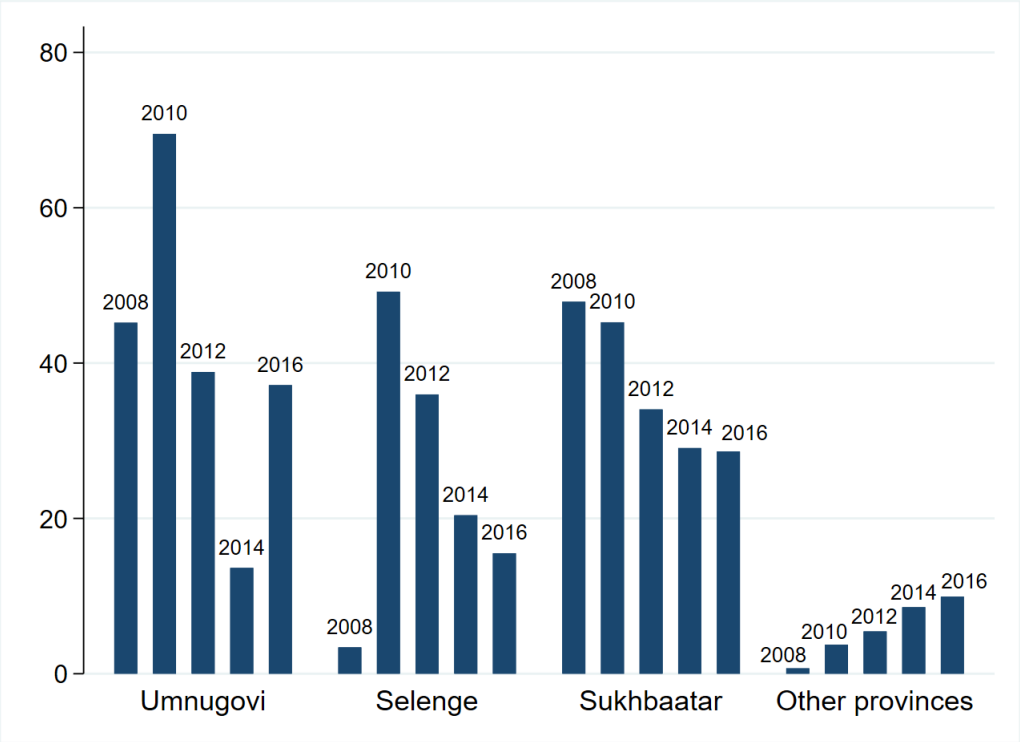
3.1. Identification of mining provinces

Mining provinces are identified based on the intensity of mining activities in the local economy and the strategic importance of the commodity for the country. Copper, iron ore and zinc are the main minerals for exports in Mongolia and accounted for over 40 percent of total exports, on average, in 2010-2016. Copper alone accounted for 30 percent of total exports, which increased significantly with the inception of the Oyu Tolgoi (OT) mine operation in 2012 (NSO, 2018b). OT is located in Umnugovi province and it is the country's largest copper deposit discovered in 2001. It is also one of the five largest copper deposits in the world. The investment agreement to develop the deposit was signed by the Mongolian government and Rio Tinto Corporation in October 2009, with 34 percent owned by the state and the remainder owned by the foreign corporation (OT, 2018). OT, the country's largest foreign-investment project, attracted USD6 billion (50 percent of GDP) in foreign direct investment (FDI) in 2010, with another USD5 billion FDI expected for the second stage of development (Li et al., 2017). The country was the eighth largest exporter of copper ore and concentrates in the world in 2016 (United Nations, 2017).

Mongolia started exporting iron ore concentrates in 2005 when a new deposit came into operation in Selenge province. In the same year, the country's first zinc mining and processing plant commenced its operations in Sukhbaatar province (Mineral Resources and Petroleum Authority, 2016). The initial export volume of iron ores was 178,000 tons in 2005, which jumped to 3,539,000 tons in 2010, with continuous increases since that time. Zinc concentrate exports were 23,000 tons in 2005 and reached 150,000 tons in 2009, with steady levels of exports since then (NSO, 2018b).

