final report

Economic and environmental impact of FDI in the Mongolian coal export sector

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Final Report 2
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Abstract

This paper examines the impact of Foreign Direct Investment (FDI) destined to increase the exporting capacity of coal sector on the Mongolian economy and environment by using a recursive dynamic Computable General Equilibrium model. FDI is assumed to expand coal export sector as well as to construct a railway line connecting the Mongolian main coal reserve and the Chinese border. It is found that the FDI has a positive impact on macroeconomic variables such as GDP, employment, investment and household consumption but produces a Dutch disease effect on some sectors. The new railway reduces the environmental impact of transporting coal.

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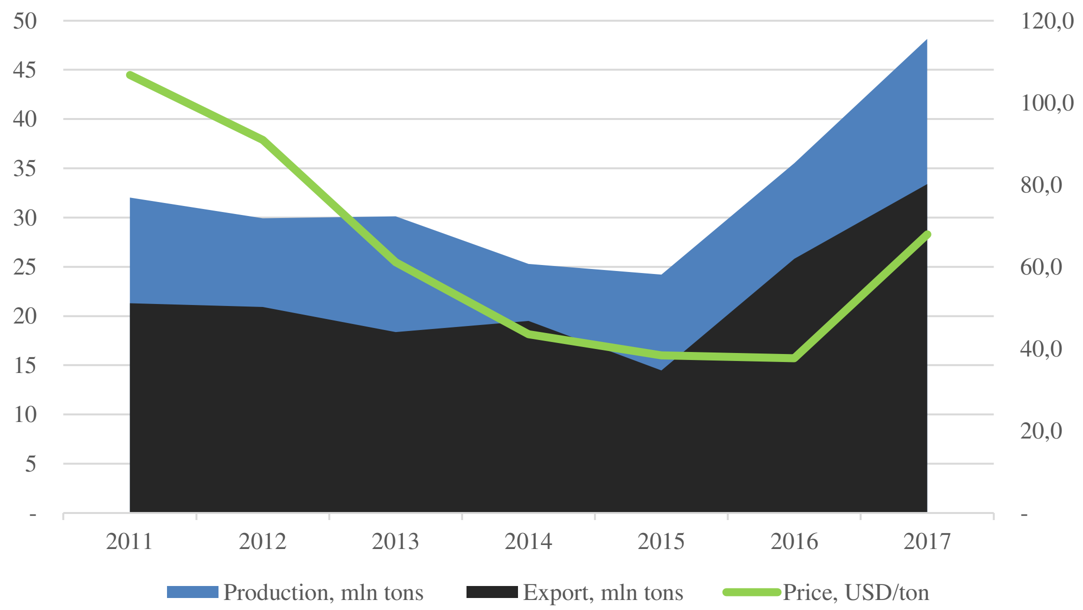
1. Introduction

Mongolia has abundant natural resources with an estimated wealth of 1 to 3 trillion USD with coal, copper, and gold making up the primary reserves (Fisher *et al.*, 2011). The economy is thus highly dependent on the mining sector as it has contributed 82% of total export revenue on average and about 20% of GDP between 2010 and 2017, according to the National Statistical Office (NSO). The mining sector grew rapidly between 2010 and 2014 and GDP growth peaked at 17 percent in 2011. However, the mining growth has been decreasing since 2015 because of low prices on the international export market. As a result, economic growth slowed down to 1% in 2016. Since then, however, the conditions in the world commodity markets have been favorable to the Mongolian exports allowing a 5% economic growth in 2018 and expected higher growth in the following 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.[1]

Figure 1. Coal production, export (left axis) and price (right axis)



Source: NSO and authors' calculation

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

Most of exported coal is extracted from two major strategic reserves, Tavan Tolgoi and Nariin Sukhait. The coal mining companies which have joint capacity of extracting 80 million tons of coal annually (Mineral Resource and Petroleum Authority) operate in these reserves. 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 by gravel or paved roads of 276 km. The transportation cost of paved and gravel roads is 0.06 USD ton/km – i.e., 17 USD per ton between the mine and the border. Given the observed price of coal (40-100 USD/ton), this is significant cost which imposes a major constraint on the production and export of coal when the price of coal is low and hence deteriorates the competitiveness of the Mongolian coal. When the price of coal is sufficiently high, the current road system creates a bottleneck problem. It is reported that the queue of dump trucks to the border is over 100 km long in 2017. In addition, high utilization of road transport has a major environmental impact – dust, air and soil pollution. These have motivated investors and government to build a railway system connecting the mine and border. Although there are various estimates, it is likely to cost about 1 billion USD of which 700 million is to build the railway and the remaining 300 million is to set up the service through the purchase of wagons and trains and hire of employees (the Feasibility Study of the railway and authors' calculation).[2] This is almost 7 times as expensive as building a road with a single lane in each direction. However, the cost of transporting coal by railway is expected to be significantly lower. According to Renaissance Capital and Rio Tinto, railway transportation will cost 12 USD per ton to Gantsmod, and it is said to be 5-7 USD per ton if coal export can reach 30 million tons per annum. Based on these estimates, one may conclude that the railway service will create an economically efficient condition for export of coal and reduce the environmental impact as the exporters would use fewer dump trucks to transport coal to the border.

In this paper, we attempt to examine the impact of FDI in coal (only exported) and railway sectors on the Mongolian economy and environment. For this purpose, we modify the recursive dynamic PEP-1-t model (Decaluwé *et al.,* 2013) and simulate 2 scenarios over 10 years (2014-2023). In the first scenario, we simulate a business-as-usual (BAU) scenario in which GDP follows the IMF's projections until 2021, then grows at 4.5% per annum, metal

[2] At the moment, its earthwork progress is 87% and overall progress is about 52%. The railway project has been intensifying since 2016 because of the "State policy on the mineral sector 2014-2025", "Mongolian sustainable development vision 2030" and the Government Action Plan for 2016-2020.

ores sector (including copper, gold and iron ores) receives a flow of FDI over 5 years starting from 2016 (reflecting the development in the underground mine of Oyu Tolgoi copper project) and the world export price of coal is 50% higher than its 2014 value for the simulation period. In the alternative (or FDI) scenario, we consider a situation in which coal export and railway sectors receive FDI to increase the export capacity of coal export sector. In addition, we introduce a shift from truck services to railway to reflect the utilization of the new railway and measure the change in environmental impact through a calculation of Greenhouse gas emission. We find that increasing capacity of coal export sector and building railway have a positive impact on macroeconomic indicators despite a Dutch disease effect on most sectors through higher domestic prices. The impact on households and employment are also positive. Meanwhile, the negative environmental impact of coal extraction is reduced.

The paper is structured as follows. Section 2 briefly outlines the relevant literature. Section 3 discusses the methodology and data. Section 4 explains the scenarios and closures. Section 5 presents the results of the simulations. Section 6 concludes the paper.

