Exploring the Synergy and Trade-off between Sustainable Development Goals and Climate Change Mitigation in Mongolia using the Global Trade Analysis (GTAP) Model

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This study employs the Global Trade Analysis Project（GTAP）model to explore the intricate relationship between Sustainable Development Goals（SDGs）and climate change mitigation efforts in Mongolia. Given its unique position as a resource-rich, landlocked country, Mongolia faces distinct challenges and opportunities in aligning its development trajectory with environmental sustainability and global climate objectives. The research aims to quantify the economic and environmental impacts of various policy interventions across key sectors such as mining, energy, and agriculture, which are pivotal to Mongolia's economy and its environmental footprint. By simulating a range of policy shocks—including the implementation of carbon taxes, subsidies for renewable energy, changes in mining regulations, and technological advancements in agriculture—the analysis provides insights into the potential pathways Mongolia can pursue to achieve sustainable development while contributing to global climate change mitigation efforts.

The findings revealed potential synergies between targeted policy measures and the dual objectives of advancing the SDGs and reducing greenhouse gas emissions. For instance, policies introducing global carbon tax, promoting renewable energy not only contribute to SDG 7（Affordable and Clean Energy）but also support climate action（SDG 13）by lowering carbon emissions. However, the study also identifies trade-offs, such as the short-term economic impacts of global carbon tax and stringent environmental regulations on the mining sector, underscoring the need for careful policy design and implementation.

Keywords: Sustainable development, climate, economic development, CGE models
JEL classification codes: Q01, Q54, O3, C68

Introduction

Mongolia, a landlocked country with vast landscapes ranging from desert to mountainous regions, stands at a pivotal juncture in its development trajectory towards sustainable development and climate resilience. Rich in natural resources, including coal, copper, and gold, Mongolia's economy has been heavily reliant on mining and agriculture for recent decades. However, this reliance poses significant challenges to sustainable development and environmental conservation, exacerbated by the pressing global issue of climate change. The Sustainable Development Goals（SDGs）, adopted by the United Nations in 2015, offer a comprehensive framework for addressing these challenges, aiming to achieve a balance between economic growth, social inclusion, and environmental sustainability by 2030. The SDGs act as a universal call to action to bring an end to poverty, safeguard the planet, and generate prosperity for all by the year 2030. These goals consist of 17 interconnected objectives including 169 targets and 231 unique indicators, intending to balance three crucial dimensions of sustainable development: *economic growth, social inclusion, and environmental protection*. Among these goals, SDG 13 specifically targets climate action, emphasizing the need for immediate measures to combat climate change and its impacts. This study seeks to explore the synergy between the SDGs and climate change mitigation in Mongolia, employing the Global Trade Analysis Project（GTAP）model to analyze the economic and environmental implications of several policy scenarios.

The GTAP model that represents global economies and their interconnections through trade, provides a robust framework for assessing the impacts of policy interventions on Mongolia's pursuit of the SDGs and climate change mitigation. By incorporating shocks that simulate *global carbon tax, policy changes and technological advancements in the country*, this analysis aims to identify strategies that Mongolia can adopt to align its economic growth with sustainable development and climate objectives.

The objectives of this study are twofold: first, to quantify the potential impacts of specific policy measures on Mongolia's economy and environment, focusing on key sectors such as mining, energy, and agriculture; and second, to highlight the synergies and trade-offs between achieving the SDGs and mitigating climate change. Through this analysis, the study seeks to provide valuable insights for policymakers, guiding them in formulating integrated policies that foster economic resilience, social well-being, and environmental sustainability.

This research aims to contribute to the ongoing global discourse on sustainable development and climate action. Understanding how the SDGs are interlinked will help policy makers to develop

strategies that maximize synergies and minimize trade-offs. Therefore, along with identifying interventions that leverage synergies between the SDGs and push simultaneous progress on several of the individual goals, the policy makers need to recognize also areas where different SDGs conflict（Bennich, T. et. al., 2023）.

By focusing on Mongolia, a country facing unique developmental and environmental challenges, this study adds to the understanding of how nations with significant natural resources can navigate the path toward sustainable development while actively participating in global efforts to mitigate climate change. Moreover, the findings from this study are expected to offer broader implications for other countries with similar economic structures and development aspirations, enhancing the global knowledge base on sustainable development and climate action.

Background

As mentioned earlier, Mongolia stands at a crossroads of environmental sustainability and economic development, while the economy continues to face a variety of challenges, primarily driven by its vulnerability to global commodity prices and climatic conditions. Additionally, Mongolia's environment is experiencing significant pressures from overgrazing, deforestation, and the impacts of climate change, such as increased frequency and intensity of extreme weather events, desertification, and water scarcity. These environmental challenges pose a threat to Mongolia's economic stability and the well-being of its population.

The country is endowed with significant mineral resources, including copper, coal and gold, which account for a large segment of its GDP and exports. However, heavy dependence on these resources, makes the economy vulnerable to global commodity price fluctuations. Its agriculture sector, which is dominated by pastoral livestock that is crucial for rural income and food supply, is often hit by harsh weather conditions, including *dzud*（a severe winter condition when a massive livestock loss occur）.

This section provides an overview of Mongolia's economic development strategy and the country's commitments to SDGs and climate change mitigation.

（1）Mongolia's Economic Development Strategy: Vision-2050

Vision 2050 is Mongolia's long-term development policy, adopted by the Parliament of Mongolia in May 2020. It serves as a strategic roadmap for the nation's development over the next three decades, aiming to ensure sustainable and inclusive growth while addressing the social, economic, and environmental challenges Mongolia faces. Vision 2050 is structured around nine fundamental goals, which align with the Sustainable Development Goals（SDGs）and are designed to transform Mongolia into a developed country with a high quality of life for all its citizens. Vision 2050 is ambitious in its scope, aiming to address Mongolia's immediate needs while laying the foundation for future generations. Overall, the key components and goals of the Vision 2050 can be summarized as below:

- *Ensure human development and quality of life* by enhancing education and healthcare systems to improve the overall quality of life for the citizens and foster a knowledgeable, skilled, and healthy population;
- *Achieve economic diversification and competitiveness* of Mongolian industries, thereby reducing reliance on the mining sector;
- *Attain sustainable environment and climate resilience* by implementing measures to protect the environment and sustainable use of natural resources, while strengthening resilience to climate change through adaptation and mitigation strategies, including the development of green technologies;
- *Build smart and sustainable governance and decentralization* by improving governance structures with enhanced transparency, accountability, and efficiency in public services and empowering local governments to ensure more equitable development across regions;
- *Sustain social welfare and inclusiveness* by strengthening social welfare systems to reduce poverty and inequality and encouraging active participation of all segments of society in the development processes;
- *Enhance national security and global integration* by ensuring national security and promoting peace and stability, enhancing the country's role and participation in global affairs and fostering international cooperation;
- *Secure urban and rural development*, by promoting balanced urban and rural development to reduce disparities and improve living standards across the country and developing infrastructure and services to support sustainable urbanization and rural revitalization;
- *Inspire culture and heritage* by preserving Mongolia's cultural heritage and promoting its national identity along with encouraging the development of arts, culture, and sports to enrich societal well-being;
- *Embrace innovation and technology* to drive economic growth and improve public services, whereby fostering a digital economy and ensuring access to information and communication technologies for all citizens.

The Vision-2050 recognizes the importance of sustainable development, environmental stewardship, and social inclusion as key drivers of progress and its successful implementation will require comprehensive planning, effective governance, and the engagement of all stakeholders, including the government, private sector, civil society, and international partners. Implementation of

the Vision-2050 goals is supported by the mid（5-year）and short term（annual）development plans and the government action plans（4-year）. The country aims to advance from the current lower-middle income country into an upper-middle income country by 2030 and high-income country in 2050, when manufacturing industry would become the largest economic sector. The Vision 2050 implementation has three phases: (i) 2020-2030; (ii) 2031-2040; and (iii) 2041-2050 and the key development indicators are provided in Table 2.1.

Mongolia's economy rebounded strongly from the COVID-19 pandemic, supported by a combination of effective health measures, despite lack of adequate preparedness[1], elevated global commodity prices, and revitalized exports, particularly to neighboring China, which is its largest trading partner. According to data from the National Statistical Office of Mongolia（NSO）, Mongolia's real GDP expanded by 1.6% and 5% in 2021 and 2022 respectively, recovering from the previous year's contraction of 4.6%, which was the first decline since 2009. Further, the economy expanded by 6.9% during the first 3-quarters of 2023. However, the economy continues to face a variety of challenges, primarily driven by its vulnerability to global commodity prices, climatic conditions and energy insufficiency. For example, according to the Environmental Performance Index（EPI）[2], Mongolia was in the bottom quintile or the 155th among the 180 countries evaluated. This requires effective strategies and enhanced resilience to manage risks associated with these challenges.

Table 2.1 Selected Indicators of Mongolia's Economic Development

Indicators		2022	Vision-2050		
			2025	2030（SDGs）	2050
GDP, Billion US$		17.1	23.9	47.6	209.0
GDP growth, annual, %		5.0	6.0	6.0	6.0
GDP Per Capita, US$		5,126	6,520	12,054	38,359
GDP share, %	Mining	23.6	30.6	31.4	25.3
	Manufacturing	8.6	12.0	14.6	27.4
	Transport & storage	4.8	5.1	4.8	11.6
Ratio of domestic production in total fuel supply		15.5*	70	100	100
Share of industrially processed products in total consumption	Meat	26.0*	50	70	100
	Milk	22.5*	30	50	70
Exports, Billion US$		12.54	14.0	29.7	139.9
Number of inbound foreign tourists, annual, million persons		0.3	1.0	2.0	6.0
Inflation, %		15.2	6.0	6.0	2.0
Unemployment rate, %		6.7	7.8	7.0	3.0
National poverty headcount ratio, %		27.8**	20.0	15.0	5.0
Environmental Performance Index（EPI）		29.6	58	59	61+

Note:1.*Figures as of 2021; 2. **Figure as of 2020.
Sources: GOM, 2024; NSO, 2024.

(2) Mongolia's Commitments to the SDGs and Climate Change Mitigation

Mongolia's unique natural landscape is both a source of national pride and a significant challenge in the face of climate change. In response to these challenges, Mongolia has committed to the 2030 Agenda for Sustainable Development and its 17 SDGs. Based on national characteristics[3], Mongolia has 16 goals and 134 targets. The Agenda aligns with the country's strategic objectives revolving around economic diversification, environmental conservation, improving social welfare, and fostering democratic governance. The government has integrated these goals into its national development plans（the Vision-2050）, focusing on areas such as poverty reduction, education, health, and environmental sustainability.

As stipulated in Vision-2050, the key SDGs focus on:

- *Economic Growth*: As a country largely reliant on its mineral wealth, has a strategic focus on SDG8, which promotes sustained, inclusive, and sustainable economic growth. Notably, the government aims to diversify its economy to reduce dependence on mining and promote a more inclusive economic model that generates broad-based employment opportunities;
- *Social Inclusion*: Addressing poverty and improving education and healthcare under SD1, SDG3, and SDG4 is

[1]GOM, 2023. [2]Wolf, M. J et. al., 2022. [3]As a landlocked country, SDG 14（Life below Water）is not applicable for Mongolia.

another priority for Mongolia. The government is undertaking initiatives to reduce income and regional inequality, improve access to quality health and education services, and protect vulnerable groups.

- *Environmental Protection*: Mongolia's unique geographical and climatic conditions necessitate a strong emphasis on SDGs related to ecological sustainability. An emphasis is placed on SDG13（Climate Action）and SDG15（Life on Land）. Efforts are aimed at curbing air and water pollution, conserving biodiversity, promoting sustainable land and water management, and enhancing resilience to climate change. Specifically, Mongolia has emphasized its commitment to SDG 13 by pledging to reduce its greenhouse gas emissions and enhance resilience to climate-related hazards. These commitments are reflected in Mongolia's Nationally Determined Contributions（NDCs）under the Paris Agreement, where it has outlined specific targets and strategies for mitigating climate change（Table 2.3）.

Mongolia prepared its Voluntary National Reviews in 2019 and 2023. Being the smallest economy in Northeast Asia, Mongolia's progress towards achievement of the SDGs were the lowest as well. With its SDG Index Score of 64.69, Mongolia positioned the 106th among the 166 countries ranked worldwide（Table 2.2）.