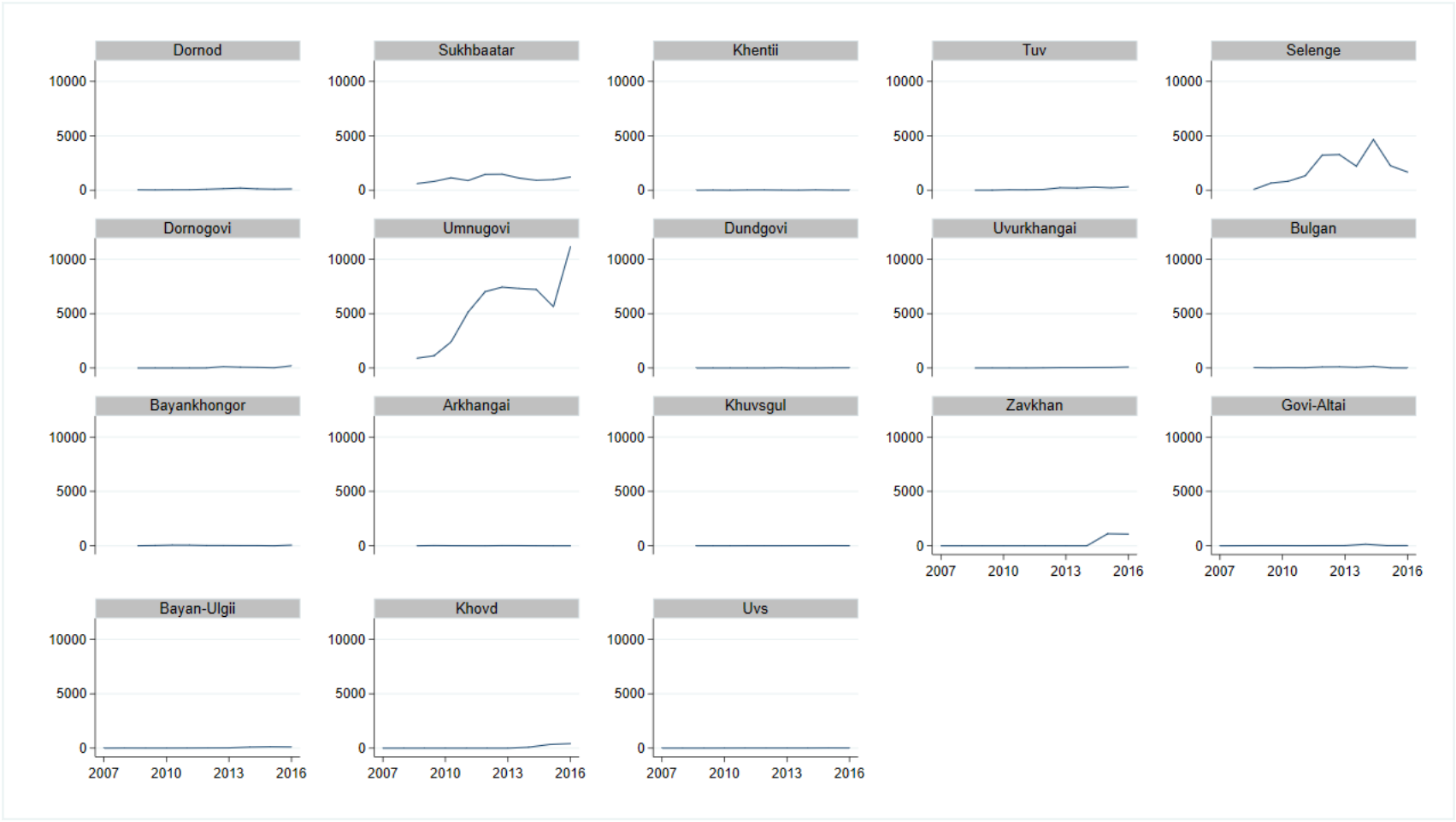
In all the above-mentioned three provinces - Umnugovi, Selenge and Sukhbaatar - the mining sector alone produced more than 40 percent of provincial GDP in 2010, which was

the highest in the period 2010-2016, as shown in Figure 1. The share of the mining sector in provincial GDP was much lower in other provinces in 2010, and has increased to only a minor extent since. Not surprisingly, the per capita value of commodity production was much higher Umnugobi, Selenge and Sukhbaatar than for other provinces in the period 2007-2016 (Figure 2). Based on the significance of the mining sector in the local economy and the importance of minerals in the country's foreign trade, households in Umnugovi, Selenge and Sukhbaatar are identified as households in mining provinces (treatment households hereafter). Households in all other provinces, where the share of the mining sector in the provincial GDP was below 10 percent in 2010, are identified as households in non-mining provinces (control households hereafter).



Source: National Statistics Office, 2019

FIGURE 1: **Share of mining in provincial GDP, by provinces for selected years, (percent)**



Source: National Statistics Office, 2019

FIGURE 2: **Per capita value of commodity production by provinces, 2007-2016 (thousand MNT)**

However, it is important to note that mining activities varied over time across the mining provinces. In 2010 the share of the mining sector in GDP of Umnugovi was close to 70 percent, while it was around 50 percent and 45 percent for Selenge and Sukhbaatar provinces, respectively. Clearly, mining sector was at its peak of production in 2010 in the mining provinces due to surges in global commodity prices and large inflows of FDI in the mining sector (Mineral Resources and Petroleum Authority, 2016). In 2012, all mining provinces produced more than 30 percent of their GDP from mining sector (38 percent for Umnugovi, 36 percent for Selenge and 34 percent for Selenge). The mining sector's contribution to GDP in Umnugovi fell further to 13 percent in 2014, due to the sudden drop in FDI by 52 percent in 2013 and by 58 percent in the first nine months of 2014 (World Bank, 2014). While the production of the mining sector remained stable in Sukhbaatar in 2014 and 2016, the share of the mining sector in Selenge's economy kept falling in the same period. Overall, the level of mining sector's contribution to GDP fluctuated noticeably in each province. Thus, such a heterogeneity in mining activities are not expected to have similar effects on local communities for all mining provinces.

3.2. Emprirical strategy

We employ a difference-in-differences (DD) model similar to that used by Aragón and Rud (2013) but modify the model to a flexible DD model to analyse the effects of different scales of mining activity on household consumption. This model has an advantage over a conventional DD model as it is able to show differences between mining provinces, instead of overtime changes showing an aggregate estimate for all. The DD model compares the difference in the outcome variable between treatment and control households before and after the mining activity occurred. The DD model is specified below:

$$\begin{aligned} ln(Y_{ist}) &= \alpha + \sum_{t=1}^{4} \beta_t (Year_t) + \sum_{s=1}^{3} \delta_s (Province_s) + (\mathbf{Province_s} \times \mathbf{Year_t})\phi \\ &\quad + X_{ist}\gamma + \lambda_s + \varepsilon_i \end{aligned} \tag{1}$$

where Y is the (logarithm of) monthly total consumption (or specific categories of consumption) of household i (i = 1,...n) in province s (s=1,..s) at time t (t = 2010, 2012, 2014 and 2016). $Year_t$ is a set of indicator variables that equals one for $Year_t$ and zero otherwise. $Province_s$ is also a set of indicator variables taking the value of one if the household is located in the mining province.

The main variables of interest in the model are the interaction terms $Year_t \times Province_s$, which provides information about the effect pf mining activity had on the consumption of households living in those provinces where large-scale mining is undertaken. This variable, therefore, is the difference-in-differences estimate that shows whether the average change in the outcome variable from before mining to after mining is different in the two groups. X_{ist} is the set of control variables, consisting of both continuous and indicator variables, as mentioned in Section 3.3. The model also includes province fixed effects (λ_s) to account for the time invariant region specific factors such as provincial macroeconomic situation and the distance from the capital city.

