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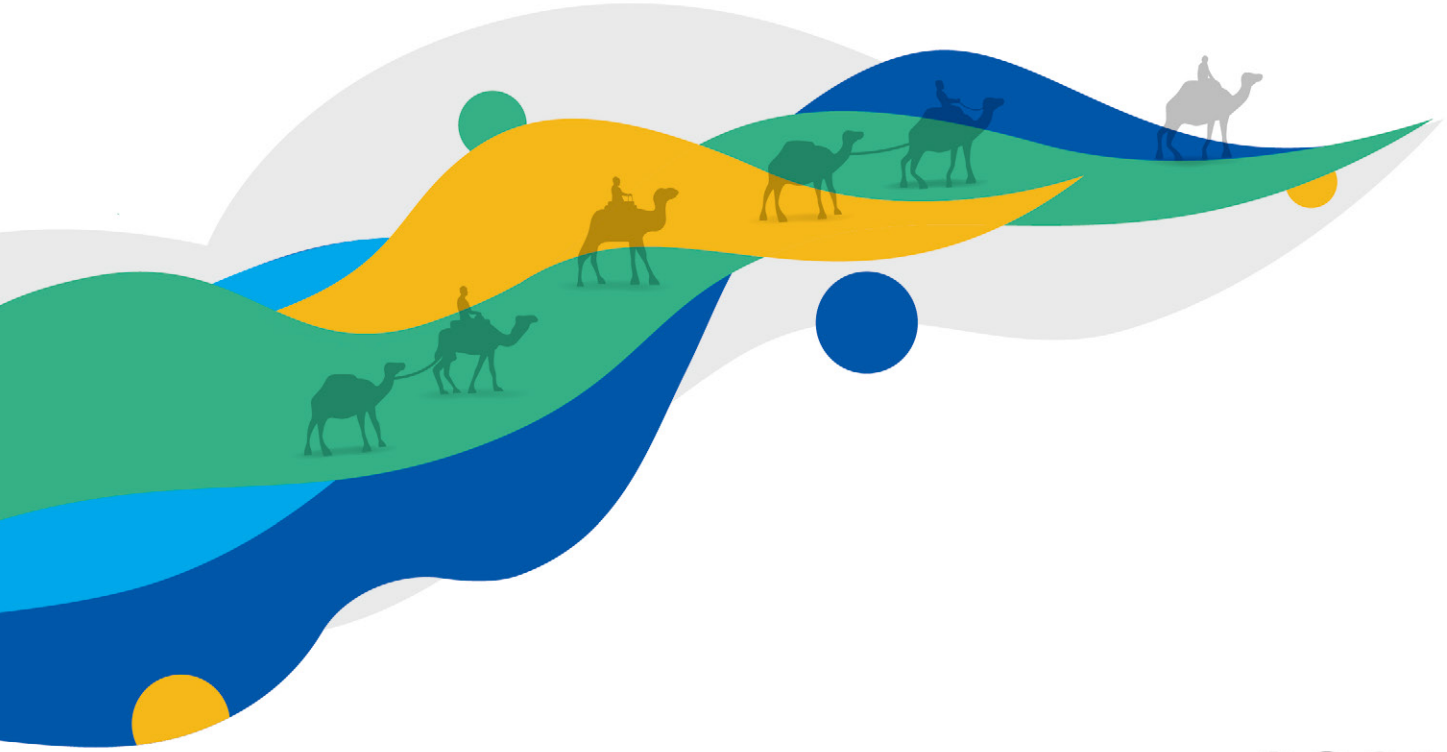
Analysis of the Significance and Feasibility of Establishing Carbon Markets in Major Countries and Regions Along the "BELT AND ROAD"



2021

Introduction of research institution

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Founded in 1967 and headquartered in New York, Environmental Defense Fund (EDF) is one of the world's leading environmental organizations. EDF has more than 2.5 million members, a staff of nearly 700 professionals, and 12 offices around the world including the United States, China, United Kingdom, and Mexico. Areas that EDF works in include: climate and energy, oceans, ecosystems, health, etc. Since inception, EDF has been guided by principles of science and economics to find practical and lasting solutions to the most serious environmental problems.

Institute of Energy, Environment and Economy (3E), Tsinghua University

Institute of Energy, Environment and Economy (3E), Tsinghua University was founded in 1980 which is a school-level interdisciplinary research institution, key team and think tank institution. It is also the earliest research institution for energy and climate change policy among Chinese universities. The discipline of "Management Science and Engineering" co-built with the School of Economics and Management is rated as A+, ranking the first in China. The Institute has undertaken more than 200 important national, provincial and international cooperation projects, and successively provided more than 10 major policy advice and suggestions to government. In 2020, the "Research on the Overall Scheme of the National Carbon Emission Trading Market with Chinese Characteristics" won the first prize of the 8th Science Research Famous Achievement Award in Higher Institution (Humanities and Social Sciences).

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Introduction

The Belt and Road Initiative (BRI) represents not only a road to economic prosperity, but also a road to green development. In 2013, Chinese President Xi Jinping proposed to jointly build the Belt and Road, an initiative winning positive responses from various parties. As of the end of January 2020, China has signed approximately 200 BRI cooperation documents with 138 countries and 30 international organizations. Green is the salient background of the BRI development, as highlighted by President Xi. In response to this call, the Ministry of Ecology and Environment of China (MEE) and its Chinese and foreign partners jointly launched the BRI International Green Development Coalition, which aims to foster green development consensus and facilitate sustainable development in the BRI countries and regions.

The global climate change situation has never been so urgent, making it imperative to drastically reduce greenhouse gas (GHG) emissions. At present, changes in the climate system characterized by global warming, rising sea levels and frequent extreme weather events have intensified and ranked among the toughest challenges facing human survival and development. In 2018, the carbon dioxide (CO_2) emissions from fossil fuel combustion worldwide hit 33.2 billion tonnes, about 2.4 times the level of 50 years ago.

While the international community is actively cooperating to address climate change, carbon pricing mechanisms represented by carbon market have developed rapidly. The Paris Agreement, which was concluded in December 2015 and entered into force in November 2016, opened a new stage of global cooperation to address climate change. Article 6 of the Paris Agreement encourages the Parties to engage in cooperative approaches such as the use of international carbon market towards their nationally determined contributions (NDCs). As of 2019, over 46 countries and regions have signed 58 carbon pricing initiatives[1] , covering 20% of the global GHG emissions or 11 billion tonnes CO_2e. In such increasingly severe climate change situation, the space for carbon emissions becomes more apparently scarce. The use of carbon market mechanisms to realize the effective allocation of production factors for carbon emissions has risen as an important link in the global response to climate change, as well as in the international cooperation and competition on low-carbon development.

[1] World Bank. State and Trends of Carbon Pricing 2019. 2019.

This study will review the status of socio-economic development and emissions and analyze, both qualitatively and quantitatively, the feasibility of carbon market establishment in major BRI countries and regions (Southeast Asia, Russia, South Korea, Middle East, Africa, and South Africa). The research content and structure are as shown in Figure 1.