Table 2.3　SDGs Progress in Northeast Asia(2022)

Indicators	Japan	ROK	Russia	China	Mongolia	DPRK
UN Regional Group	OECD		Eastern Europe & Central Asia	East & South Asia		
Regional average	77.8		71.8	67.2		
SDG Index Rank	21	31	49	63	106	NA
SDG Index Score	79.41	78.1	73.8	72.01	64.69	NA
Progress over 20 years by Score	3.71	5.28	6.28	9.52	4.34	NA
VNR years	2017, 2021	2016	2020	2016, 2021	2019, 2023	2021
Population（Million）	124.3	51.8	144.7	1,425.9	3.4	25.7
GDP*（PPP）, current int.$	5.7 T	2.6 T	5.3 T	30.3 T	48.5 B	28.4 B**
GDP per Capita（PPP）, current int. $	45,584	50,331	36,308	21,483	14,260	1,107**

Notes:1. *:T-Trillion; B-Billion; 2. **GNI terms.
Sources: Sachs, J.D.,(2023); World Bank (2024).

All countries in Northeast Asia are Parties to the United Nations Framework Convention on Climate Change（UNFCCC）and its Paris Agreement, which aims to limit the global mean temperature rise well below 2℃, preferably to 1.5℃ above pre-industrial levels to prevent dangerous anthropogenic impacts on the climatic system. This requires unprecedented worldwide efforts to halve carbon emissions by 2040 and achieve net-zero by 2050. Mongolia along with Japan and the ROK is also a part of the Global Methane Pledge（GMP）[4], which was launched in 2021 at COP26 by the European Union and the United States. The GMP aims to collectively reduce global methane emissions at least 30% by 2030 from 2020 levels and currently has participation of 155 countries, representing a little over 50% of global anthropogenic methane emissions. A brief description of the evolution of the climate change mitigation efforts of the countries in Northeast Asia is described in Table 2.3.

In May 2022, the United Nations and the Government of Mongolia signed the United Nations Sustainable Development Cooperation Framework（UNSDCF）outlining collaboration on the joint strategic planning framework during the period of 2023-2027. The UN and the Government of Mongolia in collaboration and consultation with other stakeholders identified three strategic priorities and four outcomes for achieving its overarching vision of shared prosperity by 2030, whereas "leaving no one behind" is the central approach to the UNSDCF（UN Mongolia, 2022）.

Mongolia has shown strong commitment to the 2030 Agenda and has adopted the UN Secretary General's call for the "Decade of Action" and has set up institutional mechanism in the form of the National Council for Sustainable Development（NCSD）at the Government level in 2021 and the Multi-stakeholder Council for Sustainable Development（MCSD）at the Parliament level in 2022 to review the SDGs progress and steer the alignment of national development with the SDGs. SDGs councils have also been set up at local level（*Aimag centres and Soums*）, which would help in accelerating integration, localization, and achieving SDGs.

[4]For more info: https://www.globalmethanepledge.org/

Table 2.3 Evolution of GHG Emission Reduction Targets in Northeast Asia

Country	Quantified Economy-Wide Targets for 2020	INDC Targets for 2030	NDC	Net-Zero (Carbon Neutral) Target Year
0	1	2	3	4
Mongolia	Non-quantified emission reduction measures	14% reduction by 2030 compared to BAU (excluding LULUCF)	22.7% reduction by 2030 compared to BAU (74.3MtCO2eq.), excluding LULUCF; 44.9% including conditional measures and forest sink.	Beyond 2050
Japan	3.8% reduction in 2020 compared to 2005;	26% reduction by FY2030 compared to FY2013. (17/07/2015)	46% (challenging at 50%) reduction by FY2030 compared to FY2013 (25.4% compared to FY2005), (Emission cap at approx. 1.042 BtCO_2eq in 2030); Improve carbon and energy intensity and energy efficiency by 20-40% by 2030 from 2013 levels; Contribute to 50% global and 80% by developed countrie's reductions by 2050; Removals by LULUCF 37 million tCO_2eq, which equal 2.6% of total emissions reduction; International contribution: Governmental JCM: 50-100 MtCO_2eq; other: 1 BtCO_2eq; (31/03/2020)	By 2050
Russia	Nationally determined commitment is set at 25% below 1990 level by 2020;	25-30% reduction by 2030 compared to 1990 level, full accounting of forest carbon removals	70% reduction by 2030 relative to 1990 level including LULUCF and other ecosystems; (Total GHG emissions incl. LULUCF in 1990: 3.1 billion tCO2eq[5];Cumulative GHG emission reduction during 1990-2030 equal over 55B tCO_2eq); Target sectors: energy, industrial processes and product use, agriculture, waste, LULUCF; all GHGs;	By 2060
ROK	Reduction by 30% from "business as usual (BAU)" emissions in 2020;	37% reduction of BAU emissions by 2030 (Jun., 2015);	40% reduction by 2030 on 2018 level. Nationwide ban on new coal-fired power plants. (709.1 MtCO_2eq) (30/12/2020, 1st updated)	By 2050
China	Reduction of CO_2 emissions per unit of GDP by 40-45% by 2020, compared to 2005 level	30/06/2015 (03/09/2016) Enhanced Actions on Climate Change: China's INDC: Peak by 2030 or earlier, lower CO_2 emissions per unit of GDP by 60-65% by 2030 from 2005 level; increase non-fossil fuel share to 20% of primary energy consumption; increase forest stock by 4.5 billion m3 on 2005 level	Peak before 2030; 2030 targets: ・Lower per GDP GHG emissions by over 65% on 2005 level; ・Non-fossil share in energy consumption mix 25%; ・Forest stock up by 6 billion m3 on 2005 level; ・Wind and solar power capacity is over 1.2 billion kW;	Before 2060
DPRK		Sep. 2016 8% from BAU by 2030; 32% with international cooperation.	19/09/2019 16.4% from BAU by 2030; Additional 36% with international cooperation; (Total 52.4%)	NA

Source: Compiled by the author based on the UNFCCC, 2024.

[5] CAIT (Climate Analysis Indicators Tools) data equals 2.89 billion tCO2eq.

The Analysis

(1) The Model and Data

In quantifying the synergies and trade-offs along with the economic and environmental impacts of various policy interventions across key sectors such as mining, energy, and agriculture in Mongolia, this analysis employed the Global Trade Analysis Project (GTAP) Data Base (Version 11B) and standard GTAPv7 model with E-Power extension (The Model) documented in Peters, J., 2016. The GTAP Model is a multi-region and multi-sector Computable General Equilibrium (CGE) model[6], widely used for analyzing the economic impacts of trade policies, environmental policies, and other global changes. The GTAP model's comprehensive nature allows for the examination of policy impacts not only on trade and economic output but also on environmental and social outcomes. This makes it particularly suitable for analyzing the synergies and trade-offs between achieving the SDGs and mitigating climate change in a country like Mongolia.