We use the ordinary least squares method to estimate the DD model although a better model would have fit if panel data were available. In our analysis the year 2008 is the reference time period and we expect to see the effect of mining activity on household consumption in 2010 and onwards up to 2016. The identifying assumption for this model is that the difference in the outcome variable between the treatment and control households would have remained the same in the absence of the mining activity that started as a result of exogenous shocks in the global demand for minerals. We cannot test the assumption directly but performed a Placebo test for 2002 and 2008.

3.3. Data

We use data from the Mongolia Household Socio-Economic Survey (HSES) in our analyses.[3] The HSES is a nationally representative cross-sectional survey conducted by the National Statistics Office (NSO) every two years. A stratified two-stage sample design is

[3]The HSES questionnaires and the primary datasets are publicly available from the NSO Census and Survey data catalogue http://web.nso.mn/nada.

used for the survey based on the population figures obtained from the administrative records held by the local governments. In the first stage, a stratification is undertaken for the capital city Ulaanbaatar and the 21 provinces. In the second stage, the 21 provinces are divided into two substrata: urban, comprising of the provincial capitals, and rural, consisting of small towns and the countryside (NSO, 2018a).

The HSES collects detailed data on various sources of income, food and non-food consumption, and different sources of energy, in addition to variables indicating household members' age, education, employment and household living conditions (NSO, 2014a,b, 2016a, 2018a). Our main focus is on the effects of mining activity on household consumption while we conducted same robustness check with income. We prefer the estimates with household consumption as such an analysis provides a thorough understanding about household consumption behaviour. Income estimates obtained from household surveys tend to be more volatile than consumption that affects household welfare, directly and indirectly through the health and cognitive development of household members (Deaton, 1997). Thus, the outcome variables are households' total consumption, food and non-food consumption, and energy expenses, which are important indicators of welfare. The control variables in our analysis are the (log of) household monthly income, household head's age, gender, marital status, highest education of any household member and household size. In addition, the urban/rural status of a household and the type of dwelling are included to account for the differences in living conditions.

We use five rounds of HSES for 2008-2016, with an initial sample of 67,806 households. We dropped 17,792 households in Ulaanbaatar, 2,452 households in Darkhan-Uul, 2,371 households in Orkhon and 527 households in Govisumber. Ulaanbaatar was omitted because it is a separate urban strata in the survey sample; it is the largest settlement in Mongolia, with per capita income above the national average (NSO, 2014a). Darkhan-Uul province has the country's largest metallurgical plant that has been operating since 1994 (Darkhan Metallurgical Plant, 2019). Orkhon province has the first industrial scale copper mine established in 1978 (Fisher et. al, 2011). These locations have different economic characteristics to the other provinces where mining has recently commenced. Govisumber was

included in the HSES only for 2014 and 2016 (NSO, 2018a). Another 324 households were excluded because they did not report income or food expenditure.[4] Consequently, our final sample included 44,340 households, including 6,994 households for 2008; 7,004 households for 2010; 7,800 households for 2012; 11,180 households for 2014 and 11,362 households for 2016.

The summary statistics of the dependent variables for treatment and control households for 2010-2016 are reported in Table 1. We observed an increase in total consumption of both types of households in 2010 but the increase was almost twice higher for treatment households (65 percent increase for treatment and 34 percent for control). While consumption increased by 24 percent for treatment households and 66 percent for control households in 2012, it more than doubled from its 2008 levels for both types of households groups. Total consumption increased at a similar rate, at least by 45 percent both groups of households in 2014, which is more than triple its 2008 level for control households. Total consumption fell by 15 percent for treatment households and 13 percent for control households in 2016. Although energy expenses increase for the control households in all years, the electricity expenses are higher for the treatment households, suggesting that infrastructure is better developed in mining provinces. Incomes for both types of households increased at a similar rate over time until 2016 when income again fell for both groups.

T-tests were performed prior to estimating the empirical model in order to check if there were significant differences in household total consumption and various categories of consumptions between the treatment and control households. The means of the dependent variables and their differences between the two types of households are reported in Table 2. Significant differences in total consumption, food consumptions, categories of energy expenses and income existed in the two types of households before and after 2010. However, the magnitude of the differences declined over time.

[4]The households that did not report spending on education, medical, utilities and energy were given a value of zero to consolidate the sample. We exchanged e-mails with the National Statistics Office staff to confirm that missing values represent zero spending on some categories.

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

	2008		2010		2012		2014		2016	
Variable	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
Consumption	400	348	659	466	818	775	1,199	1,127	1,020	981
	(445)	(278)	(577)	(374)	(721)	(733)	(1197)	(971)	(840)	(784)
Food consumption	185	165	267	217	317	314	414	414	387	360
	(111)	(118)	(153)	(166)	(200)	(222)	(256)	(261)	(242)	(223)
Non-food consumption	215	183	392	249	501	461	785	713	633	621
	(403)	(211)	(502)	(278)	(643)	(638)	(1102)	(855)	(752)	(685)
Energy expenses	95	103	208	193	244	306	444	448	460	501
	(91)	(122)	(162)	(189)	(181)	(237)	(258)	(265)	(244)	(277)
Electricity expenses	44	34	79	60	87	86	127	110	180	158
	(46)	(45)	(82)	(77)	(92)	(89)	(133)	(113)	(148)	(153)
Non-electricity energy expenses	52	69	128	134	158	220	317	338	280	342
	(64)	(97)	(116)	(149)	(141)	(195)	(258)	(229)	(215)	(226)
Income	181	170	519	391	673	567	968	813	831	740
	(217)	(357)	(1413)	(2811)	(683)	(546)	(1006)	(684)	(717)	(601)
Number of households	1,022	5,972	1,025	5,979	1,115	6,685	1,854	9,326	1,864	9,498

Note: Means are reported in thousand Tugrik (MNT): The exchange rate for the end of survey period (December) ranged from 1US$ $\approx$ 1229 MNT in 2008 to 1US$ $\approx$ 2483 MNT in 2016. All values are in current prices. Standard deviations are reported in the parentheses.

