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ASEAN +3 MACROECONOMIC RESEARCH OFFICE

Analytical Note

Policy Challenges for China's Carbon Neutrality[1]

January 17, 2022

I. Introduction

1. **In September 2020, China announced that it would aim to peak its carbon dioxide emissions by 2030 and achieve carbon neutrality by 2060.** This move represents an important commitment by China to align its emissions targets with the levels of rapid and deep decarbonization needed to reduce the risks of climate change. As the largest emitter of carbon dioxide in the world annually, China faces daunting challenges in reaching this long-term net zero goal. A lasting nationwide transformation of the economy and energy system would be needed, and this will not happen without significant efforts by both the public and private sectors.

2. **This note analyzes the key policy challenges for China's carbon neutrality transition**. It explores the technological and economic feasibility of moving to carbon-free economy and highlights the importance of developing a credible long-term roadmap. A comprehensive carbon mitigation policy package is recommended, followed by a discussion on complementary reform to manage risks and facilitate the transition.

II. Net Zero Challenge

3. **China's race towards reaching carbon net zero will make a critical contribution to global climate change efforts.** Responsible for 28 percent of the world's annual carbon emission in 2020 and 60 percent of its annual increase since 2000 (Figures 1), China's 2060 carbon neutrality pledge is expected to curb global warming by 0.2-0.3°C by 2100 in comparison with its previous commitment under the Paris Agreement (Höhne et al, 2021). This would help move the international community closer to the Paris Agreement goal of holding global warming to 1.5°C or less, relative to pre-industrial levels.[2]

4. **China needs a concerted national effort to transform its economy and energy system to meet its net zero target.** The country's remarkable economic success in the past 40 years has left a huge carbon footprint. Rapid industrialization and urbanization have

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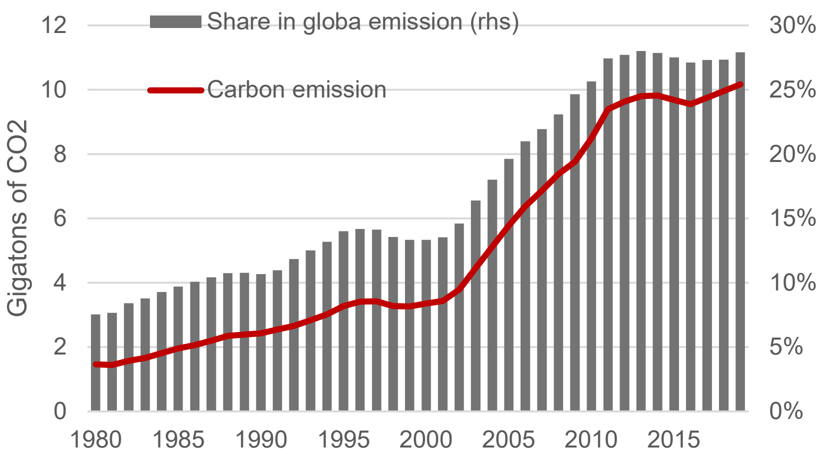
[2] The UNEP's 2021 annual Emissions Gap Report estimates that the current Nationally Determined Contributions (NDCs) under the Paris Agreement would put the world on the path towards a temperature increase of at least 2.7°C by 2100. If everything else remains constant, China's new commitment for carbon neutrality would represent one fourth of the effort needed to limit the global warming to the 1.5°C target.

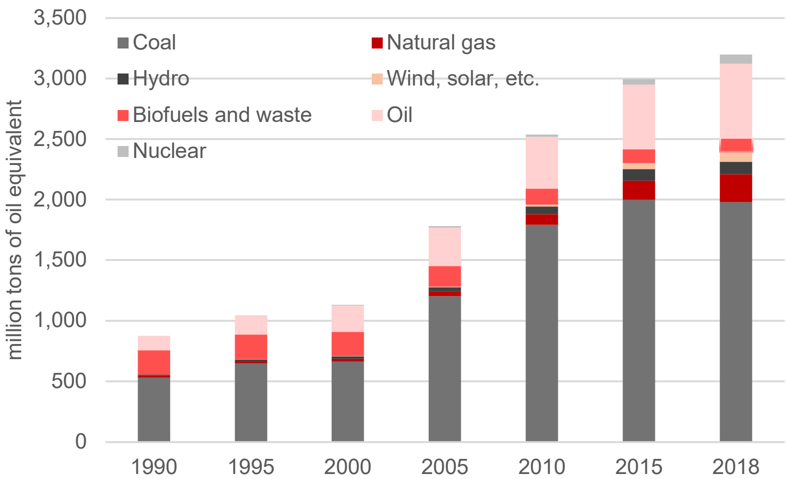
propelled the energy demand of China. With abundant coal supplies, coal-based power generation was ramped up to meet rapidly-growing electricity demand, leading to a coal-dominated energy mix in China (Figure 2). While important progress has been made in improving energy efficiency and reducing carbon intensity in the past decade, and emission growth has been relatively stable since 2013, China's carbon emission per capita is likely to rise towards the levels of other developed countries unless there are significant policy interventions (Figure 3). Achieving the 2060 carbon neutrality target requires reversing the current upward trend in fossil-fuel energy consumption radically and swiftly, which is only possible with fundamental changes to China's economy and energy system.

