LIFE COASE

Impacts and evolution of emissions trading systems: insights from research and regulation

Report from the Net Zero Carbon Market Policy Dialogue 2023

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Executive Summary

The first Net Zero Carbon Market Policy Dialogue (NZCMPD) held on 21 September 2023 took stock of the current state of play of carbon markets and initiated discussions on their economic and social implications.

As of April 2023, 73 carbon taxes and Emissions Trading Systems (ETSs) are in operation, covering approximately 23% of global GHG emissions.

Compliance and voluntary carbon markets are two distinct carbon pricing mechanisms characterised by different design features, such as permit types, sectoral coverage, and monitoring methods. The integration potential between different types of carbon pricing mechanisms largely depends on these specificities.

Few linkages exist between compliance markets due to their heterogeneous design and worries that linking would increase regulatory uncertainty and negatively impact the robustness of each system. There is also caution about linking compliance with voluntary carbon markets, because of concerns about environmental integrity, additionality, and monitoring, reporting and verification issues connected with the latter. However, developments in relation to Article 6 of the Paris Agreement, which provides for Internationally Traded Mitigation Outcomes (ITMOs), may accelerate such linkage.

Models can be useful to gain ex-ante insights into the potential social and economic impacts of carbon pricing. As such, they can highlight relevant policy designs for regulators. The models compared in this NZCMPD show considerable heterogeneity, mainly due to the various foci and aims of the studies contextualizing each model. Among others, a shared feature across all models is the use of Marginal Abatement Cost Curves (MACCs). Different assumptions, especially regarding the discount rate applied, greatly affect predicted prices of technology MACCs.

Across the scopes of models studied, there is little agreement on the carbon price levels necessary to reaching net-zero emissions. Further work is required to understand the causes of this divergence. The integration of limited foresight and capturing carbon leakage also appear as two research areas to be implemented in future models.

Assessing the effects of carbon pricing is increasingly centered on examining its distributional impacts (both between and within different income groups), and its effects on industrial competitiveness.

The distributional impacts are highly dependent on the use of carbon pricing revenues. Judicious use of these revenues can make carbon pricing progressive overall, though it can be challenging to target some adversely affected households and industries effectively. Both the actual and the perceived distributional impacts play an important role for the social acceptability of carbon pricing mechanisms. Hence, improved communication on the functioning and impacts of carbon pricing is crucial to its success.

There is little evidence of substantial losses of competitiveness, or associated carbon leakage being reported across the ex-post assessment literature so far. The issue remains of major concern and further research is necessary to better evaluate the potential carbon leakage in the context of rising carbon prices.

The progressive implementation of the European Union's Carbon Border Adjustment Mechanism (CBAM), which started in October 2023, is also affecting the political landscape of carbon pricing. This policy is sending a strong message to other jurisdictions and an increase in the uptake of carbon pricing policies is expected across the globe. However, CBAM alone will not be enough to ensure the decarbonisation of hard-to-abate industries. Complementary industrial policy packages to support innovation in the development and implementation of low carbon technology will also be key to support the transition to net-zero emissions.

1. Introduction

In the context of the LIFE COASE project,[1] the first NZCMPD took place on 21 September 2023. This Policy Dialogue is held yearly to discuss the latest developments and challenges faced by carbon markets across the world related to net-zero targets. This event brings together ETS regulators, researchers, policymakers and other stakeholders of major ETSs. This year's edition focused on the competitiveness effects, carbon leakage, distributional effects, and social implications of emissions trading.

To inform the different sessions of the NZCMPD, a background report was shared with the participants ahead of the event[2]. The present document synthesises both the background report and key points which emerged from the Policy Dialogue. The first chapter gives an overview of existing carbon pricing mechanisms and outlines the trends of carbon markets in 2023. The second chapter compares ex-ante permit trading models, and the third chapter summarises insights gained from assessing the ex-post impacts of emissions trading. The second and third chapter both build upon a workshop and a conference held on 5 June 2023 and 20 June 2023, respectively.