2. Literature review

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

CGE models are increasingly used to examine the impact of the overall mining sector as well as the impact of investments into the mining sector and infrastructure on economic growth in Mongolia. Fisher *et al.*, (2011) utilize a global recursive dynamic CGE model (MINCGEM) and find that the development of the Oyu Tolgoi copper-and-gold deposit has a significant long-term positive impact on the Mongolian economy. Lkhanaajav (2017) uses Centre of Policy Studies (COPS)-style CGE models (ORANIMON and MONAGE) and, through historical and decomposition simulations, identifies that growing export of mining commodities is the main source of economic growth and structural changes in Mongolia between 2005 and 2012. Baatarzorig *et al.,* (2018) calibrate a PEP-1-1 (a static CGE) model of Decaluwé et al. (2013) to a 2010 Mongolian Social Accounting Matrix and emphasizes that importance of the mining sector for the economy by simulating two scenarios – an expansion in coal export and a decrease in copper price. Byambasuren *et al.,* (2015) find a positive impact of a public investment in a power plant and copper refinery on the domestic economy in an analysis based on the MINCGEM model.

The economic impact of railway projects is examined in CGE models in the case of other countries. Horridge and Wittwer (2007) examines the impact of the Chongqing–Lichuan rail link project on on the economic development of surrounding provinces using a multi-regional CGE model of the Chinese economy. Mostert and Van Heerden (2015) develop 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) utilize a CGE approach to highlight the impact of creating a Mediterranean rail corridor in Andalusia.

In recent years, CGE models have been used to estimate the impact of environmental policies on economic and environment. As mentioned in Xie and Saltzman (2000), these environmental models can be divided into several types. The first type of models extends standard CGE model with either pollution emissions using fixed pollution coefficient per unit of sectoral outputs or intermediate inputs or exogenous prices or taxes on environmental activity without any changes in model structure. The second type of models have pollution control cost specified in production function. The third type of models specify the production functions of pollution abatement activities or pollution abatement technologies. Robinson, Subramanian and Geoghegan (1993) utilize a CGE model to estimate impact of imposing emission charges for air pollutants in Los Angeles case. In the research, sectoral emission of pollutant is specified as proportional to output which is an approach we employ in our analysis.

3. Methodology and data

We modify the recursive dynamic PEP-1-t model of Decaluwé et al., (2013). The modifications are detailed in Appendix 1. In brief, we consider

- a different treatment of public and private investment;
- the wage curve – i.e., the Phillips curve showing the relationship between unemployment and wage;

- uniform (or economywide) Total Factor Productivity (TFP) augments value-added of each sector;
- sector-specific TFP;
- a measure of environmental pollution (greenhouse gas emission).

We construct the SAM using data from 2014 including the Supply and Use Table (SUT), the balance of payments, and the government budget data from the 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 expenditure, 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 them (90.7%) is the share of total value added in GDP and the remaining 9.3% is 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			185.8
10	**Commodities**			56.6	13.0				51.6	95.1	20.1	28.6	6.6	268.2
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 84 columns and rows. The accounts of the SAM consist of 24 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).[3]

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

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)
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 them as the rest is self-explanatory. Water represents water supply, sewerage, waste management and remediation activities. Accommodation represents accommodation, food, and beverage services. Information represents information and communication. Professional represents professional, scientific and technical activities. Administrative represents leasing or rental services, support services, sanitation, and other similar services.

We create 2 new sectors and 2 new commodities (coal export and railway) for the purpose of this study: a) Coal export is a commodity/sector which represents a part of existing coal sector/commodity only exported. The remaining coal is sold domestically (domestic coal). The cost structure of the 2 coal sectors are assumed to be the same. b) Railway sector/commodity represents a new railway connecting the Tavan Tolgoi (TT) coal mine and the border. For railway sector/commodity, we extract the relevant data from the existing transport commodity/sector accounts. Specifically, railway service is produced only by railway sector, and the cost structure of railway sector is the same as the existing railway sector in the SUT.[4] We assume that railway service is used only as transport margin in

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

exporting coal and is set at 10 percent of total transport margin on coal exports in the base year.[5]

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

Production structure: Trade sector contributes most to the total labor income while livestock and mining of metal ores sectors contribute most to the capital income. Crude oil and livestock sectors are highly intensive in capital while public administration, education and health sectors are most intensive in labor (Table 3). The economy as a whole is relatively more intensive in capital.

Table 3. Production structure (%)

Sector	Labor	Capital	Value added	Value added/ total	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

[5] 10% is an arbitrary value. It could be any non-zero value so that one could shock it.

Trade structure: Table 4 shows the trade structure. More than half of the total export is metal ores. Fuel, coke oven products, chemicals and other manufacturing products contribute most of the imports. Crude oil and metal ores are almost only exported. Most of manufacturing commodities are imported. Especially, fuel is only imported – i.e.., not domestically produced. On the other hand, some commodities including trade, railway and public administration are not traded internationally.

Table 4. Trade structure (%)

Commodities	Export shares	Import shares	Export intensity[6]	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		

Demand structure: Table 5 shows the demand structure for each commodity. Most of food, textile, accommodation and information services are consumed by households. Following the United Nations national account convention, public administration, education and health are essentially consumed by the government. Electricity and mining commodities are mainly used as intermediate input for production. Trade and railway are 100% margin commodity while 19% of other transport services are used as margin. It is seen that construction service is mainly used for investment purpose.

Table 5. Demand structure (%)

[6] Export excluding taxes and margins – i.e., at base prices.

Commodities	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 chem.	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 act.	14.6	-	85.4	-	-	-	100.0
Information	58.2	1.2	40.6	-	-	-	100.0
Public admin.	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

Household account structure: Labor and capital constitute the main source of household income. Households spend over half of their income on consumption, save about 20.4% and pay 13.9% as direct taxes (Table 6).

Table 1. Structure of household account (%)

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

Government activities: The main sources of government revenue were direct taxes (personal income taxes and corporate taxes) and taxes on products constituting 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 expenditure, which jointly accounts for 46.1% of total government expenditure. It also transferred 36.7% of its expenditure to households through the social security and social assistance funds in the form of reimbursement, repression reimbursement and other current transfers. The remaining government revenue is recorded as savings in the SAM and is destined to cover its capital expenditure (Table 7).

Table 7. 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

Investment/Savings structure: More than half of the total investment (adjusted by 19% for the value of stock building) is financed by household savings[7]. Rest of the world and government contribute 33% and 12% of total investment budget (source) respectively. 44% and 37% of total investment budget is dedicated to financing private and public investment (gross fixed capital formation).

Table 8. 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

Emission rates: Besides the SAM, we introduce the values of the greenhouse gas emission (GHG) rate by sectors as additional data for the purpose of the study (Table 9). The data source and calculation procedures can be found in Appendix 2. According to Table 9, GHG emission per unit of electricity and crop production are the highest. On the other hand, GHG emission per unit of production for air transport, trade and metal ore are the lowest. Furthermore, GHG emission per unit of production for the whole agricultural sector (including animal, crops, fishing) is relatively higher than that of other sectors. More relevantly, GHG emission per unit of railway production is 3.8 times less than other transport sector which is mainly the truck/road service.