Figure 1. China's Carbon Emission



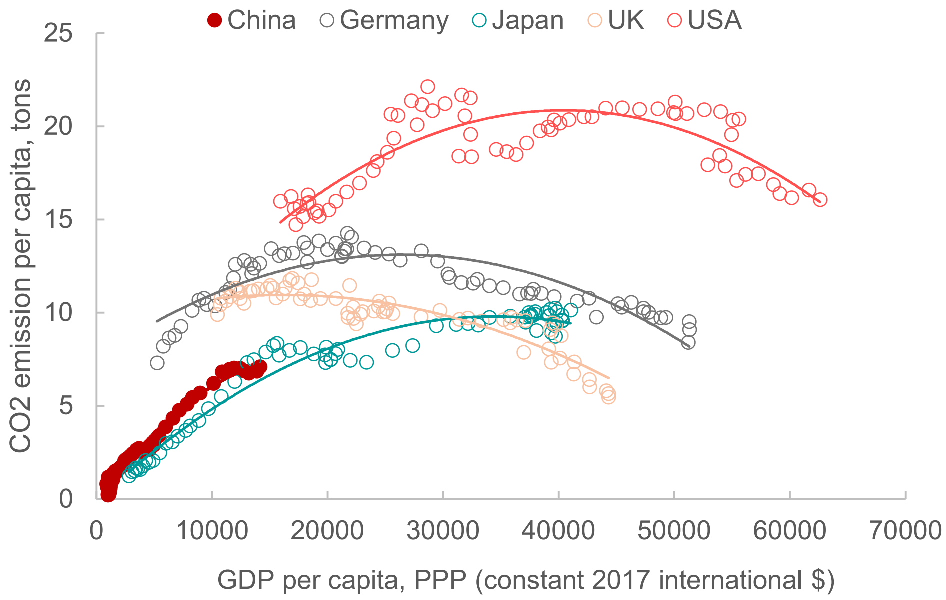
Source: Our World in Data, authors' calculation.

Figure 2. China's Energy Mix



Source: IEA World Energy Balances.

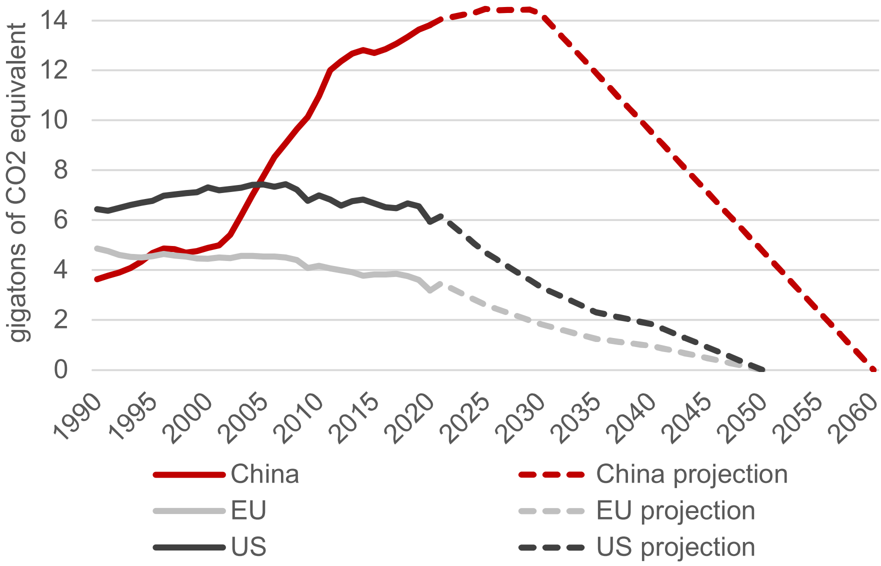
Figure 3. CO2 Emission and per Capita Income



Source: Our World in Data, Penn World Table.