This analysis used the GTAP-Power Data Base – a satellite data of the GTAP 11B[7] Data Base - with the reference year of 2017; thus the values indicated in this analysis are expressed in constant 2017 US$ terms if not indicated otherwise. The GTAP-Power is an electricity-detailed extension of the original GTAP Data Base, where 'ely' sector is disaggregated into: transmission & distribution, nuclear, coal, gas (base and peak load), oil (base and peak load), hydroelectric (base and peak load), wind, solar, and other power technologies. These new sectors are combined with the original GTAP 65 sectors resulted in a power sector disaggregated data base with 76 sectors. For this analysis, the regions in the data were aggregated into 12 from the original 160 regions in the model, while the 76 sectors in the model were aggregated into 19 sectors in consideration of the specific context of Mongolia's economic structure and key industrial sectors as provided in the Appendix Tables I and III respectively. The original eight factors in the Model were aggregated into four factors: land, labor, capital and natural resources, where land and natural resources are immobile and labor and capital are mobile factors (Appendix Table IV).

The default value of the parameter RORDELTA in the Model equals 1, where investment is allocated across regions to equate the change in the expected rates of return, *rore* (r) which implies international capital mobility. The solution method was Gragg or a multiple step extrapolation method.

(2) The Experiments

This analysis aims to quantify the impacts of such policies on Mongolia's economy and identify strategies that Mongolia can adopt to align its economic growth with sustainable development and climate objectives by incorporating shocks that simulate *global carbon tax, policy changes and technological advancements in the country*. The analysis incorporated four experiments as follows:

Experiment 1: Global carbon tax (*CTAX15*), where a uniform global carbon tax of US$15/t$CO_2$ is imposed in all regions without emissions trading. The shock value was chosen arbitrary based on Sneha D. et. al. (2022), where a global CO_2 price of $16.2 per tonne of CO_2 emissions were introduced. According to the World Bank's Carbon Pricing Dashboard, the implemented carbon tax ranges varied considerably. For example, in 2023, it equaled $2.17/ in Japan and $130.81 in Liechtenstein per tonne of CO_2 (WB, 2023). Also, carbon credit prices in China and the ROK equaled $10.49 and $6.86 per tonne of CO_2 as of 15 February 2024 (Carbon Credits, 2024).

Experiment 2: Renewable energy promotion (*REN50*): This experiment assumes that Mongolia reduces output tax on renewable energy (wind, hydro and solar) by 50%. According to the data, ad valorem base tax rate on wind energy baseload equaled 15.96%, hydro and solar peak loads 20.04% in Mongolia.

Experiment 3: Stricter environmental regulations for extractive industry (*MINE20*): This experiment considers that Mongolia enforces stricter regulations for extractive industries that would increase the cost of mining equivalent to 20% increase of output tax. The extractive industries comprise of coal, other mining, gas extraction and distribution in the Model.

Experiment 4: Technological improvement in agriculture sector (*AGR10*): is a scenario that would increase Mongolia's factor productivity in the sector by 10%, whereas improvements would

[6]For more details on the GTAP model and database, refer to Hertel, T. (ed.), 1997.

[7]Aguiar, A. et al (2022), where:

Protection Data:

International Trade Center, Market Access Map: Improving Transparency in International Trade and Market Access. Methodology available online at: https://www.macmap.org/en/about/methodology

Organisation for Economic Cooperation and Development (OECD). Producer and Consumer Support Estimates database. Available at: https://www.oecd.org/unitedstates/producerandconsumersupportestimatesdatabase.htm

World Trade Organization, Agricultural Export Subsidies Notifications. Available from: https://docs.wto.org/dol2fe/Pages/FE_Browse/FE_B_S006.aspx

Trade Data:

United Nations Statistics Division, UN COMTRADE. International Merchandise Trade Statistics. Available online at http://comtrade.un.org/

International Monetary Fund, Balance of Payments Statistics. Available online at http://www.imf.org/external/np/sta/bop/bop.htm

OECD, Statistics on International Trade in Services. Available online at https://www.oecd.org/sdd/its/international-trade-in-services-statistics.htm

Energy Data

Original Data Source: IEA Energy Statistics © OECD/International Energy Agency, [2006] (www.iea.org). The data have been modified by the Center for Global Trade Analysis as documented in http://www.gtap.agecon.purdue.edu/databases/v11/v11_doco.aspx

occur in both the livestock and other agriculture. Productivity of the factors can be represented by the technical change variable of "afeall", which is primary factor (land, labor, capital and natural resources) augmenting technical change variable in the Model.

Sensitivity of the simulation results with respect to (w.r.t.) shocks has been tested with the SSA (Systematic Sensitivity Analysis) tool of the RunGTAP. An overview of the shocks and sensitivity analysis (SSA) introduced in the Model is provided in Table 3.1.

Table 3.1 Overview of the Shocks and SSA

Scenarios	Shock						SSA w.r.t. shocks
	Variable	Elements			Type	Value	
		COMM (c)	ACTS (a)	REG (r)			
CTAX15	del_nctaxb	ALL BLOC			% change	15	100 (% variation)
REN50	to	WindBL	WindBL	Mongolia	% change rate	50	45 (ordinary change)
		HydroBL	HydroBL				
		HydroSolarP	HydroSolarP				
MINE20	to	Coal	Coal	Mongolia	% change rate	20	15 (ordinary change)
		OtherMining	OtherMining				
		Gas_gdt	Gas_gdt				
AGR10	afeall	ALL ENDW	Livestock	Mongolia	% change	10	5 (ordinary change)
			Agr				

Notes: 1. del_nctaxb: nominal carbon tax (current USD per tonne of CO2);
2. to: power of tax on commodity "c" supplied by activity "a" in region "r";
3. afeall: primary factor "e" augmenting technical change for activity "a" in region "r";

(3) The Results

Synergies: As expected, the aggregate carbon dioxide emissions reduction levels will be reduced in the experiments 1, where a global carbon tax is imposed and when Mongolia introduces renewable energy promotion policy Experiment 2. The emissions reduction levels will be the highest, when global carbon tax is introduced and Mongolia could achieve 19.2% reduction of its aggregate carbon dioxide emissions. This will support Mongolia's climate change mitigation and carbon emissions reduction targets. At the same time, Mongolia's nominal GDP may increase due to increased trade surplus of $101.3 million supported by higher merchandise exports, which would grow by 0.99%. Also, regional income "y", which is the sum of primary factor income and indirect tax receipts, would increase by 0.84% along with increase of private consumption expenditure by 0.85%. Although at smaller scales, the renewable energy promotion scenario would have similar synergies, except those for exports and trade balance. However, terms of trade would see improvements (Table 3.2).