Monitoring the progress of carbon pricing mechanisms has gained significance due to the proliferation of such systems over the world. As one of the oldest systems in place, the EU ETS is approaching what some have called its "endgame" (Pahle et al, 2023). Examining the potential for connections with other systems is timely and relevant as integration could result in price convergence, thereby mitigating the risk of carbon leakage across the linked jurisdictions. The inclusion of offsets in compliance carbon pricing systems is also being discussed in policy debates as a potential avenue to expand the lifetime of ETSs in the future. Additionally, voluntary carbon credits may be needed to offset remaining emissions of hard-to-abate sectors.

Apart from documenting the policy landscape evolution of ETSs, the scientific evaluation of the effects of the different systems in place is fundamental. Research providing ex-ante assessments can inform policymakers of the potential implications of certain policy designs. Ex-ante models are rarely compared, whether on their assumptions, results or aims. This could however broaden the scope of knowledge and build a strong community of researchers. Ex-post studies inform of the impacts of the already existing policies. Pooling the results from different ex-post assessments is essential to report on the performance of implemented policies and feed the learning-by-doing process.

2. State-of-play in international carbon markets

2.1. Introduction

The global carbon pricing landscape has become increasingly complex over the years. The World Bank (2023) finds that as of April 2023 there were 73 carbon taxes and ETSs in operation, covering approximately 23% of global GHG emissions. These compliance instruments provide an explicit price signal to incentivize GHG emissions reductions. They also interact with other direct (e.g., the EU's CBAM) and indirect (e.g., fuel excise taxes) carbon pricing instruments. Some of them feature flexibility mechanisms utilizing carbon credits issued by crediting mechanisms which are also suppliers in voluntary

1 LIFE COASE – Collaborative Observatory for the ASsessment of the EU ETS – is a project co-funded by the EU Life Programme of the European Union. More information: https://lifecoase.eui.eu

2 The background document was composed of three independent chapters reflecting the insights collected by external collaborators of the project.

carbon markets (VCMs). Against this backdrop, the assessment of the level of integration of the global carbon market, a key aim of this annual report, requires the specification of certain carbon market concepts and interactions. For the purposes of this report, the global carbon market consists of both compliance markets for allowances and VCMs and markets for credits where “allowances to emit” and “carbon credits to offset” emissions are traded. The focus of the report is on compliance markets and links between them. Crediting mechanisms and VCMs feature in the report only to the extent that they interact with compliance markets.

The defining feature of a compliance market is that covered entities are required to obtain and surrender allowances or eligible credits (sometimes referred to as “offsets” or “offset credits”) against their regulated emissions.[3] This definition captures a broad range of instruments including ETSs with fixed, i.e., predetermined, caps (e.g. EU ETS; California Cap-and-Trade program) and systems where the overall cap on emissions depends on the level of economic activity and may not be known in advance (e.g. China ETS; federal and provincial Output-Based Pricing System (OBPS) in Canada). The compliance units are primarily government-issued allowances, but some systems also allow the use of credits issued by crediting mechanisms. Other types of compliance markets include baseline-and-credit (e.g., Alberta Technology Innovation and Emissions Reduction (TIER) Regulation in Canada; Saitama ETS in Japan) or baseline-and-offset systems (e.g., CORSIA for international aviation) where surrender obligations of covered entities are assessed against an individual baseline. The compliance units which can be used in these markets are credits awarded to overachieving entities by the government in the former, and eligible credits issued by approved crediting mechanisms in the latter. In all cases, the government plays a central role by creating the demand for the compliance units by requiring regulated entities to surrender allowances or credits against their emissions and hence creating the demand for the compliance units.

Carbon credits offer an additional avenue to achieve net-zero goals of various government and private actors. They can reduce compliance obligations under carbon pricing instruments, as mentioned above, or offset hard- or impossible-to-abate GHG emissions in sectors that are not covered by them. They also provide a source of finance for mitigation activities that are outside the scope of compliance markets, particularly in the developing world and in the near term. The market for credits is where buyers and sellers trade credits issued by domestic, international or independent crediting mechanisms. These credits are generated in projects that meet certain requirements imposed by the governments or the crediting mechanisms. The market for credits simultaneously serves both compliance demand for eligible credits in compliance carbon markets and voluntary demands in VCMs, creating an important connection between compliance markets and VCM markets for offset credits. The defining features of VCMs are that buyers purchase credits voluntarily rather than to meet a regulatory requirement and that supply is driven by crediting mechanisms rather than the government.

