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Working Paper (WP/25-04)

China-Plus Research Studies

Navigating Carbon Regulations and Green Investment in BRI Partner Countries in ASEAN

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February 2025

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February 2025

Abstract

This study examines the implications of the European Union's (EU) Carbon Border Adjustment Mechanism (CBAM) on key sectoral exports and renewable energy investments in ASEAN economies engaged in the Belt and Road Initiative (BRI). Using a global computable general equilibrium model, it simulates CBAM's impacts on carbon-intensive exports—iron, steel, and aluminum—critical to BRI projects, and its potential to reshape trade dynamics. While the initial scope of the CBAM has limited effects on ASEAN exports, expanded coverage could cause notable declines especially in Indonesia, Malaysia, Thailand, and Vietnam. Beyond immediate trade implications, CBAM represents one of many drivers in greening the BRI, aligned with global climate agenda. China's leadership in advancing renewable energy and low-carbon projects under the BRI plays a pivotal role in this transition. The study underscores how CBAM-induced compliance costs and green investments intersect, offering opportunities for ASEAN economies to enhance sustainability. By fostering renewable energy adoption and integrating green practices into BRI projects, ASEAN can leverage the global green transition to bolster economic resilience. This research provides insights into aligning regional priorities with international climate commitments while maintaining competitiveness in a low-carbon future.

JEL classification: F14, Q42, Q56, R58

Keywords: ASEAN+3, carbon border adjustment mechanism, carbon emissions, belt and road initiative, renewable energy, economic growth, exports

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[2] The authors would like to thank Dr Hoe Ee Khor, Dr Jae Young Lee, Dr Jorge Chan-Lau, and Dr Laura Fermo for the helpful comments and review. All remaining mistakes are the responsibility of the authors.

Abbreviations

ADB	Asian Development Bank
ASEAN	Association of South-East Asian Nations (Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam)
ASEAN+3	ASEAN plus China (including Hong Kong), Japan, Korea
BCA	Border carbon adjustments
BRI	Belt and Road Initiative
CBAM	Carbon border adjustment mechanism
CGE model	Computable General Equilibrium model
CO2e	Carbon dioxide emissions
ETS	Emissions trading system
EU	European Union
EU18	Euro area
Eurasia	Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan.
GHG	Greenhouse gas
GMMET	Model for the Energy Transition
GTAP	Global Trade Analysis Project
MENA	Middle-East and North Africa, comprising Bahrain, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, Yemen, Algeria, Egypt, Morocco, Tunisia
MMT	Million metric tons
RFSN	Regional financial safety net
tCO2e	Ton of carbon dioxide equivalent emissions

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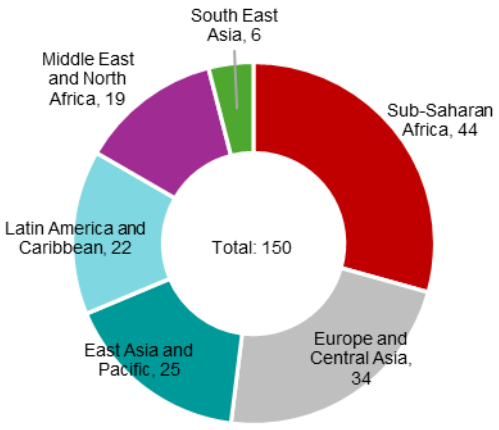
I. Introduction

A. Significance of the Belt and Road Initiative (BRI) and the Growing Environmental Challenges

Launched in 2013, the BRI, commonly known as the New Silk Road, is a significant infrastructure development initiative spearheaded by China. Its primary objective is to enhance trade and connectivity across Asia, Europe and Africa. At its core, the BRI is built upon five key priorities that serve as foundational pillars for its implementation: policy coordination, facilities connectivity, unimpeded trade, financial integration, as well as people-to-people bonds (Belt and Road Portal, 2023). Through these five key priorities, the BRI aspires to create a vast network of interconnected economies, ultimately driving regional development and enhancing global economic growth.

A decade since its inception, the number of countries participating in the BRI has increased, alongside the rise in cooperation agreements. Figure 1 shows that as of December 2023, there were 150 participating countries in the BRI, of which 29.3 percent were from Sub-Saharan Africa, followed by Europe and Central Asia (22.7 percent), and East Asia and Pacific (16.7 percent). Over 200 BRI cooperation agreements have been signed with countries and international organizations across the five continents, reflecting the initiative's diversity, which span sectors such as transportation (roads, ports, railways), energy (oil and gas pipelines), telecommunications, and digital infrastructure (Feingold, 2023).

Figure 1. Number of Belt and Road Initiative (BRI) Participating Countries (December 2023)



Source: AMRO staff.

As the BRI expands its reach, the pressing need to integrate sustainability into its framework has become increasingly apparent, particularly in response to escalating environmental challenges. Given that the BRI involves large-scale infrastructure projects, the environmental implications are significant, with potential impacts on biodiversity, air and water quality, and carbon emissions. Recognizing these challenges, there is a growing call for the BRI to prioritize green development practices that align with international climate commitments, such as the Paris Agreement.

To meet these demands, BRI projects are increasingly encouraged to adopt environmentally sound practices that align with the global climate change agenda. This involves the integration of carbon regulations and low-carbon development standards aimed at reducing the carbon footprint of BRI projects, such as adopting green construction practices, enhancing energy efficiency in infrastructure projects, and supporting clean energy initiatives. These measures are critical amid growing concerns over climate change risks and for mitigating the environmental risks associated with extensive infrastructure developments in vulnerable regions. As a result, green and low-carbon development is increasingly being adopted as part of the "greening the BRI" agenda to ensure sustainable and eco-friendly growth for both China and BRI partner countries. Such greening initiative is not only beneficial for the environment but also crucial for its long-term success and sustainability. In this regard, China has gradually shifted its focus on the development of green and low-carbon energy projects with its partner countries (The State Council Information Office of the People's Republic of China, 2023). As a result, many green energy projects, including hydropower and solar plants have been launched.

At the same time, countries involved in the BRI would also need to navigate carbon regulations imposed by developed economies outside the BRI, such as the European Union (EU)'s carbon border adjustment mechanism (CBAM). While many BRI projects focus on domestic infrastructure development or regional connectivity and are not directly export-oriented, the implications of CBAM can still be far-reaching. These BRI projects may encounter indirect effects as the global push for decarbonization and evolving carbon regulations reshape the cost structure and strategic priorities of industries critical to BRI projects. For carbon-intensive sectors such as iron and steel, aluminum, cement, and chemicals—which play a key role in large-scale infrastructure under the BRI—the challenges stem not so much from direct with export-related standards, but from adapting to the broader international shift toward stricter carbon norms. Developing economies participating in the BRI often face constraints such as weaker regulatory frameworks and limited technological capacity to transition to lower-carbon production processes. As global carbon standards tighten, these industries may face escalating operational costs to meet emerging requirements, potentially undermining their competitiveness and profitability, even in non-export-focus contexts.