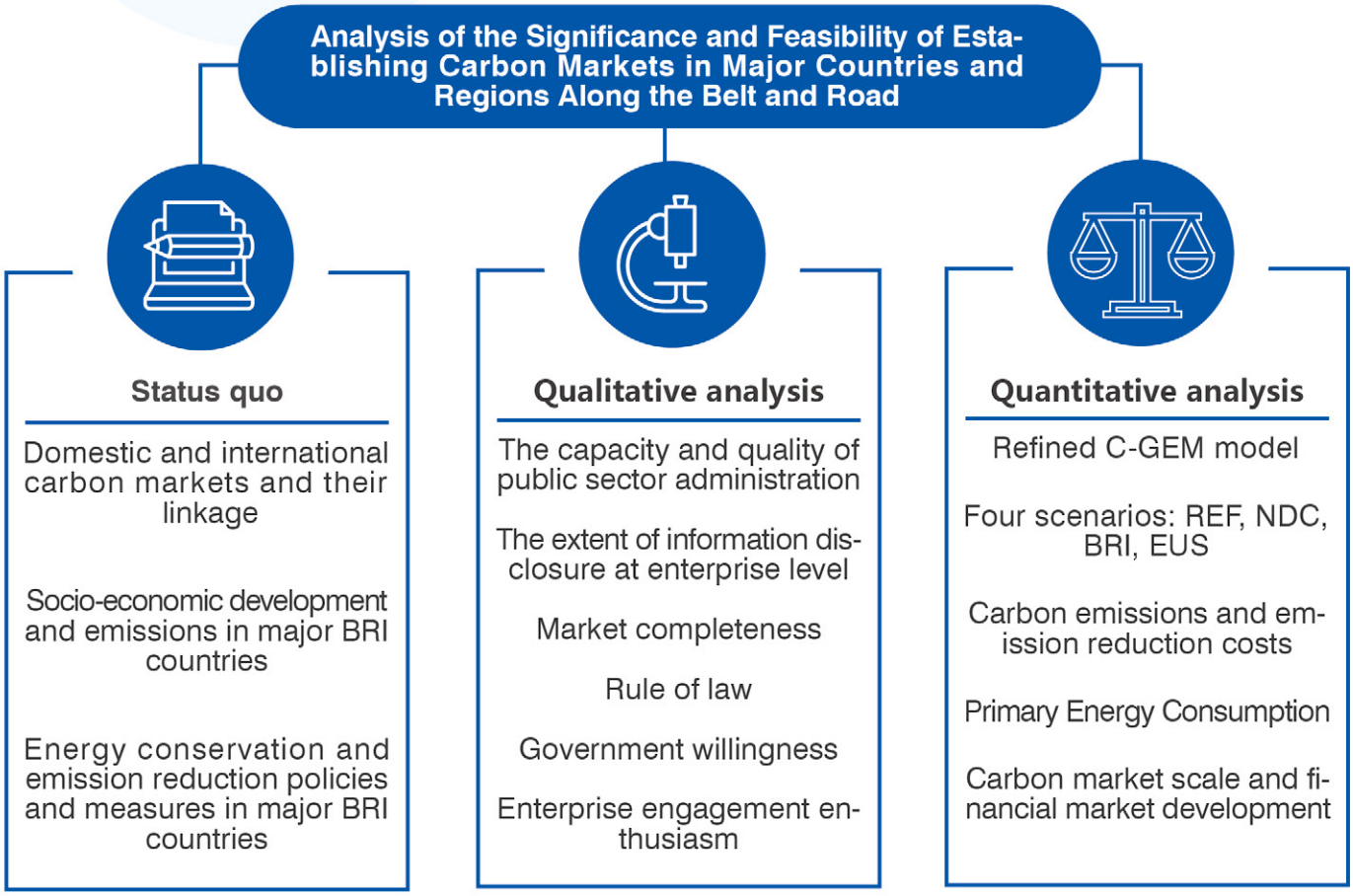


Figure 1. Research content and structure

Socio-Economic Development and Emissions in Major BRI Countries and Regions

The BRI countries are at different stages of development. Only by effectively identifying the socio-economic development and emission status in these countries can it be possible to reasonably predict the direction of their future development and examine the impact of carbon market on their socio-economic development and emissions. Based on the indicators as shown in Figure 2, this study discusses the future trend and present situation of socio-economic development, energy consumption, and emissions in major BRI countries.

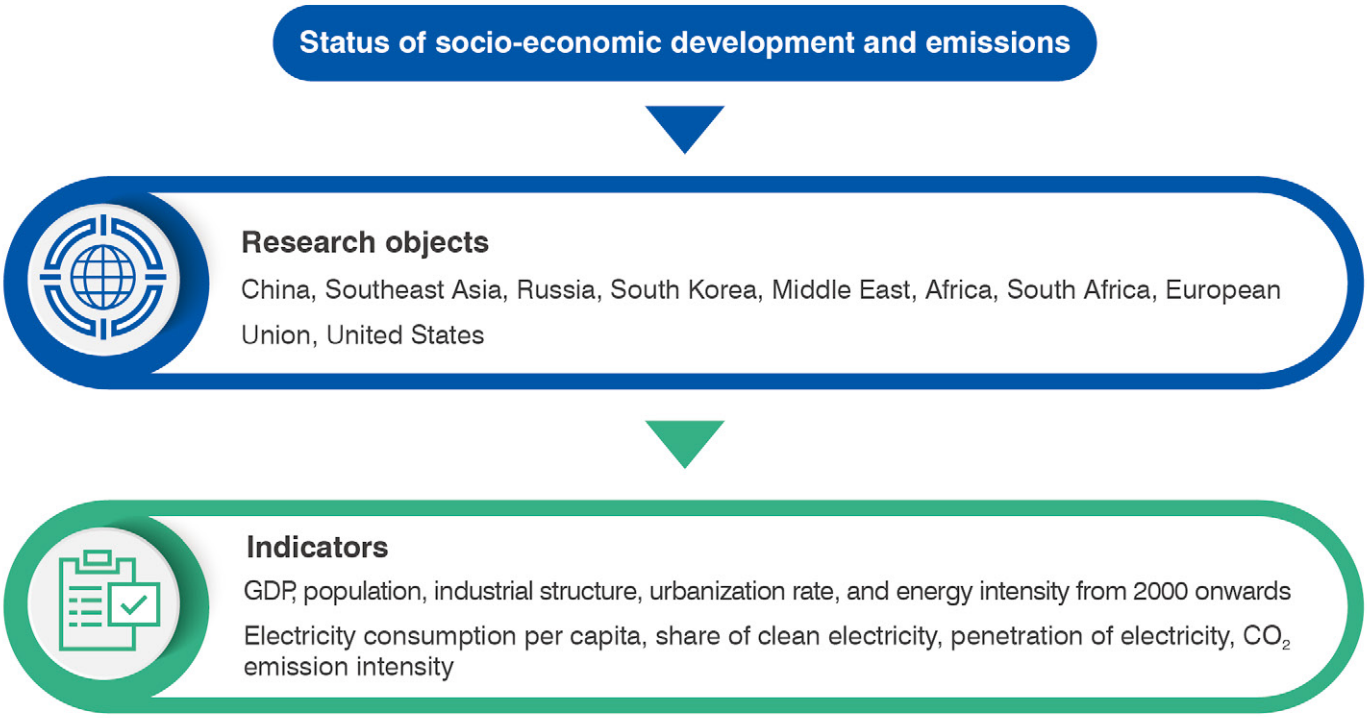


Figure 2. Research objects and indicators

As revealed by Table 1, in 2018, China boasted the largest economic output and population base. South Korea topped in the proportion of urban population, up to 82%, with the bottom of 42% in Africa. South Africa saw the most value added by service as a percentage of gross domestic product (GDP), reaching 61%, with the least of 43% in other parts of Africa. South Korea showed the greatest value added by industry as a percentage of GDP, reaching 44%, with the lowest of 37% in South Africa. Russia presented the largest energy intensity of 0.39 kilograms of oil equivalent per US dollar, and Africa, the smallest of 0.15 kilograms of oil equivalent per US dollar. South Africa registered the highest carbon intensity of 0.95 kilograms CO_2e per US dollar, with the lowest of 0.36 kilograms CO_2e per US dollar in other parts of Africa. South Korea consumed the most amount of electricity with a per capita level of 10,900 kWh, against the least of 673 kWh only in Africa. China achieved the highest share of 26% of renewable energy in electricity generation, with 8% sourced from wind power and solar power, while the Middle East had the lowest share of only 2%. China also outpaced other BRI countries in terms of average GDP growth in both past 18 years and recent 5 years, with rates of 9.2% and 6.7% respectively, while Russia and South Africa saw slow GDP growth rates of 0.4% and 0.9% in the past five years respectively.

