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Analysis on Indirect Influences of the U.S. Withdrawal from the Paris Agreement on China's Coal Production and Carbon Emissions of Surrounding Nations

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1. Introduction

The President Trump announced his decision to withdraw from the Paris Agreement on 1st June, 2017. Although the announcement invoked a strong disappointment both domestically and internationally, it did not affect the position of major greenhouse gas (GHG) emitting nations nor domestic entities to commit themselves to emission reductions. The previous analysis using static GTAP-E model (ver. 6-pre2) also showed that the U.S. withdrawal does not have a significant influence on the Paris Agreement in terms of unit reduction cost of major emitting countries (less than USD 2)[1] and their GDPs (less that positive or negative 0.01%), as well as the change in the U.S. carbon emissions (about 2% increase in addition to the increase due to dropping off its reductions target, compared to the case of remaining in the Agreement) (Kato, 2017).

On the other hand, the U.S. leaving the role of world's climate leader may bring about an important change. Many believe that China could take over the leading role – it has been the largest renewable energy investor since 2012 (Bloomberg New Energy Finance, 2018) and is preparing to introduce a nation-wide emissions trading scheme. There is, however, a great uncertainty in China's coal production, which might also place uncertainties in coal consumption by other nations especially in surrounding nations of South-east Asia. If China produces excessive coal, it will likely become a coal exporter, leading to a possible increase in other nations' carbon emissions. Under the Obama administration, the U.S. and China created a cooperative partnership on decarbonization. In addition to being a driving force to make the Paris Agreement enter into force, the partnership played a certain role of keeping the two biggest emitters in the world to stay on track. In the joint presidential statement on climate change in 2015, it is mentioned that "China will strengthen green and low-carbon policies and regulations with a view to strictly controlling public investment flowing into projects with high pollution and carbon emissions both domestically and internationally."[2] With the change in U.S. administration, the U.S.-China cooperation on climate change and influences from each other under this cooperative partnership has become practically invalid.

According to IEA (2017), China actually has difficulty in aligning its coal output capacity with future demand needs. While the authority has been actively implementing measures to cut the capacity, the plan is prone to change due to various factors such as price of natural gas and demand spike in winter. The drop-off of the U.S. from the cooperative partnership with China on decarbonization could also be a factor to slow down China's efforts to lessen its dependence on coal and its coal production because of absence of the external pressure.

It can be said that the U.S. withdrawal from the Paris Agreement could be more important in indirect ways than in direct ways. The purpose of this research, therefore, is to analyze such indirect influences specifically those on coal production in China and how it affects carbon emissions of surrounding nations.

[1] Except for France where it has the highest unit cost of reduction and therefore experiences the largest change in reduction cost by the U.S. withdrawal, with nearly USD4 per ton of CO2.
[2] U.S.-China Joint Presidential Statement on Climate Change
https://obamawhitehouse.archives.gov/the-press-office/2015/09/25/us-china-joint-presidential-statement-climate-change

2. Methodology

2.1 Data and Model

As an indirect influence of the U.S. withdrawal from the Paris Agreement, this study assumes that it will increase China's coal production compared to the baseline. Baseline is the situation where all the major emitters including the U.S. meet their mid-term emission reduction targets under the Paris Agreement. To analyze the influences leading up to 2030, for which the countries set their mid-term emission reductions targets, we apply the GDyn-E model (Golub 2013), a multi-sector multi-region recursive dynamic computable general equilibrium (CGE) model, with some modifications. The GDyn-E model is a merger with improvements between two strands of extensions stemming from the GTAP model (Hertel 1997), a standard comparative static CGE model. On the one line of extensions, investment dynamics and international capital mobility have been introduced into the GTAP model, dubbed as the GDyn model (Ianchovichina and McDougall (2001), Ianchovichina and Walmsley (2012)). On the other, energy substitution and carbon taxation are incorporated into the GTAP framework as GTAP-E (Burniaux and Truong (2002), McDougall and Golub (2007)).