5. The key challenge lies in the fact that China has to start the absolute reduction in carbon emission at a relatively early stage of economic development and achieve net zero at a very fast pace. China's climate pledge sets the path for peaking its absolute carbon emission level at a per capita GDP of around USD15,000 and to reduce its net carbon emissions from peak to zero within 30 years. This stands in contrast to the U.S. and E.U., which have observed their carbon emission peaks at a much higher level of per-capita GDP and are aiming to achieve the transition from peak to zero at a more gradual pace (Figure 4). The environmental Kuznets curve, which postulates an inverted-U-shaped relationship between pollution and development, suggests that environmental degradation worsens as an economy develops, but beyond a certain level of per capita income, adverse environmental trends begin to reverse. Unlike the E.U. and U.S., which have already peaked and are now on the down-hill part of the Kuznets curve, China's curve has yet to peak and hence, the country will face unprecedented and more daunting challenges in achieving transformation to zero-carbon pathways.

Figure 4. Historical and Target Greenhouse Gas Emission



Source: Climate Action Tracker, authors' estimation.

III. From Pledge to Actions

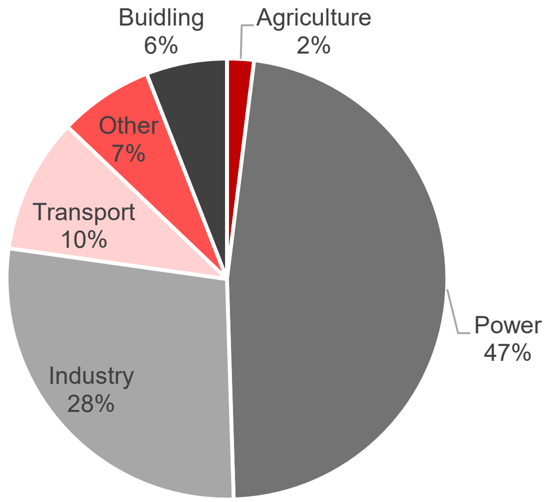
6. **China's carbon neutrality ambition is underpinned by recent developments in carbon abatement technologies.** The power sector, accounting for 47 percent of China's carbon emission (Figure 5), represents the biggest source for carbon reduction in the short term because of the rapid advances in renewable energy technologies. Electrification of end-uses, accompanied by large renewable-based power supply and the scaling-up of energy storage technologies such as supercapacitors, large-scale batteries and hydrogen, is expected to play important roles in carbon abatement of buildings, transportation, and industry. Clean hydrogen is also the most promising alternative to fossil fuels in some energy-intensive industrial processes as well as long-haul transportation. To eventually achieve net zero emission, carbon capture, utilization and storage (CCUS), i.e., sequestering carbon in natural systems or through CO2 removal technologies, needs to be deployed as a last-resort technology to offset residual emissions from some of the hard-to-abate sectors or processes.

7. **The existing decarbonization technologies differ in terms of technological and commercial maturity and the cheapest technologies have only limited scalability, leading to steep cost curve and large total costs to achieve net zero emission.** The China-specific marginal carbon abatement cost curve developed by Goldman Sachs (2021) indicates that based on current technologies, China could achieve a reduction of 7 gigatons CO2 equivalent, at an average annual cost of US$32 per ton, or total annual cost of US$ 220 billion (Figure 6).[3] The total annual cost spikes to US$720 billion for a greenhouse gas (GHG) emission reduction of 10.5 gigatons CO2 equivalent, and to US$1.8 trillion for a GHG emission reduction of 12.6 gigatons CO2 equivalent, as China needs to largely rely on high-

[3] Marginal abatement cost curve (MACC) is a commonly used tool indicating emission abatement potential and associated abatement costs. Each bar in the MACC represents different technological abatement option. The width of bars along the x-axis is the total annual emissions that could be reduced by each single abatement measure, while the height of bar is the marginal cost for each measure to reduce a ton of emissions. The total abatement cost is the area of the bars.

