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The Economic and Environmental Impact of Foreign Direct Investment on the Mongolian Coal-Export Sector

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Abstract

This paper examines the impact of Foreign Direct Investment (FDI) intended to increase the exporting capacity of the coal sector on the Mongolian economy and environment by using a recursive dynamic Computable General Equilibrium model. FDI was used to expand the coal-export sector as well as to construct a railway line connecting the Mongolian main coal reserve and the Chinese border. FDI had a positive impact on macroeconomic variables such as GDP, employment, investment, and household consumption but produced a Dutch disease effect in some sectors. The new railway reduced the environmental impact of transporting coal.

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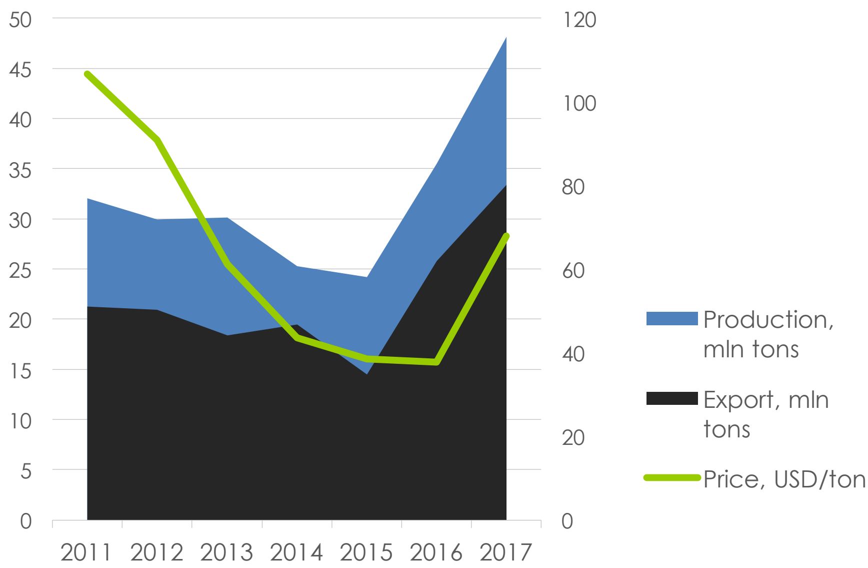
I. Introduction

Mongolia has abundant natural resources. Coal, copper, and gold make up the primary reserves with an estimated value of $1-3 trillion USD (Fisher et al., 2011). The economy is thus highly dependent on the mining sector which, between 2010 and 2017, contributed 82% of total export revenue on average and about 20% of GDP, according to the Mongolian National Statistical Office (NSO).1 The mining sector grew rapidly between 2010 and 2014, and GDP growth peaked at 17% in 2011. Mining growth has steadily decreased since 2015, however, because of low international export prices. As a result, economic growth slowed to 1% in 2016. Since then, however, conditions in world commodity markets have been favorable to Mongolian exports, allowing a 5% economic growth in 2018 and expected higher growth in subsequent years.

Coal is one of the main export commodities in the economy. In 2017, coal export revenue exceeded the copper revenue due to the higher world prices and increased production (NSO). Figure 1 shows the recent historical data on coal production, export and price.[2]

Figure 1. Coal Production, Export (Left Axis), and Price (Right Axis)



Source: NSO and authors' calculations.

[1] Here NSO refers to www.1212.mn which the website of the National Statistical office.

[2] Copper concentrate, which contributed up to 30% of total export revenue on average between 2010 and 2017, is also an important export commodity (NSO).

Most exported coal is extracted from two major strategic reserves, the Tavan Tolgoi reserve and the Nariin Sukhait mining complex. Several companies extract from these areas. Coal is exported mainly through two major borders, Gashunsukhait-Gantsmod and Shivee Khuren-Ceke, and sold to steel producers in China. Historically, more than half of total coal has been exported through the Gashunsukhait-Gantsmod border on 276 km of gravel or paved roads. Chinese and domestic freight companies carry coal via dump trucks on this route at a transportation cost of $0.06 USD per ton per km (or $17 USD per ton for 276 km).

Given the price of coal ($40-100 USD/ton) since 2010, this significant cost imposes a major constraint on the production and export of coal when coal prices are low which, in turn, erodes the competitiveness of Mongolian coal. When the price of coal is high, the current road system creates a bottleneck. The queue of trucks to the border was over 100 km long in 2017. In addition, high utilization of road transport has a major environmental impact, including air and soil pollution.

Issues such as these motivated investors and the Mongolian government to build a railway system connecting the mine and border. This project is likely to cost about $1 billion USD, of which $800 million USD will go to railway construction and $200 million USD will be used to establish the transportation service, including equipment purchases and hiring of employees (authors' calculation).[3] This is almost seven times more expensive than building a two-lane road, but the cost of transporting coal by railway is expected to be significantly lower than it currently is. According to market research conducted by the Economic Research Institute (ERI), railway transportation will cost $12 USD per ton to Gantsmod and will fall as low as $5-7 USD per ton if coal exports reach thirty million tons per annum.

Based on these estimates, railway services will create an economically efficient system for the export of coal and will reduce environmental effects (because fewer trucks would transport coal to the border).

In this paper, we attempted to examine the impact on the Mongolian economy and environment of Foreign Direct Investment (FDI) in the coal (exported only) and railway sectors. For this purpose, we modified the recursive dynamic PEP-1-t model (Decaluwé et al.,

[3] As of this writing, progress is 87% on the earthworks but only 52% of the overall project is complete. The railway project has intensified since 2016 because of a number of policy and strategic planning initiatives undertaken by the Mongolian government.

2013) and simulated two scenarios over ten years (2014-2023). In the first scenario, we simulated a business-as-usual (BAU) scenario in which GDP followed IMF projections until 2021, then grew at 4.5% annually; the metal-ores sector (including copper, gold, and iron) received a flow of FDI over five years beginning in 2016 (reflecting the development of the Oyu Tolgoi copper mine project); and the world export price of coal was 50% higher than it was in 2014 throughout the simulation period.

In the alternative (or FDI) scenario, we considered a situation in which the coal-export and railway sectors received FDI to increase coal-export export capacity. In addition, we introduced a shift from truck services to railway transport and estimated the environmental impact through a calculation of greenhouse gas emissions. We found that increasing the capacity of the coal-export sector and building a railway system had a positive impact on macroeconomic indicators despite a Dutch disease effect on most sectors as the result of higher domestic prices. The impact on households and employment were also positive. Meanwhile, the negative environmental impact of coal extraction was reduced.

II. Literature review

Computable General Equilibrium (CGE) modelling is an extensively used and widely accepted tool for estimating both the impact of changes in foreign markets and government policies on economic sectors and the resulting income redistribution among institutions. CGE models are the economy-wide class of models that provide industry disaggregation in a quantitative description of the whole economy (Dixon & Rimmer, 2010). The CGE framework helps capture interrelationships between economic sectors and accounts for the repercussion effects of policy (Dixon & Rimmer, 2002).

CGE models are increasingly used to examine the impact on economic growth in Mongolia of the overall mining sector as well as the impact of investments in mining and infrastructure. Fisher et al. (2011) used a global recursive dynamic CGE model (MINCGEM) and found that the development of the Oyu Tolgoi copper and gold deposit had significant long-term positive effects on the Mongolian economy. Lkhanaajav (2017) used Centre of Policy Studies (COPS)-style CGE models (ORANIMON and MONAGE) and, through historical and decomposition simulations, identified the growing export of mining commodities as the main source of economic growth and structural change in Mongolia between 2005 and 2012. Baatarzorig, Galindev, and Maisannave (2018) calibrated the PEP-1-1 (static CGE) model, developed by Decaluwé et al. (2013), to a 2010 Mongolian Social Accounting Matrix (SAM) and emphasized the importance of the mining sector for the economy by simulating two scenarios: an expansion in coal exports and a decrease in copper price. Byambasuren, Purevjav, and Erdenekhuyag (2015) found a positive impact of public investment in a power plant and copper refinery on the domestic economy in an analysis based on the MINCGEM model. Galindev et al. (2019) studied the impact of fiscal consolidation on the Mongolian economy using the PEP-1-1 model in conjunction with a microsimulation model. They find that the impact of fiscal contraction depends on the state of the mining sector, in particular, the price of the main mining commodities.

It is common for countries receiving large amounts of foreign currency to experience the so-called Dutch disease effect—the inflow of foreign currency leads to appreciation in the real exchange rate which, in turn, reduces the competitiveness of tradable commodities (see, e.g., Gregory, 1976; Corden & Neary, 1982; Rodriguez & Sachs, 1999; and Sachs & Warner, 2001). Baatarzorig, Galindev, and Maisannave (2018) identified a Dutch disease effect in Mongolia.