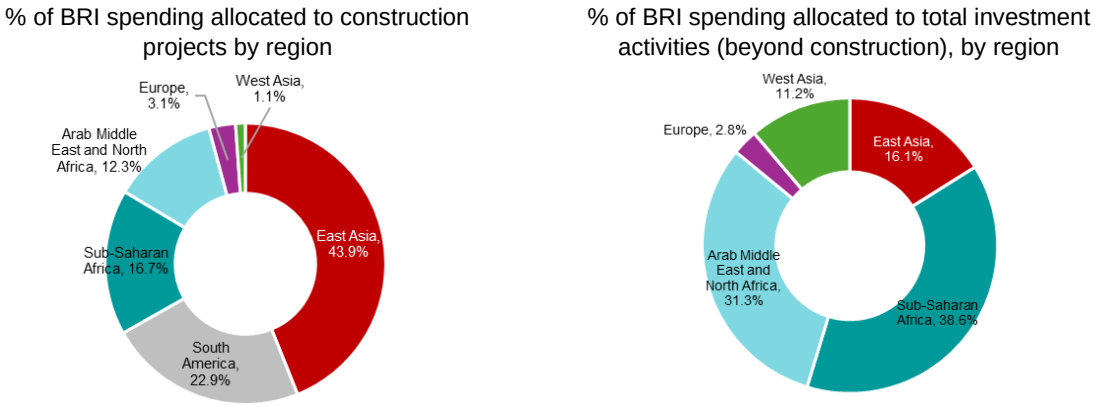
B. Achievements of the BRI over the Past Decade and its Focus on Sustainability

Having established itself as a transformative force in driving growth and development, the BRI has significant implications for trade, investment, economic as well as financial integration across BRI partner countries. A report by Nedopil (2023) showed that over the past decade, the cumulative BRI spending has reached USD 1.053 trillion. About 63 percent of this amount has been allocated to construction projects. By 2027, global spending on the BRI is projected to reach USD 1.3 trillion, with some analysts estimating that over 2,600 projects worldwide would be implemented, valued at USD 3.7 trillion (Umbach, 2022). According to estimates by the World Bank (2023), once completed, the transport BRI projects in particular, are expected to reduce commuting times along economic corridors by 12 percent, increase trade between 2.7–9.7 percent, while raising income by up to 3.4 percent.

The achievements of the BRI over the past decade have yielded substantial benefits for China and BRI partner countries. Between 2013–2023, China's trade volume with BRI participating countries surged by 172 percent, reaching RMB 19.5 trillion (USD 2.74 trillion) at the end of 2023 (or 46.6 percent of China's total trade volume). In terms of investment, China's non-financial outbound direct investment (ODI) in BRI participating countries also increased by 20 percent to USD130 billion in 2023. Through China's large-scale infrastructure projects overseas, the BRI has helped address China's industrial overcapacity in sectors such as steel, aluminum, cement, chemicals, and amongst others (Rafi, 2024; Rana and Ji, 2020). The expansion of trade network and investment partnerships with many countries has enabled China to position itself as a key player in driving global economic development, while extending its global influence.

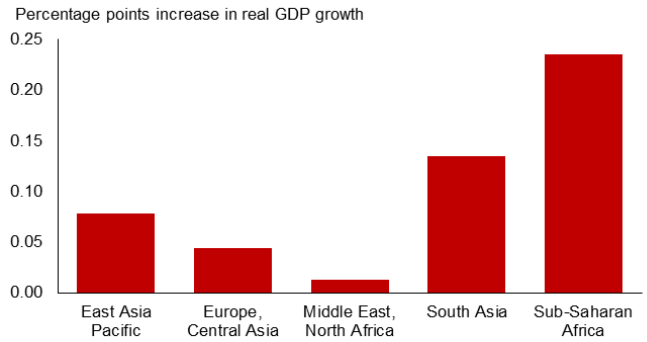
For partner countries, the BRI has offered much-needed infrastructure investment and many opportunities for their economic growth and development (Khor, Poonpatpibul and Foo, 2021). Figure 2 shows that since its inception, BRI projects and investments have expanded across Asia, Africa, Europe and even South America. These projects involve the construction or upgrading of transportation and energy infrastructure such as roads, ports, railways, energy pipelines, alongside building digital connectivity. Estimates by the World Bank (2023) showed that the BRI's transportation infrastructure alone would likely increase the economic growth of BRI participating countries by between 0.078 to 0.235 percent as shown in Figure 3. So far, Indonesia, Hungary and Peru are the largest beneficiaries of BRI investment.

Figure 2. Total BRI Engagements (First Half of 2023)



Source: AMRO staff

Figure 3. Estimated Effects of BRI Transportation Infrastructure on Economic Growth in BRI Participating Countries



Source: AMRO staff

However, mounting concerns over negative environmental impacts of the BRI have prompted China to introduce BRI reforms, which aim to integrate sustainable practices into the BRI. Many BRI projects, including large-scale infrastructure construction, have resulted in deforestation and affected biodiversity in BRI hosting nations. Moreover, a study by Xin Wang et al. (2023) suggests that the construction of railway projects under the BRI led to an increased carbon footprint, inducing approximately 2,095 Mt CO2 emissions during 2008–2017. Besides, the construction of coal-fired power plants outside China has also contributed to the rise in carbon emissions. Considering significant environmental risks, the government has undertaken BRI reforms, mainly focusing on reducing carbon emissions and pollution as well as protecting biodiversity in BRI host nations (Chiu, 2022). From 2017, Chinese government started to encourage green BRI projects, followed by the president's pledge in 2021 to cease building new coal-fired power plants overseas (Patel, 2023).

Looking at the five BRI priority areas, progress is evolving to meet both economic and sustainability goals, as policy coordination is being expanded to incorporate environmental priorities. A notable achievement is the multilateral cooperation between China and BRI partner countries, spanning sectors such as transportation, energy and finance. This reflects growing attention to a unified approach to carbon policies and regulatory alignment. This process has culminated in over 65 countries signing agreements centered on low-carbon development standards.