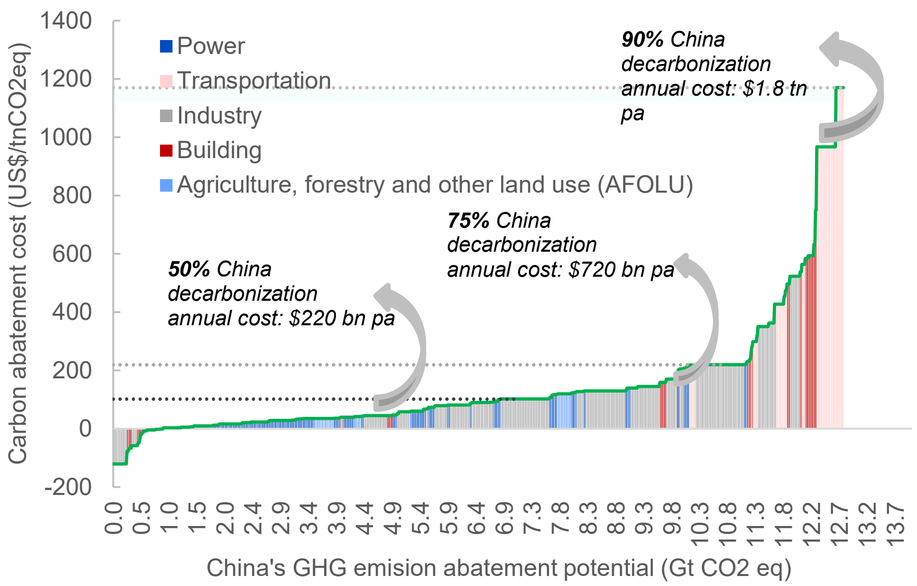
cost abatement technologies in transportation and buildings when moving beyond 75 percent decarbonization target. The cost curve based on static engineering costs of the current available technologies indicates that great efforts are required to improve the efficiency of clean technologies to bring down the large abatement costs over time.[4] Given the wide range of low to medium-cost abatement technologies, even a moderate policy change towards decarbonization would yield meaningful impact.

Figure 5. Share of Energy-related CO2 Emission in China, 2019



Source: Statista.

Figure 6. China's Marginal Abatement Cost Curve



Source: Goldman Sachs (2021).

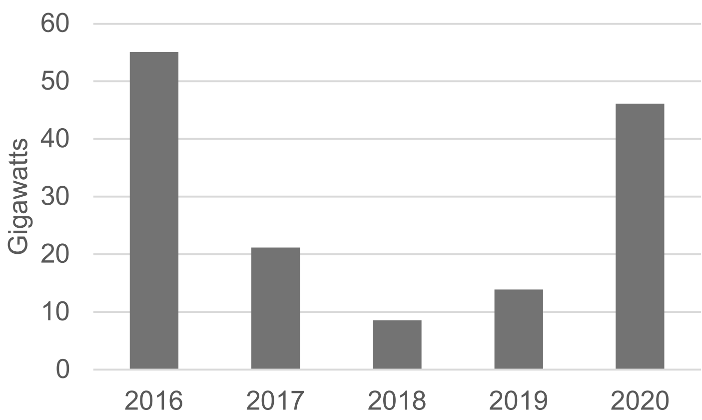
8. A clear roadmap is important to turn this net zero emission vision into reality. The authorities have released a national action plan for carbon emissions to peak before

[4] The analysis of marginal abatement cost curve also neglects the adaption costs associated with enterprises and workers having to get used to new methods of production, distribution and sales. These adaption costs could potentially be large.

2030. This is a welcome step, and an extension of the plan for meeting the 2060 carbon neutrality target should be pursued. Based on investigations of technical feasibility, the roadmap should define plausible pathways to decarbonize the Chinese economy, lay out a mitigation policy framework, set sectoral targets and strategies, assess the economic and social impacts of different net zero paths, and identify important constraints and challenges that may arise. By linking long-term pledges with shorter-term targets and policy actions, the detailed roadmap will not only enhance the credibility of the Chinese government's climate change commitment and gain public confidence, but also serve as a policy anchor to guide the expectations of different economic agents – enterprises, consumers and local governments - in their planning and decisions. The roadmap should be updated periodically to reflect evolving economic realities and technological development, and new unexpected challenges.

9. A key consideration for the carbon neutrality roadmap is on how to allocate the carbon budget across the transitional period to smooth the adjustment costs. The recent power crunch in the coal producing parts of China highlights the tough short-term constraints for China's transition to decarbonization, as the supply disruptions arising from a sharp near-term reduction in energy consumption may make it economically infeasible and socio-politically difficult. The national action plan for peaking carbon emission before 2030 sets the targets for reduction in emission intensity by 18% over the period 2021 to 2025, and by 65% from the 2005 level in 2030. While both targets appear feasible, the prospects for further gains in emission reduction will likely become increasingly difficult as China's energy efficiency levels approach the global frontier. Several studies suggest that an "early and steady" mitigation path that takes more stringent measures to curb carbon emissions at early stage is more cost-effective than a "late and rapid" path (Victoria et al., 2020). Sharp reductions in later stage also increase the risks of undershooting carbon targets. Moreover, a less stringent carbon reduction target for the initial period risks greater accumulation of stranded assets, and the sharp increase in China's newly approved coal-based power capacity in 2020 may partially reflect this risk (Figure 7).