We modify the GDyn-E to be configured with the GTAP-E database (ver. 9a) to develop the baseline. The countries in the GTAP-E database are aggregated into 19 regions and sectors into 12 (See Appendix). The baseline database for each year from 2011 to 2030 is created by giving shocks of annual growth rate to population, labor, GDP, and capital according to the projections from U.N. World Population Prospect (2017) and IMF World Economic Outlook (2017). In addition, a new exogenous parameter is introduced to the GDyn-E model to make CO2 emissions follow the path forecasted by U.S. Energy Information Administration (EIA) (2016). The parameter is denoted as "e_r(r)" and indicates rate of emissions reduction in each region from consumption of both final products and intermediate inputs. Figures for e_r(r) are to be calculated for each year by swapping e_r(r) with regional CO2 emissions and giving it exogenous shocks of figures based on EIA CO2 emissions forecast.

2.2 Scenarios

The baseline scenario is created by adding shocks of emission caps according to each country's nationally determined mid-term reduction targets to the baseline database prepared by the procedures described above. Caps on carbon emissions are applied only to major emitting nations considering the fact that most of the developing countries/emerging economies do not set a numerical reduction target nor describe specific policies/measures to reduce their greenhouse gas emissions[3]. This assumption allows evaluation on how the fact that China increases its coal production but meets its own reduction target influences other countries with small emissions, especially those surrounding China.

Influences of the U.S. withdrawal from the Paris Agreement are reflected to policy scenarios in both direct and indirect ways. Directly, it is simply the removal of emissions cap from the U.S. while all the other major emitters keep their reduction targets. Regarding the indirect influence, it is interpreted as increase in China's coal production as explained above. In policy scenarios, therefore, additional shocks are given to China's coal production. To make the endogenous parameter of China's coal production exogenous, it is swapped with a parameter of output augmenting factor. For comparison, simulations are also conducted with another way of giving exogenous shocks to the parameter of China's coal production, which is to swap it with a parameter of production tax on coal in China. Since there is no empirical reference on how much China's coal production increases if China's cooperative relationship with the U.S. diminishes, the figure of exogenous shock to China' coal production is hypothetically set at 10%.

Influences from difference in the length of the current administration – just one term (2017-2020) or two terms (2017-2024) – are also to be analyzed by conducting simulation for each case. Since the current administration officially decided to withdraw from the Paris Agreement in the middle of 2017, it is assumed that the actual influences take place from 2018. Shocks are therefore given from 2018 onward to the year when the administration ends in each simulation.

[3] Brazil and Russian Federation, although they do have a numerical reduction target for 2030, are categorized as countries/regions without emissions reduction target in this analysis since emissions that can be analyzed by GTAP-E is those from fossil fuel consumption. This is based on the evaluation of nationally determined contribution by Climate Action Tracker (https://climateactiontracker.org/), which evaluates that the major part of emissions reduction by these two countries is from land use, land-use change and forestry.

In total, four simulations – A-1, A-2, B-1 and B-2 – are conducted. Simulation A is the one where the parameter of China's coal production is swapped with that of output augmenting factor of coal in China and B with that of production tax on coal in China. Further, scenario 1 with just one term of the current administration and scenario 2 with two terms are conducted for each of A and B.

3. Results and Discussion

3.1 Baseline

Developing countries and emerging economies except China, India, and Mexico are assumed to be without Carbon emissions reduction targets. Table 1 lists the countries/regions without targets as well as each of their share in the global carbon emissions in 2011 based on GTAP-E database (ver. 9a).

Table 1 List of countries/regions without reduction targets and their share in the global carbon emissions

Country/ Region[4]	South and Southeast Asia (SSEA)	Russian Federation (RUS)	Brazil (BRA)	Latin and South America (LSA)	Middle East and North Africa (MENA)	Sub-Saharan Africa (SSA)	Rest of the world (ROW)
Share of carbon emissions (%)	3.6	5.2	1.3	2.6	7.6	2.0	5.7

Changes in the emissions of the countries/regions without target in the baseline simulation are first discussed to establish the basis of comparison to the results from the simulations of policy scenarios. In the baseline simulation, where all the major emitting countries/regions including the U.S. meet their reduction target by 2030, the countries without targets increase their carbon emissions by 40-70% cumulatively by 2030 compared to the case without the Paris Agreement. Russia is an exception with an increase of carbon emissions only by 10% (Figure 1). A fall in the price of coal as a result of reduction efforts by major emitters basically accounts for the increase in carbon emissions of countries without targets. Coal exporters are also influenced by the major destination of their coal export. Table 2 lists major coal exporters and the main destinations of their coal export in 2011 based on GTAP-E database (ver. 9a).