TABLE 2: **Difference between treatment and control households**

Variable name	2008	2010	2012	2014	2016
ln(Consumption)	0.127***	0.357***	0.065***	0.012	0.040**
	(0.024)	(0.024)	(0.023)	(0.017)	(0.016)
ln(Food consumption)	0.180***	0.300***	0.044*	-0.014	0.083***
	(0.025)	(0.026)	(0.024)	(0.018)	(0.018)
ln(Non-food consumption)	-0.055*	0.378***	0.025	-0.002	-0.026
	(0.032)	(0.029)	(0.029)	(0.021)	(0.020)
ln(Energy expenses)	2.180***	1.550***	-0.176*	-0.025	-0.054***
	(0.185)	(0.157)	(0.105)	(0.020)	(0.019)
ln(Electricity expenses)	1.983***	1.740***	0.270	0.506***	0.618***
	(0.182)	(0.183)	(0.170)	(0.137)	(0.132)
ln(Non-electricity energy expenses)	1.198***	1.409***	-0.707***	-0.552***	-0.733***
	(0.194)	(0.179)	(0.140)	(0.094)	(0.099)
ln(Income)	0.091***	0.255***	0.168***	0.090***	0.098***
	(0.030)	(0.028)	(0.026)	(0.019)	(0.018)
Number of households	6,994	7,004	7,800	11,180	11,362

Note: Mean of differences between households in treatment and control regions are reported for each year. Standards errors are recorded in the parentheses. * p <0.10, ** p <0.05, *** p <0.01.

Table 3 provides the summary statistics of the control variables used. The variables defining the characteristics of the household head vary over time. For example, the age of household head decreased to 45 for the treatment households, while it tended to increase for the control households. Educational attainment of household members also increased, with the treatment households acquiring more years of education. The percentage of married couples decreased for both groups. Furthermore, there is a movement to urban areas, which was noticeable in 2014 for the control households. Although there are variations in household living conditions, there is no general tendency of improvement for either type of households. Therefore, it is necessary to control for such factors in the empirical model.

TABLE 3: **Summary statistics of control variables**

	2008		2010		2012		2014		2016	
Variable	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
HH head age	46.07	44.99	43.78	45.24	45.86	45.61	46.12	46.46	44.97	46.62
	(14.01)	(14.24)	(13.48)	(14.62)	(14.28)	(14.11)	(14.55)	(14.09)	(14.11)	(14.53)
HH head is male	0.79	0.83	0.82	0.82	0.77	0.82	0.78	0.80	0.78	0.78
	(0.40)	(0.37)	(0.38)	(0.38)	(0.42)	(0.38)	(0.42)	(0.40)	(0.41)	(0.42)
Years of education	11.74	11.17	12.05	11.36	12.62	12.13	12.59	12.55	12.52	12.07
	(3.29)	(3.61)	(3.39)	(3.71)	(3.93)	(4.26)	(4.46)	(4.34)	(3.30)	(3.65)
HH head is married	0.68	0.72	0.70	0.72	0.62	0.70	0.62	0.69	0.60	0.64
	(0.47)	(0.45)	(0.46)	(0.45)	(0.49)	(0.46)	(0.48)	(0.46)	(0.49)	(0.48)
Number of household members	3.90	3.89	3.74	3.81	3.42	3.65	3.23	3.58	3.25	3.45
	(1.69)	(1.67)	(1.55)	(1.69)	(1.55)	(1.62)	(1.52)	(1.66)	(1.55)	(1.72)
Lives in rural area	0.66	0.70	0.65	0.70	0.68	0.71	0.62	0.61	0.62	0.62
	(0.47)	(0.46)	(0.48)	(0.46)	(0.47)	(0.45)	(0.49)	(0.49)	(0.49)	(0.48)
Lives in apartment/house	0.09	0.09	0.18	0.15	0.10	0.08	0.11	0.07	0.12	0.09
	(0.28)	(0.28)	(0.38)	(0.36)	(0.31)	(0.26)	(0.31)	(0.26)	(0.33)	(0.28)
House has no infrastructure	0.40	0.26	0.30	0.20	0.32	0.29	0.30	0.32	0.33	0.33
	(0.49)	(0.44)	(0.46)	(0.40)	(0.47)	(0.46)	(0.46)	(0.47)	(0.47)	(0.47)
Number of households	1,022	5,972	1,025	5,979	1,115	6,685	1,854	9,326	1,864	9,498

Note: Education is the highest number of years for any member of the household. Categorical variables indicating rural/urban status and living conditions show their sample proportions. Standard deviations are reported in the parentheses.

4. Results

The results of the empirical analysis are presented in this section. The empirical analyses on the categories of consumption using the DD estimates were carried out in two stages. First, the model was estimated with only the indicator variables and fixed effects specified in Section 3.2. Second, the control variables were added to the model, which is the preferred model for accounting for both household and province level differences. All the tests are performed at the five percent significance level.

Table 4 reports the estimates for total consumption, non-food and food consumptions. For every outcome variable, estimates from the simple DD model with fixed effects are reported in the first column, followed by the estimates from the model with both fixed effects and control variables. We expect large-scale mining development to have significant negative effects on household consumption patterns as the operations of mining companies can have both direct and indirect impacts on the local economy.