For example, in the area of infrastructure connectivity, new projects such as the China-Europe Railway Express and improvements to the Silk Road maritime network—both serving as vital trade routes—are adopting measures to reduce carbon footprints. The "Air Silk Road" has also incorporated sustainable practices in new air transport agreements, highlighting the initiative's comprehensive approach to environmentally conscious connectivity. On the financial integration front, various models of financial cooperation are being implemented by BRI partners and institutions, including policy-based, development, and commercial finance that prioritize low-carbon projects. The Silk Road Fund, in particular, has invested over USD 24.3 billion in low-carbon projects across more than 70 countries and regions, with green finance becoming a central pillar of the BRI (The State Council Information Office of the People's Republic of China, 2023).

In view of the growing environmental concerns and the shift towards addressing climate change, this study examines the impact of external carbon regulations, notably the EU's CBAM on ASEAN's key export sectors, given the region's extensive involvement in the BRI. The CBAM, as a pivotal regulatory measure, represents both a challenge and an impetus for ASEAN economies to align with the evolving climate agenda. By simulating the impact of the CBAM on ASEAN's exports—both at the aggregate level and within key BRI-related sectors such as infrastructure, energy, and manufacturing—this study provides valuable insights into the scale of changes driven by CBAM. Furthermore, with China emerging as the leader the green transition, and expanding investments in renewable energy across ASEAN, this study explores how these initiatives can accelerate the diversification of ASEAN's energy mix while supporting its broader sustainability goals. Together, these analyses provide critical insights into how CBAM and green investment trends, driven by the global climate agenda may reshape ASEAN's trade and energy landscape.

II. Literature Review

A. Global Trends in Carbon Barriers and Their Role in the De-Carbonization Agenda

Carbon barriers—regulatory measures aimed at curbing greenhouse gas (GHG) emissions—are increasingly becoming integral to global climate policies. These include carbon taxes, emission standards, and border carbon adjustments (BCA). The evolution of these carbon barriers can be traced back to market-based climate policies that emerged in the late 20th century, focusing on reducing GHG emissions through mechanisms like cap-and-trade systems and carbon taxes. Over the years, these approaches have gained significant traction, with developed economies leading the way in adopting such measures to meet their climate commitments. Stavins (2020) provides a comprehensive overview of these developments, highlighting the strengths of each pricing mechanism and noting their rapid adoption in developed economies. Global carbon pricing has also expanded beyond the developed world, with large emerging economies such as China establishing emission trading systems (ETS), demonstrating a growing recognition of the need for carbon regulations (World Bank, 2022). Around 40 countries have used some form of carbon pricing mechanisms so far, covering half of their emissions, or equivalent to roughly 13 percent of annual GHG emissions (World Bank, 2023).

As carbon pricing and regulations become increasingly mainstream, the BCA has emerged as a critical policy to prevent carbon leakage—where production shifts to countries with less stringent emissions policies. Such BCA is a strategic regulatory development aimed at leveling the carbon cost burden among trading partners. More fundamentally, the emergence of BCA signals a shift in how environmental concerns intersect with international trade. Developed economies have led the way, with the EU's CBAM serving as a benchmark (European Commission, 2021). CBAM imposes a levy on imported goods based on their carbon content, incentivizing exporters to adopt greener practices. During the transitional period, the mechanism will serve as a preparatory phase before stringent requirements are enforced. Once fully operational, the CBAM system will necessitate emissions reporting and financial adjustments through the purchase of certificates from importing entities (Carbon Chain, 2024). Once fully implemented, the EU's CBAM is expected to capture over 50 percent of the emissions (European Commission, 2024). Many industries—particularly those in developing economies—could face challenges in aligning with these standards due to limited technological and regulatory capacities. Despite these challenges, global decarbonization trends, driven by climate agreements such as the Paris Accord, are compelling both developed and developing nations to adopt sustainable practices. This shift transcends trade-specific measures like CBAM, reflecting a broader movement toward green economic transformation.

In the context of the BRI, the implications of carbon barriers are nuanced. While some projects involve export-oriented industries directly exposed to mechanisms like CBAM, the majority focus on domestic or regional development and are not immediately affected by such regulations. However, the global trend toward decarbonization indirectly impacts these projects in several ways. It reshapes investment priorities, drives the adoption of low-carbon industrial processes, and fosters alignment with international climate goals. These shifts underscore the growing need for BRI projects to integrate sustainability considerations into their design and implementation to remain relevant and resilient in a rapidly evolving global landscape.

B. Importance of Studying the Implications of Carban Barriers on Trade, Industry and Policy Design

In recent years, anti-globalization sentiments and protectionist measures have gained momentum. This trend has been further exacerbated by rising risks of global fragmentation across trade, technology, and foreign direct investment. Environment concerns and the impact of climate change further complicates these dynamics, adding another layer of complexity to the challenges posed by fragmentation and protectionism. The transition to net zero carbon emissions necessitates a profound transformation of regional economies. Significant investments will be required to expand the region's climate-friendly production capacity, highlighting the urgent need for policy coherence and strategic action. However, the transition involves managing difficult tradeoffs and navigating complex bilateral and multilateral relationships amongst nation states.

While pricing carbon emissions is essential to mitigate climate change, yet regional economies' reliance on fossil fuels for energy means that carbon pricing could exert sustained upward pressure on medium- to long-term inflation especially if affordable alternative energy sources are unavailable. Conversely, not pricing carbon could undermine the region's competitiveness if trading partners with stringent carbon policies impose border adjustments. While such mechanisms aim to curb carbon leakage and preserve competitiveness, they could also serve as tools for protectionist trade and industrial policies, disrupting efforts to design policies that support high-quality growth and climate sustainability.

To avert adverse outcomes with wide-ranging implications far into the future, it is important to study the implications of carbon barriers on trade, industry, and policy design. There has been growing interest in the idea of BCA to counter losses in competitiveness and carbon leakage due to asymmetric carbon prices. Conceptually, BCA would accompany domestic carbon pricing policies and be imposed on the "embodied carbon" in an economy's imports – these imports would be subject to fees and other charges on their emissions content as if they were produced domestically, thus levelling the playing field between local and foreign producers.

Widespread use of BCAs globally could affect the region, i.e., ASEAN+3 trade and production substantially, as regional economies account for about 40 percent of carbon emissions embedded in global trade, more than half of which is China. BCAs would make the region's exports more expensive, which could reduce external demand and trade flows for the affected goods.