Figure 1 Changes in carbon emissions of countries without reduction targets under the Paris Agreement

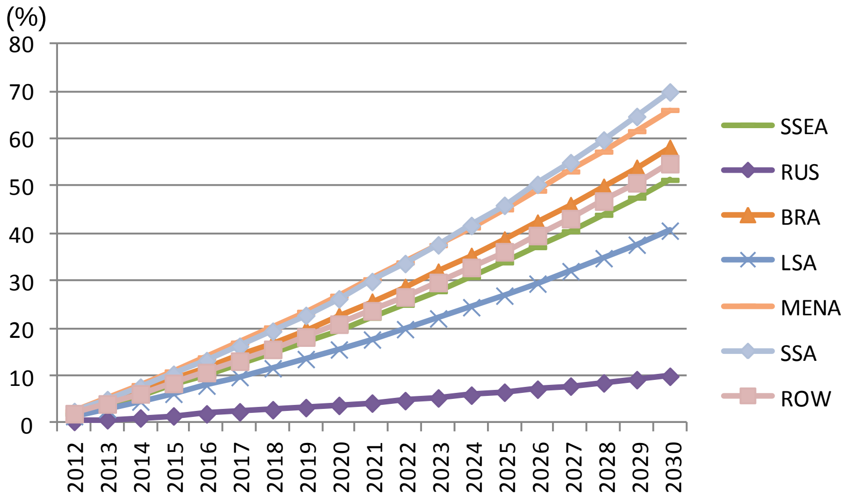


Table 2 Major coal exporting countries/regions and their main destinations

[4] Refer to Appendix for the countries included in each region.

		Share in the global total export of coal (%)	Main destination of coal export and share of each destination (%)				
			CHN	JPN	IND	KOR	EU25
Country /region	SSEA	31.6	46.8	7.5	15.9	7.5	1.8
	AUS	26.6	13.8	22.4	35.7	9.2	1.9
	RUS	10.3	20.8	12.5	1.5	12.0	19.0
	USA	9.8	6.8	5.5	5.0	4.6	1.2
	LSA	6.0	4.6	0.9	0.2	0.6	27.8
	SSA	5.2	20.7	0.8	35.6	3.6	11.5

Russia's coal price keeps rising throughout the simulation period of the baseline. Its coal production keeps falling because of the suppressed demand in the European countries, second largest destination of Russia's coal export, due to their stringent reduction targets. At the same time, domestic demand for coal is not suppressed without an emissions cap. The price of coal rises in Russia and therefore the extent of carbon emissions increase in Russia becomes smaller than other countries.

South and Southeast Asia (SSEA), whose main destination of coal export is China and India, increases its coal production throughout the simulation period. Production for export is enhanced more significantly than for domestic market, with China and India increases the share of SSEA in their sources of coal import. Australia, the other major coal exporters to China and India, become less competitive against SSEA due to imposition of carbon tax.