[7] Note that the SAM does not have firms, implying that household saving covers all the saving of the private sector.

Table 9. GHG emission rate by sectors

	GHG emission (tons per million MNT)
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 manufacture sectors	0.24
Air trans	0.11
Trade	0.01
Metal ore	0.00

Source: Authors' calculation

4. Scenarios and simulation results

In this section, we simulate two scenarios – a business-as-usual (BAU) and an alternative (FDI) scenarios – and compare their results to examine the impact of the FDI destined to expand the exporting capacity of coal sector on the economy and environment.

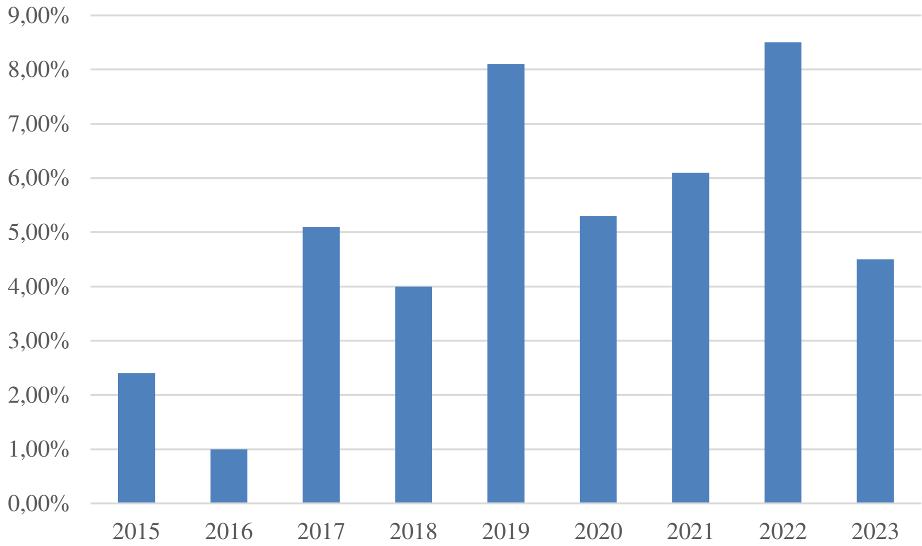
4.1. BAU scenario

We consider the following closure rules and assumptions in the BAU scenario:

- Current account balance and the minimum consumption of households are fixed at their initial values.
- Factor payments from rest of the world, new capital investment in public sectors grow at the GDP growth rate.
- Potential labor supply grows at the population growth rate.
- Stock variation for each commodity grows at the growth rate of total demand of the corresponding commodity.
- Current public expenditure in nominal terms grows at the GDP growth rate.
- The world price of each commodity is fixed at the initial levels except for coal export which increases by 50% in 2017 and stays at this value thereafter to reflect the current situation.

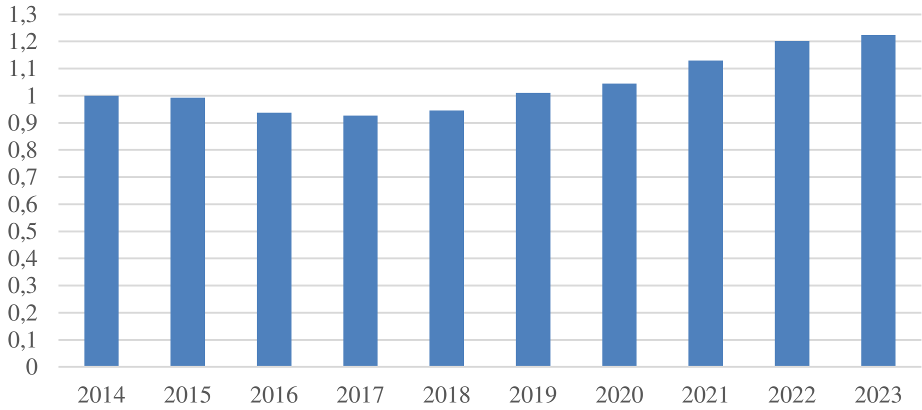
- FDI in OT copper-gold mine is also imposed in accordance with the 2014 Feasibility Study – USD 5.7 billion is to be invested during the construction of the underground mine in 2016-2020. Due to the lack of detailed information, we assume that the same amount will be spent in each year – i.e., about 2.8 trillion MNT (USD 1.14 billion) each year. These values are introduced as shocks to the new capital formation in metal ores sector which is mainly copper concentrate.
- The uniform TFP is calibrated so as to reproduce the GDP growth projections in the IMF Article IV published in May 2017. Figure 2 shows the GDP growth in the BAU scenario. As can be seen, GDP follows the IMF's projections until 2022 and grows at 4.5% per annum afterwards.

Figure 2. GDP growth in BAU scenario



We simulate the BAU scenario and obtain the TFP levels in Figure 3 and other endogenous variables consistent with the conditions that we impose in the closure. As can be seen, during the FDI in metal ores sector, TFP is declining which indicates that the growth expected to happen in 2016-2020 is driven by the FDI in OT.