Minimizing the negative consequences of BCAs on ASEAN+3 exports will require strong policy and regulatory adjustments. ASEAN+3 economies with no carbon pricing will need to adopt some form of it. A carbon tax would help to generate revenue that could be directed toward domestic "green" projects or other climate-related purposes, instead of being channeled to the BCA-implementing trading partner. Adopting a carbon pricing policy would also provide a strong signal on policy direction, even if the carbon price is initially low. Other targeted policies could include measures that incentivize or assist domestic exporters to shift to climate-friendly products and technologies.

C. CBAM and Its Implications on Trade and Investment Dynamics

The EU's CBAM represents a pivotal development in global climate policy which could establish a precedent for future border carbon adjustments in other major economies, including in Canada, the United Kingdom, and the United States. Earlier studies on the effects of CBAM largely focused on minimizing carbon leakages and reducing carbon emissions (Monjon and Quirion, 2011; Weisbach et al., 2013). Recent research focuses on the implications of CBAM on international trade and export competitiveness. For instance, a study by Hufbauer et al. (2021) found that, based on the "Scope 1 emissions" criteria of the EU's CBAM, the iron and steel industry would be the most affected amongst the five carbon-intensive industries identified for the initial phase of implementation. Based on the value of EU imports of CBAM products from the 10 largest trading partners for each product, it is found that EU's imports of iron and steel from China, India, Korea, Russia, Türkiye, Ukraine, and the United Kingdom would be the most impacted. However, in the short run, the study suggests that the total industry impact resulting from the initial implementation of the CBAM on EU's major trading partners would be limited: EU imports of the initial CBAM products from the top 10 major countries accounted for only about 3 percent of total EU goods imports from those countries.

Similarly, Zhong and Pei (2022) also found that China, India, Russia, Türkiye are amongst the countries most sensitive to CBAM. The study assesses the impact on EU's CBAM that covers all goods sectors, as well as the energy and transportation sectors. Using input-output analysis, the findings indicate that the CBAM would result in competitiveness redistribution amongst countries. Of significance, the EU's CBAM would trigger the most violent shift in the export market share of non-metallic mining products (such as cement), where China would incur an enormous export loss, followed by Türkiye, India and Korea. In contrast, most EU countries would gain sales revenue in the EU market.

In the ASEAN region, the EU remains the third-largest export market for ASEAN goods since 2015. However, from the BRI point of view, the direct impact of CBAM's initial coverage on ASEAN would be small, given that the majority of BRI projects are domestic or regional in nature. Most of these BRI projects are not heavily reliant on exports to the EU, and therefore insulated from direct exposure to CBAM. Instead, these projects—particularly in infrastructure and energy—are influenced by the broader climate agenda, which drives the need for greener practices regardless of export considerations. However, CBAM does create challenges for industries linked to international trade.

Indonesia, Malaysia, and Vietnam, with significant exports of carbon-intensive goods such as steel and aluminum, may face some pressures to adapt to greener practices even if their participation in the BRI is primarily domestic, since these economies are highly integrated into global supply chains that involve exporting goods to various markets, including the EU (Ghosh, Xi and Won, 2024). Pressures from international buyers and trading partners to comply with greener standards can influence their domestic industries to adopt more sustainable practices. Conversely, countries like Cambodia, Lao PDR, Myanmar, and Singapore, whose primary exports to the EU include agricultural products, textiles, and organic chemicals, remain largely insulated from CBAM. AMRO (2023) showed that the EU's CBAM—under its initial scope—is expected to have limited impact on ASEAN's aggregate exports. Using a global computable general equilibrium (CGE) model following He, Zhai and Ma (2022), the study which simulated the impact of the CBAM's initial scope up to 2030,

found that exports to the EU could decline by 0.12 percent in 2030 relative to the counterfactual scenario (absent the CBAM). The study also concluded that Indonesia and Vietnam are the two ASEAN countries likely to feel the greatest impact, consistent with earlier findings in the literature.

The comprehensive application of CBAM—if extended to all EU imports of manufactured goods and transportation services, and encompassing indirect emissions ("Scope 2 and 3 emissions"[3]—would likely exert significant impacts on industries across ASEAN. This broader implementation would extend compliance costs beyond direct emissions, impacting not only carbon-intensive sectors but also any industries that rely on significant energy or complex supply chains with substantial embedded carbon emissions.

ASEAN countries that are heavily reliant on electronics, machinery, and motor vehicle exports could potentially see an increase in production costs, as many of these industries depend on carbon-intensive electricity sources and/or materials with high upstream emissions. In Indonesia, Malaysia, and Thailand, manufacturing sectors linked to global supply chains would be particularly vulnerable to these added compliance costs, potentially reducing their price competitiveness in the EU market. Industries such as textiles in Vietnam and electronics in the Philippines, though not traditionally seen as carbon-intensive, might still face indirect carbon cost increases due to Scope 2 and 3 emissions if their supply chains are heavily reliant on energy-intensive processes or imported materials from carbon-intensive sources. Additionally, the expansion to include transportation services could impact ASEAN's logistics and shipping industries, which are integral to the region's export economy, potentially leading to higher shipping costs for products bound for Europe. This shows that the broader application of CBAM to encompass indirect emissions or additional sectors could have larger implications for ASEAN. However, its influence will likely remain secondary to the overarching climate change agenda, which continues to shape green investments and policy reforms in the region.

D. Impact of CBAM on Green Investment

The introduction of EU's CBAM is expected to shape global investment flows, particularly by incentivizing the adoption of green technologies. For countries heavily engaged in trade with the EU, CBAM compliance necessitates cleaner production practices, driving investments in renewable energy, energy efficiency, and other green technologies. Research highlights CBAM's potential to incentivize cleaner production practices as industries attempt to maintain market access and competitiveness in the EU. For instance, Lin and Zhao (2023) argued that carbon pricing, including border adjustments like CBAM, can be a powerful tool to encourage investment in low-carbon technologies, particularly in sectors with high emissions such as steel, cement, and aluminum. As firms adopt greener practices, CBAM could promote regional growth in clean energy and sustainable technology sectors, with potential positive spillovers for green investment.

[3] "Scope 2" refers to indirect emissions generated from purchased energy like electricity, heating, and cooling, while "Scope 3" encompasses all other indirect emissions occurring throughout a company's value chain, including upstream (suppliers) and downstream (product usage and disposal) activities, which are not directly controlled by the company itself (Cited from https://www.compareyourfootprint.com/difference-scope-1-2-3-emissions/).