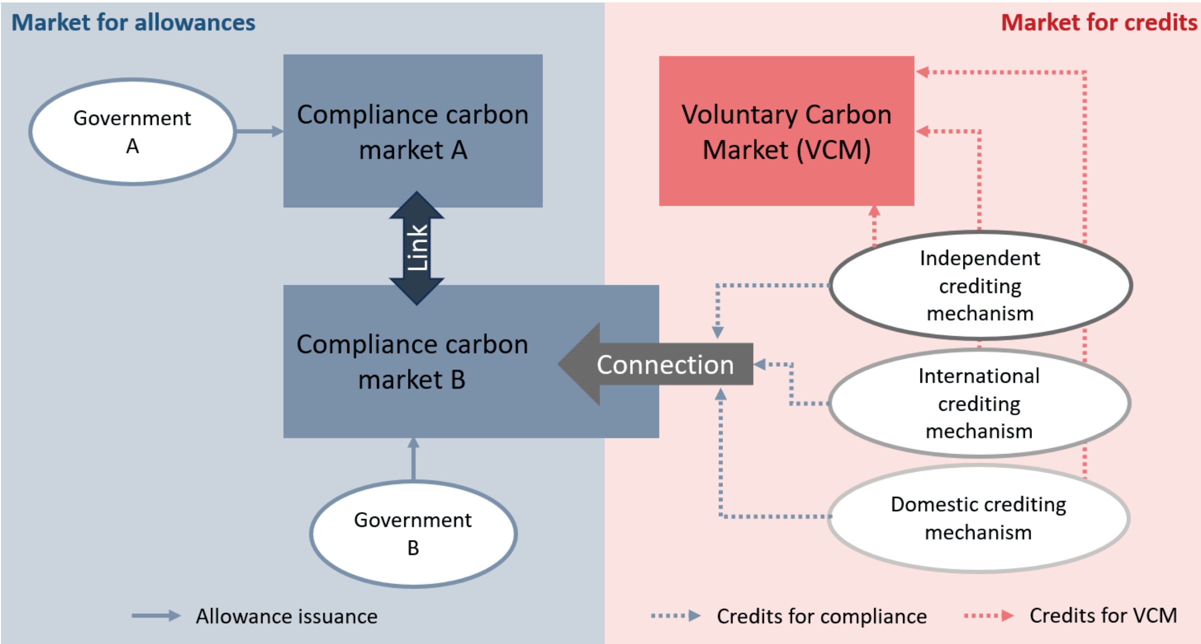
Against this backdrop, the current report uses the description of compliance markets, markets for credits and VCMs to define linking as the possibility to trade compliance units between two or more compliance markets. Specifically, if regulated entities in one compliance market can use compliance units accepted by the regulator in another, then the two markets are linked (e.g., the link between the EU and Swiss ETSs or that between California and Québec).[4] Interactions between compliance markets and markets

3 Taken together allowances and eligible carbon credits are known as “compliance units”. Eligible carbon credits are sometimes called “offsets” or “offset credits” and the qualifiers eligible and carbon are frequently omitted. The term compliance market can refer to ETSs, cap-and-trade programs, baseline-and-credit systems, tradable performance standards etc. and there is no established taxonomy. Occasionally, the term carbon market is used to refer to a compliance market.

4 Note that linking agreements may explicitly allow the use of credits deemed eligible by the partner regulator.

for credits are referred to as connections. This could involve connections with domestic, international or independent crediting mechanisms. For example, there was a connection between the EU ETS and the Clean Development Mechanism (CDM) when credits issued by the CDM were accepted under certain restrictions. A new international crediting mechanism under Article 6 of the Paris Agreement is currently being set up as the successor to the CDM and may in the future be an important foundation for future connections. Figure 2.1 illustrates the different concepts related to carbon markets defined and used in this report.