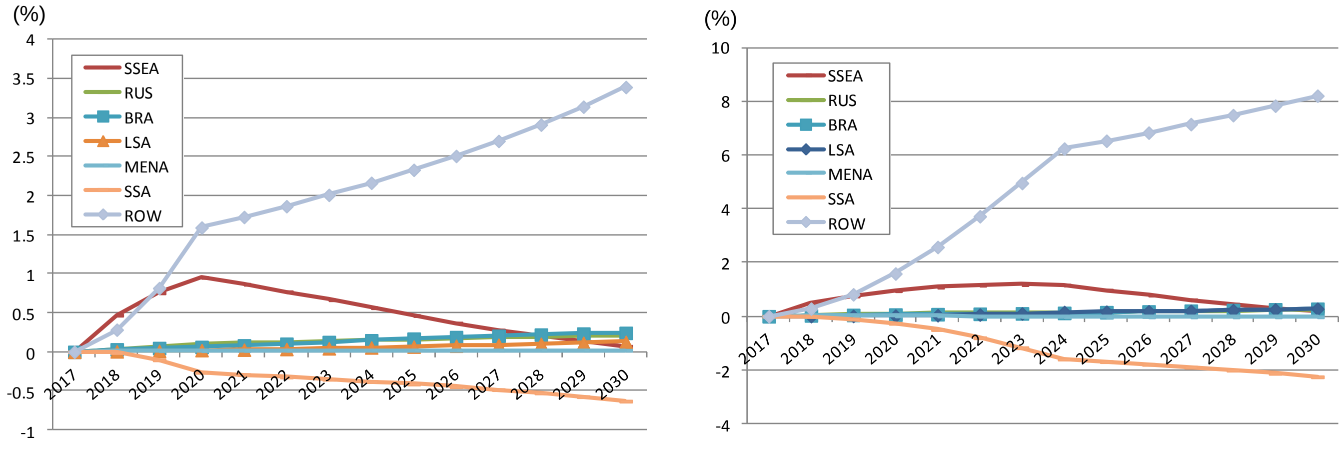
3.2 Change in Carbon Emissions

In the simulation of policy scenarios, indirect influence of the U.S. withdrawal, or the enhancement of coal production in China, are analyzed. How they will change carbon emissions in countries without a reduction target is discussed below. Results are discussed mainly on simulation A and then simulation B is looked into for comparison.

Figure 2 shows changes in emissions of countries without a reduction target compared to the baseline. The figures show the results from 2017 when influences of policy shocks start to take place. Among them, only Sub-Saharan Africa (SSA) experiences negative changes in its emissions up to 2030 compared to the baseline. What causes the reduction of SSA's emissions is the decrease of firms' usage of domestic coal, mainly as an input of heavy manufacturing and electricity. With the increase of coal production in China, price of imported coal falls and thus demand for it increases in all the countries/regions. Although decrease in domestic coal consumption is outweighed by increase in imported coal consumption in other countries, it is not the case in SSA. SSA's coal consumption starts decreasing once China starts expanding its coal production and its negative change continues even after the policy shocks end. Since coal is SSA's major item of export, firms' demand for coal shrinks as intermediate for coal production. The influences remain even after the policy shocks end with a drop in rental price of capital as a result of shrunk demand for capital, which keeps away investment in SSA.

Figure 2 Change in carbon emissions of countries without reduction targets

a): Simulation A-1 **b): Simulation A-2**



Other than SSA, all the countries/regions without a reduction target keep increasing their emission throughout the simulation period. Substitution of domestic coal with imported one and enhanced consumption of imported coal as intermediate outweighs the decrease in consumption of domestic coal mainly as intermediate of electricity generation. With the price drop of coal as intermediate, the countries without emissions reduction target expands production of manufactured goods.

SSEA's dependence on domestic coal is relatively large and therefore a shift to imported coal due to the lower price of coal from China is less significant. In addition, SSEA's price of production factors especially natural resources and capital – major production factors of coal – falls as demand for them shifts from coal to other sector because of a large drop in coal production for export, of which China accounts for the largest share as a destination with nearly half of its total export of coal. Lower price of domestic coal enhances firms' demand for coal and therefore carbon emissions increases slightly during the period of policy shocks.

However, SSEA decreases its emissions after the term of policy shocks ends. By 2030, its emissions are almost the same as the baseline. Because of the fact that SSEA's coal production is largely influenced by export to China, SSEA starts increasing coal production once China's expanded coal production ends. As a result, SSEA's price of natural resources and capital goes up, which leads to a rise in domestic coal supply price. It also causes supply price of other manufactured goods to rise and therefore the production of such goods decreases. It accounts for the decrease in SSEA's carbon emissions after the policy shocks end.

At the end of the simulation period, the largest change in emissions is in ROW, with 3.4% increase. The change in all the other countries/regions without targets is less than 1%. Combined with the emissions increase of the U.S., which is 2.6% at the end of the simulation period, total increase in the global carbon emissions is about 0.7% in 2030.

In the simulation A-2 with two terms of the current administration, where the U.S. withdrawal continues from 2018 to 2024, same tendency is observed after the policy shocks end. While the change in the emissions of SSEA also gets close to zero by 2030, that of SSA accumulates to -2.3% and of ROW to 8.2%. Combined with the emissions increase of the U.S., which is 6.2% at the end of the simulation period, total increase in the global carbon emissions in simulation A-2 is about 1.6% in 2030.

In the simulation B, where coal production in China is made exogenous by being swapped with to("CHN","coal"), no significant difference is observed in terms of carbon emissions with less than 1% cumulatively by 2030 in all the countries/regions.