At the same time, output of wind baseload, coal and meat and dairy products, which is the major food industry in Mongolia, would increase by 8.53%, 4.82% and 0.24% respectively in experiment 1 (CTAX15). The scales of output expansion for wind baseload, hydro and solar peak loads will be much higher compared to output changes in other industries, when renewable energy is promoted in experiment 2 (REN50). Wind baseload and hydro and solar peak loads would rise by 0.61% and 0.83% respectively in the scenario 3 (MINE20). Also, wind baseload would witness 0.12% increase due to technological improvements in agriculture sector in experiment 4 (AGR10). Increased production of renewable energy contributes to SDG 7 (Affordable and Clean Energy), while supporting climate action (SDG 13) and meet carbon emissions mitigation targets (Figures 3.1, 3.2, 3.3, 3.4).

Moreover, even stricter environmental rules are imposed for the country's mining sector (MINE20), outputs of all sectors would see expansions, except that of coal production. This would help in diversifying the country's economic structure and reducing vulnerability and its heavy dependence on mining. Energy intensive industries would expand its output by 1.62%, while outputs of the country's main manufacturing industries, such as textile and apparel (+1.01%), leather (1.57%), and meat and dairy (+0.51%) would also expand (Figure 3.3).

In terms of the equivalent variation (EV), which is an indicator for measuring the effect on public welfare, Mongolia would benefit from welfare improvements of $3.69 million in experiment 3 (Table 3.2, Figure 3.3).

Trade-offs: However, some trade-offs have been observed in implementing these experiments. Mongolia would witness a welfare loss of $81.76 million and real GDP contraction by 0.41% in experiment 1, when global carbon tax of $15/tCO$_2$ is introduced.

Also, the country's terms of trade would decrease by 0.24%. Introduction of stricter environmental rules for mining would result in real GDP contraction by 0.03% and the regional household income would decline by 0.17% as mining is Mongolia's dominant industry currently. Most importantly, the country's aggregate carbon dioxide emissions would grow by 0.04% and 0.69% respectively in experiments 3 (MINE20) and 4 (AGR10). This would undermine the country's climate change mitigation efforts (Table 3.2).

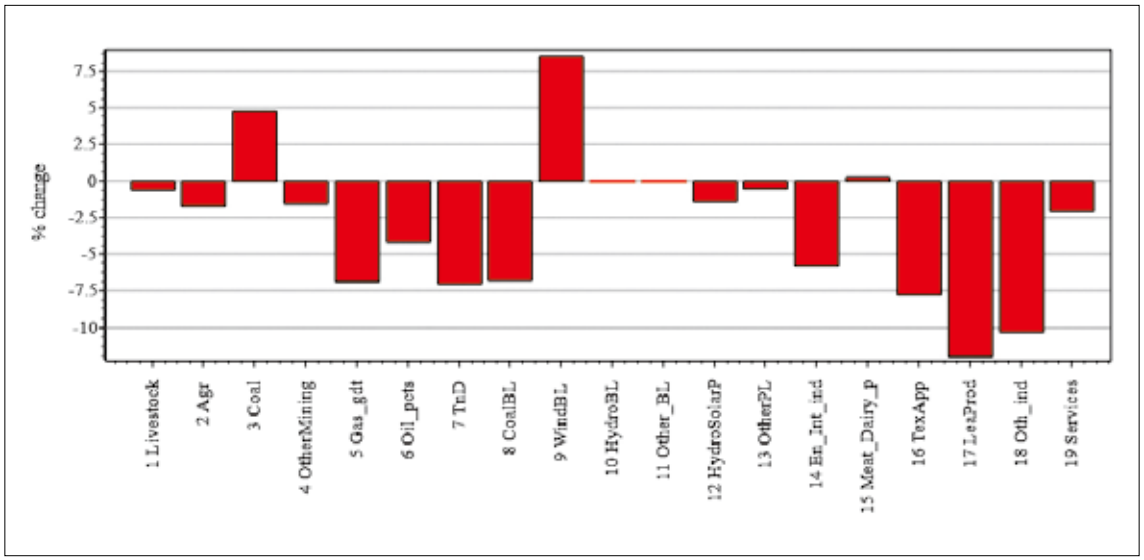
The SSA results with 95% confidence intervals are also provided in Table 3.2. Also, the welfare effects of global carbon tax of $15/tCO2 (Exp. 1) are provided in Appendix Table II.

Table 3.2 Selected Results for Mongolia

Indicators	Scenarios	Results	SSA (95% confidence intervals)	
			Lower	Upper
Aggregate carbon dioxide emissions (gco2t), % change	CTAX15	−19.18	−43.85	6.74
	REN50	−0.0008	−0.80	0.74
	MINE20	0.04	−1.64	1.56
	AGR10	0.69	0.22	1.15
Equivalent variation (EV), $ US million	CTAX15	−81.76	−298.87	127.25
	REN50	0.01	−3.76	2.02
	MINE20	3.69	−146.99	120.93
	AGR10	119.09	23.82	213.67
Change in real GDP (qgdp) (expenditure-side), %	CTAX15	−0.41	−1.46	0.60
	REN50	0.00001	−0.04	0.02
	MINE20	−0.03	−1.24	0.92
	AGR10	0.82	0.19	1.45
Change in value of GDP (vgdp), %	CTAX15	0.78	0.58	0.80
	REN50	0.00007	−0.04	0.03
	MINE20	−0.18	−6.52	6.10
	AGR10	0.64	0.16	1.12
Regional household income (y), % change	CTAX15	0.84	0.67	0.80
	REN50	0.0001	−0.04	0.02
	MINE20	−0.17	−6.30	5.83
	AGR10	0.93	0.21	1.64
Regional private consumption expenditure (yp), % change	CTAX15	0.85	0.63	0.86
	REN50	0.00005	−0.04	0.02
	MINE20	−0.17	−6.18	5.72
	AGR10	0.80	0.19	1.41
Terms of trade: tot (r) = psw (r) - pdw (r), % change	CTAX15	−0.24	−1.23	0.69
	REN50	0.00011	−0.08	0.09
	MINE20	0.01	−0.53	0.54
	AGR10	0.02	−0.03	0.06
Volume of merchandise exports (qxwreg), % change	CTAX15	0.99	−0.61	2.57
	REN50	−0.00052	−0.42	0.38
	MINE20	−0.04	−1.36	1.15
	AGR10	−0.25	−0.55	0.05
Change in trade balance X - M, $ US million	CTAX15	101.32	−66.29	266.52
	REN50	−0.03	−26.08	23.19
	MINE20	17.91	−622.91	634.50
	AGR10	−78.88	−145.84	−11.26