Column 1 of Table 4 reports the estimates of the DD model for total consumption. Households in Umnugovi and Sukhbaatar had significantly higher consumption than the control households in 2008. Although the consumption of households in Selenge was also higher, it was not significantly different from that of the control households in the reference year. There was significant growth in consumption across all provinces in 2010. The DD estimates for each mining province show that the increase in their consumption was significantly greater than that of the control households. For example, the consumption of households in Umnugovi and Selenge increased, respectively, by 31 percent and 32 percent more than the increase in consumption of control households in 2010. Although the increase for households in Sukhbaatar was smaller than that of households in Umnugovi and Selenge, it was still 14 percent higher than the control households' increase in consumption.

TABLE 4: **Effect of mining on household consumption, food and non-food consumptions**

	ln(consumption)		ln(non-food consumption)		ln(food consumption)	
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Umnugovi	0.416***	0.272***	0.838***	0.668***	-0.088*	-0.204***
	(0.047)	(0.030)	(0.054)	(0.037)	(0.046)	(0.035)
Selenge	0.026	-0.053**	-0.452***	-0.557***	0.150***	0.101***
	(0.032)	(0.027)	(0.056)	(0.049)	(0.032)	(0.027)
Sukhbaatar	0.110***	0.134***	0.130**	0.167***	0.059	0.059**
	(0.042)	(0.027)	(0.057)	(0.040)	(0.039)	(0.029)
Y2010	0.295***	-0.094***	0.359***	-0.125***	0.257***	-0.006
	(0.013)	(0.009)	(0.016)	(0.012)	(0.013)	(0.011)
Y2012	0.786***	0.159***	0.928***	0.144***	0.634***	0.219***
	(0.012)	(0.010)	(0.015)	(0.014)	(0.013)	(0.012)
Y2014	1.190***	0.352***	1.413***	0.388***	0.949***	0.367***
	(0.011)	(0.011)	(0.014)	(0.014)	(0.012)	(0.012)
Y2016	1.067***	0.291***	1.305***	0.353***	0.806***	0.268***
	(0.011)	(0.010)	(0.014)	(0.014)	(0.012)	(0.012)
Umnugovi x Y2010	0.271***	0.231***	0.157**	0.108**	0.357***	0.323***
	(0.061)	(0.038)	(0.071)	(0.048)	(0.064)	(0.051)
Umnugovi x Y2012	-0.175***	-0.079*	-0.323***	-0.212***	-0.061	0.020
	(0.061)	(0.040)	(0.071)	(0.051)	(0.065)	(0.049)
Umnugovi x Y2014	-0.179***	-0.039	-0.412***	-0.272***	0.044	0.189***
	(0.055)	(0.033)	(0.063)	(0.041)	(0.055)	(0.041)
Umnugovi x Y2016	-0.222***	-0.086***	-0.528***	-0.389***	0.103*	0.239***
	(0.052)	(0.033)	(0.061)	(0.041)	(0.054)	(0.041)
Selenge x Y2010	0.276***	0.193***	0.740***	0.638***	0.073*	0.017
	(0.045)	(0.034)	(0.074)	(0.060)	(0.040)	(0.034)
Selenge x Y2012	-0.125***	-0.080**	0.147**	0.198***	-0.168***	-0.131***
	(0.045)	(0.037)	(0.073)	(0.063)	(0.046)	(0.039)
Selenge x Y2014	-0.147***	-0.065**	0.219***	0.315***	-0.189***	-0.122***
	(0.037)	(0.032)	(0.063)	(0.054)	(0.040)	(0.034)
Selenge x Y2016	0.023	0.037	0.342***	0.361***	0.051	0.059*
	(0.037)	(0.030)	(0.062)	(0.053)	(0.037)	(0.032)
Sukhbaatar x Y2010	0.133**	0.035	0.311***	0.194***	-0.051	-0.123***
	(0.054)	(0.034)	(0.070)	(0.049)	(0.052)	(0.038)
Sukhbaatar x Y2012	0.118**	-0.021	0.330***	0.147***	-0.138***	-0.221***
	(0.053)	(0.033)	(0.069)	(0.047)	(0.050)	(0.037)
Sukhbaatar x Y2014	-0.026	-0.085***	0.206***	0.118***	-0.355***	-0.372***
	(0.051)	(0.031)	(0.066)	(0.044)	(0.047)	(0.034)
Sukhbaatar x Y2016	-0.085*	-0.161***	0.114*	0.012	-0.382***	-0.429***
	(0.050)	(0.031)	(0.065)	(0.044)	(0.047)	(0.036)
ln(Income)		0.472***		0.582***		0.328***
		(0.005)		(0.006)		(0.005)
HH head age		0.001***		0.001***		-0.000
		(0.000)		(0.000)		(0.000)
HH head is male		-0.017**		-0.037***		-0.003
		(0.007)		(0.009)		(0.010)
HH head is married		0.082***		0.120***		0.050***
		(0.007)		(0.009)		(0.009)
Log of household size		0.223***		0.210***		0.273***
		(0.005)		(0.007)		(0.006)
Lives in rural area		-0.166***		0.021***		-0.399***
		(0.004)		(0.006)		(0.006)
Lives in apartment/house		0.129***		0.169***		0.055***
		(0.009)		(0.011)		(0.010)
House has no infrastructure		0.118***		0.126***		0.092***
		(0.005)		(0.007)		(0.007)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.33	0.74	0.33	0.69	0.23	0.55
Number of households	44,340	44,340	44,340	44,340	44,340	44,340

Note: 1. Robust standard errors are reported in the parentheses. * p <0.10, ** p <0.05, *** p <0.01.

The consumption of the control households increased significantly in 2012. However, the increases in the consumption of households in Umnugovi and Selenge were 19 percent and 13 percent lower than that of their counterparts. Conversely, the households in Sukhbaatar increased their consumption by 12 percent more than the control households in 2012. Although the consumption pattern persisted in 2014, the control households more than doubled their consumption. The households in Umnugovi and Selenge increased their consumption by 19 percent and 16 percent less than the control households in 2014. The consumption of households in Sukhbaatar grew less than that of the control households but not at statistically significant level.