However, the relationship between CBAM and green investment is complex, particularly for developing economies participating in the BRI. For ASEAN economies, CBAM-induced cost increases in export-oriented industries could redirect financial resources away from long-term green projects toward short-term compliance solutions. A recent analysis by Carbon Market Watch (2022) emphasizes that countries with limited financial and technological resources might struggle to absorb these costs. Small- and medium-sized enterprises (SMEs), which often lack access to capital for such transitions, may be disproportionately affected (Government of the United Kingdom, 2023). Nevertheless, the broader climate agenda—coupled with China's emphasis on greening the BRI—offers a counterbalance. By channelling resources into renewable energy projects and sustainable infrastructure, China's green investments under the BRI are transforming the landscape for participating countries. These efforts align with global decarbonization trends, providing ASEAN countries with opportunities to enhance energy efficiency, reduce emissions, and build resilience against climate-related risks.

While CBAM acts as a catalyst, the primary driver of green investment in BRI projects remains the overarching climate change agenda. As noted earlier, China's leadership in renewable technologies positions it as a pivotal actor in this transition. For ASEAN, leveraging these green investments can facilitate the shift to a low-carbon future, mitigating the risks posed by carbon regulations and enhancing long-term sustainability. The integration of these investments into national development strategies will be crucial for balancing economic growth with environmental goals.

III. Research Method and Results

A. Research Methods and Scenario Settings

To explore the economic and environmental impacts of EU's CBAM and China's green investment under the BRI, we employ a global CGE model to simulate a hypothetical scenario, and is calibrated to Global Trade Analysis Project (GTAP) database 11 covering 160 countries and regions as well as 65 industrial sectors. The CGE model is the commonly employed approach in the empirical literature to explore the impact of the CBAM on carbon emissions, social welfare, trade and the overall economy.

To examine the impacts of the EU's CBAM-induced price shifts on ASEAN's key export sectors, we distinguished between a baseline scenario (without the CBAM), and two alternative scenarios ("Initial coverage" and "Full coverage"). The "Initial coverage" refers to direct emissions from the covered sectors, represented in the model by chemicals, electricity, iron and steel, nonferrous metals, and nonmetallic minerals.[4] The "Full coverage" refers to all exports and both direct and indirect emissions.[5] Both scenarios assume a carbon price of USD 75 per ton of carbon dioxide equivalent (tCO2e) embodied in imports from the EU while the carbon price per ton for China is assumed to be USD 9.2; for Indonesia, USD 2.09; for Singapore, USD 3.7; and 0 for the rest of ASEAN. The CBAM,

[4] As the sectoral disaggregation in GTAP database is not detailed enough, the model uses GTAP sectors of chemicals, minerals and non-ferrous metals to represent fertilizer, cement and aluminum, respectively, in the scenario of "initial coverage".
[5] The direct emissions of a sector are calculated from the emission factors of its production inputs. Indirect emissions, which included those embodied in intermediate inputs, are calculated based on global input-output table using the Leontief inverse matrix.

which adjusts for differences between the EU carbon price and carbon price in exporting economies, is assumed to be imposed from 2026.

To examine the impacts of China's green investment in BRI partner countries, we assume that China invests USD300 billion in renewable power generation across BRI countries between 2025 and 2035, based on the literature where it is estimated that Chinese companies invested approximately USD 31.1 billion in overseas renewable energy projects between 2015 and 2024 (World Resources Institute).[6] The CGE model is most suited for this hypothetical scenario as it has detailed disaggregation of the electricity sector and allows for a high degree of substitution between different electricity generating technologies. The model features six electricity generation technologies: coal, oil, gas, nuclear power, hydropower, and renewables (solar and wind). These technologies vary in their cost structures and emission intensities. The outputs from these technologies are combined into an aggregate electricity generation bundle, which is further paired with the output of power distribution and transmission sector to produce final electricity output.

Following the IMF's Global Macroeconomic Model for the Energy Transition (GMMET) model (Carton et al., 2023), we model renewable power generation with a "renewables-plus-backup" approach. Given the intermittent nature of renewable energy, wind and solar power generation is paired with a flexible back-up capacity based on fossil fuels to covers periods of shortfalls in renewable electricity. The size of the back-up capacity relative to the renewable capacity is endogenously determined by a cost-minimization problem based on the degree of intermittency and the relative costs of both generation technologies. The scenario of the green investment assumes that the investment from China is allocated across BRI countries based on the average shares of total and renewable electricity output.

B. Simulated Results

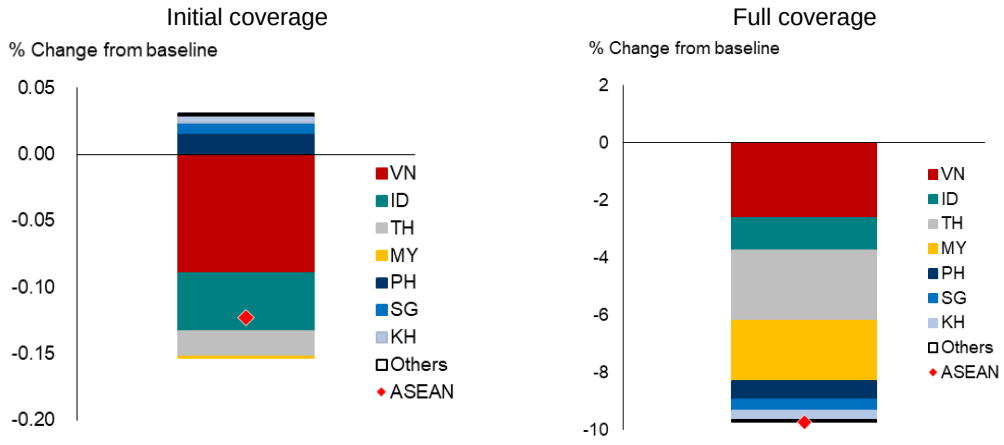
(I) Impact of CBAM on Key Sectoral Exports in ASEAN

The results showed that the EU's CBAM—under its initial scope—is expected to have a limited impact on ASEAN's exports to the EU by 2030. Figure 4 (panel a) shows that under the "Initial coverage", the simulated impact on ASEAN's exports to the EU is a decline of 0.12 percent relative to the baseline scenario of no CBAM, by 2030. In this scenario, Indonesia's and Vietnam's exports to the EU would be the most affected.

Under the "Full coverage" where all products and services and all indirect emissions from upstream value chains are included in the simulation, the EU's CBAM would result in a decline of approximately 10 percent of ASEAN's exports to the EU. In this scenario, exports from Indonesia, Malaysia, Thailand and Vietnam would be the most affected, as key sectoral exports notably, manufacturing of electronics, machinery, motor vehicles, iron, steel and aluminum are major contributors to total exports of these economies. As a result, the effects of EU's CBAM on these export sectors are clearly negative, given the large exposures of ASEAN to the BRI, as shown in Figure 5.