The economic impact of railway projects has been examined through CGE models in other countries. Horridge and Wittwer (2007) examined the impact of the Chongqing–Lichuan rail link project on the economic development of surrounding provinces using a multi-regional CGE model of the Chinese economy. Mostert and Van Heerden (2015) developed a CGE model to assess the short- and long-term impact of building a railway link from the Limpopo province of South Africa to Richards Bay harbor. Cardenete and López-Cabaco (2017) used a CGE approach to examine the impact of a Mediterranean rail corridor in Andalusia.

In recent years, CGE models have been used to estimate the impact of environmental policies on the economy and on the environment. As Xie and Saltzman (2000) mentioned, these environmental models can be divided into several types. The first extends standard CGE modelling to examine pollution emissions using a fixed pollution coefficient per unit of output by sector, intermediate inputs, exogenous prices, or taxes on environmental activity with no change in the structure of the model. The second type specifies a pollution-control cost in the production function. The third type specifies the production functions of pollution abatement activities or technologies. Robinson, Subramanian, and Geoghegan (1993) used a CGE model to estimate the effects of imposing emission charges for air pollutants in Los Angeles. In their research, emission of pollutants by sector was specified as proportional to output which is an approach we employed in our analysis.

A CGE model was suitable for our study because it accounted for the direct and the indirect effects that a change in one side of the economy might have on the whole system. This allowed us to assess the impact of different shocks/policies on sectors and institutions and, thus, on the structure of the economy. We modified the recursive dynamic PEP-1-t model developed by Decaluwé et al. (2013), and these modifications are detailed in Appendix 1. In brief, we considered:

- public and private investment separately;
- the wage curve (that is, the Phillips curve) to show the relationship between unemployment and wages;
- capital accumulation dynamics that allowed for a time-to-build structure;
- uniform (or economy-wide) Total Factor Productivity (TFP), which augmented the value-added of each sector;
- sector-specific TFP; and
- a measure of environmental pollution (greenhouse gas emissions).

III. Data

We constructed the SAM with 2014 data, including the Supply and Use Table (SUT), the balance of payments, and government budget data from the Mongolian National Statistical Office (NSO). Table 1 shows the macro SAM as a share of nominal GDP, which was 22.2 trillion MNT in 2014. Household consumption, government current expenditures, investment, exports, and imports were 56.6%, 13.0%, 35.2%, 51.6% and 56.4% of GDP, respectively. The economy was relatively more intensive in capital (55.4%) than in labor

(35.3%). The sum of these (90.7%) was the share of total value-added in GDP, and the remaining 9.3% came from import taxes (TM 1.6%) and commodity taxes (TI 7.7%).

Table 1. Mongolian Macro SAM 2014 (% of GDP)

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	**Labor**								0.4	34.8				35.3
2	**Capital**								0.0	55.3				55.4
3	**Households**	33.9	49.1		10.4				2.4					95.7
4	**Government**			4.7		13.4	1.6	7.7	0.3	0.5	0.0			28.2
5	**TD**			13.4										13.4
6	**TM**										1.6			1.6
7	**TI**										7.7			7.7
8	**ROW**	1.4	6.3	1.5	0.8						56.4			66.4
9	**Sectors**										185.8			185.
10	**Commodities**			56.6	13.0				51.6	95.1	20.1	28.6	6.6	268.
11	**GFCF**			19.6	4.1				11.6					35.2
12	**VSTK**											6.6		6.6
13	**TOTAL**	35.3	55.4	95.7	28.2	13.4	1.6	7.7	66.4	185.8	268.2	35.2	6.6	

Note: TD=direct taxes; TM=import duties; TI=indirect taxes on commodities; ROW=rest of the world; GFCF=gross fixed capital formation; VSTK=inventory changes.

The detailed SAM is a square matrix with eighty-four columns and rows. The SAM consist of twenty-four sectors and commodities, two production factors (capital and labor), three types of institutions (households, government, and the rest of the world), three types of taxes (income tax, import duties, and taxes on commodities), and savings (investment) accounts divided into public investment, private investment, and changes in inventories (Table 2).[4]

Table 2. Accounts in the SAM

Sectors (24)		Commodities (24)	Institutions (3)
1	Agriculture	Agriculture	Households (H)
2	Livestock	Livestock	Government (GVT)
3	Domestic coal	Domestic coal	Rest of the world (ROW)
4	Coal export	Coal export	
5	Crude oil	Crude oil	**Taxes (3)**
6	Metal ores	Metal ores	Income taxes (TD)
7	Other mining	Other mining	Import duties (TM)
8	Food	Food	Taxes on commodities (TI)
9	Textile	Textile	
10	Coke and chemicals	Coke and chemicals	**Factors (2)**
11	Manufacturing	Manufacturing	Labor (Lab)
12	Electricity	Electricity	Capital (Cap)

[4] In the SAM, firms and households are combined into one agent named "Households." In that sense, "Households" refers to the private sector.

13	Water	Fuel	
14	Construction	Construction	**Savings-Investment (3)**
15	Trade	Trade	Public investment (INV_PUB)
16	Transportation	Transportation	Private investment (INV_PRI)
17	Railway	Railway	Changes in inventories (VSTK)
18	Accommodation	Accommodation	
19	Information	Information	
20	Financial activities	Financial activities	
21	Public administration	Public administration	
22	Education	Education	
23	Health	Health	
24	Other activities	Other services	

Notes: The names of sectors and commodities represent broader activities and a larger set of commodities. Here we clarify a few of these; the rest are self-explanatory. Water: water supply, sewer systems, waste management, and remediation activities. Accommodation: accommodations and food and beverage services. Information: information and communication. Professional: professional, scientific, and technical activities. Administrative: leasing or rental services, support services, sanitation, and other similar services.

We created two new sectors and two new commodities (coal export and railway) for the purpose of this study: a) Coal export represents only the part of the existing coal sector/commodity that is exported. The remaining coal is sold domestically (domestic coal). The cost structure of the two coal sectors is assumed to be the same; b) The railway sector/commodity represents a new railway connecting the Tavan Tolgoi coal mine to the border. For the railway sector/commodity, we extracted relevant data from existing transport commodity/sector accounts. Specifically, railway service was produced only by the railway sector, and the cost structure of the railway sector was the same as that of the existing railway sector in the SUT.[5] We assumed that railway service was used only as a transport margin in exporting coal and was set at 10% of the total transport margin on coal exports in the base year.[6]

We also distinguished between public and private investment expenditures in the SAM. Total public investment expenditure in the SAM corresponded to government capital expenditures in 2014, including off-budget spending of the Development Bank of Mongolia (DBM) in line with IMF Article IV. The remainder was considered as private investment expenditures. The demand for each commodity, for public and private investment purposes, was fixed proportions of corresponding total investment expenditures.

[5] The structure of all transport sectors is known from a more detailed SUT. The other transport sectors are aggregated in the SAM, however.

[6] Ten percent is an arbitrary value. It could be any non-zero value susceptible to shock.

Beyond what is presented below, further details regarding the SAM can be found in Appendix 2.

Production Structure: The trade sector contributed largely to total labor income while livestock and mining of metal ores sectors contributed largely to capital income. The crude oil and livestock sectors were highly capital-intensive whereas public administration, education, and health sectors were the most labor-intensive (Table 3). The economy as a whole was relatively more intensive in capital.

Table 3. Production Structure (%)

Sector	Labor	Capital	Value added	Value added/	Factor intensity	
					Labor	Capital
Agriculture	1.6	1.4	1.5	41.6	41.7	58.3
Livestock	2.2	20.5	13.4	77.6	6.2	93.8
Domestic coal	0.4	0.4	0.4	27.9	37.5	62.5
Coal export	1.1	1.1	1.1	27.9	37.5	62.5
Crude oil	0.1	3.5	2.2	39.3	2.6	97.4
Metal ores	8.6	16.0	13.1	40.7	25.2	74.8
Other mining	1.1	0.9	1.0	33.1	45.0	55.0
Food	1.5	5.8	4.2	31.0	14.3	85.7
Textile	1.8	1.1	1.4	42.6	51.6	48.4
Coke and chemicals	1.3	3.5	2.7	43.5	19.2	80.8
Manufacturing	1.4	1.5	1.5	39.0	38.0	62.0
Electricity	2.4	1.0	1.6	37.1	59.0	41.0
Water	0.7	0.3	0.4	35.0	61.8	38.2
Construction	5.4	4.6	4.9	22.0	42.0	58.0
Trade	22.5	6.5	12.7	64.7	68.4	31.6
Transportation	7.9	3.9	5.4	40.0	56.2	43.8
Railway	0.1	0.0	0.0	44.3	77.3	22.7
Accommodation	1.6	0.6	1.0	38.6	63.5	36.5
Information	2.2	2.7	2.5	54.0	34.3	65.7
Financial activities	3.8	6.0	5.2	78.3	28.8	71.2
Public admin	9.4	1.4	4.5	59.9	80.4	19.6
Education	10.4	1.6	5.0	76.5	80.6	19.4
Health	4.5	0.5	2.1	60.6	85.0	15.0
Other activities	8.0	15.1	12.3	61.1	24.9	75.1
Total	100.0	100.0	100.0		38.6	61.4

Primary income distribution: Labor and capital income were distributed between domestic (households) and foreign (rest of the world) institutions. While households received the majority of factor income, foreigners received 3.9% and 11.4% of labor and capital income, respectively. Domestic public institutions (government) did not receive factor income.