Figure 3. Level of TFP



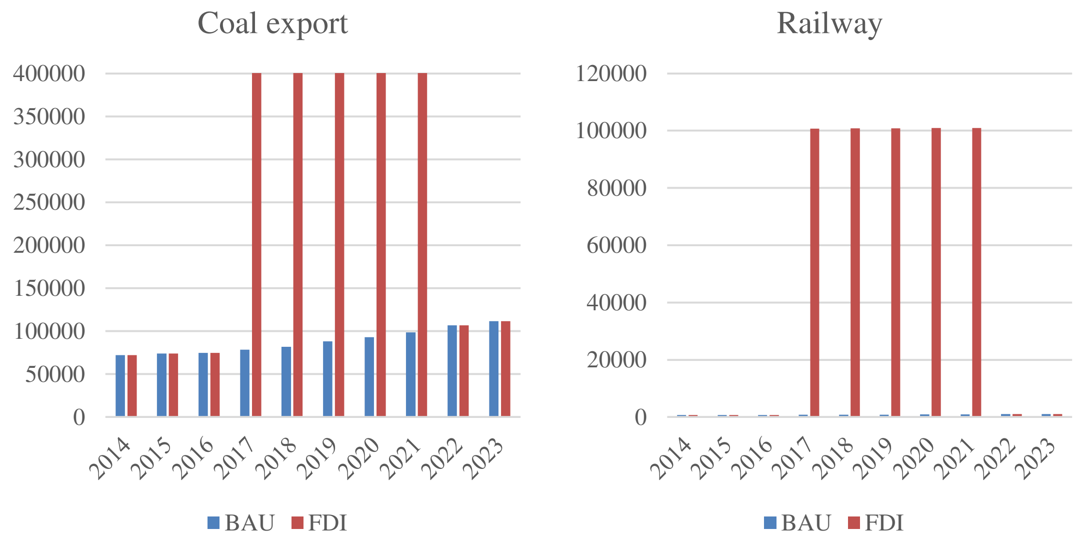
4.2. FDI scenario

In the alternative (or FDI) scenario, we consider a situation in which coal export and rail sectors receive FDI to establish railway service and expand the production capacity of coal export sector. According to the Feasibility Study of the TT railway, 1 billion USD will be invested. However, it does not have other specifics relevant to our methodology. We, therefore, assume that FDI by 500 billion MNT is invested in each year between 2017 and 2021 – i.e., the total investment is 2.5 trillion MNT (equivalent to 1 billion USD). The FDI is to increase the capital stock in coal export and rail sectors as shown in Figure 4. We assume that 80% of the FDI is available to purchase goods and services for investment purposes in coal export sector while the remaining 20% of the investment is used in the construction of the railway. However, the FDI in these sectors would not generate productive capital until 2022 in which the new railway and other new capital become fully operational (Figure 7). This time-to-build delay is adjusted by a new variable, $cap\_adj_{k,j,t}$, in the following capital accumulation equation.

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

where $KD_{k,j,t}$ is type k capital stock in sector j in year t. $IND_{k,j,t}$ is volume of new capital in type k in sector j in period t, $\delta_{k,j}$ 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 railway and coal export sectors until 2022 and to introduce the new railway and more capacity in coal export sector in 2022.

Figure 4. Creation of new capital in coal export and railway sectors



Once the railway is operational, coal export sector would transport its commodity mostly by the railway, and the use of traditional road transport services would be reduced. To replicate this, we shock the rate of transport margin applied to coal export commodity. Specifically, we twist 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 from 2022. This means that coal export sector switches from the traditional truck service to the railway service from 2022.

In addition to the above specific shocks, the TFP levels are calibrated in the BAU scenario are fixed so that the GDP growth rates in the FDI scenario are endogenous. All the other conditions in the closure remain the same.

4.3. Simulation results

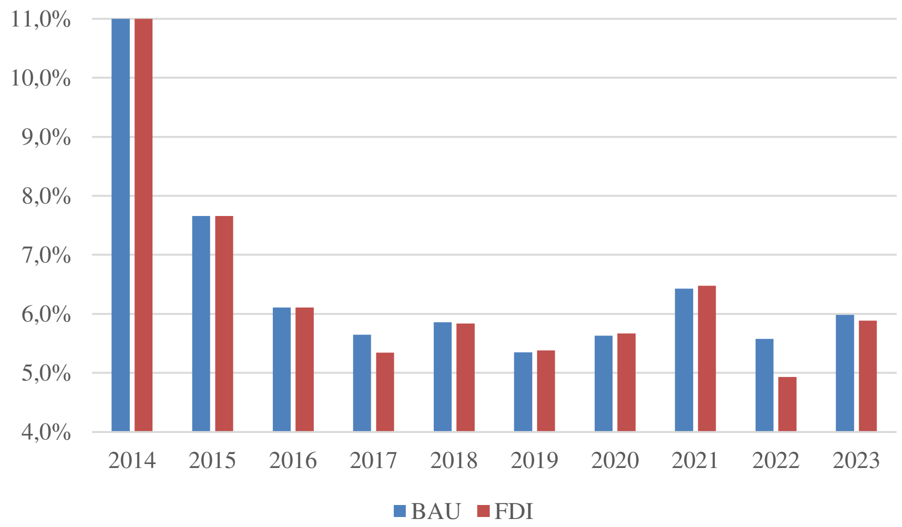
Table 10 summarizes the percent differences between the two scenarios for macroeconomic indicators. As can be seen, there are no changes in 2014-2016 because of no shocks during this period. The main difference appears in 2017-2023. Real GDP, household consumption, real investment, exports and imports increase while real public consumption decreases in the FDI scenario due to a price effect. Overall, the FDI has a positive impact on the real variables.

Table 10. Real macroeconomic indicators, % changes with respect to 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 is set at 11% for the base year, decreases over time and approaches the natural unemployment rate, 6.5%, in both scenarios. However, it is lower in the FDI scenario between 2017 and 2022 because of the FDI and the boost in the production of coal export and rail sectors respectively.

Figure 5. Unemployment rate, %



Investment in railway and coal export sectors would increase the demand for other commodities. However, the domestic supply response is relatively limited for those commodities. As a result, all commodities except railway become relatively more expensive in the FDI scenario. This is reflected by the consumer price index (Figure 6).

Figure 6. Consumer price index

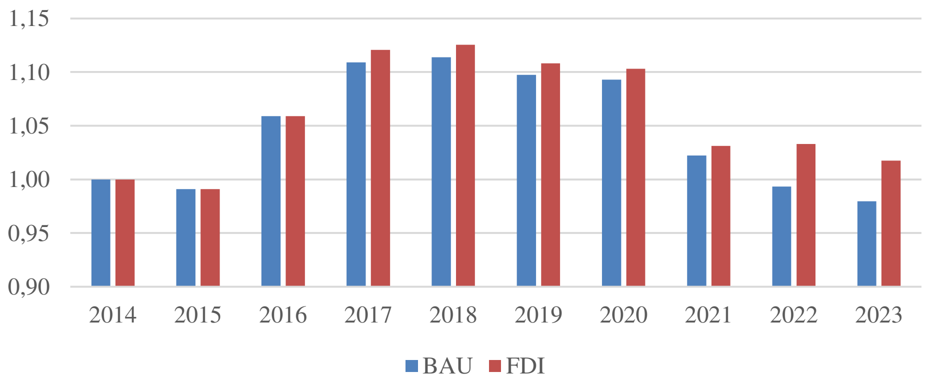
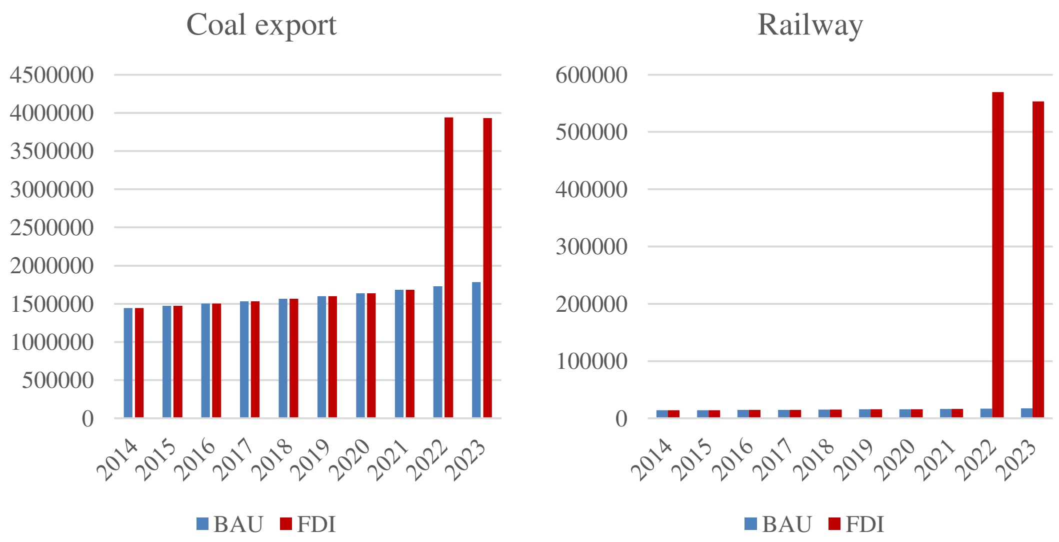


Figure 7 shows that the capital stock in coal export sector increases by more than 100% in 2022 as the accumulated FDI creates new productive capital. Similarly, the capital stock in railway sector soars and becomes about 34 times as large as that in the BAU in 2022 which represents that the new railway is fully operational. Labor demand in these sectors evolves in more or less the same way as capital stock as the elasticity of substitution between factors in these sectors are low.