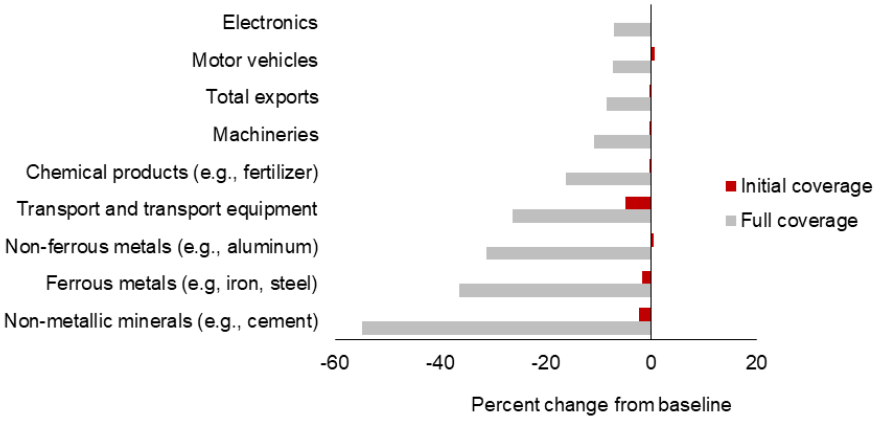
[6] Even if green investment were to increase tenfold compared to the previous decade, its share in total BIR investment would still be relatively small.

Figure 4. Effects of European Union (EU)'s CBAM on ASEAN's Exports to the EU, (Relative to Baseline, by 2030)



Source: AMRO staff
Notes: VN = Vietnam; ID = Indonesia; TH = Thailand; MY = Malaysia; PH = Philippines; SG = Singapore; KH = Cambodia.

Figure 5. Changes in ASEAN's Exports by 2030 Relative to the Baseline (Full Coverage, Selected Key Sectors)



Source: AMRO staff

Indonesia's reliance on exports of iron, steel, and aluminum—critical inputs for infrastructure projects—makes it vulnerable to CBAM. Even though CBAM primarily applies to exports destined for the EU and not to purely domestic projects or those serving regional markets, its indirect effects can influence domestic sectors that are integrated into global supply chains or rely heavily on carbon-intensive processes. For example, while projects like the Jakarta-Bandung high-speed rail primarily serve domestic infrastructure needs, they may still rely on industries such as steel and aluminum that produce for both domestic and export markets. Unintended cost increases due to CBAM on their exports of iron, steel and aluminum could indirectly affect their overall competitiveness and pricing, potentially impacting costs for domestic projects as well. However, the direct impact of CBAM on entirely domestic BRI projects remains minimal.

Malaysia, which is a significant exporter of electronics and machinery, also stands to be impacted by EU's CBAM. The BRI's emphasis on developing Malaysia's manufacturing hubs—such as the Malaysia-China Kuantan Industrial Park—has driven growth in heavy industries. However, should CBAM extend to electronics and machinery, Malaysia could see increased costs due to its heavy reliance on carbon-intensive manufacturing processes.

In Thailand, the automotive industry—a major pillar of its economy—is highly exposed to EU markets. With substantial BRI investments in automotive manufacturing zones, any carbon-related cost increases due to CBAM could reduce Thailand's competitive edge in the EU. The Eastern Economic Corridor (EEC) has been a key area of focus, aiming to transform Thailand into a regional hub for high-tech industries, but CBAM may pose a new challenge in maintaining cost competitiveness.

Similarly, Vietnam has become a manufacturing powerhouse within ASEAN, particularly in electronics and textiles, partly due to BRI investments in transport and energy infrastructure. As the EU remains a significant market for Vietnam's manufacturing exports, expanded CBAM coverage could lead to substantial compliance costs. This may require adjustments in production practices to align with EU carbon standards, potentially affecting Vietnam's export revenues and the broader economic benefits derived from BRI project.

The broader exposure of ASEAN economies to BRI-related investments in these sectors suggests that EU's CBAM may not only impact trade flows but also affect the longer-term strategic alignment of these economies with the BRI. The increased costs associated with carbon compliance could potentially undermine the economic benefits of BRI projects by eroding the price competitiveness of exports to major markets like the EU.

(II) *Impact of China's Green Investment on BRI Partners in ASEAN*

Since its launch in 2013, China's investment under BRI have become a key component of the global infrastructure landscape. However, these overseas investments have historically drawn criticism for funding coal plants and environmentally unsustainable projects. Between 2013 to 2022, approximately 70 percent of China's power sector investments in BRI countries were directed towards fossil fuel infrastructure. A notable shift happened in 2021, when China pledged to halt the building of new coal projects abroad and redirect efforts toward low-carbon infrastructure. This shift reflects China's growing commitment to global climate agreements and aligns with the world's push for net-zero emissions. As the world pivots towards clean energy, China is well-positioned to play a key role in financing and building renewable energy projects across Asia, Africa, and beyond.

As shown in Table 1 (column 3), Lao PDR, Vietnam and Eurasian countries receive more BRI investment from China relative to their GDP due to their relatively large shares of power generation sector in the economy. The additional investment in the renewable sector leads to lower electricity prices and larger electricity output across BRI countries. By 2035, total electricity output in BRI countries (excluding China) increases by 1.1 percent compared to the baseline, with EU BRI countries (EU18) seeing the largest gain. Electricity prices are expected to decline by 0.1 percent in Lao PDR to 1.5 percent in EU18, while within ASEAN, Cambodia and Vietnam experience the largest price reductions of 0.8–1.0 percent.