Figure 2.1: Overview of carbon market-related concepts



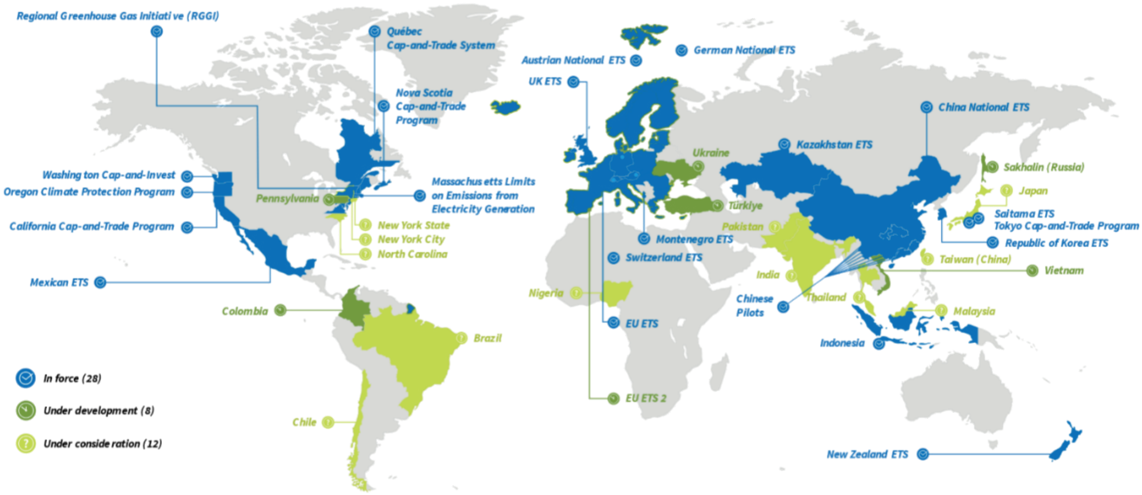
In this context, we consider that the global carbon market becomes more integrated when a greater number of links and/or connections enable a greater volume of transactions in allowances and credits between and among compliance markets and markets for credits. It is important to note that both links and connections can be domestic or international.

The rest of this chapter is organized as follows. Section 2.2 reviews developments in compliance markets while Section 2.3 focuses on markets for credits. Section 2.4 assesses the state of play in systems which are already linked and where future links may emerge. Section 2.5 concludes this chapter.

2.2. Review of compliance markets internationally

The diffusion of compliance markets worldwide, particularly ETSs, is developing dynamically. The number of ETSs in force has steadily increased from 13 systems in 2013 to 28 systems in 2023 (ICAP 2023). This includes ETSs at regional, national, and subnational level (see Figure 2.2). Together these systems cover more than 17% of global GHG emissions at present (ICAP 2023). In 2022, they generated over USD 63 billion in revenues (ICAP 2023). The latest additions include ETSs in Austria (October 2022), Washington (January 2023), and Indonesia (February 2023).

Figure 2.2: Status of ETSs worldwide (ICAP 2023)



The ETSs in force differ considerably in how they approach regulating emissions. While each system has its unique design features, we can group them into five rough types. The US Regional Greenhouse Gas Initiative (RGGI), the Massachusetts Limits on Emissions from Electricity Generators, the China national ETS, and the Indonesian ETS cover only the energy sector (electricity and/or heat). These systems can be designed to have a narrow scope or be intended to expand their scope over time. The ETSs in the European Union[5], Kazakhstan, Mexico, Montenegro, Switzerland, and the United Kingdom as well as most of the Chinese pilot ETSs[6] regulate big direct emitters and hence cover electricity and heat generation, industry, and/or aviation. These two types focus on regulating point-source emissions. The subnational systems in Beijing, Saitama, Shanghai, Shenzhen, and Tokyo take a slightly different approach. They regulate big emitters in the industry, buildings, and/or transport sectors, covering both direct emissions from point sources and indirect emissions from electricity and heat downstream. The Austrian and German systems focus on smaller emitters, mainly in the buildings and transport sector and/or small industry, regulating fuel distributors upstream. The last type includes comprehensive ETSs that cover a broad range of sectors. The systems in California, New Zealand, Nova Scotia, Oregon, Québec, the Republic of Korea, and Washington fall into this category.

Table 2.1 presents an overview of the ETSs in force and their respective type while Figure 2.3 illustrates the sector coverage of individual systems. The percentage values in the outer ring indicate the share of jurisdictions' aggregate emissions covered by the system and the small, encircled arrows identify sectors with upstream coverage.[7]

5 In 2023 the creation of the EU ETS2 extended the ETS coverage in the EU to fuel combustion emissions from transport, buildings and some small industry through upstream regulation of fuel suppliers, see https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/ets-2-buildings-road-transport-and-additional-sectors_en.