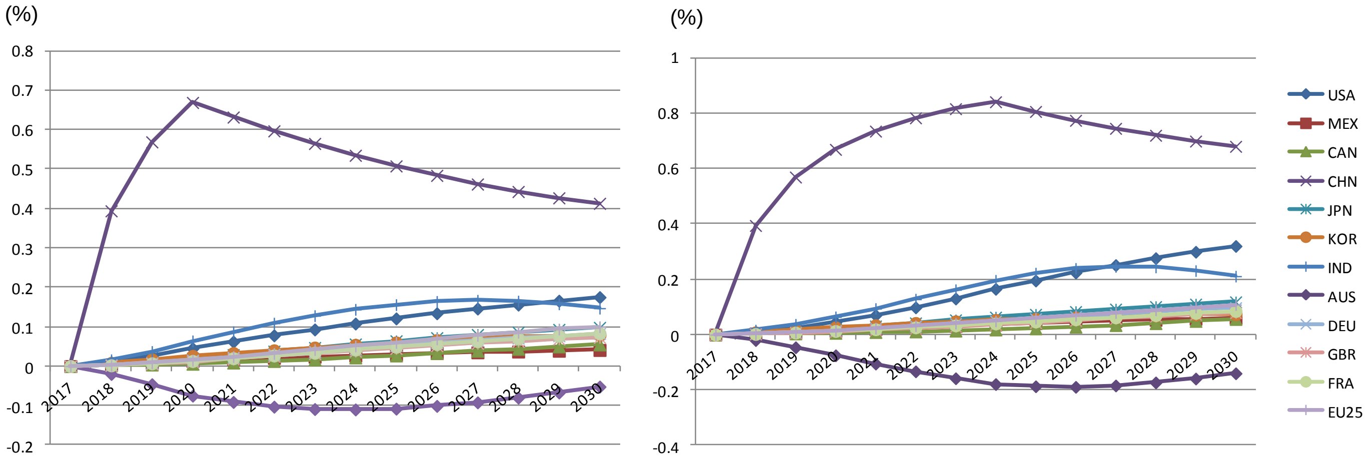
3.3 Changes in Economic Impacts

While carbon emissions of countries with reduction targets are the same under the policy scenarios as the baseline, their reduction costs are to be influenced by the policy shocks. Figure 3 shows the changes in GDP of countries/regions with reduction target in the simulation A-1 and A-2. In all of them except Australia GDP grows larger than the baseline due to the lower price of imported coal from China with expanded coal production. A fall in the price of manufactured goods because of the lower price of coal as an intermediate results in increased consumption, which outweighs the negative effect from increased import. Production for domestic demand increases and therefore investment is expanded. The increase of GDP in the U.S. is relatively larger than others due to the absence of carbon tax during the withdrawal period. The tendency continues even after the policy shocks end. Once the policy shocks terminate, total consumption and export increases and import falls in countries/regions with reduction target except Australia and China due to the loss of China's competitiveness, resulting in a positive change in GDP.

Towards the end of the simulation period, India's GDP goes down because of a shift in production from manufacturing to coal. While import of coal from Australia increases as it gains competitiveness as a coal exporter, that from China and SSEA decreases. In total, coal import changes negatively and domestic coal production increases. Due to the shift, the price of labor as well as capital falls and this results in negative changes in India's GDP.

Figure 3 Changes in GDP of countries/regions with reduction targets

a): Simulation A-1 **b): Simulation A-2**



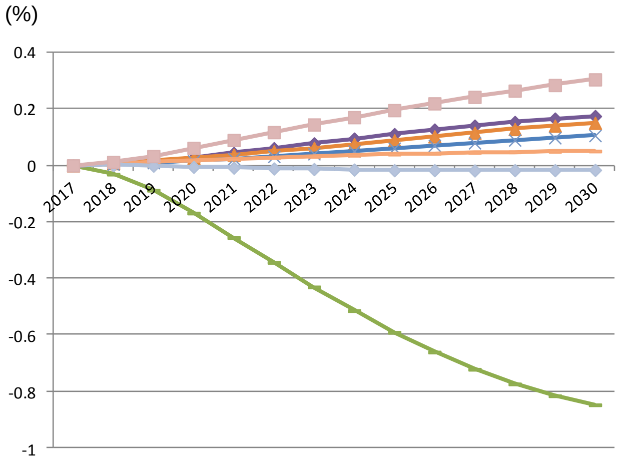
China's GDP increases by the policy shocks, with cumulative percentage of 0.67 and 0.84 in simulation A-1 and A-2, respectively by the last year of the policy shocks. It is mainly because of increased exports and decreased imports of coal as a result of its enhanced competitiveness. After the period of the policy shocks, a yearly change in GDP turns negative, which continues throughout the rest of the simulation period. In addition to a fall in export due to the loss of competitiveness in trading of coal as well as manufactured goods, main factor of this negative change is a decrease in private consumption due to a fall in income as the price of labor and natural resource drops.