Figure 7. China's Annual Capacity of Newly Approved Coal-fired Power Plants



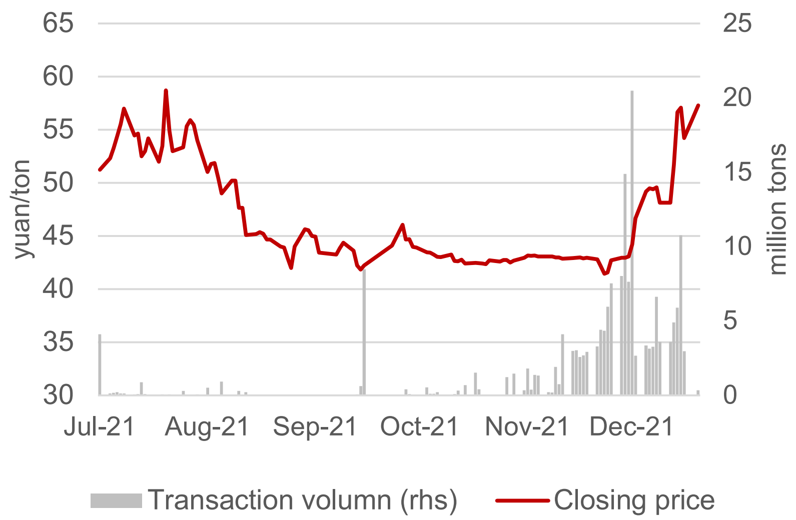
Source: Greenpeace East Asia (2021).

IV. Getting the Policy Right

10. Climate change represents the greatest market failure in human history (Stern, 2007), and strong policy interventions are needed to correct the market failure and steer the global economy from a high to a low carbon economy. Carbon pricing, which imposes a price on carbon emissions, is widely regarded as a cornerstone of the climate mitigation policy framework. Through carbon tax or cap-and-trade, carbon pricing induces economic agents to internalize the negative externalities of carbon emissions and redirect investment to clean technologies and infrastructure.

11. The recent rollout of the national emissions trading scheme (ETS) offers an opportunity to establish a robust carbon pricing scheme in China. Building on the experience of the eight provincial pilot ETS, China launched a national ETS in July 2021. The national ETS covers 2225 power plants and more than 4 billion tons of CO2 emission, making it the largest carbon market in the world. In the initial phase, instead of setting an absolute cap and one single sector-wide benchmark, China's national ETS uses an intensity-based allocation of carbon allowances and sets four benchmarks based on the size and fuel type of power generators. The authorities may have deliberately chosen this approach to minimize disruptions to power supply and smooth the transition, as some less developed regions in China still heavily dependent on small power generation units. As a result of this cautious approach, the price of carbon allowance has been modest – less than USD10 per ton of CO2 compared to EUR80 per ton in the E.U. ETS in December 2021 - and the impact of the national ETS on curbing carbon emission of the power sector is likely to be limited for the time being (Figure 8).

Figure 8. Trading Volume and Prices in China's National ETS



Source: WIND.

12. To turn the ETS into a genuine cap-and-trade system, absolute carbon emission caps will need to be adopted, and the emissions allowances will need to be reduced markedly over time to align the ETS with the nation's long-term net zero target. A transition to a single benchmark is also necessary to encourage entities to shift away from carbon-intensive fuel sources and towards clean energy. The coverage of ETS should expand to other high carbon emission sectors such as steel, cement, chemical production and other heavy industries. In the longer term, the authorities may consider introducing auctions as an alternative to the current free allocation of allowances, and facilitate the liquidity and robustness of the market through broadening the participant base and introducing derivative products such as carbon allowance futures.

13. **A carbon tax should be included as a major instrument in China's carbon mitigation policy toolkit.** A carbon tax directly sets a price on carbon by imposing a tax rate on the carbon content of fossil fuels used by the polluters. Given its greater administrative simplicity, a carbon tax is a more effective tool for reducing emissions than emission trading in sectors such as transport, agriculture and construction, where monitoring and verification of emissions is difficult (Raiser and Eckardt, 2021). While an ETS provides certainty in emission target, the implied carbon price can be volatile. Carbon taxes provide more certainty about future prices, which is important for facilitating business decisions in investing in green technologies and infrastructure. In considering the possible adverse impact of a carbon tax on vulnerable groups, the government may introduce the carbon tax in a revenue-neutral manner and introduce income transfers to low-income households and SMEs. "Double Dividends" can also be achieved if the additional revenues were returned through a reduction in other more distortionary taxes.