The increase in the consumption of the control households almost doubled in 2016 whereas the households in Umnugovi increased their consumption by 24 percent less than their counterparts in non-mining provinces. Morever, the households in Selenge increased their consumption more than the control households but not at statistically significant level. Finally, the households in Sukhbaatar increased their consumption around nine percent less than the control households in 2016.

The pattern of consumption reflects the mining sector development trend in mining provinces. For example, the treatment households increased their consumption significantly more than the control households in 2010 when each province produced more than 40 percent of its GDP from the mining sector. However, later on the mining activities slowed down differently in each mining province, which explains the varying consumption patterns of the treatment households. Especially the differences in the increases in the consumptions between households in Umnugovi and the control households grew larger and larger every two years, while the trend is ambiguous for Selenge and Sukhbaatar. The DD model with the province fixed effects explain 33 percent of the variations in consumption.

The model with fixed effects and control variables are presented in Column 2 of Table 4. The coefficients of each variable are smaller but their significance levels remain mostly similar

to the previous results, with only a few variables affected by the addition of control variables in the model. For example, the consumption of households in Selenge is significantly lower than that of the control households in 2008. The change in the consumption of households in Selenge in 2010 is not statistically significant whereas the increase in their consumption is smaller than the control households but not statistically significant in 2012. Moreover, the increase in the consumption of households in Umnugovi in 2014 is not statistically different from that of the control households.

Most of the control variables included in the model are economically plausible and statistically significant. For instance, a one percent increase in income leads to around a 0.5 percent increase in total consumption, which shows that consumption is income inelastic. However, low-income households spend their incomes mostly on food, which is income inelastic. The variables defining the characteristics of household head, such as age and marital status indicate that male household head affects consumption negatively, while household head age has a negligible effect but statistically significant. On the other hand, married couples consume around eight percent more than a household with a divorced or a single head. This is probably because married couples together can earn stable incomes, which may induce them to consume more. Household size also has a significantly positive effect on consumption which, as expected, reflects the general household consumption patterns for bigger households.

An interesting result from the analysis is that households living in rural areas have around 18 percent lower consumption than their urban counterparts. This is not surprising, however, as rural households in Mongolia are isolated from major markets, sometimes by hundreds of kilometres, and perishable food items such as various types of fruits, vegetables and different types of meat are not readily available in local markets on a daily basis. Those living in an apartment or a house that is connected to water, sewage and heating infrastructure have

14 percent higher consumption than those living in Mongolian traditional gers.[5] Similarly, those living in a house that is not connected to these infrastructure still have significantly higher consumption than those living in traditional gers. These results accord with the *a priori* expectation that higher incomes and consumption are correlated with better living standards. They also reflect the wide range of living conditions across Mongolia, something that mining in regional areas might be expected to mitigate. Overall, the model explains 74 percent of variations in consumption.

The findings are consistent with the theory of the large literature on the Dutch disease discussed in Van der Ploeg (2011) and findings of other empirical studies. For example, the resource-rich counties in the U.S. experienced lower per capita income growth than their resource-poor counterparts (James and Aadland, 2011; Douglas and Walker, 2017). Furthermore, a booming shale-energy sector in North Dakota in the U.S. did not increase in-migration to mining localities, nor did it ensure an even distribution of benefits across the region (Richter et al., 2017). Evidences from Ghana and Brazil also show that increased mining activities did not result in improved living standards (Caselli and Michaels, 2013; Aragón and Rud, 2015).

Columns 3 and 4 of Table 4 report the estimates for non-food consumption. Non-food consumption includes household expenditures on consumer goods, education and medical services, energy and utilities. The non-food consumption estimates are similar to total consumption estimates for Umnugovi. Conversely, the increase in non-food consumption of households in Selenge and Sukhbaatar provinces was significantly higher in 2010-2016 compared to the control households. This shows that the non-food consumption behaviour of households in Umnugovi is exactly the opposite of those in the other two mining provinces.

[5]A ger is a Mongolian traditional 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. However, people still live in gers in both rural and urban areas in Mongolia. According to the HSES 2016 report, 40 percent of the total population live in gers, 36 percent live in detached houses and 24 reside in apartments (NSO, 2017).

The scale of mining in Umnugovi and its impacts on local communities as well as the national economy have been substantial as the province has been contributing significantly to central government revenues.[6] In addition, the large-scale copper mining company provided scholarships to 242 university students and free medical check-ups for over 740 people in Umnugovi, in addition to establishing 42 vocational training centres and training over 6,600 people nationwide by 2014 (OT, 2012, 2014). These initiatives had visible impacts on household non-food consumption behaviour in Umnugovi, whereas households in Selenge and Sukhbaatar provinces are forced to spend much more on non-food consumption as the mining companies less careful in supporting local communities.

The results for food consumption are shown in Columns 5 and 6 of Table 4. The food consumption of households in Umnugovi was significantly lower than that of the control households, while the households in both Selenge and Sukhbaatar had higher food consumption in 2008. Rural households in developing countries mainly live on a subsistence income, with over half of their incomes spent on food consumption (Bhalotra and Attfield, 1998). Although more than 20 percent of household monthly income is spent on food consumption on average in Mongolia, the availability and variety of food items varies across regions (NSO, 2019). In the case of Umnugovi, the food consumption of households increased significantly more than the control households. This indicates that households in Umnugovi province were able to increase their food consumption as a result of wider development associated with increased mining activities. Such a pattern in food consumption is beneficial for households as it enhances the nutritional intake of household members, which will have a significant impact on human development in the long-run.

Households in Selenge and Sukhbaatar did not increase their food consumption as much as the control householders. The reason for this consumption pattern is that food consump-

[6]Umnugovi province has been the second largest provider of grants to the central government since 2009 when the new mining project started its development (NSO, 2016b).

tion in these two mining provinces was significantly higher than their counterparts in 2008. Thus, compared to the control households, their food consumption increased significantly less because they started from a higher base. However, when the patterns of non-food and food consumption are compared, we can see that the households in Selenge and Sukhbaatar provinces increased their non-food consumption significantly more than the households in Umnugovi. This is again the opposite of the non-food consumption pattern of households in Umnugovi, where mining companies invested substantially in the local community through their corporate social responsibility activities.