It also strongly affects coal exporters. GDP in Australia decreases during the period of policy shocks and the following several years. Decrease in consumption, investment, and export accounts for the negative change in its GDP. While the other countries also reduce exports, expanded consumption and investment outweighs such negative effects, resulting in an increase in GDP. Since Australia is one of the major coal exporters to large coal consumers in Asia such as Japan, India and South Korea, increase of coal export to these countries by China results in significant negative influences on Australia. Price of production factors drops due to a large cut-back on production of coal. Lower price of production factors also leads to an increase in production and exports of manufactured goods, but it does not outweigh the loss from the drop in coal export of Australia. Change in the total export of Australia is therefore negative. Once the policy shocks end, its coal production for export to China as well as India starts to recover while that for Japan and South Korea does not with China's influences still remaining. In total the change in trading is still negative but what makes the change in GDP positive several years after the policy shocks end is increase in consumption and investment due to a rise in the price of labor and capital. The change in GDP compared to the baseline becomes close to zero by the end of the simulation period.

With regard to countries without reduction targets, SSEA is the only country which experiences negative changes in its GDP from the start of the policy shocks (Figure 4). Decrease in consumption and investment because of a fall in the price of production factors accounts for the negative changes of GDP. Regarding export, coal significantly drops while the increase in manufactured goods outweighs the loss, resulting in a positive change in the total export. Unlike Australia whose GDP also changes negatively but recovers after the policy shocks end, negative change in GDP continues in SSEA toward the end of the simulation period. The continuing decline in SSEA's GDP comes from the fact that its supply price of coal starts to go up after the period of policy shocks (Figure 5). Since China is the main destination of coal export of SSEA, the termination of coal production increase by China affects SSEA most significantly, with its price of natural resource to go up the largest. The loss of competitiveness as a coal exporter results in a continuous decline in export to major coal consumer countries other than China. To India, Australia increases its export and to Japan and South Korea, increased export from China remains although with a slight yearly decline after the period of policy shocks.

Figure 4 Changes in GDP of countries/regions without reduction targets

a): Simulation A-1



b): Simulation A-2

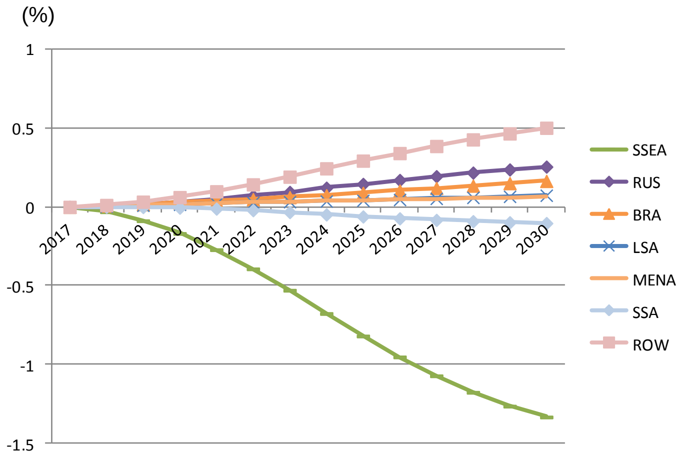
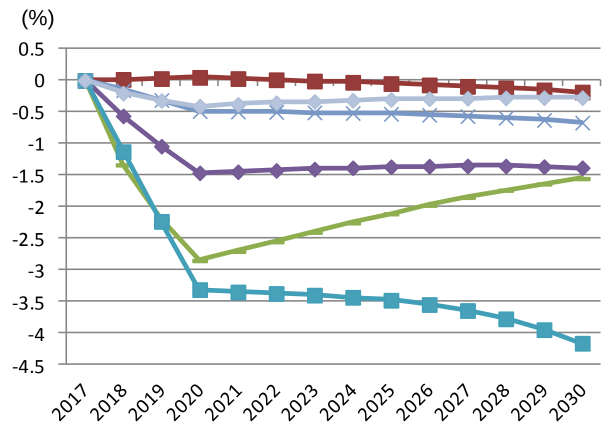
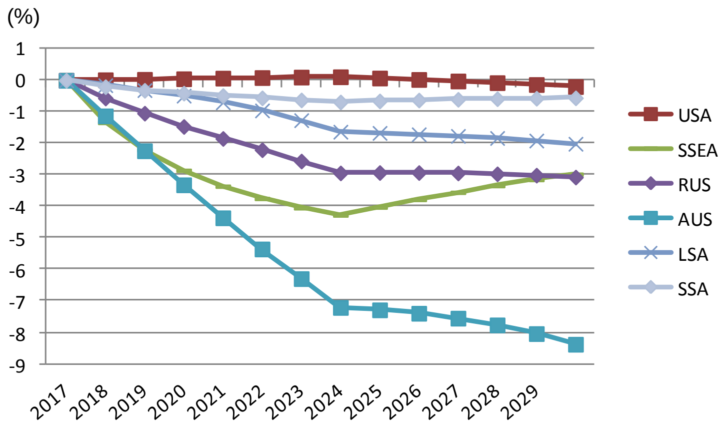