Table 1. Social development, energy consumption and emissions in major BRI countries and regions, 2018

	China	Southeast Asia	Russia	South Korea	Middle East	South Africa	Africa(except South Africa)
GDP, 2018 (trillion dollars)	**11.6**	3.2	1.8	1.5	2.9	0.5	2.2
Population, 2018 (100 million)	**13.9**	6.6	1.4	0.5	2.5	0.6	12
Proportion of urban population, 2018	59%	49%	74%	**82%**	73%	66%	42%
Value added by service as a percentage of GDP, 2018	52%	51%	54%	54%	58%	**61%**	43%
Value added by industry as a percentage of GDP, 2018	41%	39%	43%	**44%**	41%	37%	41%
Energy intensity, 2018 (kgoe/ USD)	0.25	0.17	**0.39**	0.21	0.26	0.27	0.1 5
Carbon intensity, 2018 ($kgCO_2$/ USD)	0.91	0.51	0.92	0.49	0.76	**0.95**	0.36
Electricity consumption per capita, 2018 (kWh)	5120	1598	7495	**10900**	4763	4420	673
Share of renewable energy in power generation, 2018	**26%** (wind and solar power 8%)	24% (hydropower 18%, wind and solar powerr 1%)	18% (hydropower 17%)	21% (biomass and garbage power 17%, wind and solar power 3%)	2%	5%	19% (hydropower 16%)
Average GDP growth rate, 2000-2018	**9.2%**	5.1%	3.4%	3.8%	3.7%	2.7%	4.6%
Average GDP growth rate, 2014-2018	**6.7%**	4.9%	0.4%	2.9%	2.5%	0.9%	3.0%

Feasibility Analysis of Carbon Market Establishment in Major BRI Countries and Regions

The carbon emission trading scheme (ETS) refers to a system of trading GHG emission allowances or GHG emission reduction credits for the purpose of controlling GHG emissions. Therefore, carbon market as a policy-based market not only needs a strong national administrative system to ensure policy stability, transparency and consistency, but also requires effective disclosure of information about carbon emissions and energy consumption of enterprises to ensure data reliability. Besides, a relatively complete market environment is necessary to ensure transaction order and price formation.

This study first identifies the key factors affecting the operation of carbon market by analyzing the working principles and participants in the ETS, then selects, through data research and screening, specific indicators that can reflect the above key factors, and concludes, based on rating, which countries now have the capacity to establish or link to an existing carbon market.

The World Bank has suggested the FASTER principles for successful carbon pricing, which include Fairness; Alignment of policies and objectives; Stability and predictability; Transparency; Efficiency and cost-effectiveness; Reliability and environmental integrity.

- Fairness: Successful carbon pricing policies should reflect the "polluter pays" principle and contribute to distributing costs and benefits equitably and avoiding disproportionate burdens on vulnerable groups.
- Alignment of policies and objectives: Successful carbon pricing policies are part of a suite of measures that facilitate competition and openness, ensure equal opportunities for low-carbon alternatives, and interact with a broader set of climate and non-climate policies.
- Stability and predictability: Successful carbon prices are part of a stable policy framework that gives a consistent, credible, and strong investment signal, the intensity of which should increase over time.
- Transparency: Successful carbon pricing policies are clear in design and implementation. In the policy formulation process, open communication with affected stakeholders on the basic principles of policies is required, and their feedback is incorporated into policy design and implementation. At the same time, an independent and open review system and an effective monitoring and verification system are needed to timely report carbon emissions and related information and build public trust in carbon pricing.
- Efficiency and cost-effectiveness: Successful carbon pricing schemes increase economic efficiency and reduce costs of emission reduction. A relatively complete market environment is necessary to ensure that effective carbon prices can be formed in the carbon market, thereby improve economic efficiency, reduce emission reduction costs, and provide consistent, credible and strong investment signals.
- Reliability and environmental integrity: Successful carbon pricing schemes result in a measurable reduction in environmentally harmful behaviors. The public sector has a certain degree of transparency, normal channels for administrative accountability, and a low degree of corruption to ensure fairness in policy formulation. Public management quality is good enough to support a series of reliable measures consistent with emission reduction targets. In addition, the public sector performs governance based on rules to guarantee policy implementation and environmental integrity.

In short, the feasibility of carbon market establishment in major BRI countries and regions can be qualitatively analyzed in six dimensions, that is, rule of law, government willingness, public sector (government) capacity and quality, enterprise engagement enthusiasm, market completeness, and business disclosure (collectively referred to as the following 4 aspects which are Government, Enterprise and Market and Law, GEML for short)