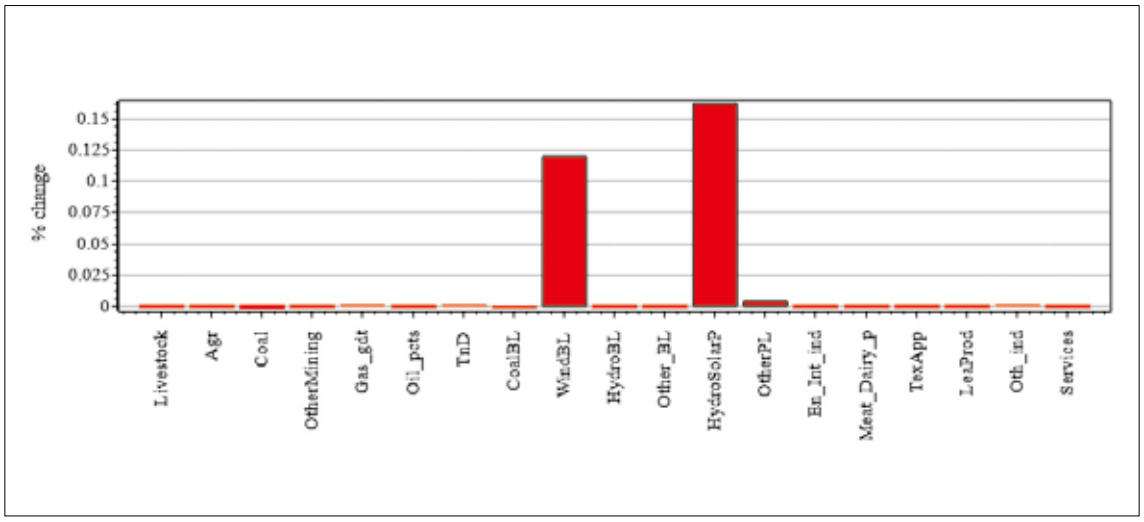
Source: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

Figure 3.1 Mongolia: Output Changes in Exp.1: Global Carbon Tax



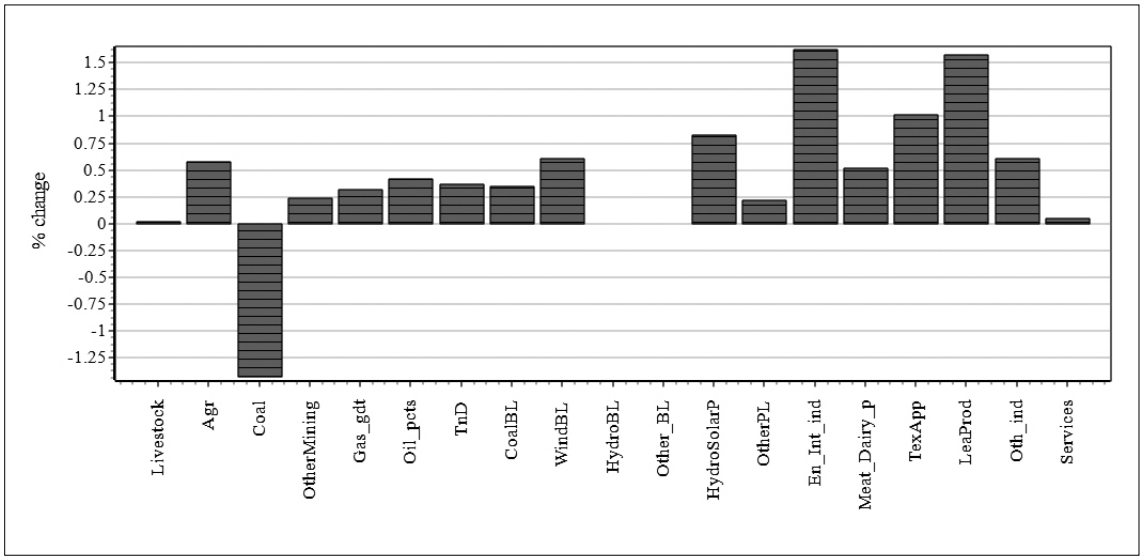
Source: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

Figure 3.2 Mongolia: Output Changes in Exp. 2: Renewable Energy Promotion



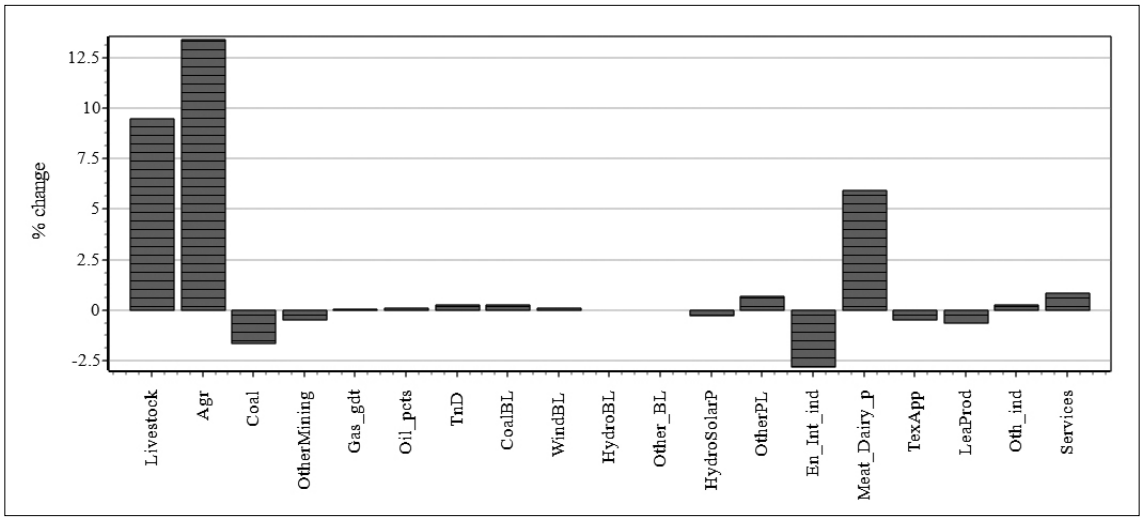
Source: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