Table 4. Factor Income Distribution (%)

Labor income		Capital income	
Domestic	96.1	Domestic	88.6
Foreign	3.9	Foreign	11.4
Total	100.0	Total	100.0

Household account structure: Labor and capital constituted the main source of household income. Households spent over half of their income on consumption, saved about 20.4%, and paid 13.9% as direct taxes (Table 5).

Table 5. Structure of Household Accounts (%)

Household income		Household expenditure	
Wages	35.4	Consumption	59.2
Capital income	51.3	Direct taxes	13.9
Transfers from government	10.8	Transfers to the government	4.9
Transfers from row	2.5	Transfers to ROW	1.5
		Savings	20.4
Total	100.0	Total	100.0

Investment/Savings structure: More than half of total investment (adjusted by 19% for the value of stock building) was financed by household savings.[7] The rest of the world and the government contributed 33% and 12% of total investment budget (source), respectively. Forty-four and thirty-seven percent of the investment budget was dedicated to financing private and public investment (gross fixed capital formation).

Table 6. Investment/Savings Structure (%)

Source		Allocation	
Household	55.5	Private investment	44.0
Government	11.5	Public investment	37.1
Rest of the world	32.9	Change in inventories	18.9
Total	100.0	Total	100.0

[7] Note that the SAM does not include firms, implying that household saving covers all savings in the private sector.

Emission rates: Besides the SAM, we introduced greenhouse-gas-emission (GHG) rates by sector as additional data for the purposes of the study (Table 7). The data source and calculation procedures can be found in Appendix 3. As Table 7 shows, GHG emissions were highest per unit in electricity and crop production. On the other hand, GHG emissions per unit of production were lowest for air transport, trade, and metal ore. Furthermore, GHG emissions per unit of production for the whole agricultural sector (including animal, crops, fishing) were relatively higher than those in other sectors. Even more relevant, GHG emissions per unit of railway production were 3.8 times less than in other transport sectors, which were mainly truck/road service.

Table 7. GHG Emission Rate by Sector

	GHG emission
Electricity	11.24
Crop	10.92
Animal	2.84
Fishing, aquaculture	2.58
Forestry	2.58
Other transport/land	1.06
Oil	0.66
Waste	0.65
Water supply	0.65
Domestic coal	0.38
Export coal	0.38
Mining support service	0.38
Other mining	0.38
Railway	0.28
All manufacturing	0.24
Air trans	0.11
Trade	0.01
Metal ore	0.00

Source: Authors' calculations.

IV. Scenarios and Simulation Results

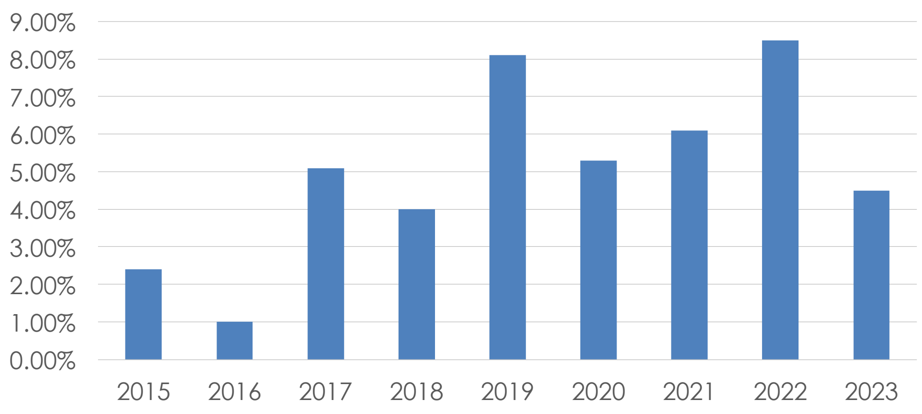
In this section, we simulated two scenarios—a business-as-usual (BAU) and an alternative (FDI) scenario—and compared these results to examine the impact on the economy and environment of FDI intended for the expansion of the coal sector's exporting capacity.

4.1. BAU Scenario

We considered the following closure rules and assumptions in the BAU scenario. Current account balance was fixed at its initial values so that the real exchange rate was flexible. The minimum consumption of households was fixed at initial values. The distribution of factor income between domestic and foreign institutions was maintained at base-year levels. In addition, domestic public institutions did not receive factor income. Factor payments from rest of the world and new capital investment in public sectors grew at the GDP growth rate. Potential labor supply grew at the population growth rate. Stock variation for each commodity grew at the growth rate of total demand of the corresponding commodity. Current public expenditure in nominal terms grew at the GDP growth rate.

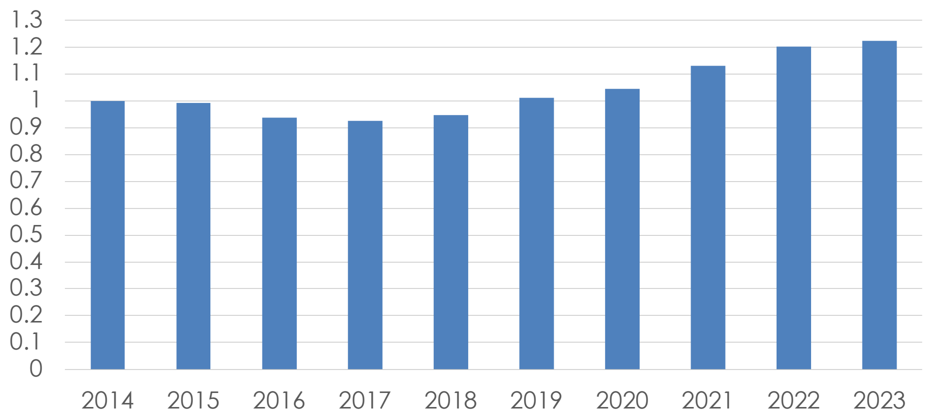
The world price of each commodity was fixed at initial levels except for coal export which increased by 50% in 2017 and stayed at this level through to the present. FDI in the Oyu Tolgoi copper-gold mine was also imposed in accordance with the 2014 Feasibility Study; $5.7 billion USD were to be invested during the construction of the underground mine in 2016-2020. Because of a lack of detailed information, we assumed that the same amount would be spent in each year—that is, about 2.8 trillion MNT ($1.14 billion USD) each year. These values were introduced as shocks to the new capital formation in the metal ores sector (mainly copper concentrate). The uniform TFP was calibrated to reproduce the GDP growth projections in the IMF Article IV published in May 2017. Figure 2 shows GDP growth in the BAU scenario. As can be seen, the GDP followed IMF projections until 2022 and subsequently grew at 4.5% per annum.

Figure 2. GDP Growth in the BAU Scenario



We simulated the BAU scenario and obtained TFP levels shown in Figure 3, as well as other endogenous variables consistent with the conditions we imposed in the closure. As can be seen, during FDI in metal ores sector, TFP declined, indicating that the growth expected for 2016-2020 was driven by FDI in the Oyu Tolgoi mine.

Figure 3. Level of TFP



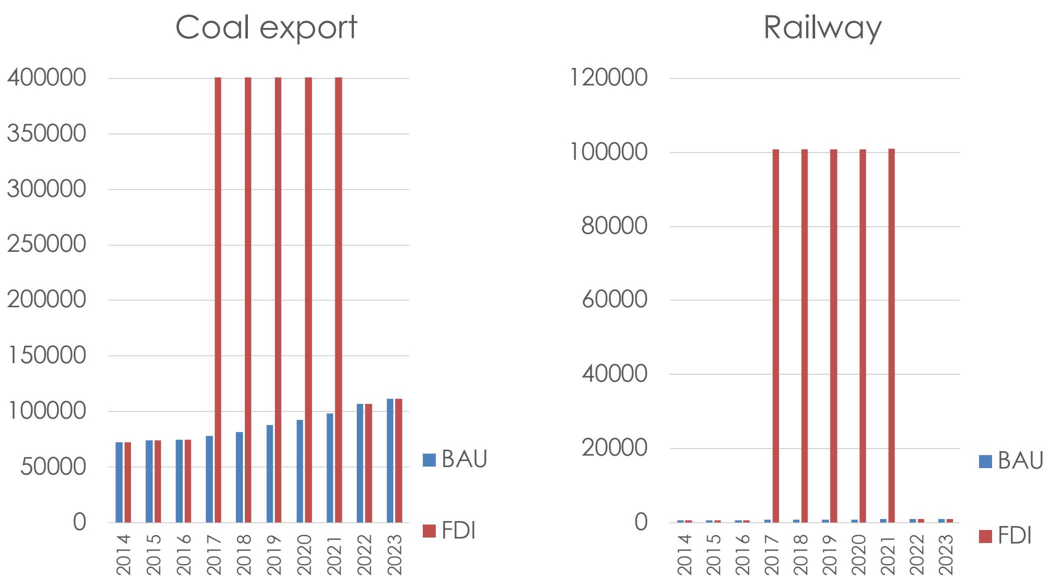
4.2. FDI Scenario

In the alternative (or FDI) scenario, we considered a situation in which the coal export and rail sectors received FDI to establish railway services and expand the production capacity of the coal-export sector. Cost estimates for building the railway service seem to vary but are generally around $1 billion USD. We assumed, therefore, FDI of 500 billion MNT each year between 2017 and 2021 (for a total investment of 2.5 trillion MNT, equivalent to $1 billion USD). FDI was intended to increase capital stock in the coal-export and rail sectors as shown in Figure 4. We assumed that 80% of the FDI would be available to purchase goods and services for investment purposes in the coal-export sector while the remaining 20% of the investment would be used for railway construction. FDI in these sectors would not generate productive capital until 2022, however, at which point the new railway would become fully operational (Figure 7). This time-to-build delay was adjusted by a new variable, $cap\_adj_{k,j,t}$, in the following capital accumulation equation:

$$KD_{k,j,t+1} = \left(1-\delta_{k,j}\right) KD_{k,j,t} + IND_{k,j,t} + cap\_adj_{k,j,t} \qquad (1)$$

where $KD_{k,j,t}$ is type k capital stock in sector j in year t, $IND_{k,j,t}$ is the volume of new capital in type k in sector j in period t, and $\delta_{k,j}$ is the depreciation rate of type k and in sector j. The variable, $cap\_adj_{k,j,t}$, is used to control the stock of productive capital in the railway and coal-export sectors until 2022 and to introduce both the new railway and greater coal-export capacity in 2022.

Figure 4. Creation of New Capital in the Coal-Export and Railway Sectors



Once the railway was operational, the coal-export sector would transport its commodity mostly by rail, and the use of traditional road transport services would be reduced. To replicate this, we shocked the transport-margin rate as applied to coal exports. Specifically, we adjusted the rate of railway and other transport margins from 0.017 and 0.154 in the BAU scenario to 0.15 and 0.01, respectively, beginning in 2022. This means that the coal-export sector switched from traditional truck service to railway service beginning in 2022. In addition, TFP levels were fixed in the BAU scenario so that GDP growth rates in the FDI scenario were endogenous. All the other conditions in the closure remained the same.

V. Simulation Results

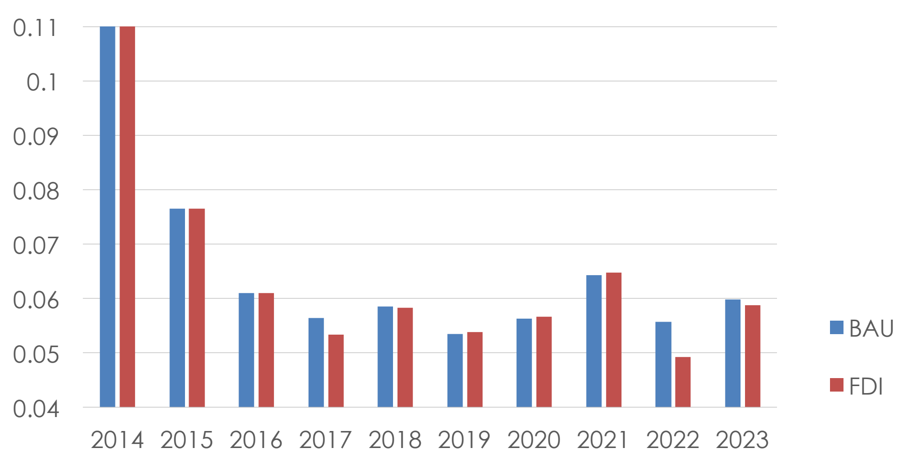
Table 8 summarizes the percent differences in macroeconomic indicators between the two scenarios. As can be seen, there were no changes in 2014-2016 because there were no shocks during this period. The main difference appears in 2017-2023. Real GDP, household consumption, real investment, exports, and imports increased while real public consumption decreased in the FDI scenario as the consequence of a price effect. Overall, the FDI had a positive impact on the real variables.

Table 8. Real Macroeconomic Indicators, % changes with respect to the BAU

	Private consumption	Public consumption	Private investment	Public investment	Exports	Imports	GDP_BP	GDP_MP
2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2017	0.7	-1.6	-0.5	8.2	-0.7	2.2	0.1	0.8
2018	0.5	-1.7	-0.7	8.0	-0.8	2.0	0.0	0.7
2019	0.4	-1.5	-0.5	7.7	-0.8	1.8	-0.1	0.5
2020	0.4	-1.4	-0.4	7.5	-0.8	1.7	-0.1	0.5
2021	0.3	-1.3	0.7	12.1	-0.7	1.9	-0.1	0.4
2022	2.1	-5.4	8.2	-1.6	8.6	6.0	1.8	2.6
2023	2.0	-5.4	8.0	-1.5	8.1	5.6	1.7	2.5

The unemployment rate, which was set at 11% for the base year, decreased over time to approach the natural unemployment rate, 6.5%, in both scenarios. The rate, however, was lower in the FDI scenario.

Figure 5. Unemployment Rate (%)



Investment in railway and the coal-export sectors would increase the demand for other commodities. Domestic-supply response was relatively limited for those commodities, however. As a result, all commodities except the railway became relatively more expensive in the FDI scenario as reflected in the consumer price index (Figure 6).

Figure 6. Consumer Price Index

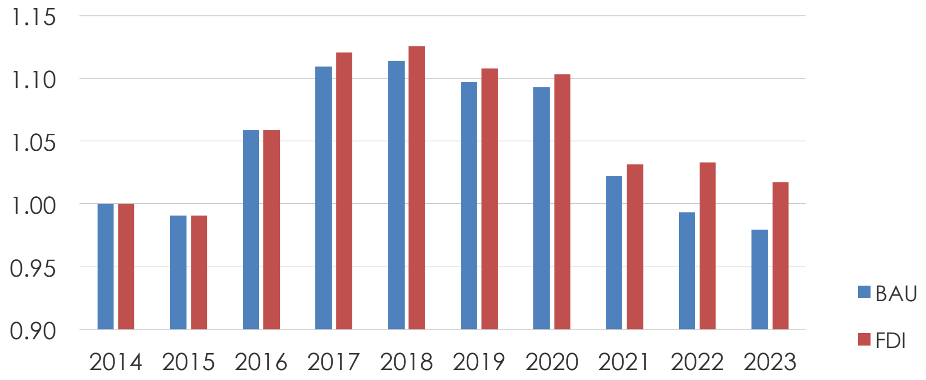
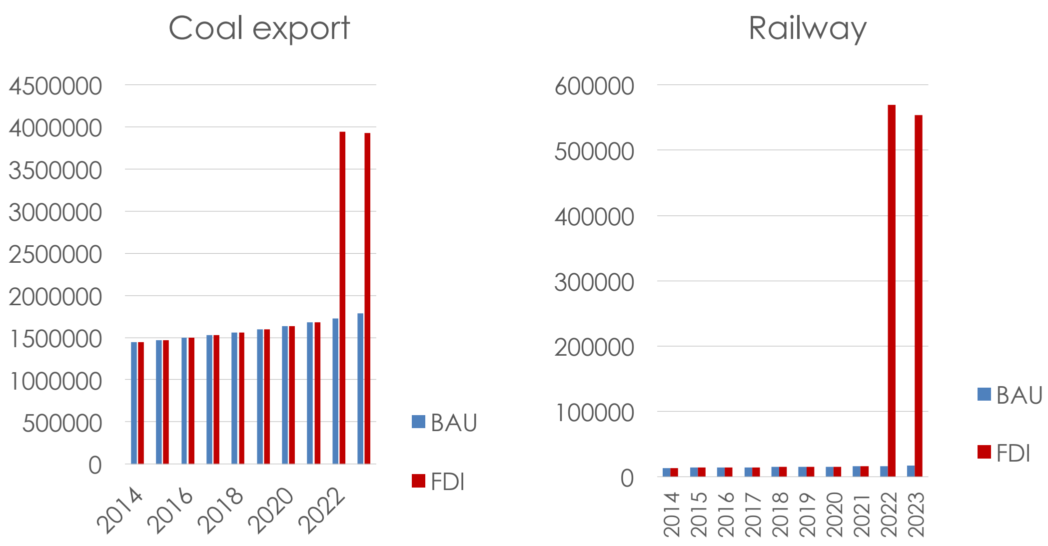


Figure 7 shows that capital stock in the coal-export sector increased by more than 100% in 2022 as the accumulated FDI created new productive capital. Similarly, capital stock in the railway sector soared to become about thirty-four times as large as that in the BAU in 2022 (at which point the new railway was assumed to become fully operational). Labor demand in these sectors evolved in more or less the same way as capital stock because the elasticity of substitution between factors in these sectors was low.