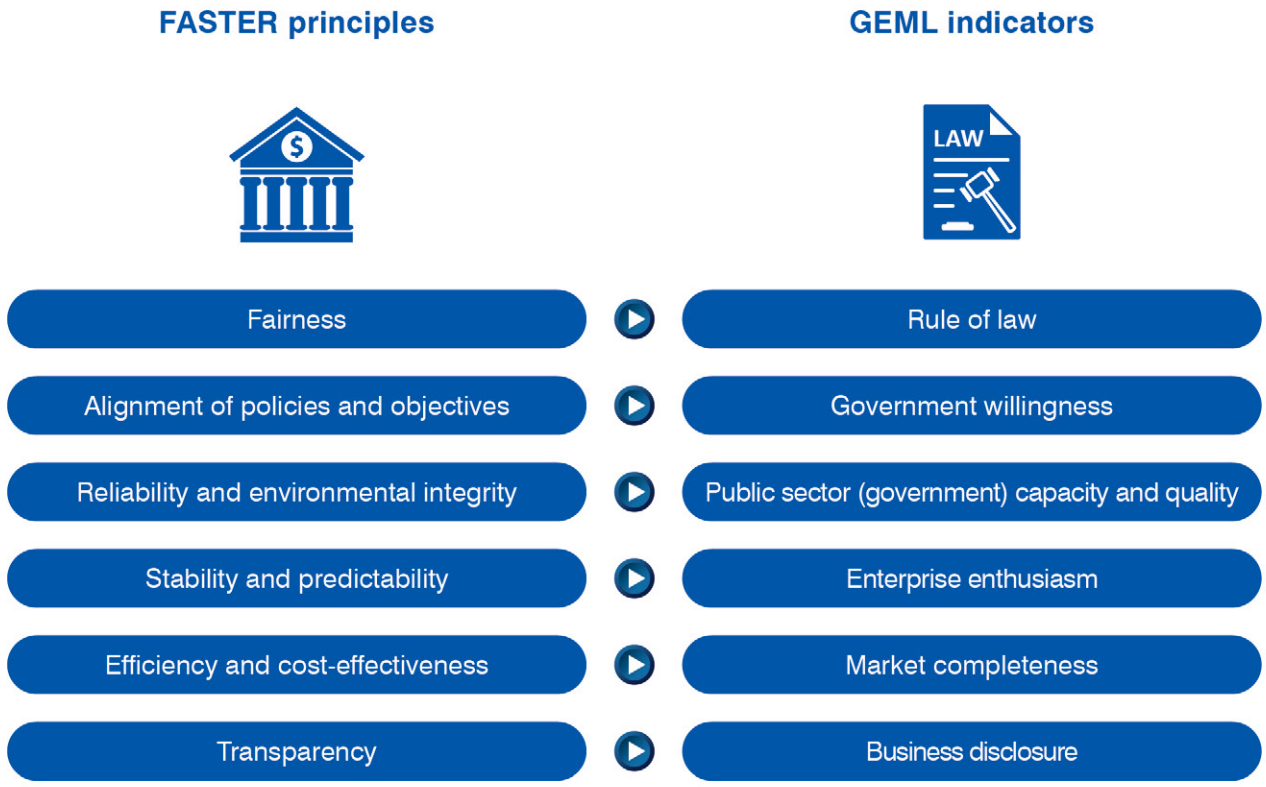


Figure3. Prerequisites for successful carbon market—GEML

Through data research and screening, six indicators are selected, including the public sector management and institutions cluster average in the World Bank's Country Policy and Institutional Assessment (CPIA), ease of doing business index, extent of business information disclosure index, rule of law index of the Global Justice Project, inclusion of domestic and international carbon market in the published policy documents, and CDP's enterprise engagement index. To ensure the comparability of indicators, this study rates the six indicators of countries or regions within the range of 1 to 4 points (see Table 2), wherein 1 means weak, 2 moderate, 3 relative strong and 4 strong.

Table 2. Carbon market feasibility index of major countries and regions

	Public sector capacity and quality	Extent of Business information disclosure	Market completeness	Rule of law	Government willingness		Enterprise engagement enthusiasm	Average score
					Willingness to establish a domestic carbon market	Inclusion of international carbon market linkage in published policy documents		
China	4	4	4	3	4	–	3	3.7
South Korea	4	4	4	4	4	Yes	3	3.8
Russia	4	3	4	3	2	–	3	3.2
South Africa	4	4	3	3	2	–	3	3.2
Southeast Asia	4	4	3	3	3	Singapore, Thailand, Indonesia, Vietnam, Laos and Cambodia	3	3.3
Middle East	2	3	3	3	1	Jordan only	2	2.3
Africa (except South Africa)	3	2	1	3	2	30 countries including Botswana and Cameroon	2	2.2
United States	4	3	4	4	3	Yes	4	3.7
European Union	4	3	4	4	4	Yes	3	3.7

As indicated by Table 2, China, South Korea, the European Union and the United States have mature conditions for building domestic carbon markets, of which South Korea and the European Union express explicitly the willingness to promote an international carbon market. Russia, Southeast Asia and South Africa enjoy relatively mature conditions, making it fairly feasible to establish carbon markets, which is not unlike the situation in the Middle East and Africa.

Among Southeast Asian countries, Singapore, Malaysia, Thailand, Indonesia and Vietnam have the appropriate conditions and near-term feasibility of establishing domestic carbon market .

In the Middle East, the United Arab Emirates, Israel, and Saudi Arabia meet the objective conditions for carbon market establishment. Among them, Saudi Arabia is strongly willing to establish a carbon market, implying high near-term feasibility.

Within the African region, Rwanda, Morocco, Kenya, and Tunisia have strong objective conditions and subjective desire to establish carbon markets, so carbon market establishment is quite feasible in the near future.

Quantitative Impact Analysis of Carbon Markets in Major BRI Countries and Regions

4.1 Scenario design

Taking into account carbon market construction progress, the committed emission reduction targets and policy pathways timeline of major BRI countries and regions, this study proposes four scenarios for BRI countries with explicit emission reduction targets and pathways, and conducts the C-GEM simulations for the target years 2020, 2025, 2030, and 2035.

(1) Reference (REF) scenario.

In this scenario, countries or regions such as China, South Korea, Russia, South Africa, Southeast Asia, the United States, and the European Union adopt energy-saving and new-energy policies other than carbon tax and carbon market in respective emission reduction pathways. It is a reference scenario for other scenarios containing carbon market policies.

(2) NDC scenario.

The scenario assumes that countries deliver committed emission reductions for 2020–2030 by establishing nationwide carbon markets on the basis of energy-saving and new-energy measures, and maintain the national carbon intensity constraints towards 2035. Since the United States has withdrawn from the Paris Agreement with no NDCs, this study takes carbon emissions projections in the stated policies scenario in the 2019 World Energy Outlook of the International Energy Agency (IEA) as its emissions reduction targets. In essence, the NDC scenario sets carbon emission allowance caps for country-specific nationwide independent carbon markets based on committed emission reduction targets towards 2020 and 2030, providing a comparative basis for impact analysis on linking carbon markets across regions.

(3) BRI scenario.

According to the forgoing analysis, China, South Korea, Russia, South Africa, and Southeast Asia all meet the conditions of establishing a carbon market among the BRI countries and regions. Therefore, this scenario assumes that in 2025, these five BRI countries and regions will realize two-way linkage of carbon market on the basis of the NDC scenario. The initial carbon emission allowances for each country and each target year are carbon emissions in the NDC scenario. The BRI scenario is designed to analyze the development and impact of carbon market with multiple participants in the future under ideal circumstances.

(4) EUS scenario.

At present, the European Union has established the world's largest carbon market, while the United States has begun to implement carbon markets at the sub-national level, including California's Cap-and-Trade Program and Regional Greenhouse Gas Reduction Initiative (RGGI). As the European Union and the United States are large carbon emitters spending heavily on emission reduction, their participation in the BRI carbon market will contribute to maximizing the benefits of emission reduction in the BRI countries. Therefore, this scenario assumes that in 2025, the EU and US carbon markets will further realize two-way linkage with the five BRI carbon markets mentioned in the BRI scenario. The initial carbon emission allowances for each country and each target year are carbon emissions in the NDC scenario. Under the EUS scenario, the various carbon markets can be deemed as markets with absolute cap.

4.2 Result analysis

4.2.1 Carbon emissions and emission reduction costs of various countries under current policies

For further analyzing the impacts of domestic and international carbon markets on major BRI countries and regions, it is necessary to effectively identify their emission reduction pathways (covering emissions from industrial processes and fossil energy combustion) towards NDC targets (current policy objectives for the United States) and emission reduction costs. As shown in Figure 4, China's carbon emissions will peak at 12.1 billion tonnes CO_2 in 2030, and then drop to 11.7 billion tonnes CO_2 in 2035. The United States will see its carbon emissions peak at 5 billion tonnes in 2020 and then gradually shrink to 4.2 billion tonnes in 2035. The European Union has cut its carbon emissions from 2014 onwards, with an aim of 2 billion tonnes in 2035 from 3.3 billion tonnes in 2014. In this period, however, carbon emissions in the Southeast Asia will increase from 1.4 billion tonnes to 2.6 billion tonnes. South Korea's carbon emissions has already reached its peak and will fall from 730 million tonnes in 2018 to 520 million tonnes in 2035. Carbon emissions in South Africa will slowly decline to 420 million tonnes in 2035 after peaking at 450 million tonnes in 2025.