Figure 3.3 Mongolia: Output Changes in Exp. 3: Stricter Environmental Rules for Mining



Source: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

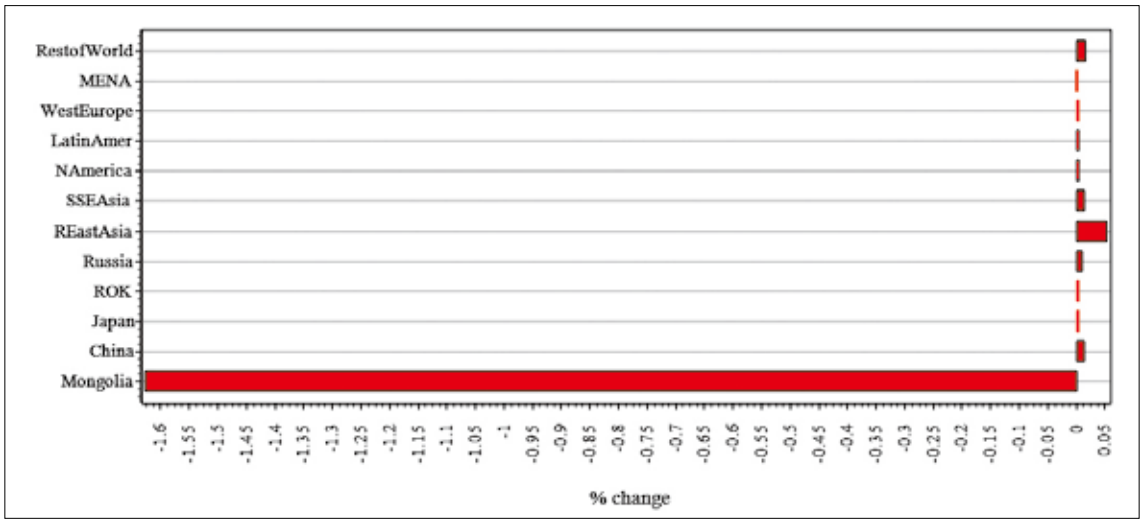
Figure 3.4 Mongolia: Output Changes in Exp.4: Technological Improvement in Agriculture



Source: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

The results provided above is a tiny part of the results offered by the GTAP model. As a powerful global CGE model, GTAP model can simulate impacts of a country's domestic policies on other countries. For example, in experiment 4, when technological improvements occur in Mongolia's livestock and other agriculture (i.e. factor productivity increases by 10%), outputs of the sectors would grow by 9.4% and 13.4% respectively. This policy may result in rise of coal output in all other regions with the highest rates being in the Rest of East Asia (+0.053%) and the Rest of the World (+0.015%). But, China's coal output change was the highest in terms of volume, compensating for almost half of the decreased coal output volume in Mongolia. Such situation was associated with the fact that as Mongolia's economy diversifies to other sectors, such as livestock, agriculture, meat and dairy industries, and the country's coal output drops by 1.6%, supply shortage of coal at the world market need to be compensated by increased outputs in other regions (Figure 3.4, 3.5).

Figure 3.5 Exp. 4: Coal Output Change by Regions (% change)



Source: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

Conclusion

While Mongolia has shown a strong commitment to achieving SDGs, several challenges persist. A major challenge is the country's economic structure, dominated by mining, leading to environmental degradation and cyclical economic turbulence. Despite challenges, Mongolia continues marching toward achieving its SDG targets and with its vast natural resources, including coal, minerals, and potential for renewable energy, the country is at a critical juncture where it can align its development trajectory with both SDGs

and climate change mitigation efforts. In order to set priorities, a particular attention shall be given to identify areas where different SDGs conflict.

The use of the GTAP model provided valuable insights into the potential impacts of adopting sustainable practices in various sectors, including agriculture, mining, and renewable energy. The simulation results quantified the synergies and trade-offs between SDGs and climate change mitigation policies in the context of Mongolia. This may help policymakers in Mongolia to make informed decisions, identify potential challenges and opportunities, and guide the development of sustainable practices in key sectors, thereby contributing to the country's long-term economic growth, environmental sustainability, and social well-being.

Furthermore, a more holistic approach is needed to ensure sustainable development, including but not limited to strengthening governance and capacity-building, diversifying the economy, ensuring that growth is inclusive and sustainable, and leveraging international partnerships for sustainable development. It is evident that one way for Mongolia's decision- makers to turbocharge progress in the remaining years of the 2030 Agenda is to identify interventions that leverage synergies between the SDGs and push simultaneous progress on several of the individual goals.

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Appendix TableⅠ Classification of Regions in the Model