Table 1. Simulated Impact of China's Green BRI Investment by 2035 (Change from the Baseline)

	BRI Investment over 2025-34		Electricity Output (%)	Electricity Price (%)	Renewable Electricity Output (%)	Share of Renewable in Power Mix (% Points)	Carbon Emission (mn ton CO2e)	Carbon Emission (%)	Carbon Contents Embodied in Exports to EU (%)	GDP (%)	Exports (%)
	(USD bn)	as % of 2023 GDP									
BRI Countries	**300.0**	**1.4**	**1.1**	**-0.9**	**123.9**	**6.7**	**-268.2**	**-1.7**	**-0.9**	**0.2**	**0.3**
ASEAN	**40.0**	**1.0**	**0.7**	**-0.5**	**53.9**	**3.6**	**-35.6**	**-1.1**	**-0.7**	**0.1**	**0.2**
Brunei	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*6.7*	*0.0*	*0.1*	*0.1*	*-0.1*	*-0.1*
Cambodia	*0.3*	*0.9*	*1.2*	*-1.0*	*90.4*	*2.3*	*-0.9*	*-2.6*	*-1.1*	*0.2*	*0.1*
Indonesia	*4.6*	*0.3*	*0.3*	*-0.3*	*470.9*	*1.8*	*-7.3*	*-0.6*	*-0.5*	*0.0*	*0.1*
Lao PDR	*0.5*	*3.6*	*0.6*	*-0.1*	*579.2*	*3.0*	*-0.1*	*-0.2*	*-0.3*	*0.2*	*0.3*
Malaysia	*3.0*	*0.6*	*0.5*	*-0.4*	*160.7*	*3.4*	*-5.6*	*-1.2*	*-0.9*	*0.1*	*0.1*
Philippines	*3.5*	*0.8*	*0.6*	*-0.5*	*85.7*	*2.4*	*-7.6*	*-1.9*	*-1.3*	*0.1*	*0.2*
Singapore	*1.9*	*0.4*	*0.4*	*-0.3*	*73.4*	*6.4*	*-0.3*	*-0.2*	*-0.4*	*0.0*	*0.1*
Thailand	*7.3*	*1.3*	*0.9*	*-0.7*	*151.2*	*3.9*	*-6.0*	*-1.3*	*-1.0*	*0.2*	*0.2*
Vietnam	*18.0*	*3.8*	*1.0*	*-0.8*	*25.2*	*5.4*	*-7.6*	*-1.3*	*-0.8*	*0.3*	*0.4*
Myanmar	*0.6*	*1.0*	*0.4*	*-0.5*	*297.4*	*3.9*	*-0.4*	*-0.7*	*-0.3*	*0.0*	*-0.1*
South Asia[1]	**9.9**	**1.9**	**0.7**	**-0.6**	**138.8**	**5.3**	**-16.3**	**-1.7**	**-1.3**	**0.2**	**0.5**
MENA[2]	**73.9**	**1.2**	**1.0**	**-0.8**	**122.5**	**8.4**	**-95.9**	**-1.9**	**-1.2**	**0.3**	**0.4**
Eurasia[3]	**60.2**	**2.2**	**1.1**	**-0.8**	**369.3**	**14.8**	**-43.3**	**-1.5**	**-1.1**	**0.2**	**0.3**
EU18[4]	**49.8**	**1.6**	**1.7**	**-1.3**	**115.6**	**9.1**	**-7.5**	**-1.0**	**-0.9**	**0.2**	**0.2**
OBRI[5]	**66.4**	**1.4**	**1.6**	**-1.3**	**115.1**	**6.7**	**-69.5**	**-2.5**	**-2.3**	**0.2**	**0.3**
World							**-254.4**	**-0.6**		**0.0**	**0.0**

Source: AMRO staff

Notes:

[1] Afghanistan, Bangladesh, Bhutan, Maldives, Nepal, Pakistan, Sri Lanka.

[2] Bahrain, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, Yemen, Algeria, Egypt, Morocco, Tunisia

[3] Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan.

[4] Austria, Albania, Bulgaria, Cyprus, Czech, Croatia, Estonia, Greece, Hungary, Latvia, Lithuania, Luxembourg, Malta, Poland, Portugal, Romania, Slovakia, Slovenia

[5] Mongolia, Timor-Lester, Bosnia and Herzegovina, Macedonia, Moldova, Montenegro, Serbia, and all BRI members in Africa and Latin America.

More pronounced changes happen in the power mix. The output of renewable electricity in all BRI countries is expected to more than double in 2035 compared to the baseline. Countries with smaller initial renewable sectors, such as Indonesia, Lao PDR and Eurasia, see renewable generation expand by nearly five to seven times. In contrast, Vietnam, with the largest renewable capacity in ASEAN, sees a moderate expansion of 25 percent, the smallest increase among the modeled BRI regions. The additional renewable generation crowds out other electricity sources and leads to a rebalancing of the overall power mix. The share of renewable in total electricity production in BRI countries as a whole rises by 6.7 percentage points by 2035, increasing from 5.6 percent in the baseline to 12.3 percent in the BRI scenario. For ASEAN, the renewable share increases more modestly by 3.6 percentage points, from 6.9 percent in the baseline to 10.5 percent in the BRI scenario.

China's green BRI investment is estimated to reduces global annual carbon emissions by 254 MMT of CO2e by 2035. Emissions from BRI countries are expected to decline by 268 MMT of CO2e, while emission in the rest of the world increase slightly, partly offsetting the carbon mitigation efforts of BRI. This reflects an increase in their use of fossil fuels driven by a decline in global fossil fuel prices, which are depressed by weaker demand in BRI economies. In ASEAN, carbon emissions are expected to decrease by 36 MMT of CO2e in 2035, or 1.1 percent of the baseline level. Cambodia and the Philippines experience large reductions in carbon emissions in relative term, because the share of coal generation within their electricity mix drops more sharply and electricity sector contributes a major portion to their countries' total carbon emission. Outside ASEAN, MENA BRI countries (MENA) and the rest BRI countries (OBRI) also experience the largest relative reductions in carbon emission.

With cleaner electricity as an input, the carbon contents embodied in the products of BRI counties decline. Column 8 of Table 1 presents the change of carbon content of the exports from BRI countries to the EU. In ASEAN, the reduction in carbon content is less than 1 percent, except for the Philippine and Cambodia, which exhibit larger reductions in the carbon intensity of their economies. The carbon content of exports from OBRI decreases by as much as 2.3 percent, reflecting its relatively large reduction in carbon intensity and more carbon-intensive export structure. These modest reductions in carbon contents suggest that, even with substantial green BRI investment and significant increases in renewable generation capacity, BRI countries are unlikely to meaningfully reduce their exposures to the EU's CBAM.

As the green BRI investment generally accounts for less than 0.5 percent of BRI countries' GDP annually, their macroeconomic impact is minimal. By 2035, real GDP of BRI countries increase slightly by 0.0–0.3 percent compared to the baseline because of the increased investment, with the largest relative income gains seen in Vietnam and MENA. Overall, the real GDP of all BRI countries increase by 0.1 percent and exports increase by 0.2 percent.

IV. Policy Responses in China and BRI Partners in ASEAN in Managing the Challenges and Spillovers

China faces significant physical risks from climate change. According to a study by the ADB (2020), in the worst-case scenario, the average temperature in China can rise by as much as 2.5 degrees Celsius by 2050. This would result in more severe heat waves, especially in megacities, with substantial impact on human health, productivity, and overall economic growth. Moreover, extreme weather events such as floods and draughts will become more frequent and severe, leading to significant damage to infrastructure and livelihoods.