It is also important to understand in what type of non-food items households increase their expenditures. In particular, households in developing countries still rely on various source of energy ranging from firewood, coal and gas to electricity. Thus, the analyses of energy consumption provide background information about how household energy expenditures were affected by the development of the country. Following the categorization used in Hasan and Mozumder (2017), energy expenses are divided into electricity expenses and non-electricity energy expenses and presented in Table 5. The DD estimates for both Umnugovi and Selenge in Column 2 of Table 5 show that energy expenses in those provinces increased to a lesser extent than that of the control households. Conversely, the estimates for Sukhbaatar province are weakly significant in 2012 and 2014.

Electricity expenses are reported in Column 4 of Table 5. Households in all three mining provinces had significantly higher electricity expenses than the control households in 2008.The households in Selenge had the highest difference and the households in Umnugovi havd the lowest difference from the control households. The increases in electricity expenses of households in Umnugovi were much higher in 2014 and 2016 than that of the control households. Conversely, the electricity expenses of households in Selenge did not rise as much as the level of increase for the control households, while the same was true for Sukbaatar in 2014 and 2016.

TABLE 5: **Effect of mining on energy expenses**

	ln(energy expenses)		ln(electricity expenses)		ln(non-electricity expenses)	
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Umnugovi	3.080***	2.990***	0.558*	0.473**	5.069***	4.145***
	(0.143)	(0.134)	(0.338)	(0.212)	(0.180)	(0.187)
Selenge	2.772***	2.369***	4.046***	3.270***	1.196***	-0.093
	(0.169)	(0.166)	(0.197)	(0.207)	(0.303)	(0.293)
Sukhbaatar	-0.710**	-0.450	0.605*	1.546***	-0.568	-1.206***
	(0.338)	(0.294)	(0.337)	(0.271)	(0.347)	(0.326)
Y2010	2.295***	2.055***	1.234***	1.017***	2.573***	2.995***
	(0.094)	(0.086)	(0.098)	(0.076)	(0.102)	(0.101)
Y2012	4.082***	3.631***	2.396***	1.696***	4.560***	4.325***
	(0.082)	(0.080)	(0.094)	(0.082)	(0.090)	(0.094)
Y2014	5.357***	4.496***	2.518***	0.673***	5.758***	5.249***
	(0.073)	(0.077)	(0.089)	(0.083)	(0.083)	(0.091)
Y2016	5.505***	4.501***	3.328***	1.168***	5.646***	5.039***
	(0.073)	(0.076)	(0.087)	(0.081)	(0.084)	(0.090)
Umnugovi x Y2010	-1.268***	-1.329***	0.750*	0.504*	-1.461***	-1.528***
	(0.154)	(0.146)	(0.432)	(0.305)	(0.177)	(0.232)
Umnugovi x Y2012	-3.268***	-2.891***	-1.560***	0.025	-3.660***	-3.365***
	(0.157)	(0.140)	(0.455)	(0.309)	(0.180)	(0.212)
Umnugovi x Y2014	-3.495***	-3.058***	-0.502	0.835***	-4.447***	-4.102***
	(0.143)	(0.139)	(0.391)	(0.234)	(0.200)	(0.193)
Umnugovi x Y2016	-3.424***	-3.099***	0.084	1.072***	-4.997***	-4.505***
	(0.136)	(0.130)	(0.380)	(0.233)	(0.227)	(0.201)
Selenge x Y2010	-1.037***	-1.033***	-1.035***	-1.017***	0.529	0.615*
	(0.206)	(0.198)	(0.258)	(0.260)	(0.377)	(0.341)
Selenge x Y2012	-2.504***	-2.230***	-2.560***	-1.986***	-2.223***	-0.998***
	(0.180)	(0.184)	(0.276)	(0.274)	(0.398)	(0.345)
Selenge x Y2014	-3.218***	-3.063***	-2.409***	-2.634***	-1.989***	-1.169***
	(0.164)	(0.163)	(0.250)	(0.227)	(0.347)	(0.302)
Selenge x Y2016	-3.227***	-3.042***	-2.915***	-2.618***	-1.764***	-1.136***
	(0.163)	(0.163)	(0.248)	(0.224)	(0.345)	(0.303)
Sukhbaatar x Y2010	0.560	0.595	-0.182	0.218	1.482***	2.110***
	(0.431)	(0.383)	(0.446)	(0.368)	(0.450)	(0.469)
Sukhbaatar x Y2012	-0.759*	-0.619*	-0.601	0.582*	0.524	0.050
	(0.411)	(0.366)	(0.414)	(0.339)	(0.418)	(0.393)
Sukhbaatar x Y2014	0.570*	0.557*	-0.678*	-0.857***	0.981***	1.453***
	(0.335)	(0.295)	(0.389)	(0.293)	(0.374)	(0.331)
Sukhbaatar x Y2016	0.389	0.263	-0.471	-0.928***	0.761**	1.021***
	(0.336)	(0.294)	(0.383)	(0.302)	(0.378)	(0.331)
ln(Income)		0.271***		-0.010		0.178***
		(0.023)		(0.029)		(0.030)
HH head age		0.010***		0.015***		0.012***
		(0.001)		(0.001)		(0.001)
HH head is male		-0.253***		-0.761***		-0.216***
		(0.046)		(0.063)		(0.061)
HH head is married		-0.013		-0.107*		-0.050
		(0.045)		(0.060)		(0.059)
Log of household size		0.087***		0.064		0.202***
		(0.033)		(0.043)		(0.043)
Lives in rural area		-1.134***		-2.947***		-0.705***
		(0.025)		(0.037)		(0.039)
Lives in apartment/house		0.092**		1.606***		-7.585***
		(0.044)		(0.058)		(0.106)
House has no infrastructure		0.887***		2.714***		0.964***
		(0.031)		(0.046)		(0.042)
Province fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.30	0.39	0.07	0.52	0.20	0.41
Number of households	44,340	44,340	44,340	44,340	44,340	44,340

Note: 1. Robust standard errors are reported in the parentheses. * p <0.10, ** p <0.05, *** p <0.01.