Figure 7. Capital Stock in the Coal-Export and Railway Sectors

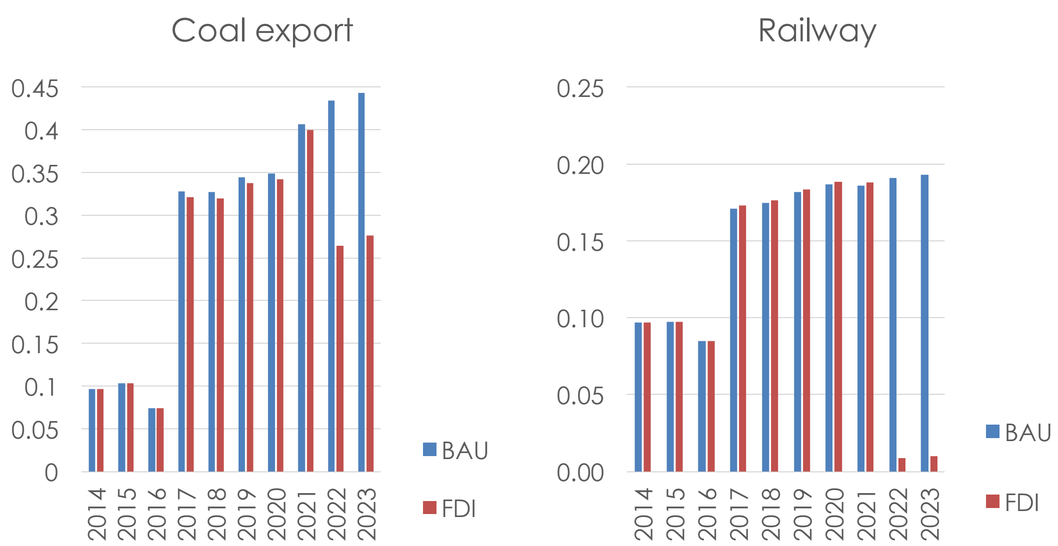


The rental rate in the rail sector decreased sharply in 2022 when its new capital began to be used (Figure 8). There were two reasons for this. First, the rail sector expanded more than did the coal-export sector, creating an excess supply of railway service. This is shown by a drop in the railway price (Figure 10b) which led the rental rate to fall. The second reason was related to the cost structure of the railway sector. In the absence of more detailed information, we assumed that the railway sector had the same cost structure as the existing railway system, which is relatively intensive in labor. This implied that production in this sector grew more slowly than did its capital stock, leading to a more precipitous decline in the rental rate.

Overall, the decreased rental rate may suggest that the new railway project would not be financially viable. We expected, however, that the new railway would likely be capital intensive and have higher rental rates (i.e., those driven by profits) compared to the existing railway system, which is a Socialist-era joint venture of the Mongolian and Russian governments. If we had more accurate information on the cost structure of the new railway, our calculations might have shown a less steep decrease in the rental rate.

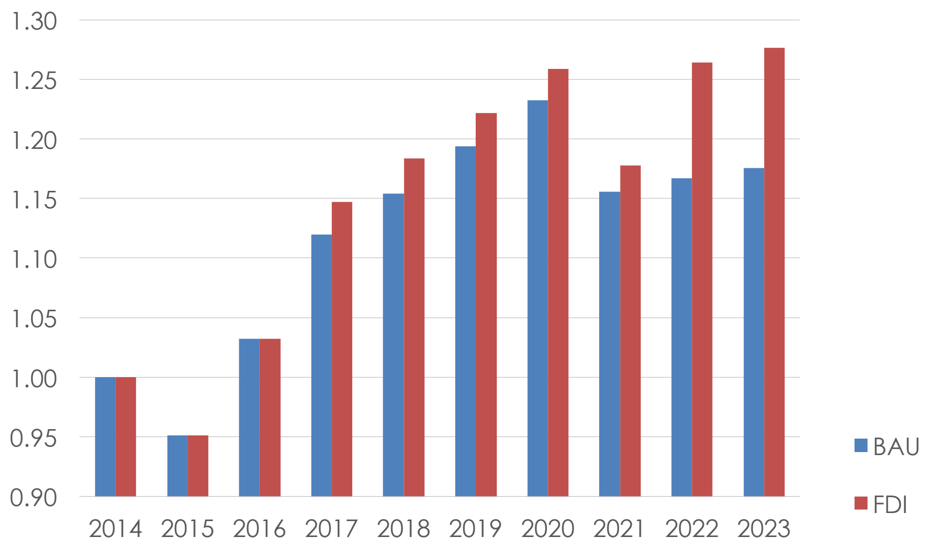
The rental rate in the coal-export sector increased in both scenarios as the result of increased world price in 2017 and then, in the FDI scenario, decreased in 2022 because of the diminishing marginal product of capital when capital stock became available (Figure 8).

Figure 8. Rental Rates in the Coal-Export and Railway Sectors



The wage rate was higher relative to the BAU scenario because labor became less abundant relative to capital in the FDI scenario (Figure 9).

Figure 9. Wage Rate



The railway service was used only as a margin commodity by the coal-export sector. Figure 10a shows the use of the railway and traditional transport services by the coal-export sector. Figure 10b shows the changes in the price of the railway and traditional transport sectors. The price of transport services remained the same as in the BAU scenario prior to full operational capacity of the new railway but, beginning in 2022, the price of the railway fell sharply while the price of other transport increased (possibly the result of a scale effect).

Figure 10a. Demand for Transport Services as Margin

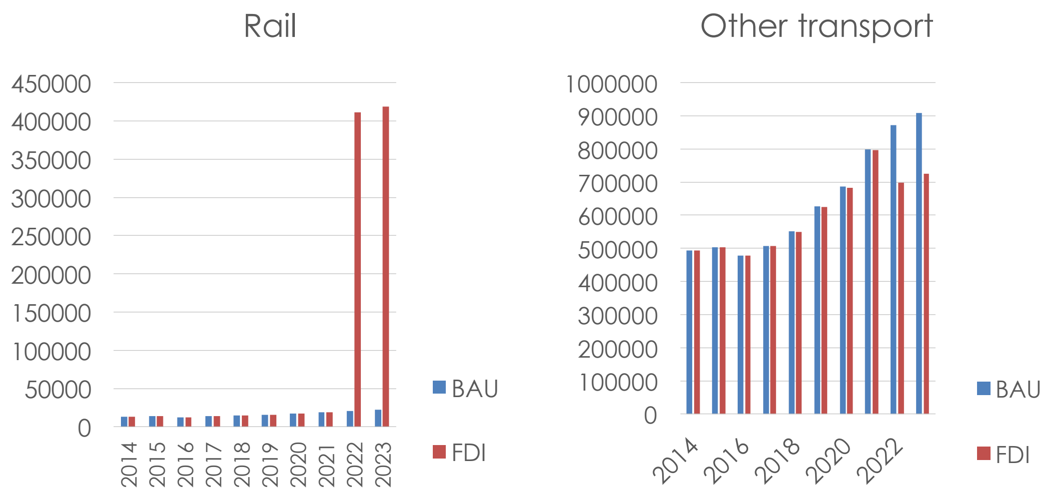
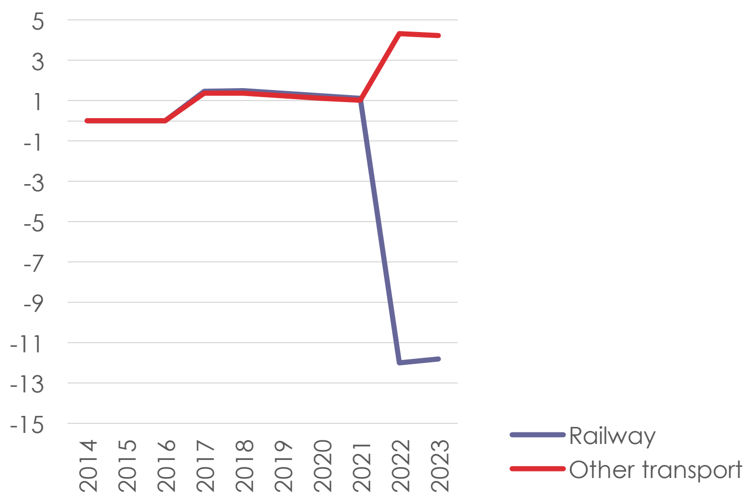


Figure 10b. % change in the Price of Transport Services with respect to the BAU



Figures 11a and 11b show the changes by sector in production and emission. Except for the construction and trade sectors, production declined in most sectors, which can be explained by the so-called Dutch disease phenomenon. The flow of foreign currency appreciated the real exchange rate, making domestic prices relatively higher and thus reduced the competitiveness of domestic production. In addition, export of all commodities except coal decreased as a consequence of the exchange-rate effect.