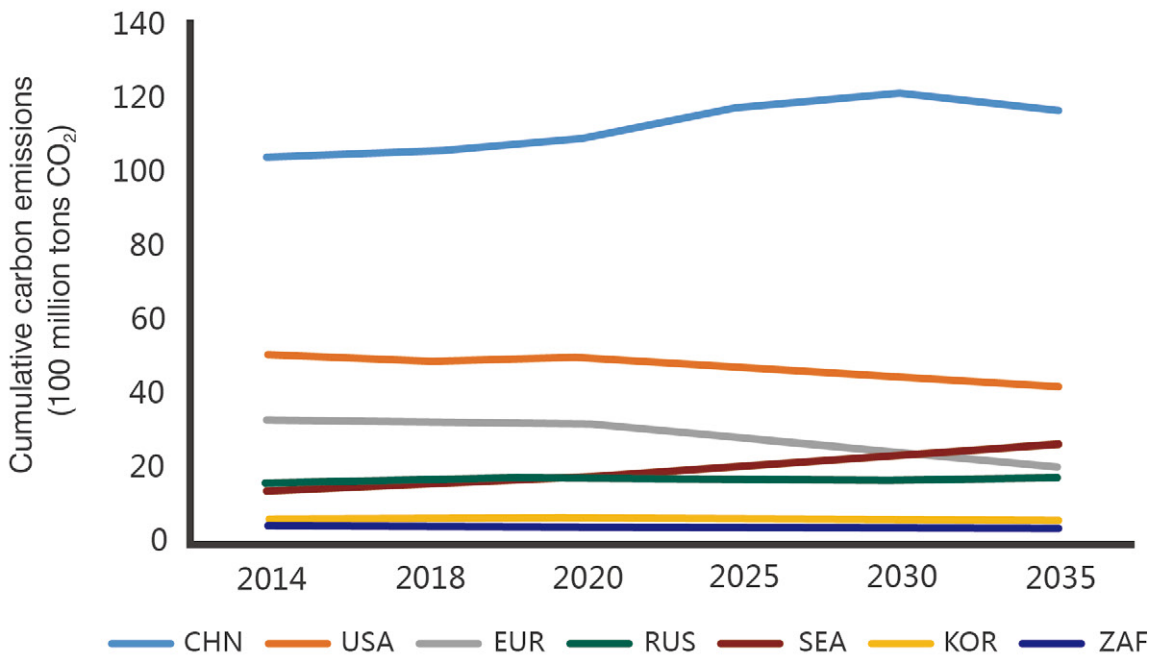


Figure 4. Carbon emission trajectories of various countries under the NDC scenario, 2014–2035

Under the NDC scenario, the marginal costs of emission reduction in major countries will increase with the tightening of carbon emission constraints (see Figure 5). China's marginal abatement costs will rise from 6.8 US dollars/tonne in 2020 to 20 US dollars/tonne in 2035. Southeast Asia and Russia are smaller than China in terms of GDP, targeted carbon intensity decline, and abatement cost. In Southeast Asia, the marginal costs of emission reduction will gradually increase from 3.3 US dollars/tonne to 15.3 US dollars/tonne during 2020–2035, and similarly in Russia, they will climb to from 3.4 US dollars/tonne in 2020 to 12.5 US dollars/tonne in 2030 and come to 15.5 US dollars/tonne in 2035. Although South Africa outperforms China in carbon intensity, their abatement costs are higher due to slower progress in renewable energy technology and energy efficiency, and will stand at 12 US dollars/tonne, 19.2 US dollars/tonne and 24.2 US dollars/tonne in 2020, 2030 and 2035 respectively. Emission reduction also costs considerably in South Korea, the European Union and the United States. In specific, the abatement costs in South Korea will gradually grow from 20.2 dollars/tonne to 50.2 dollars/tonne during 2020–2035. Despite lower carbon intensity, it costs less for the European Union to reduce carbon emissions as compared with the United States, owning to advantages in low-carbon technologies such as renewable energy. The EU emission reduction costs will expand from 24.2 dollars/tonne in 2020 to 60.2 dollars/tonne in 2035, while the US level will ascend from 28.4 dollars/tonne to 64.8 dollars/tonne during the same period.

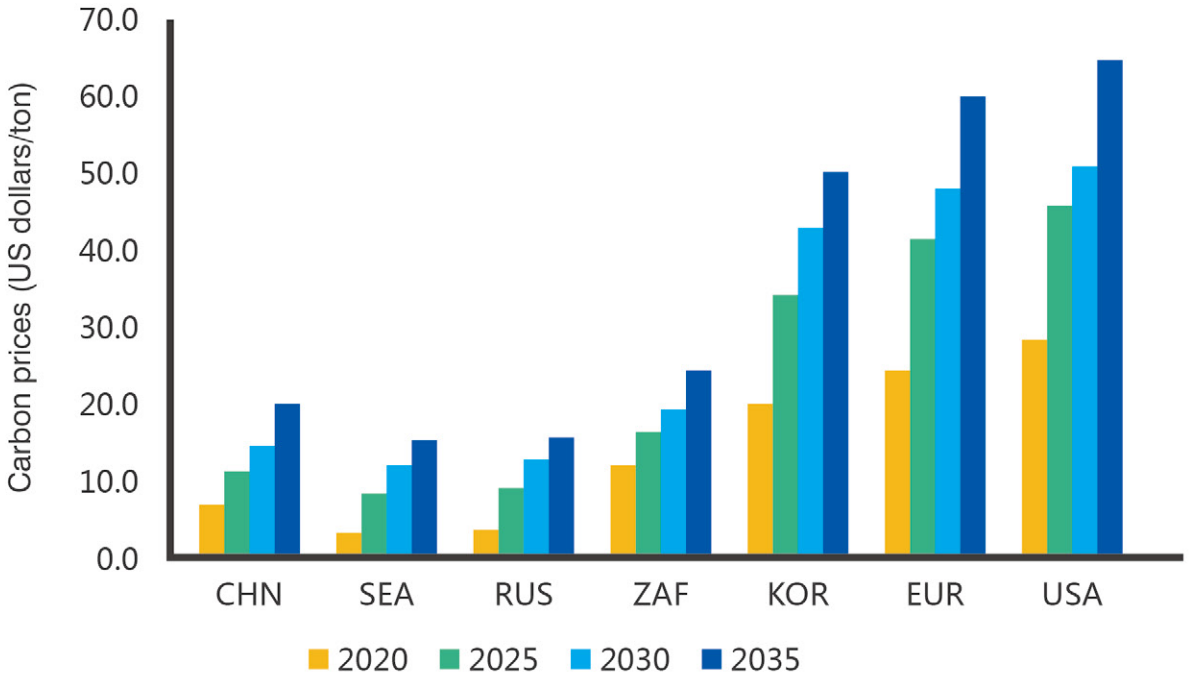


Figure 5. Emission reduction costs of various countries under the NDC scenario, 2020–2035

4.2.2 Primary energy consumption of various countries under current policies

Under the NDC scenario, China's primary energy use will be on the rise between 2014 and 2035, up from 4.28 billion tonnes in 2014 to 6.25 billion tonnes in 2035. Coal currently takes a dominant position in China's energy mix.