Most urban households in Selenge and Sukhbaatar already had electricity access before 2008, while over 7,000 households in Umnugovi province gained access to electricity connections provided by the Oyu Tolgoi mine in 2013 (OT, 2014).[7] An interesting result in the electricity expenses analysis is that increases in income has negative effect on electricity expenses. However, this reflects the fact that households in remote rural areas are still not connected to electricity despite their increasing incomes.

The non-electricity energy expenses include firewood, coal, dung, gas and other fuels. They are presented in Column 6 of Table 5. The non-electricity energy expenses of households were significantly higher than the control households in 2008. However, the households in Selenge (but not statiscally significant) and Sukhbaatar had significantly lower expenses compared to their counterparts in 2008. The DD estimates show that the households in Umnugovi province increased their non-electricity energy expenses significantly less than those of the control households in 2010-2016, with the difference growing consistently larger over time. The access to electricity for households in Umnugovi enabled them to change their energy consumption pattern as now they can use electricity for various purposes such as cooking and heating.

Although the households in Selenge increased their non-electricity energy expenses more than the control households in 2010, their non-electricity energy consumption grew less than that of the controls households at steady rates in 2012-2016. On the other hand, the households in Sukhbaatar where households had significantly lower non-electricity energy expenses in 2008 increased their non-electricity energy expenses significantly more in 2010, 2014 and 2016. This means households rely more on energy sources such firewood, coal and other fuels which are detrimental to human health if consumed for a prolonged period. Some households in Sukhbaatar province still has intermittent electricity supply or no access,

[7] In 2012, a 40 km electricity transmission wire was built from the Oyu Tolgoi mining complex to the nearest small town, Khanbogd, to provide electricity (OT, 2014).

which has been one of the priority areas of the Minister for Energy to improve since 2016 (Ministry of Energy, 2016).

The signs and significance of the control variables remain mostly unchanged from the results in Table 4. For example, electricity expenses are significantly lower for rural households than their urban counterparts. The results are similar to those of Hasan and Mozumder (2017) who found that electricity consumption is higher for urban households, whereas the consumption of other energy is higher for rural households in Bangladesh. At the same time, those living in apartments and houses have lower non-electricity energy expenses than those living in traditional gers, which do not have access to central infrastructure such as piped water, heating and sewage. Overall, the findings of the study indicate differences in the living conditions of households living in different areas in developing countries. Finally, the explanatory power of the model is reasonable as the variations in energy, electricity and non-electricity energy expenses are around 39-52 percent.

5. Conclusions and policy implications

This paper analysed the impacts of mining activity on household consumption, using data from Mongolian Household Socio-Economic Survey. The empirical strategy of the study relied on identifying the mining regions that attracted substantial foreign direct investment and produced the main export commodities of Mongolia in 2010-2016. We used a flexible difference-in-differences model to estimate the impacts of mining on the consumption of households in mining regions against that of the households in non-mining regions.

The study finds that increased mining activities have significant negative impacts on consumption of households in mining regions. However, such an impact can be desirable from a development policy perspective because when there is adequate involvement from mining companies in community development, then the non-food consumption of households in mining regions is affected in their favour. The households in mining areas, where such

community investment was substantial, had to spend less on their non-food consumption as compared to other mining areas where such involvement is not as large. Similarly, households in some mining regions, whose initial food consumption was significantly lower than that of the households in non-mining regions, increased their food consumption significantly more after the mining activity started in that province. This is an important change in consumption pattern of households in mining regions because this shift in food consumption may improve the overall welfare of households as a result of better nutritional intake, health conditions and cognitive development of households members.

The study also shows that household energy expenses reflect the overall development of regions in a country such as Mongolia. For example, with the development of large-scale mines, the electricity expenditures increased in rural areas. However, such development is not universal for all mining regions as the households in energy deficient regions such as in Sukhbaatar still rely heavily on non-electricity energy sources, despite the development of large-scale mines in those regions.

The findings of the study provide important policy implications. Households in mining regions increased their non-food consumption at a lower rate than the households in non-mining regions. This is because local spending by the mining companies on education, health and other sectors enabled the households in mining regions to spend less on non-food consumption. In addition, those householders in mining regions, who did not increase non-food consumption significantly, were able to increase their food consumption significantly more than the households in non-mining regions. It is an important development outcome for households in mining regions. Increased food consumption can help them benefit from higher levels of nutrition and better cognitive and reduce their risks of getting sick from the mining sector pollution (Edwards, 2016; Von der Goltz and Barnwal, 2018). Therefore, given the exhaustive nature of minerals, the government should insist the mining companies to improve their better corporate social responsibility. This should not only be limited to environmental

rehabilitation and responsible mining activities, but also extended to contributing to the development of the local community through infrastructure development, educating and training local people and investing in their health.

Increased electricity expenditure is an important indicator of welfare. It is a more reliable and cleaner source of energy than alternative sources in developing countries. Switching from electricity energy has important health benefits for households as their exposure to inhaling toxic smoke from burning coal and other fuels is reduced. It also provides more convenience for households because they can use electrical appliances to improve their living conditions. Therefore, policy makers should focus on improving the infrastructure of local areas in parallel with the development of the mining sector because large-scale mining is heavily dependent on electricity generation and water use. Specially, there is an urgent policy action required for Sukhbaatar province where households heavily rely on non-electricity energy consumption, which can be detrimental to their health in the long run.

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