Figure 5 Changes in supply price of coal of major coal exporters

a): Simulation A-1

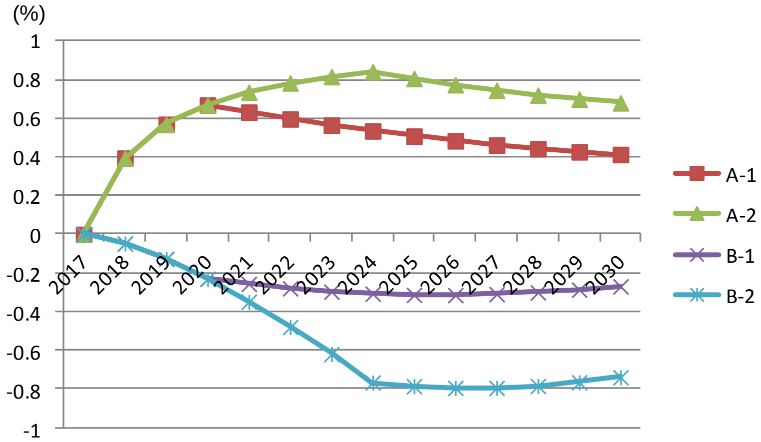


b): Simulation A-2



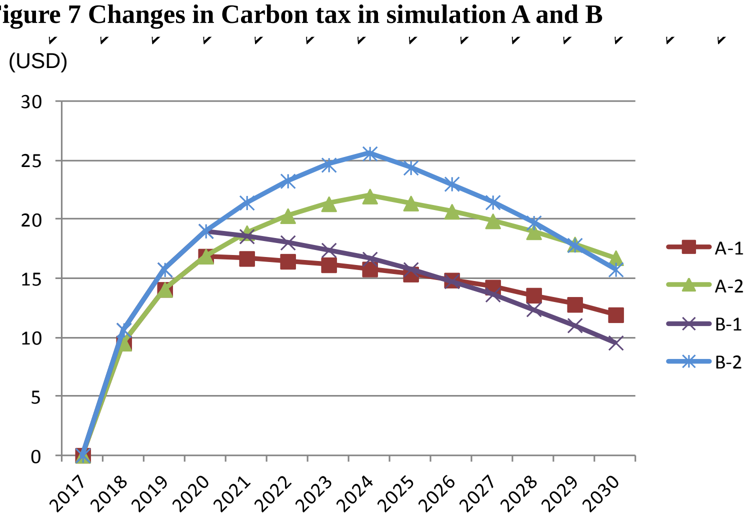
The difference in the setting between simulation A and B brings about different results in terms of some variables related with economic impacts. In simulation A, the parameter representing China's coal production (qo("coal", "CHN"))is swapped with the output augmenting factor of coal in China (ao("coal", "CHN")), while in simulation B, it is swapped with the one representing output tax on coal in China (to("coal", "CHN")). Figure 6 shows the changes in GDP in each region/country with a reduction target. Results are almost the same with those of simulation A in all the countries/regions except China. Changes in its GDP are negative, which is the opposite of the results in simulation A.