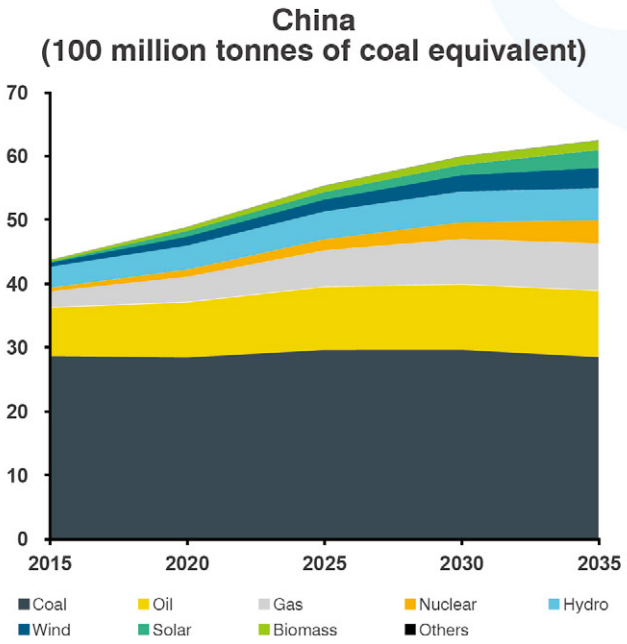
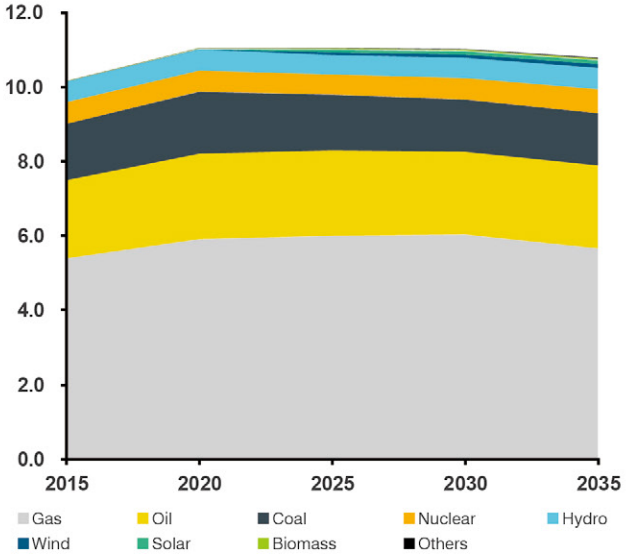


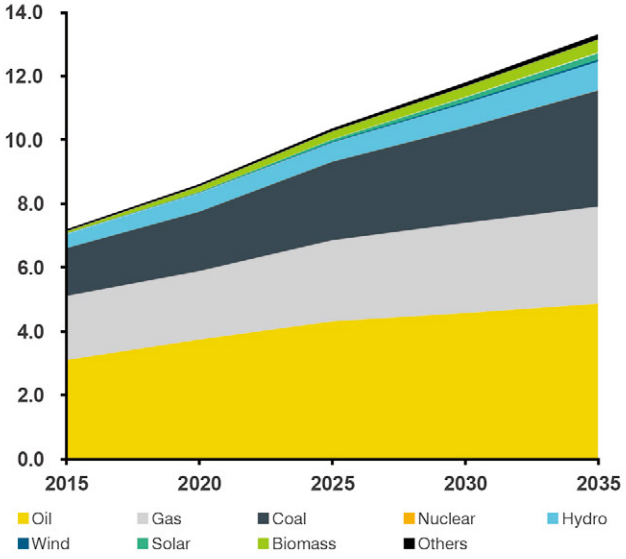
Figure 6. Primary energy consumption of major countries under the NDC scenario

Russia will maintain an annual primary energy consumption of 1.0 to 1.1 billion tonnes during 2014–2035, which is dominated by natural gas. Excluding biomass used in a conventional manner, the primary energy consumption in Southeast Asia will be doubled from 690 million tonnes in 2014 to 13.3 billion tonnes in 2035, of which oil accounts for the largest share. South Korea's primary energy consumption will gradually decrease to 420 million tonnes of coal equivalent in 2035 after peaking in 2020–2025, with the share of oil down from 48% in 2018 to 42% in 2035. South Africa will consume 180 to 190 million tonnes of coal-based primary energy every year, but such consumption will shrink in the future.

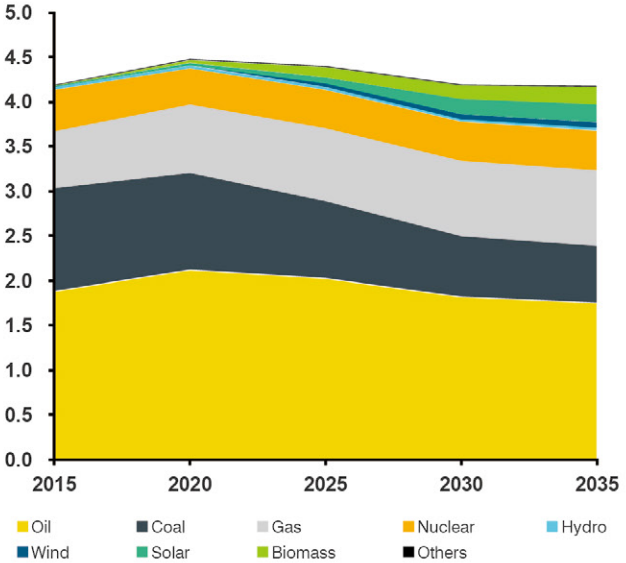
Russia
(100 million tonnes of coal equivalent)



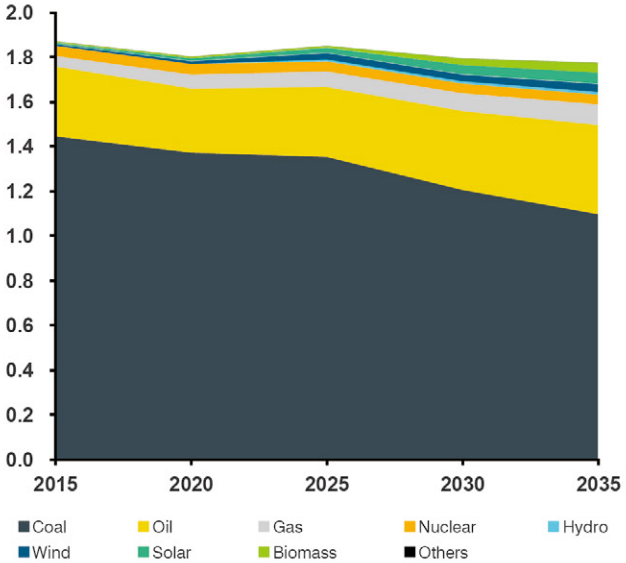
Southeast Asia
(100 million tonnes of coal equivalent)



South Korea
(100 million tonnes of coal equivalent)



South Africa
(100 million tonnes of coal equivalent)



The EU primary energy consumption will peak at 22.5 million tonnes of coal equivalent in 2020 and then slow down to 18.8 million tonnes in 2035. Due to consumpiton peaking in 2020, the share of oil will gradually fall from 34% in 2020 to 28% in 2035 and the share of nature gas from 25% to 23%.

The US primary energy consumption swelled from 3.07 billion tonnes of coal equivalent in 2014 to 3.2 billion tonnes of coal equivalent in 2018 and remained relatively stable thereafter. At present, oil and natural gas dominate the primary energy consumption in the country.