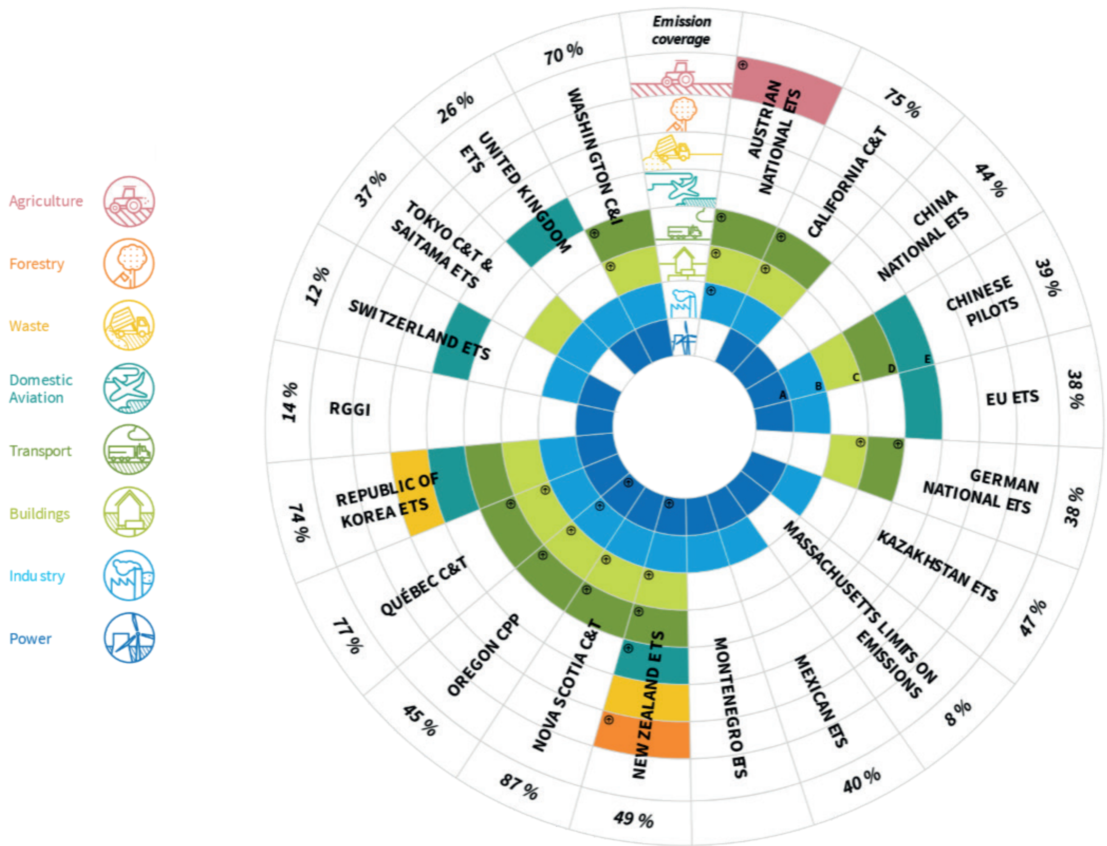
6 Chongqing, Fujian, Guangdong, Hubei, Tianjin

7 See ICAP (2023) for additional notes regarding this infographic.

Table 2.1: Overview of ETSs in force by type

Point source ETS for electricity and heat	Point source regulation of big emitters	Point source and downstream regulation of big emitters	Upstream regulation of small emitters	Comprehensive ETSs
RGGI	European Union	Beijing	Austria	California
Massachusetts	Kazakhstan	Saitama	Germany	New Zealand
China national	Mexico	Shanghai		Nova Scotia
Indonesia	Montenegro	Shenzhen		Oregon
	Switzerland	Tokyo		Québec
	United Kingdom			Republic of Korea
	Most Chinese pilots			Washington

Figure 2.3: Sectoral coverage of ETSs in force (ICAP 2023)



The potential for ETS linking is particularly big within each of these five types as the scope and regulatory framework will likely be more similar. Section 2.4 discusses linking developments and the outlook for compliance markets in detail.