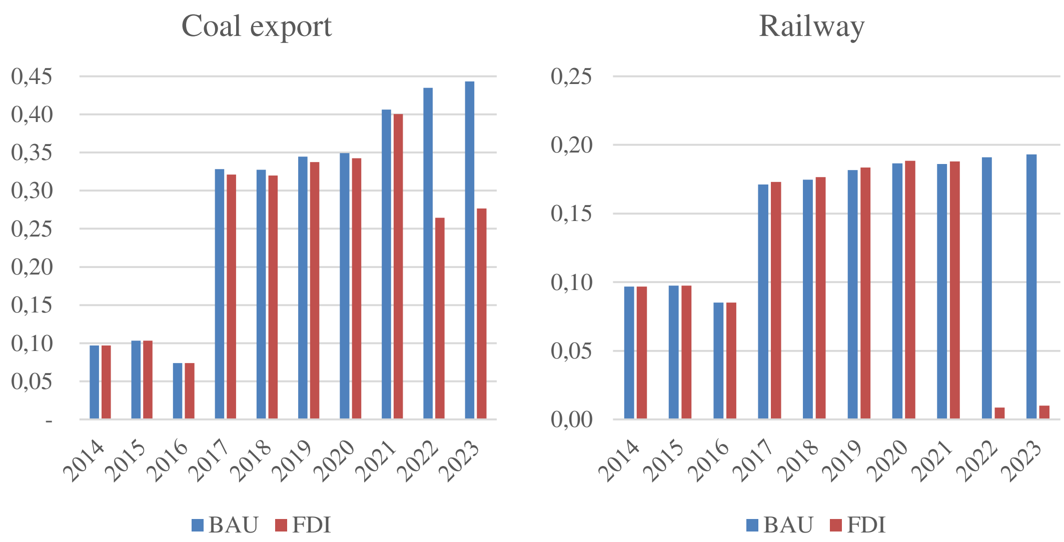
Figure 7. Capital stock in coal export and railway sectors



The rental rate in rail sector decreases sharply in 2022 when the new capital begins to be utilized (Figure 8). This is due to two reasons. One reason is that rail sector expands more compared to coal export sector so that there is excess supply of the railway service. This is shown by the fall in the price of railway (Figure 10b) which leads the rental rate to fall. Another reason is related to the cost structure of the railway sector. Due to the lack of information, we assume that railway sector has the same cost structure as the existing railway system which is relatively intensive in labor. That implies that the production of this sector grows slower than its capital stock. This leads the rental rate to decrease faster. Overall, the decreased rental rate may indicate that the new railway project may not be financially viable. However, we expect that the new railway is likely to be capital intensive and has higher rental rates (i.e., driven by profits) compared to the existing railway system which is a joint company of the Mongolian and Russians governments established in the socialist era. If we have more accurate information on the cost structure of the new railway, the rental rate may not decrease as much.

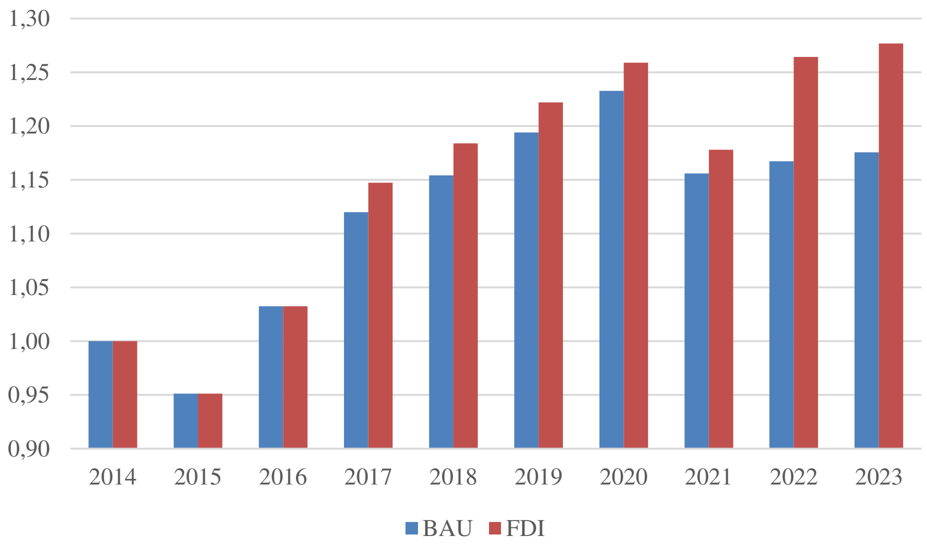
The rental rate in coal export sector increases due to the increased world price in 2017 in both scenarios and then decreases in 2022 when the capital stock becomes available in the FDI scenario due to diminishing marginal product of capital (Figure 8).

Figure 8. Rental rates in coal export and railway sectors



The wage rate is higher relative to BAU from 2017 as labor becomes less abundant relative to capital in the FDI scenario (Figure 9).

Figure 9. Wage rate



The railway service is only used as a margin commodity by coal export sector. Figure 10a shows the use of the railway and traditional transport services by coal export sector. Figure 10b shows the changes in the price of the railway and traditional transport sectors. Until the new railway becomes operational, the price of transport services is the same as in the BAU scenario. But from 2022, the price of railway falls sharply while price of other transport increases which may be explained by a scale effect.