14. **Strong public support for technological developments and innovation is essential to make low-carbon transition a success.** Without major green technological progress and innovation, achieving carbon neutrality will require extremely high carbon prices, and the transition could be prohibitively costly and the economy would become very inefficient. However, the long-time horizon of investment and high degree of uncertainty often constrain the development and diffusion of green technologies. Other classic market failures such as positive spillover effects from innovation also lead to underinvestment and underproduction of these technologies compared with their socially desired levels. Therefore, government interventions such as subsidies for R&D and deployment, technological standards and public investment are warranted. China has actively implemented industrial policies to promote technological progress and innovation, and has achieved remarkable success in some areas such as solar energy and electric vehicles. Building on past experiences and lessons, the government could ramp up its technology support and innovation policies, and direct investment towards greener and more sustainable economic growth. Due to large technology uncertainty and the potential information asymmetry between the public and private sectors, green industrial policies need to be well-targeted and carefully designed to minimize the risk of government capture and rent-seeking. Broad and effective public participation, clear and transparent performance evaluation, as well as conditionality and sunset clauses, should be included as important ingredients of the government's green industrial policy (Altenburg and Rodrik, 2017).

15. **Authorities are encouraged to complement their regulatory efforts with a more economy-wide, market-based mechanism.** Policy instruments such as energy intensity regulations, compulsory standards and technological performance requirements have been widely used by the Chinese authorities to reduce carbon intensity in the economy. In addition, national energy and carbon intensity targets have often been broken down into sectoral-level or provincial-level targets to ensure their enforcement. The regulatory approach taken by China's authorities often yields quick results and can better address sectoral and regional specificities. To complement the current approach, more holistic, economy-wide carbon pricing can be adopted to lay a stronger micro-foundation for China's low carbon transition. The market-based approach will likely incentivize households and firms to adopt greener behavior. It will also equalize the marginal cost of decarbonization across usages, eliminating potential incoherence across sectoral policies and regional policies.

V. Manage Risks and Facilitate Net Zero Transition

16. The transition towards a carbon-neutral economy could bring about both short-term and long-term economic shocks and pose challenges in macroeconomic management. An abrupt transition, before the necessary technology for the generation, storage and transmission of clean energy is introduced, will cause energy shortages and prices to increase sharply with negative spillover effects on the rest of the economy.[5] Forward-looking producers, in anticipation of future mitigation actions, may cut investment and spare production capacity of the fossil energy industry, thereby accelerating supply-side adjustment and aggravating the stagflationary pressure during the decarbonization transition. A significant increase in green investment is expected to boost demand and partially offsets the impact of high carbon prices on output, but may erode public debt sustainability if it relies heavily on fiscal subsidies.

17. Potential financial risks from asset stranding and large green investment need to be assessed and addressed. Without significant breakthrough in negative emission technologies such as Bioenergy with carbon capture and storage (BECCS) and direct air carbon capture with storage (DACCS), a large part of carbon-intensive capital investment and fossil fuel reserves would become obsolete and ultimately stranded. If the retirement of stranded assets is too abrupt, it could result in large financial losses. In China, a large portion of stranded assets may come from the power generation sector. With an average age of 12 years, China's coal power generation units are young given that coal-fired power plants have an average lifespan of 40 years, suggesting that losses from their early retirement will be relatively large. Separately, financial institutions should enhance risk management, strengthening their capacity to identify, assess, and monitor carbon-related risks. Stress tests also need to be conducted at the national level to assess the resilience of the financial system to decarbonization shocks and raise awareness of existing vulnerabilities. Risks in the transition can also arise from excessive investment in clean and renewable energy and the resulting buildup in leverage, leading to the formation of a "green bubble" – an overvaluation of green financial assets.

18. Complementary structural reform is important in supporting the transition. Carbon neutrality implies a massive structural transformation of the Chinese economy. Flexible and adaptable labor and product markets, as well as efficient financial markets, can facilitate the reallocation of resources from high- to low-carbon activities. In addition, as network infrastructure is especially important for certain clean technologies such as hydrogen, renewable energy, electrification, and carbon storage, public investment in infrastructure can act as a catalyst for industrial firms to undertake low-carbon investments. In the power sector, the heavily controlled electricity pricing system limits the ability of the power producers to pass on the carbon price signal to consumers. Complementary reform in China's power pricing and distribution is also necessary to make ETS an effective tool to cut emissions.