Figure 11a. % changes in Production and Emission by sectors from the BAU

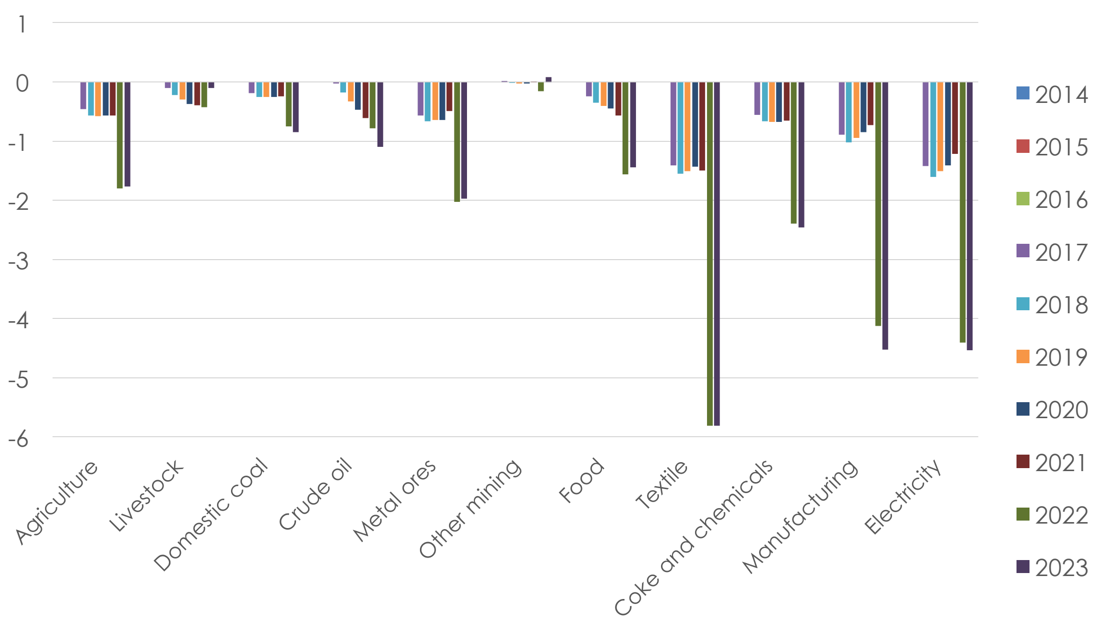
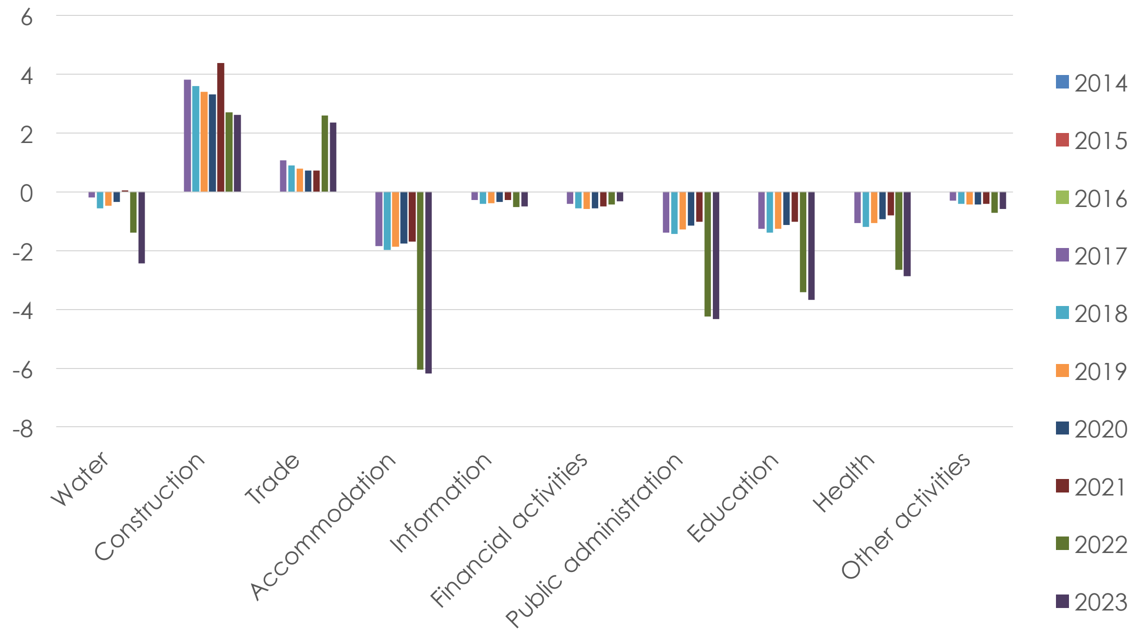


Figure 11b. % changes in Production and Emission by sector from the BAU



The coal-export and railway sectors, on the other hand, experienced huge expansions in 2022 (Figure 12). The land and water-transport sectors declined slightly between 2017 and 2021 as the result of Dutch disease effects and, later, even further declined (Figure 13) because of the combined effect of Dutch disease and the substitution effect of using railway services to transport coal exports. The volume of GHG emission increased or decreased by the same percent as the production for all sectors because we assumed a linear relationship between these two variables. Therefore, GHG emission decreased in most sectors but surged in the coal export and railway sectors. On the other hand, the land and water transport sector emitted fewer greenhouse gasses.

Figure 12. Production and Emissions in the Coal-Export and Railway sectors

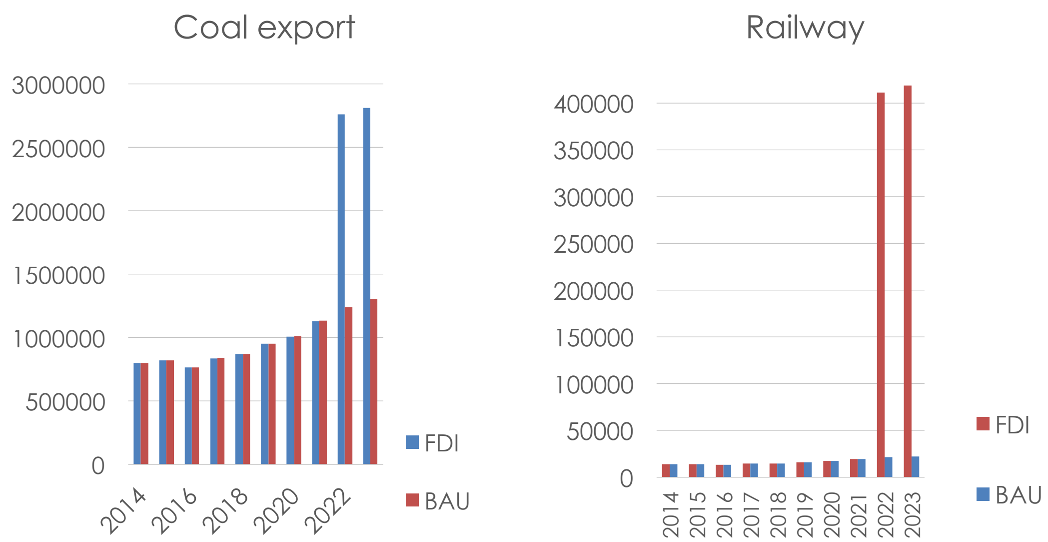
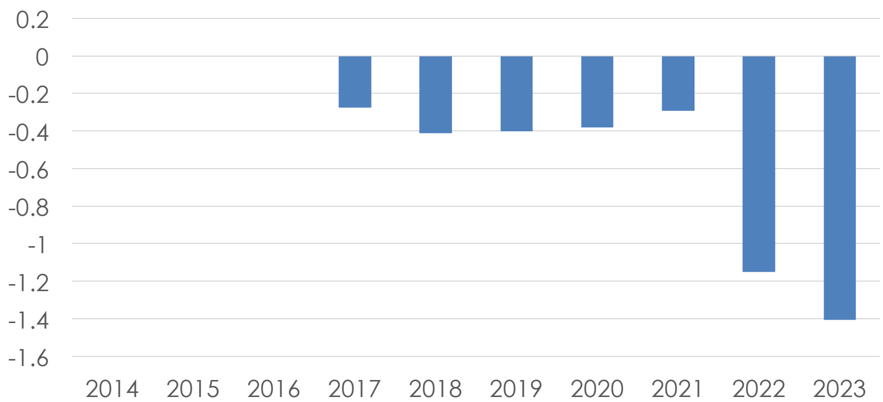
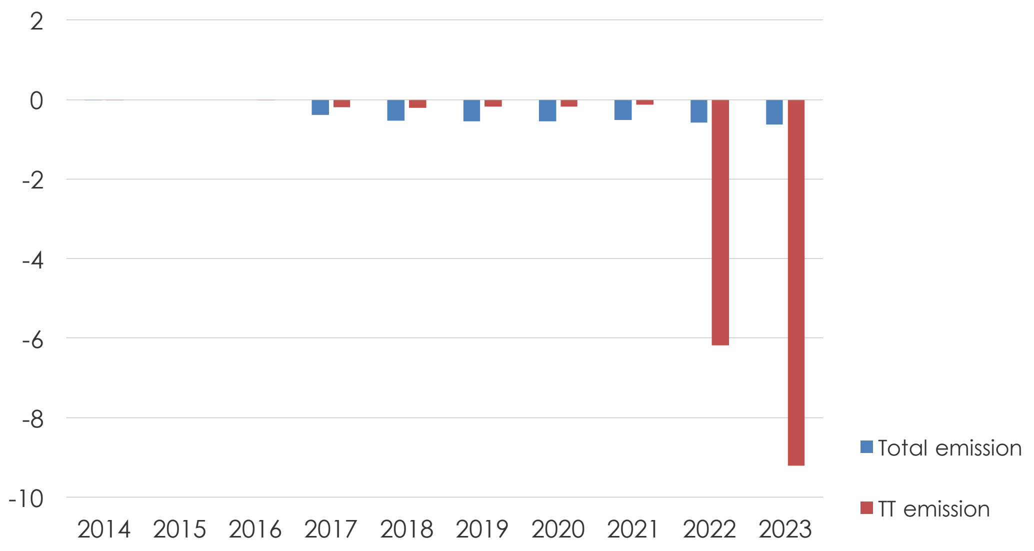