Figure 10a. Demand for transport services as margin

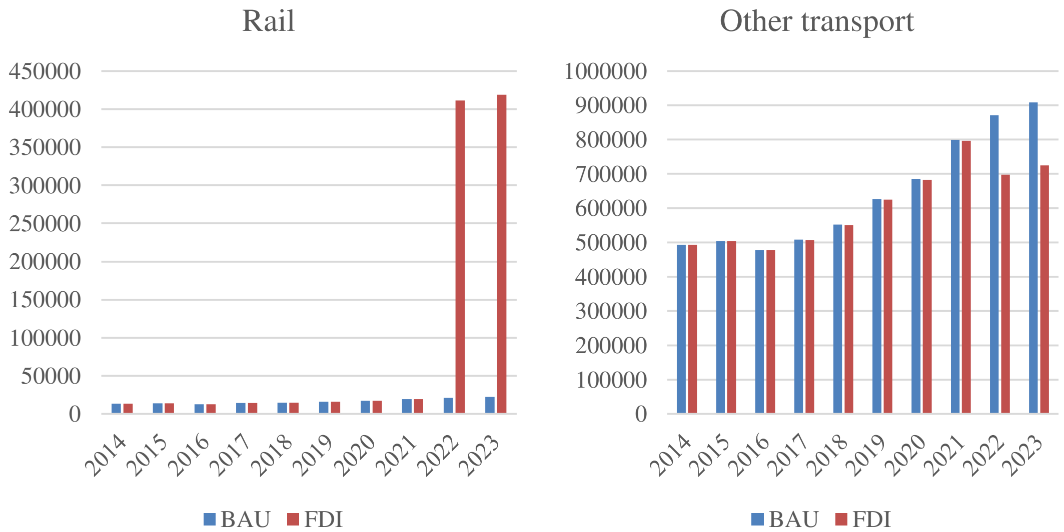
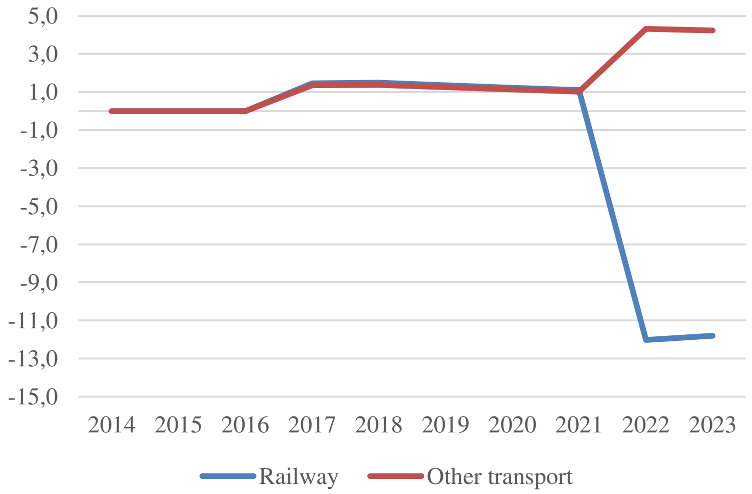


Figure 10b. Price of transport services, % change with respect to BAU



Figures 11a and 11b show the changes in production and emission of sectors. Except for construction and trade sectors, production declines in most sectors which can be explained by the so-called Dutch disease phenomenon – the flow of foreign currency reduces the competitiveness of domestic production by increasing its real exchange rate.

Figure 11a. Production and emission by sector, % changes with respect to BAU

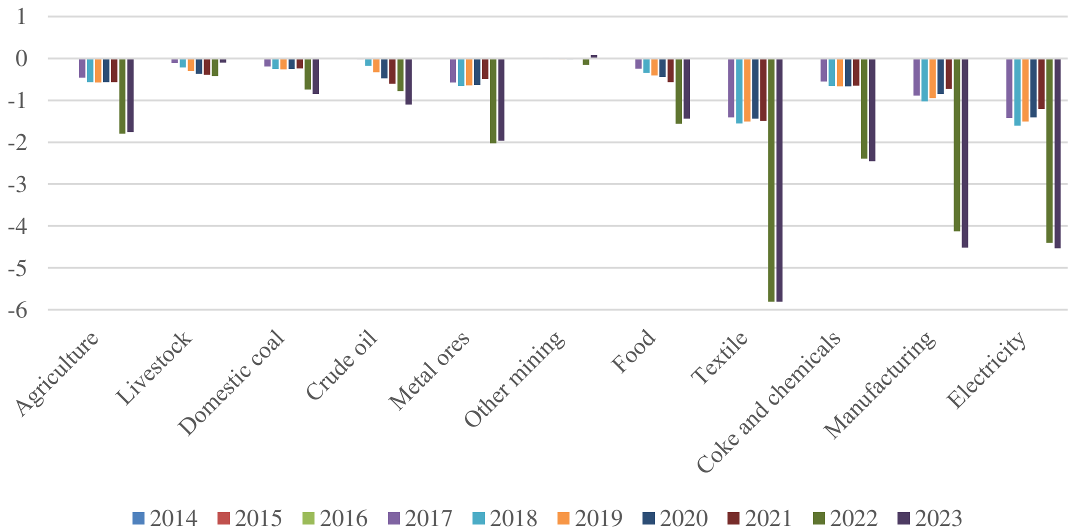
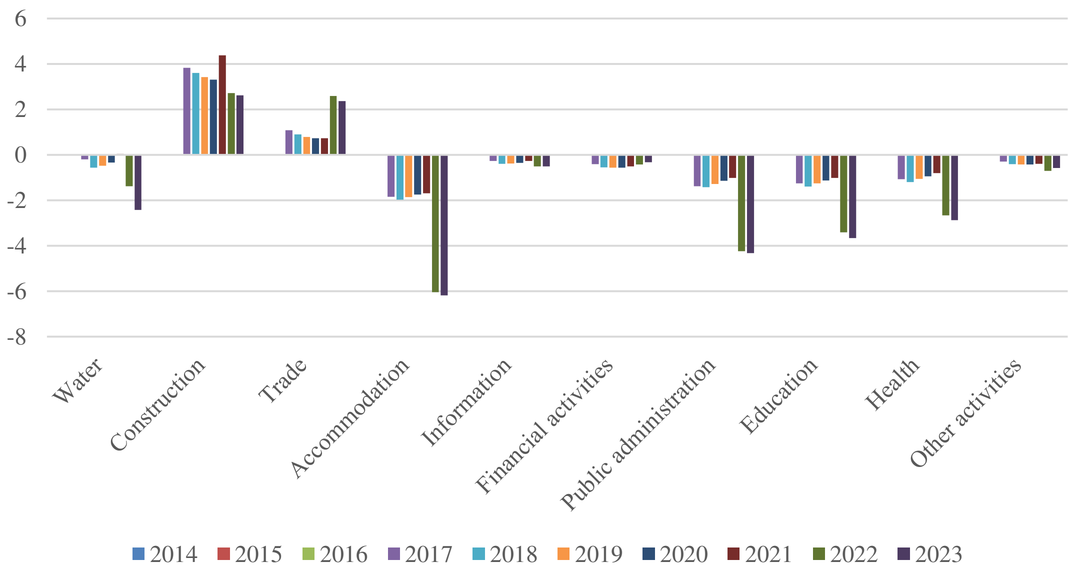


Figure 11b. Production and emission by sector, % changes with respect to BAU



Coal export and railway sectors, on the other hand, experience huge expansions in 2022 (Figure 12). Land and water transport sector declines between 2017 and 2021 slightly due to the Dutch disease effect and declines more afterwards (Figure 13) because of the combined effect of the Dutch disease and the substitution effect of using the railway service in transportation of coal export commodity. The volume of GHG emission increases or decreases by the same percent as the production for all sectors as we assume a linear relationship between these two variables. Therefore, GHG emission decreases in most sectors but surges in coal export and railway sectors. On the other hand, land and water transport sector emits less GHG.