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[5] Some recent studies have used quantitative models to investigate the effects of China's climate policies and carbon reduction. Mckibbin et al (2015) used a dynamic general equilibrium model to simulate the impact of China's NDC to the Paris Accord. They found that the NDC would lead to a 33 percent reduction of carbon emission and a 2.5 percent of real GDP loss for China in 2050, both relative to the baseline. Cao et al (2021) conduct a multi-model comparison of a carbon tax policy in China and found that a very high carbon tax would reduce China's carbon emission by 30 percent to 80 percent in 2050. The associated losses in GDP range from 2 percent to 8 percent. By linking an economic model with a bottom-up, energy-technology model, Jiang et al (2021) estimate that China's GDP could increase by 1.7 percent in 2050 in a 1.5°C scenario in comparison with the baseline.

19. Ensuring social inclusiveness and equitable burden sharing is key to increasing the acceptance of and support for net zero carbon emission. Some industries, regions and groups will bear disproportionally large economic losses from decarbonization, leading to an uneven distribution of transition costs. At a regional level, the large industrial provinces such as Jiangsu, Shandong and Hebei and the major coal-producing provinces—Shanxi, Inner Mongolia and Shaanxi—will likely face the most difficulties during the transition period. A regional income transfer scheme may be needed to compensate those provinces with low per capita GDPs but high dependence on carbon-based industries. Protection for vulnerable groups—such as displaced workers, MSMEs and low-income households—is important to mitigate the social risks of a clean energy transition. In addition, improved and affordable access to clean public transportation and utility facilities (for example, for residential heating) can also help reduce the energy burden of low-income households and alleviate regressive impacts of carbon pricing.

20. China's active participation in international cooperation and global coordination will help the country boost the effectiveness of its carbon reduction and climate mitigation actions. As a global public good, climate change mitigation should be achieved through globally-coordinated policy actions. The uneven pace of climate change mitigation across countries has caused concern over the free-rider problem and unfair competition, and a unilaterally imposed border carbon adjustment (BCA) tax has been proposed to address the problem. Due to its limited coverage and scope, the current EU BCA proposal is likely to have minimal impact on China's exports. However, if more and more advanced countries adopt BCA measures and form a de facto "Climate Club", as suggested by Nordhaus (2015), the economic cost for China, and other developing countries, could be significant (Box 1). China may consider participating in an international carbon price floor arrangement proposed by the IMF (2019) to avoid any unilateral BCA measures from its major trade partners. International cooperation and trade in clean technologies, which have the potential to bring important gains to China, should be included in China's climate change strategy. Moreover, regional cooperation towards a more harmonized climate regulatory framework will help limit the adverse impact of regulatory fragmentation on regional trade and investment.

Box 1. Impact of the EU's Carbon Border Adjustment Mechanism (CBAM)

As part of the European Green Deal, the EU has proposed to implement a CBAM with the aim of preventing carbon leakage and distortions to create a more level playing field. The CBAM will impose a levy on imported non-EU products that reflects the carbon emission contents of production and the difference between the EU ETS price and any carbon price paid in the production country. Applied to imports of electricity, cement, aluminium, fertilizer as well as iron and steel products at the initial stage, the CBAM will come into force in January 2026 after a three-year transition period.

A global computable general equilibrium (CGE) model for trade, which is a recursive dynamic extension of Zhai (2008), is used to simulate the impact of the EU's CBAM. The model has 29 sectors and 12 regions, and is calibrated using GTAP database 10.0 with 2014 as the base year. Three scenarios are simulated. The first scenario simulates the current EU CBAM proposal. It assumes a carbon price of US$50 on each tonne of CO2 embodied in imports to the EU. In this scenario, direct emissions from production and indirect emissions from electricity (Scope 1 and Scope 2 emissions) are used to calculate the embodied carbon of imports. Due to the limitation in data disaggregation in the GTAP database, we use a broader range of sectors to represent the five categories of goods to be covered by the CBAM. The second scenario assumes that the EU's CBAM expands to all imported goods and services and all indirect emissions from upstream value chains (Scope 3) are included in calculating the carbon contents. The last scenario extends the second scenario to a "Climate Club" which encompasses major OECD countries and imposes CBAM on non-members. In all scenarios, the CBAM is imposed from 2026 onwards and simulation results for 2030 are reported below. We interpret the results as the medium run response to a policy change.