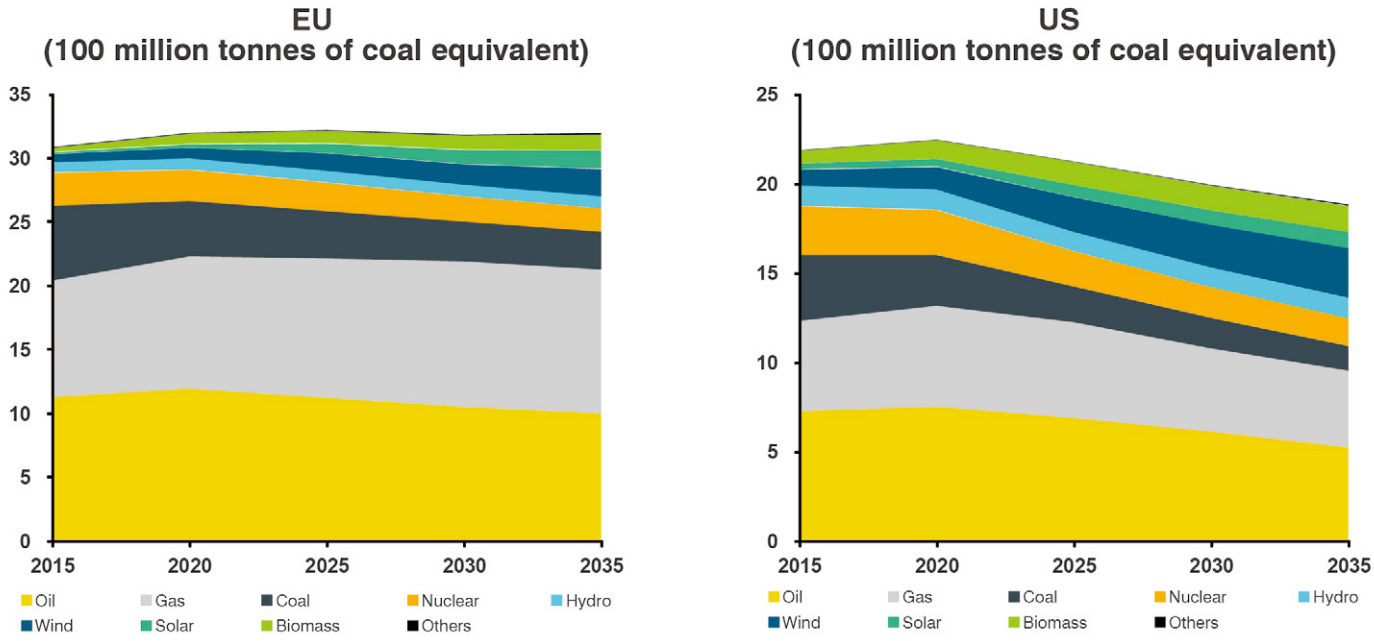


Figure 6. Primary energy consumption of major countries under the NDC scenario

4.2.3 Carbon market scale and financial market development

The results indicate that carbon market makes increasing contributions year by year to emission reduction in various countries. In an descending order of contribution rate, the country rankings are China (32–40% reduction under the NDC scenario relative to the REF scenario), South Korea (23–25% reduction under the NDC scenario relative to the REF scenario), the United States (20–26% reduction under the NDC scenario relative to the REF scenario), the European Union (18–19% reduction under the NDC scenario relative to the REF scenario), South Africa (12–13% reduction under the NDC scenario relative to the REF scenario), Russia (9–13% reduction under the NDC scenario relative to the REF scenario), and Southeast Asia (4–6% reduction under the NDC scenario relative to the REF scenario). With the involvement of major BRI countries, the carbon market transactions in various countries may reach 192.5 billion dollars in 2025, 253.3 billion dollars in 2030, and 335.2 billion dollars in 2035. When taking into account the European Union and the United States, such numbers will be even larger, hitting 525 billion dollars, 596.5 billion dollars, and 730.2 billion dollars in 2025, 2030 and 2035 respectively.

As shown in Table 3, under the NDC scenario, the trading prices of allowances vary widely among carbon markets due to different national emission reduction targets and abatement costs. This reflects the disparities between countries in emission reduction capabilities under their respective emission reduction targets, thus theoretically proving that if realized, cross-regional carbon market linkage can create larger room for national carbon market optimization. However, in the actual operation process, huge differences in regional carbon prices will cause divergences of interlinked carbon markets in carbon emission intensity, the cap of carbon emission allowances, and the post-linkage transfer of benefits, thereby increasing the difficulty of market linkage.

When carbon markets in the major BRI countries or regions are interlinked, i.e., under the BRI scenario, the equilibrium price of emission allowance in 2035 will be 20.5 US dollars/tonne and the turnover will reach 10.2 billion US dollars. When the European Union and the United States join the BRI carbon market, i.e., under the EUS scenario, the carbon market will be further expanded, driving up the equilibrium price to 24.2 US dollars/tonne and the turnover to 54.8 billion US dollars.

Table 3. Carbon prices, trading volume and turnover in 2035 under the NDC, BRI, and EUS scenarios

Major countries and regions	Emissions in 2035 under the REF scenario ($MtCO_2$)	Emission reduction allowances for 2035 ($MtCO_2$)	Carbon market contribution to emission reductions	CO_2 prices in 2035 (US dollars/ton CO_2)			Imports ($MtCO_2$) and turnover(100 million US dollars) of the global carbon market in 2035, + means imports	
				NDC scenario	BRI scenario	EUS scenario	BRI scenario	EUS scenario
China	19415	11677	7738	20.0			126 (25.9)	-786 (-190.2)
Russia	1852	1620	232	15.5			-125 (-25.5)	-153 (-36.9)
Southeast Asia	2753	2625	128	15.4	20.5		-124 (-25.5)	-194 (-46.9)
South Korea	679	516	62	50.2		24.0	111 (22.8)	92 (22.3)
South Africa	482	420	163	24.2			11 (2.3)	-1 (-0.2)
European Union	2514	2038	476	60.2	–		–	293 (70.8)
United States	5643	4200	1443	64.8	–		–	748 (181.1)

Multinational carbon market cooperation can enhance regional optimal allocation of resources and improve the overall level of GDP. By purchasing allowances, allowance importer can optimize its resource allocation and achieve slight GDP growth under the interlinked carbon market scenario. For allowance exporters, however, GDP may be adversely affected by carbon trading, depending on trading revenue and output value derived from emission reduction. For example, South Africa will experience a 0.04% decrease of GDP in 2035. With the linkage of carbon markets among the BRI countries, the global GDP total will increase by 0.04% in 2035. Carbon market cooperation will contribute to the GDP growth of allowance importers. For example, Korea and South Africa' GDP will increase by 0.3% and 0.03% in 2035 respectively. As to China, the GDP growth benefited from the BRI carbon market (the BRI scenario) is limited, only about 0.01%. The impact on the Chinese economy is small because the equilibrium price of the BRI carbon market is close to China's carbon price under the NDC scenario and a small number of allowances is trade in the BRI carbon market. Where the European Union and the United States join in the BRI carbon market, i.e., under the EUS scenario, China's GDP growth through the sale of allowances will reach 0.18% in 2035. Russia, Southeast Asia, and South Korea are the main beneficiaries of the BRI carbon market. Under the EUS scenario, the regional equilibrium carbon price will be higher. Russia and Southeast Asia can gain more revenue from the sale of allowances, and thereby further drive their GDP up. South Korea, as an allowance importer, will see its GDP decline relative to the BRI scenario because importable allowances are squeezed.