Eight ETSs are currently under development. This concerns jurisdictions in which a clear decision has been made, in the form of a law for example, to implement an ETS and authorities are in the process of developing regulation and infrastructure for the ETS. This is the case in Colombia, New York State, Pennsylvania, Sakhalin, Türkiye, Ukraine, and Vietnam. As noted in a footnote above, the European Union has developed a second ETS that will cover buildings, transport and small industry and regulate fuel distributors. This system will follow an upstream approach. Eleven other jurisdictions have publicly signalled that they are considering the introduction of an ETS. These jurisdictions are Brazil, Chile, India, Japan, Malaysia, New York City, Nigeria, Pakistan, Taiwan, and Thailand. These systems, which are at different stages of development, are also included in Figure 2.2 (ICAP, 2023).

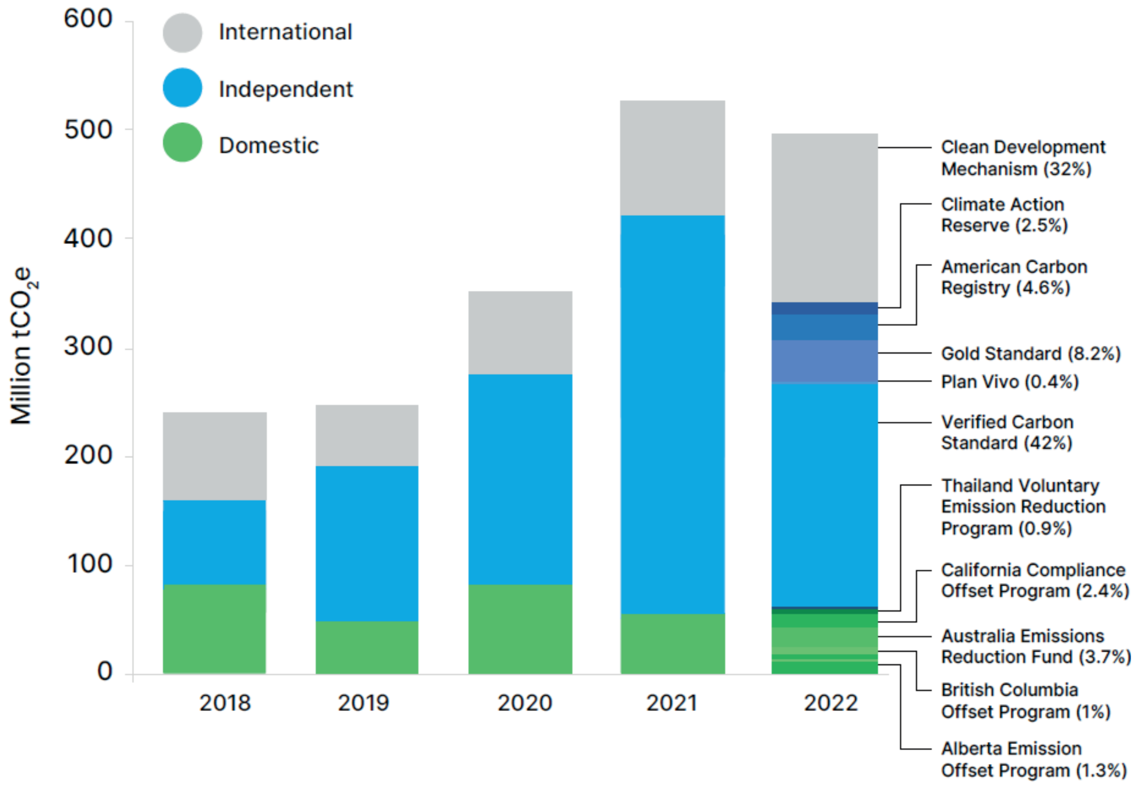
2.3. Review of markets for credits

Credits for emission reductions and removals can be used to meet compliance obligations of regulated entities under carbon pricing instruments. Indeed, many of the compliance markets mentioned in the previous sections allow credits to be used as offsets, albeit often with strict limits. Credits can also be used by governments to achieve Nationally Determined Contributions (NDCs) or by various public and private actors to set against formal or informal net-zero commitments. To serve demand from these various sources and create a source of financing for mitigation and adaptation activities, there is a large and growing number of (sub)national crediting mechanisms with many more under development, particularly in developing countries, as well as international mechanisms created under multilateral treaties such as the CDM, and independent mechanisms including, among others, the Verified Carbon Standard (Verra) and Gold Standard.[8]