The simulation results suggest that the current version of the EU CBAM would exert only a modest aggregate impact on China. The CBAM leads to high ad valorem taxes on imports of carbon-intensive products (Box Figure 1), and China's exports to the EU in these sectors are expected to shrink by 10-14 percent (Box Figure 2). However, these carbon-intensive sectors, covered by the current EU CBAM, account for only 6.0 percent of China's exports to the EU, suggesting a minimal macro impact of their contraction[6]. Indeed, the results on aggregate welfare indicate that China would experience a slight real income gain of 0.01% of its baseline GDP, mainly due to the positive terms-of-trade effects resulting from the decline in energy prices in Russia and the other former Soviet Socialist Republics (FSSR), which are more heavily hit by the adoption of CBAM in the EU (Box Table 1).

In the second scenario, a broader CBAM covering all sectors and indirect emissions leads to a larger but still-moderate loss in China's aggregate exports and real income. This is not surprising given that the EU accounts for only 15 percent of China's total exports. However, under the "Climate Club" scenario, when nearly half of its exports will be penalized by the countries in the Club, China's welfare losses would no longer be negligible, amounting to 0.76 percent of its baseline GDP.

CBAM would help reduce carbon leakage, but its impact on global emission is limited in the first and second scenarios, as the reduction in carbon emission of countries outside of the

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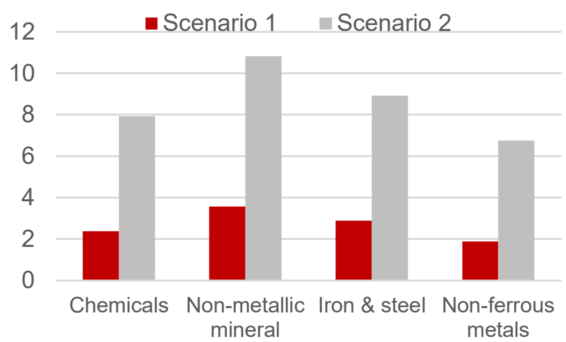
[6] Cement, aluminium, fertilizer as well as iron and steel accounted for 1.4% of China's total exports to the EU in 2020. There were no electricity exports to the EU from China. As the model uses broad sectors of chemicals, non-metallic minerals and non-ferrous metals to represent fertilizer, cement and aluminium, respectively, the simulation results of the first scenario may overestimate the impact of the current EU CBAM plan to some extent.

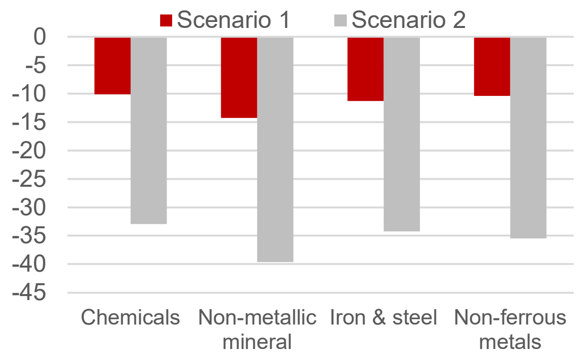
EU is partially offset by the increased carbon emission in the EU (Box Table 2). Even in the "Climate Club" scenario, the drop in global emission is still less than 1 percent compared with the baseline. It is worth noting that China's carbon emission increases in the first scenario due to the general equilibrium effects induced by cheaper energy imports. This result highlights that a unilateral CBAM is likely to be a less effective way to achieve global carbon mitigation goals in comparison with a coordinated global carbon pricing framework.

Box Figure 1. Ad Valorem Equivalent of the EU's CBAM on Imports from China (%)



Source: Authors' calculation

Box Figure 2. Change in China's Carbon-intensive Exports to the EU
(% from the baseline, 2030)



Source: CGE model simulations

Box Table 1. Macro Impacts of CBAM (% change from baseline, 2030)

	Real income	Total exports	Terms of Trade
Scenario 1			
China	0.01	-0.01	0.02
EU	-0.01	-0.10	0.02
FSSR	-0.14	-0.47	-0.05
World	-0.01	0.00	0.00
Scenario 2			
China	-0.13	-1.28	-0.21
EU	0.34	-2.88	0.36
FSSR	-0.61	-1.99	-0.30
World	-0.02	0.00	0.00
Scenario 3			
China	-0.76	-4.46	-0.87
EU	0.24	-1.95	0.43
FSSR	-1.31	-3.28	-0.43
World	-0.25	0.00	0.00

Source: CGE model simulations.

Box Table 2. Change in CO2 Emission (change from baseline, 2030)

	Scenario 1	Scenario 2	Scenario 3
(mn ton CO2)			
China	0.2	-23.4	-147.6
EU	6.7	51.4	45.2
World	-37.1	-112.5	-379.9
(% change)			
China	0.00	-0.18	-1.11
EU	0.24	1.84	1.61
World	-0.08	-0.26	-0.86

Source: CGE model simulations.

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