Figure 12. Production and emission in coal export and railway sectors

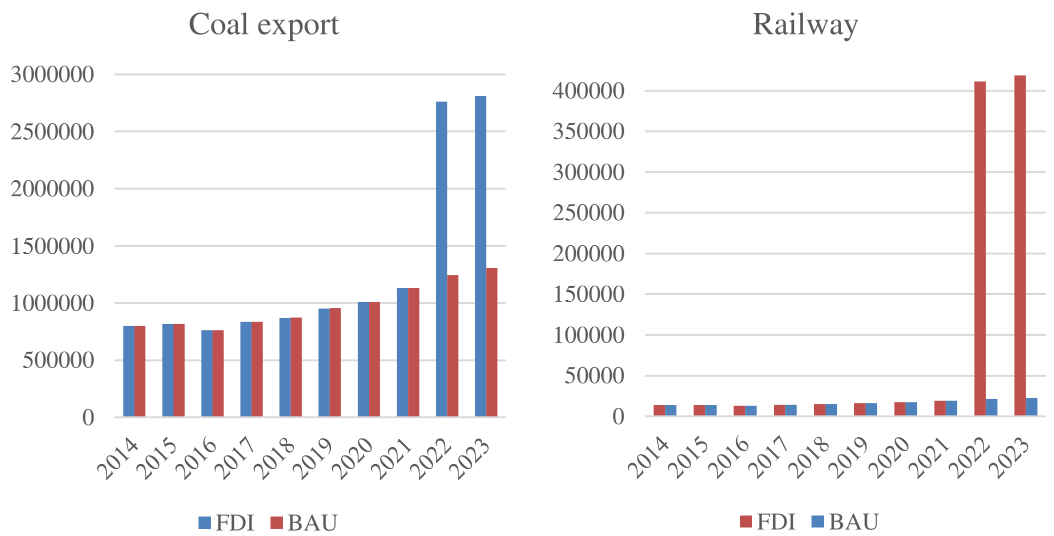
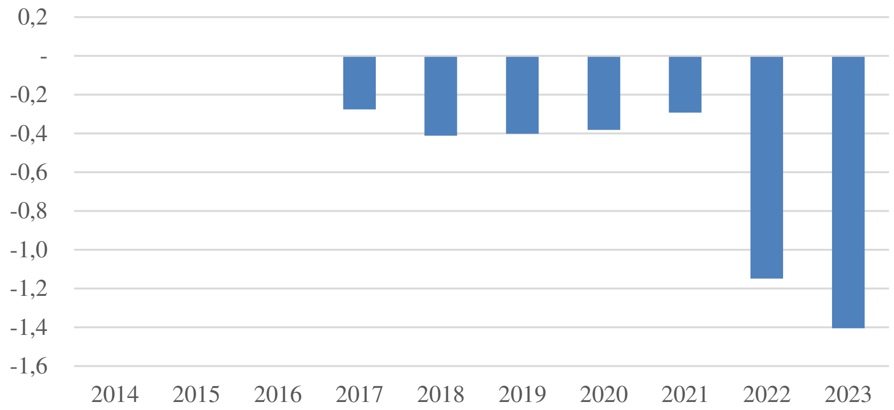
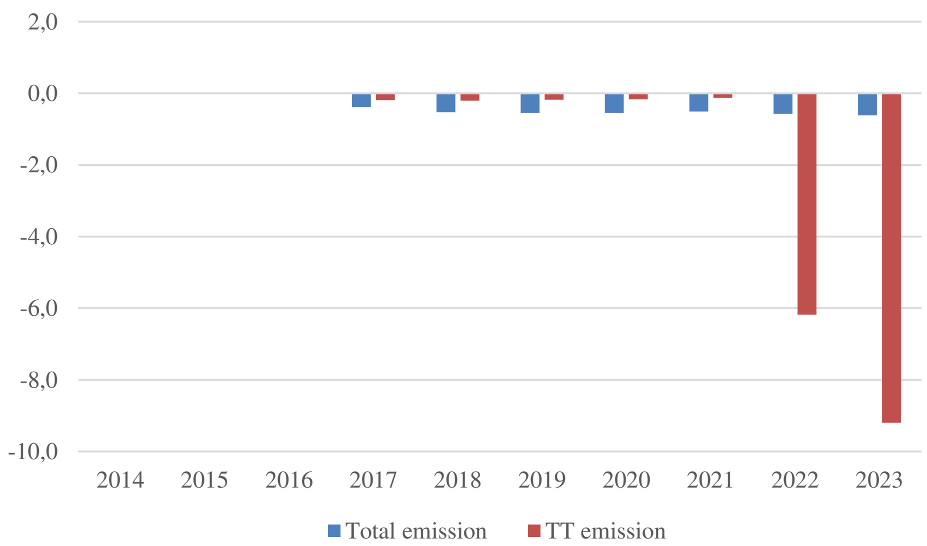


Figure 13. Production and emission in land-water transport sector (% changes with respect to BAU)



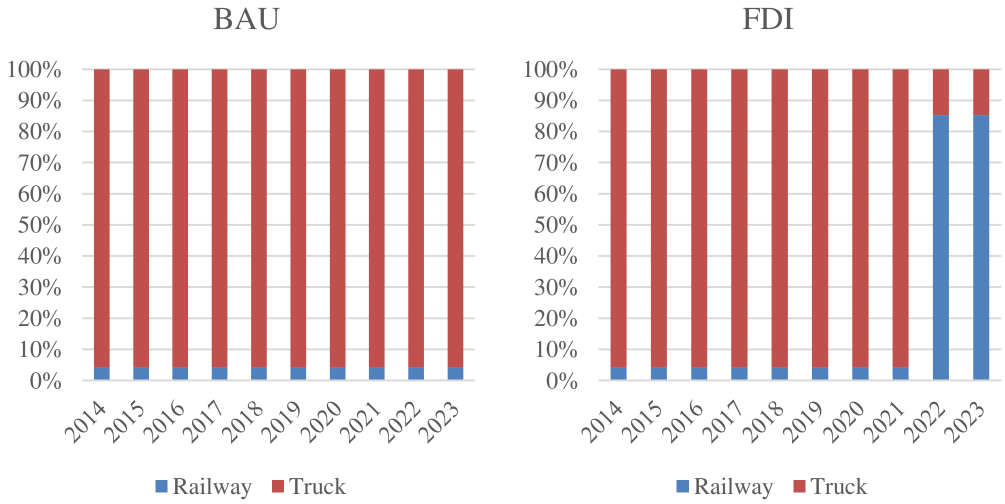
Total GHG emitted by the whole economy decreases slightly while the volume of GHG emitted due to transporting coal export to the border (TT emission) decreases sharply as soon as the new railway starts operating (Figure 14). This reflects the expected improvement in the transport of coal export regarding environment as the emission related to transport declines even if more coal is carried to the border.