Carbon market linkage has a positive effect on resident welfare in various countries. The results show that Russia, Southeast Asia and South Korea mainly benefit from the BRI carbon market. With the participation of the United States and the European Union in this regional carbon market, the welfare of not only Russia and Southeast Asia but also European and American countries will be further improved.

05 Conclusions and policy recommendations

The establishment of carbon market within countries can effectively stimulate emission reduction and achieve cap control. Hence, countries should proactively establish domestic carbon markets. At the same time, countries that have piloted carbon markets, such as China and South Korea, should actively share experiences and policies to assist other countries in early establishment of carbon market and thereby achieve cap control of carbon emissions in all countries.

The results indicate that China, South Korea, the European Union and the United States have ripe conditions for building domestic carbon markets, of which South Korea and the European Union are evidently willing to promote an international carbon market. For Russia, Southeast Asia and South Africa with relatively mature conditions, it is moderately feasible to establish carbon markets, but this is not the case in the Middle East and Africa. As far as Southeast Asia is concerned, Singapore, Malaysia, Thailand, Indonesia and Vietnam have the appropriate conditions and near-term feasibility of domestic carbon market establishment. Within the scope of the Middle East, the United Arab Emirates, Israel, and Saudi Arabia meet the objective conditions for carbon market establishment, of which Saudi Arabia have a strong desire to establish carbon market, implying high near-term feasibility. For the African region, Rwanda, Morocco, Kenya, and Tunisia have strong both objective conditions and subjective desire to establish carbon markets, so carbon market establishment is fairly feasible in the near future.

The C-GEM analysis reveals that the carbon price reflects the marginal abatement costs of each country. The costs of emission reduction towards NDC targets vary among countries. Linking regional carbon market contributes to lowering the global overall costs of emission reduction, but exerts asymmetric impacts on GDP, resident welfare, and industrial development of various countries. The interlinked carbon market covering five major BRI countries and regions, i.e. China, South Korea, Russia, Southeast Asia and South Africa, gives a weak boost to China's resident welfare and GDP because its equilibrium carbon price is close to the carbon price of China's independent carbon market. China imports carbon emission allowances, but the trading volume is relatively small. Russia, Southeast Asia and South Korea are the main beneficiaries of this regional carbon market. If linking the European Union and the United States to the BRI carbon market, China will become an exporter of carbon emission allowances, and see a significant improvement in resident welfare and GDP. Such carbon market linkage will also contribute to resident welfare and GDP improvement in Russia and Southeast Asia, and spur the economic development of the European Union and the United States, making emission reductions occur in the most effective countries and regions. Therefore, it is advisable to include developed countries such as the European Union and the United States in the linkage with the BRI carbon market, which will help lower regional emissions reduction costs and promote economic development and welfare enhancement of all countries.

As emission reduction costs vary from country to country, carbon market linkage will be conducive to bringing down the overall abatement costs of the BRI countries on a larger scale. However, it should be noted that the linkage with countries with equivalent emission reduction costs or multinational linkage with comparable equilibrium carbon prices will be unfavorable for China's abatement cost cuts. Therefore, carbon market linkage design must accurately identify international partners and clearly define the position to ensure that countries can benefit from the BRI carbon market linkage.

Based on the above analysis, this study proposes the following policy recommendations:

(1) China urgently needs to improve the national ETS further to speed up the green low-carbon transition.

As stated by Chinese President Xi Jinping, the Paris Agreement to address climate change outlines the general direction of global green and low-carbon transition. China will scale up its NDCs by adopting more vigorous policies and measures, and aim to have its CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060. China will thoroughly implement Xi Jinping's thought on ecological civilization, move faster to build a nationwide carbon market aimed at peaking CO_2 emissions and achieving carbon neutrality, and get actively involved in global climate governance, stressed Chinese Vice Premier Han Zheng.The Ministry of Ecology and Environment stated that based on the stable operation of the carbon market of the power generation industry, it would further expand the ETS coverage, gradually include more high-emission industries, enrich the trading products, transaction methods and market participants, to enhance the market activity and give full play to the role of the national carbon market in controlling greenhouse gas emissions, promoting green low-carbon technology innovation and incentivizing climate investment and financing, and then to create an enhanced synergy on pollution control as well as carbon reduction, so as to facilitate the efforts to achieve the carbon peaking target and carbon-neutral vision.

(2) The BRI countries should join hands with China to take the path of low-carbon development and launch the carbon market first in the power sector.

China has started with the power generation industry in the ETS construction to cultivate market participants, improve market supervision, and gradually expand market coverage. South Korea, Thailand, Indonesia, the European Union and the United States also prioritize the power sector in the ETS implementation. Therefore, this study suggests that China assist countries willing and able to establish carbon markets in piloting carbon market first in the power sector, especially the BRI countries with presence of China-controlled power plants, in order to promote green BRI development.

(3) China should make prudent investment in and tighten environmental management of coal power projects in the BRI region.

To this end, the following efforts are suggested: **i)** encourage enterprises to improve environmental protection technologies and emission standards, proactively benchmark against more stringent international emission standards, and guard against environmental risks; **ii)** build a national basic database of laws, regulations and standards and advance the establishment of decision support and government service systems; **iii)** actively explore the use of carbon market mechanisms to propel GHG emission reduction of overseas coal power projects. For overseas coal power projects that China has already built and put into operation, carbon offset mechanisms may be used for reducing its GHG emissions. And developing innovative mechanisms to cover the above entities into China's carbon market is also an effective way to promote GHG emission control; **iv)** draw up project strategies based on local realities and strengthen response to public opinions. It is sensible to give full play to multilateral cooperation platforms such as the BRI International Green Development Coalition, rely on domestic and foreign professional institutions such as the China Electricity Council and the Global Energy Interconnection Development and Cooperation Organization, and leverage partners with superior resources and industrial influence in power development and environmental protection to play an active role in information collection, finding solutions and public opinion guidance for coal power projects in the BRI region.

(4) A carbon market fund should be created to support the BRI countries to establish carbon markets.

Relying on the carbon market fund, training and guidance can be provided to assist the BRI countries that are willing and able to establish carbon markets in the overall design and management mechanism of the domestic carbon market and the subsequent entry into the BRI carbon market. This study suggests the fund give priority to countries with mature conditions, support them to conduct the ETS pilots, and gradually extend the ETS to other countries. Examples of these countries include Russia; Malaysia, Thailand, Indonesia and Vietnam in Southeast Asia; United Arab Emirates, Israel and Saudi Arabia in the Middle East; and Rwanda, Morocco, Kenya and Tunisia in Africa.

(5) China should promote in-depth cooperation and exchanges on carbon market among the BRI countries and accelerate the construction of disciplines and talents related to climate change and carbon market.

BRI carbon market seminars are suggested to be held to bring together representatives from the government, the academics and businesses to discuss the necessity, feasibility and challenges of establishing carbon market at home and abroad and help various countries better understand the carbon pricing mechanism. A relatively systematic training plan and a talent pool system are also needed to provide a steady stream of outstanding talents for the carbon market of various countries. At the same time, assistance should be provided to technologically weak countries and regions in accelerating the cultivation of relevant disciplines and talents.

(6) Upon the relatively maturity of China's national carbon market, it is necessary to gradually explore different models of BRI carbon market linkage and cooperation.

The design of BRI carbon market linkage can give priority to two-way linkage of China, South Korea, the European Union, and the United States, and gradually include other counties when their carbon markets become mature in the future.

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