Figure 13. % change in Production and Emissions in the Land-Water Transport Sector from the BAU scenario



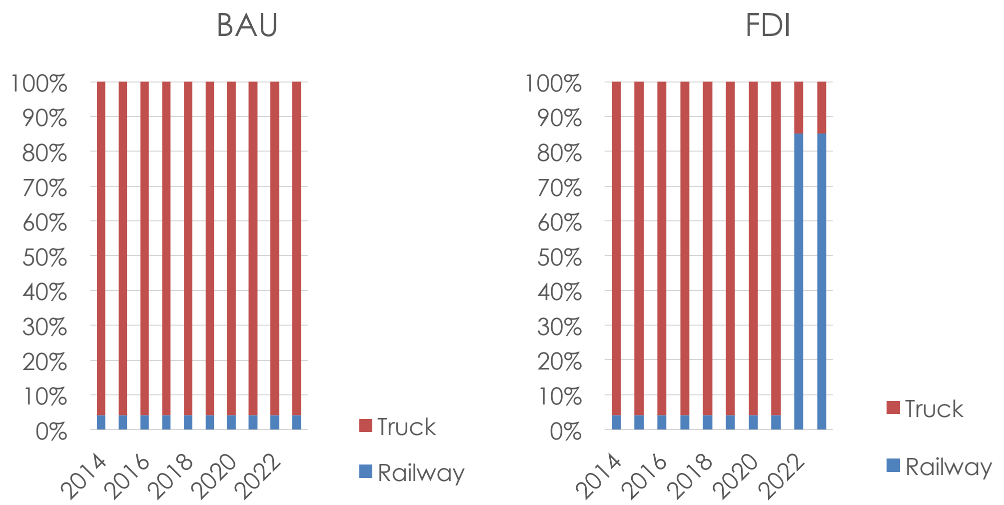
Total GHG emitted by the whole economy decreased slightly while the volume of GHG emitted due to the transport of coal exports decreased sharply as soon as the new railway began operation (Figure 14). This reflects expected improvement in the environmental impact of coal-export transport because emissions related to transportation declined even if more coal were carried to the border.

Figure 14. Changes in Total Emission and Tavan Tolgoi Emissions (%)



There was a shift in the structure of Tavan Tolgoi emissions in the FDI scenario as shown in Figure 15. Specifically, most emissions were released by truck services until 2022; once it was operational, the railway sector emitted about 85% of Tavan Tolgoi emissions. As a result of its lower emission rate, however, the railway made it possible for coal exporters to transport more coal with lower GHG emissions.

Figure 15. Structure of Tavan Tolgoi Emissions



VI. Conclusions and Policy Implications

We simulated the impact of FDI of $1 billion USD in the coal-export sector on the following assumption: 80% would be directed toward increasing production capacity and 20% to establishing railway services for the transport of coal to the border. In the absence of information about the actual cost of the new railway service, we based our simulations on the structure of the existing railway, a joint venture of the Mongolian and Russian governments. Given this structure, we found that an investment of any more than $200 million USD would be too much because it would cause the rental rate to decrease to zero, implying that the investment would not be financially viable in light of the amount of coal to be exported. With a more realistic structure, simulation results would change.

To examine the impact of FDI of $1 billion USD, we first simulated a BAU scenario that reflected IMF projections of GDP and FDI in the Oyu Tolgoi copper-gold mine until 2023. In the FDI scenario, we found the following results. FDI had a positive impact on macroeconomic variables (real GDP, real household consumption, real exports, and real imports) and on employment. Price was higher. There was a Dutch disease effect on the other sectors: that is, most sectors experienced a decrease in production while the coal-export, railway, construction, and trade sectors directly benefitted from FDI and expanded. Once the railway was built, it would be used by the coal-export sector relatively more than traditional transport services and at lower cost. Use of the new railway decreased negative environmental impacts: the transport of coal exports to the border emitted less GHG compared to the BAU scenario. Although the economy expanded, total GHG emissions decreased slightly.

Although the FDI had a positive effect on the overall economy and environment, we emphasize that the economy became increasingly dependent on the mining sector so that cycles in the international commodity market could generate significant fluctuations. This kind of analysis can be found in Baatarzorig, Galindev, and Maisannave (2018) and Galindev et al. (2019).

In such an economic environment, one policy recommendation would be to diversify the economy. In a mineral-rich economy (with a huge comparative advantage in mining commodities), however, and in light of the Dutch disease effect, diversifying the economy would be difficult without consistent and uninterrupted government policies. One such policy is the Mongolian Future Heritage Fund, a sovereign wealth fund used to control the flow of foreign currency into the economy. We emphasize the significance of this fund in stabilizing the economy. Another policy instrument is the Mongolian Fiscal Stability Fund, used to ensure stable growth in government spending so that revenues in good times generate savings for bad times. So far, the rules under this policy have been broken many times, and we recommend consistent adherence to these rules by the government.

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Appendices

Appendix 1. Extensions to the PEP 1-t model

The first original feature of our model is an adjustment in the treatment of public and private investment. Specifically, the value of public investment is taken from budget data, as opposed to the PEP 1-t model, in which it is calibrated from public service capital stock. This created a difference, and we introduced a new exogenous variable, IT_TR, to account for it:

$$IT\_TR_t = IT\_PUB_t - \sum_{k,pub} IND_{k,pub,t} PK\_PUB_t \tag{A1}$$

where IT_PUB is public investment in the budget data, *pub* is a set of public services, *k* is type of capital, *t* is a set of periods, $IND_{k,pub}$ is an additional stock in (*k,pub*), and PK_PUB is an investment price index. Private investment is determined as:

$$IT\_PRI_t = IT_t - IT\_PUB_t - \sum_{i} VSTK_{i,t} * PC_{i,t} \tag{A2}$$

where IT is total investment, $VSTK_i$ is the stock variation of commodity *i*, and PC_i is the price of commodity *i*.

The foreign savings equation is changed to include FDI_coal_t and FDI_metal_t.

$$SROW_t = -CAB_t + FDI\_coal_t + FDI\_metal_t \tag{A3}$$

where $SROW$ is foreign savings, CAB is the current account balance, FDI_coal is the amount of FDI in the coal-export sector, and FDI_metal is the amount of FDI in the metal-ore sector. CAB is exogenous so that FDI increases foreign savings.

We preferred to avoid the dichotomy between a full-employment model with a fully flexible wage rate and the one with a rigid wage rate and an endogenous level of unemployment as in the PEP-1-t model. Therefore, the second original feature of our model is the introduction of the wage curve (that is, the Philips curve relationship between the wage rate and the unemployment rate; see Blanchflower & Oswald, 1995). This relationship is interpreted by the following equation:

$$\frac{W_t}{PIXCON_t} = \frac{W_{t-1}}{PIXCON_{t-1}} \left(\frac{U_N}{U_t}\right)^{\phi} \tag{A4}$$

where W is the wage rate, $PIXCON$ is consumer price index, U is the unemployment rate, U_N is the natural unemployment rate, and ϕ is an elasticity parameter. For the first period, the equation is rewritten as:

$$\frac{W_t}{PIXCON_t} = \frac{W_O}{PIXCON_O}\left(\frac{U_O}{U_t}\right)^{\phi} \tag{A5}$$

where subscript *O* indicates the base year. The intuition of these equations is that the wage and unemployment rates adjust over time, that the unemployment rate converges from U_O to U_N, and that parameter ϕ controls the speed of convergence as well as indicates the slope of labor supply curve within t. Labor supply is determined as:

$$LS_t = LS_t^P(1 - U_t) \tag{A6}$$

where LS and LS^P are labor supply and potential labor supply, respectively.