However, China's commitment to achieving net zero emissions by 2060 can bring many opportunities for transforming its economy. Transitioning to a sustainable, low-carbon economy can spur economic growth by developing new value chains in sectors like renewable energy, energy-efficient technology, and high-value manufacturing. For instance, the promotion of green investment in clean energy technologies is expected to reduce China's dependence on fossil fuels, boost productivity, and create high(er)-skill job opportunities.

At the same time, China faces many challenges in the transition. Decarbonization is costly, especially given its reliance on primary sources of energy. Thus, incentivizing private sector investment in green technologies remains critical. Here, the government plays a crucial role. China's 1+N strategy for decarbonization combines a "command-and-control" approach with market mechanisms. The 1+N policy framework refers to one unified long-term goal to combat climate change and multiple solutions or action plans to be rolled out for various sectors and areas in the country. This strategy is suitable for a big and diverse country like China. It allows the government to set a clear national objective and still leave room for market forces to produce efficient solutions. The introduction of carbon barriers such as the ETS to internalize the social cost of carbon emissions is a positive development. China's ETS scheme, established in 2021, is an initiative to create financial incentives for firms to cut emissions. However, further improvements are needed to enhance its effectiveness, such as expanding its scope to more sectors and increasing market liquidity. Also, given the diversity across regions in such a vast country, the solutions or pace of transition will have to differ across areas or sectors. Businesses and consumers must be educated so that they understand the urgency and importance of decarbonization.

Carbon barriers like the EU's CBAM highlight the need for China and other exporting nations to align their production processes with global climate goals. The introduction of CBAM has implications for carbon-intensive sectors, especially those linked to China's BRI investments, which span infrastructure, energy, and heavy manufacturing across ASEAN. The presence of such carbon barriers can either act as a catalyst for green investment or pose a threat to the competitiveness of sectors that fail to decarbonize rapidly. To support this transition, ASEAN policymakers are increasingly focused on scaling up green finance through measures such as public guarantees for climate-related loans, public-private partnerships for emerging technology projects, and promoting green credit policies. Regional cooperation, such as establishing a unified carbon trading platform, can enhance ASEAN's ability to meet its climate commitments while driving investment in sustainable infrastructure.

In addition, China has recognized the importance of green investment to support its energy transition. The country is channeling resources into renewable energy projects, electric vehicles, and energy efficiency improvements (China Briefing, 2024). By incentivizing private sector investment in sustainable technologies, China aims to reduce its dependency on fossil fuels while sustaining economic growth. However, ensuring a smooth transition is challenging due to the high upfront costs of decarbonization and the need to balance immediate economic growth with long-term sustainability goals.

ASEAN economies, particularly those actively involved in BRI projects, are similarly grappling with the need to adapt to global climate policies. Countries like Malaysia and Thailand are well placed to leverage their established manufacturing sectors to invest in greener production processes, while resource-rich nations such as Indonesia and Vietnam are focusing on tapping into their potential for renewable energy. The shift towards a low-carbon future presents an opportunity for ASEAN countries to diversify their economic bases, particularly in areas such as green manufacturing and climate-friendly infrastructure (Lau, 2024; Asia Society, 2024). Those with surplus renewable energy generation capacity and/or massive carbon storage resources, as well as first-movers in clean energy technologies such as hydrogen, will find new markets and sources of growth as global demand for these goods and services is poised to substantially increase. Comprehensive and well-considered policies are needed. Macroeconomic and financial policies – such as economy-wide carbon pricing, providing public guarantees for mitigation-related loans, speeding up private–public partnerships for emerging technology projects, and promoting climate finance through green credit policies— can contribute to the transition by creating the right conditions and incentives.

All policy levers must be pulled, and strong regional cooperation can lead to breakthroughs. Fiscal and economic policymaking can play a role through climate-informed public expenditure and use of climate fiscal tools such as carbon taxes and ETS. Monetary and financial regulations can play a role by strengthening the ability of the financial system to mobilize funds for green and low-carbon investments while managing climate-related risks. Technological innovation is important but expensive. Government-funded and directed research could help to create new technologies. Green finance is important. ASEAN+3 policymakers, state-owned enterprises, and financial institutions should come together to drive and finance green projects. Regional cooperation can lead to breakthroughs. For example: (i) building a regional carbon / emissions trading platform can benefit countries at different stages of economic development, with different degrees of carbon intensity, with different technological capacities, and with different fiscal and monetary policy space.; (ii) strengthening the regional financial safety net (RFSN) can enable countries to tackle climate change more forcefully and boost countries' capacity to bring about needed sectoral shifts in their respective economies and can support countries in mobilizing the funds needed for large scale green investment; (iii) technical assistance by more advanced countries to less advanced ones can help to bring about regional convergence in climate action.

V. Conclusion

The findings of this study highlight the multifaceted impact of the EU's CBAM on ASEAN economies, particularly those deeply engaged in the BRI. While the initial scope of CBAM may result in limited aggregate effects on ASEAN's exports, a full-coverage implementation could significantly affect key carbon-intensive sectors such as iron, steel, and aluminum, undermining their competitiveness in global markets. The compliance costs associated with CBAM underscore the urgency for ASEAN economies to transition toward greener production practices and align with global climate standards to maintain their trade and economic positions. China's leadership in advancing green investments under the BRI offers an important avenue for addressing these challenges. By channeling resources into renewable energy projects and low-carbon infrastructure, China's initiatives could support ASEAN countries in diversifying their energy mix and reducing carbon intensity. These efforts align with the global climate agenda and present opportunities for ASEAN to leverage green technologies to drive sustainable economic growth. However, realizing these opportunities require concerted policy actions at both national and regional levels. ASEAN economies must enhance regulatory frameworks, incentivize green investments, and adopt carbon pricing mechanisms to ease the transition to a low-carbon future. Regional cooperation, including the establishment of unified carbon trading platforms and sharing best practices, will be essential for managing spillovers and ensuring a coordinated response to global climate policies. The interplay between CBAM and green investment trends underscores the need for ASEAN to proactively adapt to the evolving trade and environmental landscape. By integrating sustainable practices into BRI projects and leveraging China's green transition efforts, ASEAN can mitigate the risks posed by carbon regulations while fostering long-term economic resilience and sustainability. Policymakers must prioritize strategies that balance economic growth with environmental objectives to ensure that ASEAN remains competitive and aligned with global sustainability goals.

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