Figure 14. Changes in total emission and TT emission, %



There is a shift in the structure of the TT emission in FDI scenario as shown in Figure 15. Specifically, most emission is released by truck service until 2022 while railway sector emits about 85% of TT emission once it is operational. However, due to its lower emission rate, the railway makes it possible for coal exporters to transport more coal with a smaller amount of GHG emission.

Figure 15. Structure of TT emission



5. Conclusions and implications for policy

We simulated the impact of the FDI of 1 billion USD in coal export sector. 80% of this investment is assumed to be used to increase the production capacity of coal export sector while the remaining 20% is used to establish the railway service to transport export coal to the border. 200 million USD for the railway is smaller than that in the Feasibility Study of the railway. The reason of this assumption is the following. Since we do not have any information about the cost structure of the new railway service, we use the structure of the existing railway service which is co-owned by the Mongolian and Russian governments. Given this structure, we find that investment more than 200 million USD is too much as it yields the rental rate to decrease to zero implying that the investment is not financially viable given the amount of coal to be exported. With a more realistic structure, the simulation results could be different.

To examine the impact of the FDI of 1 billion USD, we first simulate the BAU scenario which reflects the GDP projection of the IMF and the FDI in the OT copper-gold deposits until 2023. In the FDI scenario, we find the following results.

- The FDI has a positive impact on macroeconomic variables (real GDP, real household consumption, real exports and real imports) and employment.
- Price level is higher.

- There is a Dutch disease effect on the other sectors – i.e., most sectors experience a decrease in their production while coal export, railway, construction and trade sectors expand which directly benefit from the FDI.
- Once the railway is built, it is used by coal export sector relatively more than the traditional transport service at lower cost.
- Utilization of the new railway decreases the negative environmental impact – i.e., transport of coal export to the border emits less GHG emission compared the BAU scenario.
- Although the economy is expanded, total GHG emission decreases slightly.

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Appendices

Appendix 1. Extensions to the PEP 1-t model

The first originality of our model is an adjustment in the way that public and private investment are treated. Specifically, public investment expenditure takes the value in the budget data, as opposed to the PEP 1-t model where it is calibrated from public service capital stock. This creates a difference, and a new exogenous variable, IT_TR, is introduced to account for it.

$$IT\_TR_t = IT\_PUB_t - \sum_{k,pub} IND_{k,pub,t} PK\_PUB_t \qquad \text{(A1)}$$

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

$$IT\_PRI_t = IT_t - IT\_PUB_t - \sum_{i} VSTK_{i,t} * PC_{i,t} \qquad \text{(A2)}$$

where IT is total investment, $VSTK_i$ is stock variation of commodity i and PC_i is price of commodity *i*. Foreign savings equation is changed to include FDI_coal_t and FDI_metal_t.

$$SROW_t = -CAB_t + FDI\_coal_t + FDI\_metal_t \qquad \text{(A3)}$$

where $SROW$ is foreign savings, CAB is current account balance, FDI_coal is the amount of FDI in 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 prefer to avoid the dichotomy between a full employment model with fully flexible wage rate and the opposite case of a rigid wage rate and endogenous level of unemployment.[8] Therefore, the second originality of our model is the introduction of the wage curve – i.e., the Philips curve relationship between the wage rate and the unemployment rate[9]. This relationship is interpreted by the following equation.

[8] This is the approach of the PEP-1-t model.
[9] See Blanchflower and Oswald (1995): https://pubs.aeaweb.org/doi/pdfplus/10.1257/jep.9.3.153

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

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

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

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

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

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

The last originality of this model is that it also includes a measure of environmental impact of economic activities which is represented by greenhouse gas (GHG) emission. GHG emission is specified as a linear function of output:

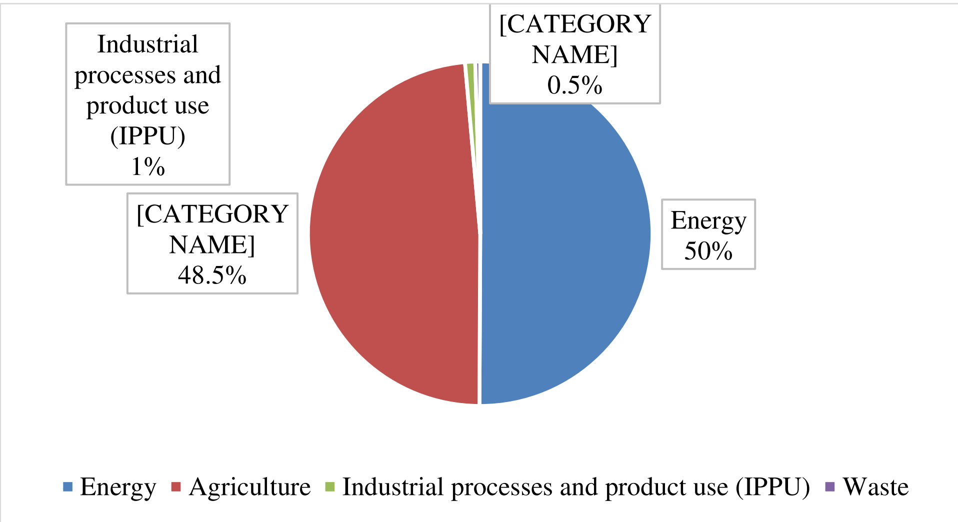
$$EMIS_{j,t} = em\_rate_j \cdot XST_{j,t} \quad \text{(A7)}$$

where $EMIS_j$ is 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. Calculation of the emission rates

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

Figure A1. Total GHG emission by main activities



Source: Mongolia's National Inventory Report-2017.

Table A1 shows the GHG emission by more detailed activities. The activity that emits the highest level of GHG emission is livestock. It is related to Mongolia's 66 million livestock. This is also one of the biggest sectors in the economy contributing to roughly 13.4% of total value-added. Furthermore, the other sectors with high GHG emissions are electricity and heat production, use of land and manufacturing and construction.

Table A1. GHG emissions by activities (sectors)

	Activities	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.

To make this information usable – i.e., consistent with the SAM and the model, we make a mapping between the activities in Table A1 and the activities in 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 correspond directly to their respective sectors in Table 2. However, some sectors in Table A1 correspond to a number of sectors in Table 2. For example, the manufacturing industries and construction activity in Table A1 corresponds to 24 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 allocate the value of GHG emission to each sector using the share of production of each sector in their total production value in the SAM. Furthermore, we assume that 15 sectors in the SAM do not emit GHG such as health, education, public administration and financial service as there is no information on GHG emission by these sectors in the National Inventory Report. Finally, we calculate the emission rate for each activity in the model which is shown in Table 9 in the paper.