After growing rapidly in 2020 and 2021, credit issuance declined slightly in 2022 (see Figure 2.4). The World Bank (2023) cites three contributing factors to this decline: the challenging macroeconomic conditions; public scepticism around the issuance of low-quality credits, particularly in the forestry sector; and the absence of commonly accepted guidance on best-practice use of credits to support net-zero claims by public and private actors. The issuance of almost 500 million tCO_2e worth of credits in 2022 was largely dominated by independent and international crediting mechanisms which together accounted for 58% and 32% of this volume, respectively. While the 2022 volume is double the number of credits issued in 2018, it continues to be relatively small compared to the current volume of allowances being issued in compliance markets. The International Carbon Action Partnership (ICAP), which tracks the caps of ETSs over time, estimates the volume of allowance issuance to be around 9 billion tCO_2e which implies that the issuance in markets for credits is only 6% of allowance issuance in the same year (ICAP, 2023).

8 See Figure 12 in World Bank (2023) for an overview of national and subnational jurisdictions where crediting mechanisms are currently implemented or under development, noting that it largely overlaps with Figure 2.2 of jurisdictions with a compliance market.

Figure 2.4: Global volume of issuances by crediting mechanism type, 2018—2022 (World Bank, 2023)



Based on data from Ecosystem Marketplace and various government sources which track the use of credits for compliance purposes, the World Bank (2023) concludes that the demand side of the market for credits is dominated by voluntary retirements to support private entities' net-zero or similar claims. Just over 43 million credits were retired in 2022 to meet obligations under domestic compliance programs including both compliance markets and carbon taxes.[9] Considering the fact that several large European systems including the EU, UK and German National ETSs do not allow offset credits and those which do place severe restrictions on it, it is not surprising that this figure is small relative to the surrender volume of allowances, which in the EU ETS alone was equal to 1.2 billion in 2022.[10]

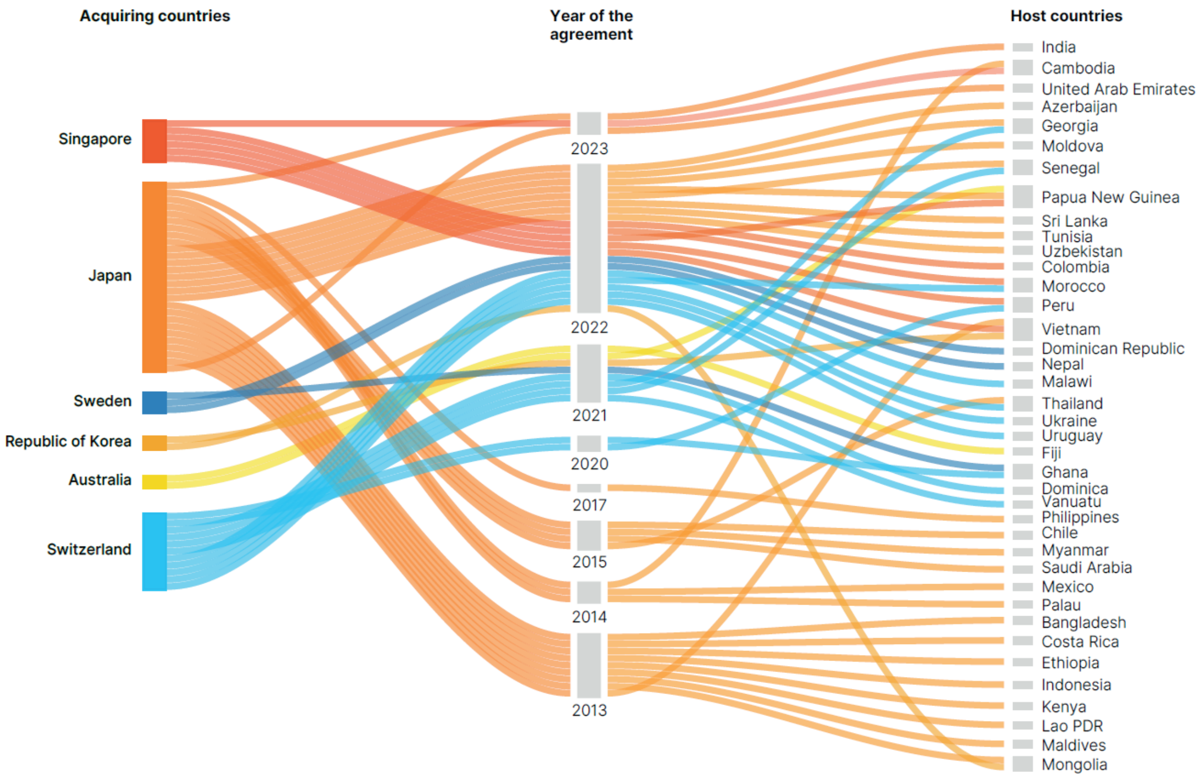
There is, however, reason to expect important changes in the market for credits in the coming years, both on the supply and demand side. First, several new domestic compliance markets come into force with plans in place to develop and use domestic crediting mechanisms to feed these compliance markets (e.g., Vietnam and Türkiye). Second, credit demand by airlines regulated under CORSIA is set to increase with the scheme moving into its first phase in 2024 (voluntary) and second one in 2027 (mandatory). Third, the number of bilateral agreements under Article 6.2 of the Paris Agreement to exchange credits is increasing. These so-called Internationally Traded Mitigation Outcomes (ITMOs) refer to the exchange of bilateral mitigation outcomes and can be counted towards nationally determined contributions (NDCs). Singapore, Japan and Switzerland are the leading acquiring countries with Vietnam and Papua New Guinea, among many others, acting as the host countries for Article 6.2 pilots (see Fig-