12 New Regions	160 Old Regions in GTAP 12B GTAP-POWER Data Base
Mongolia	Mongolia.
China	China.
Japan	Japan.
ROK	Republic of Korea.
Russia	Russian Federation.
Rest of East Asia	China, Hong Kong SAR; Taiwan Province of China; Rest of East Asia; Brunei Darussalam.
South, South East Asia（SSE Asia）	Cambodia; Indonesia; Lao People's Democratic Republic; Malaysia; Philippines; Singapore; Thailand; Viet Nam; Rest of Southeast Asia; Afghanistan; Bangladesh; India; Nepal; Pakistan; Sri Lanka; Rest of South Asia.
North America	Canada; United States of America; Mexico; Rest of North America.
Latin America	Argentina; Bolivia（Plurinational State of）; Brazil; Chile; Colombia; Ecuador; Paraguay; Peru; Uruguay; Venezuela（Bolivarian Republic）; Rest of South America; Costa Rica; Guatemala; Honduras; Nicaragua; Panama; El Salvador; Rest of Central America; Dominican Republic; Haiti; Jamaica; Puerto Rico; Trinidad and Tobago; Caribbean.
West Europe	Austria; Belgium; Bulgaria; Croatia; Cyprus; Czechia; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Latvia; Lithuania; Luxembourg; Malta; Netherlands; Poland; Portugal; Romania; Slovakia; Slovenia; Spain; Sweden; United Kingdom of Great Britain; Switzerland; Norway; Rest of EFTA.
Middle East & North Africa（MENA）	Bahrain; Iran（Islamic Republic of）; Iraq; Israel; Jordan; Kuwait; Lebanon; Oman; Palestine; Qatar; Saudi Arabia; Syrian Arab Republic; Turkiye; United Arab Emirates; Rest of Western Asia; Algeria; Egypt; Morocco; Tunisia; Rest of North Africa.
Rest of World	Australia; New Zealand; Rest of Oceania; Albania; Serbia; Belarus; Ukraine; Rest of Eastern Europe; Rest of Europe; Kazakhstan; Kyrgyzstan; Tajikistan; Uzbekistan; Rest of Former Soviet Union; Armenia; Azerbaijan; Georgia; Benin; Burkina Faso; Cameroon; C te d'Ivoire; Ghana; Guinea; Mali; Niger; Nigeria; Senegal; Togo; Rest of Western Africa; Central African Republic; Chad; Congo; Democratic Republic of the Con; Equatorial Guinea; Gabon; South-Central Africa; Comoros; Ethiopia; Kenya; Madagascar; Malawi; Mauritius; Mozambique; Rwanda; Sudan; United Republic of Tanzania; Uganda; Zambia; Zimbabwe; Rest of Eastern Africa; Botswana; Eswatini; Namibia; South Africa; Rest of Southern African Custo; Rest of the World.

Source: GTAP 12B GTAP-POWER Data Base

Appendix TableⅡ Exp.1: Welfare Effects of Global Carbon Tax of $15/tCO$_2$(2017 US$ million)

Regions	Carbon Trading Contribution	Allocative Efficiency	Endowment Supply Change	Terms of trade in Goods and Services	Terms of Trade in Investment and Savings	Total Welfare
Mongolia	0.0002	−47.30	0	−31.02	−3.44	−81.76
China	−0.6875	−53719.80	0.001	−52,902.70	5192.19	−101431.00
Japan	0.0551	−1594.65	0	10413.63	−853.09	7965.95
ROK	0.0067	207.59	0	3218.75	−856.10	2570.24
Russia	−0.0585	−298.31	0	−4027.71	960.66	−3365.41
Rest of East Asia	−0.0215	−418.06	0	2291.01	−193.87	1679.06
SSE Asia	0.0269	−3889.06	−0.0003	5245.03	−1939.61	−583.61
North America	−0.0003	−21333.29	−0.0005	18320.10	1496.99	−1516.20
Latin America	0.0167	623.22	0	769.15	342.49	1734.87
West Europe	−0.0329	6774.39	−0.0002	30005.70	−2524.49	34255.56
MENA	−0.0059	9993.14	0.0001	−10118.48	−890.90	−1016.24
Rest of World	0	478.34	−0.0001	−4052.57	−649.79	−4224.02
Total	−0.701	−63223.78	0.0001	−869.11	81.04	−64012.55

Source: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

Appendix Table Ⅲ　Classification of Sectors in the Model

New Sector		Comprising
Code	Description	76 old sectors in GTAP 11B（GTAP-POWER）
Livestock	Livestock	Bovine cattle, sheep and goats; Animal products nec; Raw milk; Wool, silk-worm cocoons.
Agr	Agric. oth, Forestry, Fishing	Paddy rice; Wheat; Cereal grains nec; Vegetables, fruit, nuts; Oil seeds; Sugar cane, sugar beet; Plant-based fibers; Crops nec; Forestry; Fishing.
Coal	Coal mining	Coal.
OtherMining	Oil and other mining	Oil; Minerals nec.
Gas_gdt	Natural gas extraction & distr	Gas; Gas manufacture, distribution.
Oil_pcts	Refined oil products	Petroleum, coal products.
TnD	Electricity: Transmission and	Electricity transmission and d.
CoalBL	Coal base load	Coal power baseload.
WindBL	Wind base load	Wind power.
HydroBL	Hydro base load	Hydro power base load.
Other_BL	Other base load	Nuclear power; Gas power baseload; Oil power baseload; Other baseload.
HydroSolarP	Hydro & solar peak load	Hydro power peak load; Solar power.
OtherPL	Other peak load	Gas power peak load; Oil power peak load.
En_Int_ind	Energy intensive industries	Chemical products; Basic pharmaceutical products; Rubber and plastic products; Mineral products nec; Ferrous metals; Metals nec.
Meat_Dairy_p	Meat and dairy products	Bovine meat products; Meat products nec; Dairy products.
TexApp	Textiles and wearing apparel	Textiles; Wearing apparel.
LeaProd	Leather products	Leather products.
Oth_ind	Other industries	Vegetable oils and fats; Processed rice; Sugar; Food products nec; Beverages and tobacco products; Wood products; Paper products, publishing; Metal products; Computer, electronic and optic; Electrical equipment; Machinery and equipment nec; Motor vehicles and parts; Transport equipment nec; Manufactures nec.
Services	Services	Water; Construction; Trade; Accommodation, Food and service; Transport nec; Water transport; Air transport; Warehousing and support activities; Communication; Financial services nec; Insurance; Real estate activities; Business services nec; Recreational and other service; Public Administration and defense; Education; Human health and social work a; Dwellings.
Livestock	Livestock	Bovine cattle, sheep and goats; Animal products nec; Raw milk; Wool, silk-worm cocoons.

Note: nec-not elsewhere cited;
Source: GTAP 12B GTAP-POWER Data Base

Appendix Table Ⅳ　Classification of Factors in the Model

New factors	Factor Description	Comprising Old Factors
Land	−1	Land.
Labor	mobile	Technicians/Associates Professional; Clerks; Service/Shop workers; Officials and Managers; Agricultural and Unskilled.
Capital	mobile	Capital.
NatRes	−0.001	Natural Resources.

Source: GTAP 12B GTAP-POWER Data Base