The last original feature of this model is the inclusion of a measure of the environmental impact of economic activities, represented by greenhouse gas emissions (GHG). GHG emission is specified as a linear function of output:

$$EMIS_{j,t} = em\_rate_j \cdot XST_{j,t} \tag{A7}$$

where $EMIS_j$ is the volume of GHG emission by industry *j*, em_rate_j is the volume of emission per output of industry *j*, and XST_j is total output of industry *j*. Volume of emission is endogenous while we set the emission rate (emission per output) for each industry as exogenous.

Appendix 2. Some Details Regarding the Micro-SAM

Table A1. Trade Structure (%)

Commodities	Export shares	Import shares	Export intensity[8]	Import penetration
Agriculture	0.3	0.7	4.5	11.5
Livestock	3.6	0.2	11.4	0.8
Domestic coal	-	0.0	-	0.2
Coal export	7.4	-	100.0	
Crude oil	10.5	-	99.4	-
Metal ores	53.2	0.0	99.4	0.5
Other mining	1.0	0.2	54.9	17.4
Electricity	0.0	1.9	0.1	20.0
Food	0.2	6.8	0.7	24.3
Textile	2.0	3.3	32.9	49.5
Manufacturing	6.8	35.1	51.3	86.4
Fuel	-	17.8		100.0
Coke and chemicals	4.6	10.9	39.8	64.6
Construction	0.3	1.3	0.8	3.6
Trade	-	-	-	-
Accommodation	2.9	5.2	62.4	77.7
Transportation	3.4	2.1	13.2	10.1
Railway	-	-	-	-
Financial activities	0.3	2.1	2.1	16.8
Information	0.2	1.3	2.9	17.5
Public administration	-	-	-	-
Education	0.1	1.4	0.9	11.7
Health	0.0	0.8	0.5	13.5
Other services	3.1	9.0	6.8	19.6
Total	100.0	100.0		

[8] Excludes taxes and margins; that is, represents base prices.

Table A2. Demand Structure by Commodity (%)

Commodity	Household Consumption	Government Consumption	Intermediate Consumption	Margin	GFCF	Stock Variation	Total Demand
Agriculture	42.7	-	57.2	-	0.0	0.1	100.0
Livestock	19.0	-	34.4	-	23.6	23.0	100.0
Domestic coal	11.2	-	96.8	-	-	-8.0	100.0
Crude oil	-	-	-	-	-	100.0	100.0
Metal ores	-	-	63.9	-	-	36.1	100.0
Other mining	1.0	-	101.3	-	-	-2.3	100.0
Electricity	8.6	-	91.4	-	-	-	100.0
Food	84.0	-	13.1	-	-	2.9	100.0
Textile	65.2	-	30.0	-	1.6	3.2	100.0
Manufacturing	14.7	-	54.0	-	26.3	4.9	100.0
Fuel	17.8	-	78.4	-	-	3.8	100.0
Coke and chemicals	13.6	-	84.4	-	-	2.0	100.0
Construction	0.3	-	26.0	-	73.6	-	100.0
Trade	-	-	-	100.0	-	-	100.0
Accommodation	66.9	0.2	32.9	-	-	-	100.0
Transportation	21.5	0.1	59.8	18.6	-	-	100.0
Railway	-	-	-	100.0	-	-	100.0
Financial activities	14.6	-	85.4	-	-	-	100.0
Information	58.2	1.2	40.6	-	-	-	100.0
Public administration	3.3	88.9	7.7	-	-	-	100.0
Education	43.2	53.8	3.0	-	-	-	100.0
Health	34.2	59.2	6.5	-	-	-	100.0
Other services	32.6	4.8	58.1	-	4.5	-0.0	100.0

Table A3 shows government revenue and spending. The main sources of revenue were direct taxes (personal income and corporate taxes) and taxes on products (47.3% and 27.4%, respectively). On the other hand, the government spent most of its revenue on education, public administration, health services, and others as current expenditures, which jointly accounted for 46.1% of total government expenditure. The government also transferred 36.7% of its expenditures to households through social security and social assistance funds in the form of reimbursement, repression reimbursements, and other current transfers. The remaining government revenue was savings in the SAM and was destined to cover capital expenditure.

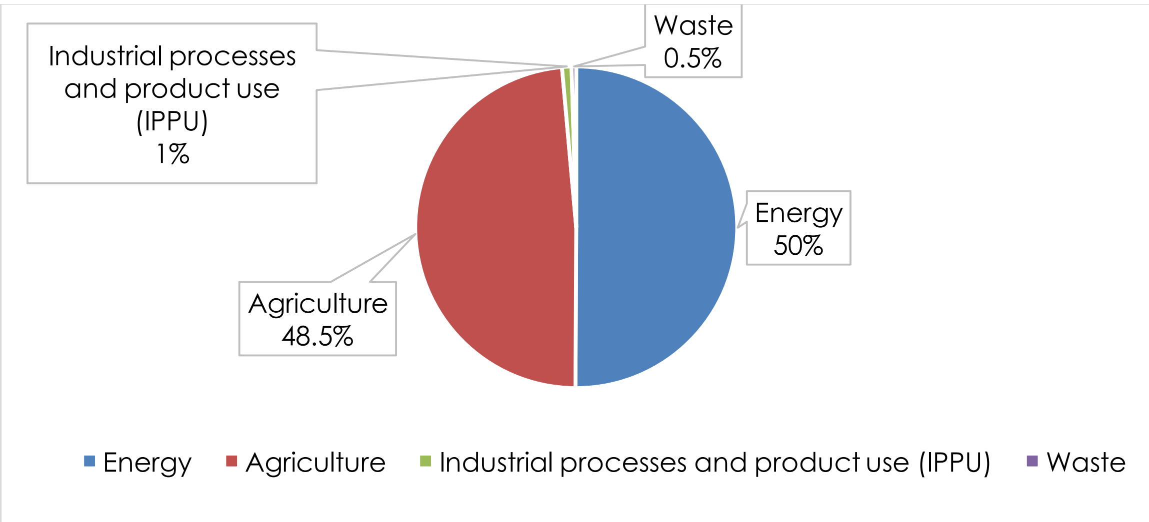
Table A3. Structure of Budget Revenue and Spending (%)

Government revenue		Government expenditure	
Transfers from households	16.7	Transfers to households	36.7
Direct taxes/TD	47.3	Transfers to ROW	2.8
Import duties/TM	5.7	Public consumption	46.1
Export taxes	0.0	Savings	14.4
Net taxes on products/TI	27.4		
Transfers from ROW	1.1		
Net taxes on production	1.8		
Total	100.0	Total	100.0

Appendix 3. Calculation of Emission Rates

We used data from Mongolia's National Inventory Report—2017 (2017). According to the report, Mongolia's total GHG emissions were 34483Kt in 2016 of which 50% were generated by energy usage, 48.5% by agricultural activities, and 1.5% by waste and industrial processes (Figure A1).

Figure A1. Total GHG Emission by Activity



Source: Mongolia's National Inventory Report—2017 (2017).

Table A4 shows GHG emissions by more detailed activities. The activity that emitted the highest level of GHGs was livestock, one of the largest sectors in the economy (it contributes roughly 13.4% of total value-added). Other sectors with high GHG emissions were electricity and heat production, use of land, and manufacturing and construction.

To make this information usable—that is, consistent with the SAM and the model--we mapped activities between Table A4 and Table 2. Land (crops), livestock, forestry, coal mining, oil production, metal industry, mineral industry, electricity and heat production, waste, commercial, road transportation, railways, and civil aviation corresponded directly to their respective sectors in Table 2.

Some sectors in Table A4, however, corresponded to different sectors in Table 2. For example, the manufacturing and construction in Table A4 corresponded to twenty-four sectors in the SAM. In particular, the main manufacturing industries are construction, food, beverage, production of coke, and basic metal sectors. In such cases, we allocated the value of GHG emissions to each sector using each sector's production share in the SAM. Furthermore, we assumed that fifteen sectors in the SAM did not emit GHG (health, education, public administration, and financial service, e.g.) because there was no information on GHG emission by these sectors in the National Inventory Report—2017 (2017). Finally, we calculated emission rates for each activity in the model shown in Table 7, above.

Table A4. GHG Emissions by Activity (Sector)

	Activity	GHG emission, Kt
Energy	Electricity and heat production	9474.7
	Manufacturing industries and construction	2313.5
	Road transportation	1674.5
	Residential	1189.0
	Stationary	903.4
	Oil production and upgrading	744.3
	Coal mining and handling	412.4
	Railways	282.0
	Agriculture/Forestry	200.4
	Civil aviation	40.7
	Commercial/Institutional	33.0
Agriculture	Livestock	9840.0
	Land	6886.9
Industrial processes and product use (IPPU)	Mineral industry	225.9
	Metal industry	5.2
	Non-energy Products from Fuels and Solvent Use	0.6
	Product Uses as Substitutes for Ozone Depleting Substances	96.4
Waste		159.9
Total		**34482.7**

Source: Mongolia's National Inventory Report—2017 (2017).