Figure 6 China's GDP change in simulation A and B



What accounts for this difference is the subsidy provided to coal producers to realize the 10% production increase and the changes in carbon tax. While the market price of domestic coal falls with the subsidy for coal production, carbon tax of China rises so that the country still meets its carbon emissions reduction target. It leads to a rise in the price of imported coal of which the market price does not fall as much as the extent of the rise in carbon tax. Larger extent of carbon tax rise in simulation B as shown in Figure 7 partially contributes to the difference in GDP changes between simulation A and B. Decline in the tax revenue of government caused by provision of subsidy is another factor of drop in government consumption. Private consumption also shrinks due to lower income and a rise in the price of imported fossil fuels. While coal export increases with lowered market price, export of gas drops significantly with only a rise in carbon tax, resulting in a reduction of investment.

Figure 7 Changes in Carbon tax in simulation A and B



4. Conclusion

This research is conducted based on the assumption that indirect impacts of the U.S. withdrawal from the Paris Agreement is more important than the direct ones or the removal of its carbon emissions reduction target. The previous analyses show that an increase in the global carbon emissions due to just the removal of the U.S. target is minor. It is because the reduction target of the U.S. is not a stringent one from the beginning and also because all the other major emitting countries have a cap on their emissions.

As an indirect consequence of the U.S. withdrawal from the Paris Agreement, this research focuses on the influences of coal production enhancement in China. The results show that the influences on carbon emissions itself is not a significant one even with two terms of the U.S. withdrawal with less than 2% increase in the global emissions. On the other hand, economic impacts on South and Southeast Asia, where China has strong relationship in trade of coal, are worth noting. Once China starts increasing its coal production, it becomes more self-sufficient of coal and also a coal exporter. It negatively affects the economy of South and Southeast Asia due to the fluctuation of its coal production and export, which then leads to the loss of its competitiveness as a coal exporter. The influences remain even after China stops the enhanced coal production toward 2030, or the end of the simulation period. Based on the simulation result, the indirect influences of the U.S. withdrawal leads to decline in efficient emissions reduction although in terms of carbon emissions itself the influences are small. As a conclusion, it is important that the U.S. comes back to the Paris Agreement to prevent the loss in efficiency in global emissions reduction.

There are several issues to be improved in the future analysis. Firstly, the extent of the coal production increase in China is hypothetically set as 10% in this analysis due to the lack of data. While the results can show the overall tendency of the consequence of the policy scenarios, the figure should be refined to draw more realistic results. Secondly, further detail of indirect influences of the U.S withdrawal, or the dissolution of its cooperative relationship with China in decarbonization should be elaborated in the simulation. It is pointed out that a number of new coal power plants are being built in South-east Asia thanks to the investments by China (GEI, 2017)[5]. It is also speculated that China will accelerate this move without the cooperative relationship with the U.S. Since it will strengthen the role of countries in South-east Asia as a potential buyer of coal from China with overproduction, how to reflect this move to the simulation should be considered in the future analysis. Lastly, another simulation should be conducted with emission reduction targets imposed on all the countries. The analysis in this research conducted based on the assumption that most of the developing countries and emerging economies do not have a cap on carbon emissions to reflect the current situation. However, it should be compared with the case of emissions reduction by all the countries in the world. It could draw further implication for the influences of setting a numerical reduction target in countries other than major emitters in the upcoming process under the Paris Agreement to review and update each country's reduction target.

[5] Global Environmental Institute (GEI) (2017). China's Involvement in Coal-Fired Power Projects along the Belt and Road.

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Appendix: Aggregation of regions and sectors

Aggregated region	Countries included
USA	United States of America
MEX	Mexico
CAN	Canada
CHN	China
JPN	Japan
KOR	Korea
IND	India
SSEA	Countries in South and Southeast Asia
RUS	Russian Federation
AUS	Australia
BRA	Brazil
LSA	Countries in Latin and South America except Mexico and Brazil
DEU	Germany
GBR	United Kingdom
FRA	France
EU25	Countries in European Union except Germany, UK, and France
MENA	Countries in Middle East and North Africa
SSA	Sub Saharan African Countries
ROW	Rest of the world

Aggregated sector	Sectors included
agr	Agricultural products, food products, forestry, fishery
coal	Coal
gas	Gas extraction
oil	Oil
min	Minerals, mineral products
oil_pcts	Petroleum, coal products
hmfg	Machinery, electronic equipment, metals, chemicals
lmfg	Textiles and wearing apparel, leather products, wood products , paper products, metal products, motor vehicles
trp	Transportation
electricity	Electricity
utl	Gas distribution, water, construction
ser	Services