9 The China national ETS and a few Chinese pilots permit the use of Chinese Certified Emissions Reductions (CCERs) and other eligible credits for compliance purposes, however there is no publicly available data on the extent of retirements for compliance purposes in China. This suggests that the figure quoted in the main text is probably an underestimation. Note that China's GHG Voluntary Emission Reduction Program which generates CCERs was suspended in 2017 but had generated 53 million credits since its inception in 2012.

10 See Dibattista et al. (2023) on the recent trends in VCM, with particular focus on nature-based solutions.

ure 2.5).[11] Fourth, since the adoption of the Article 6 rulebook in COP26 in Glasgow in 2021, progress has been made on the details of the international crediting mechanism for the validation, verification and issuance of high-quality carbon credits established under Article 6.4 of the Paris Agreement. Although the adoption of a methodology for implementing the mechanism has been deferred by a year at COP28, the anticipated key functions are as follows. In the future, credits issued by this mechanism can be used in compliance markets outside the host country (similar to how CDM credits were used in EU and New Zealand ETSs in the past), international compliance markets like CORSIA and for NDC achievement. These use cases require that the host country for the credit-generating projects authorizes the credits so that corresponding adjustments are applied to the host and acquiring countries' NDCs. In addition to these ITMOs under Article 6.4, the mechanism can also issue so-called "mitigation contribution A6.4ERs" that do not require corresponding adjustments. These credits can be used for compliance with domestic carbon pricing instruments or to serve domestic voluntary demand in the host country. They can also form the basis of evaluation for international donors who wish to provide finance through results-based climate finance initiatives. Since the associated emissions reductions would only contribute to the host country's NDC, no corresponding adjustment would be necessary. Moreover, under the current rules the mitigation contribution A6.4ERs can also be sold to buyers outside the host country in VCMs, although there is no clarity yet on what claims the buyers may make since these units are not authorized by the host country governments and therefore do not have corresponding adjustments.

Figure 2.5: Article 6.2 bilateral agreements as of April 1, 2023 (World Bank, 2023)



First credits under the new Article 6.4 mechanism are expected to be issued in 2024, but the lack of consensus at COP28 concerning the operationalisation of the mechanism may lead to further delays. Important obstacles remain, which may increase delays before the market is fully functioning. These include the lack of a registry for tracking the credits; institutional and technical capacity constraints in host

11 Article 6.2 provides the accounting basis compliance unit transactions between linked compliance markets.

countries for participation in international markets; outstanding questions around the process for giving and revoking authorization; and slow progress on agreeing on the requirements for methodologies of Article 6.4 activities, particularly emissions removals. These topics were high on the agenda during the negotiations at the COP28 in the United Arab Emirates, but no agreement was reached regarding international carbon crediting, delaying the operationalisation of the mechanism for another year.

On balance these changes suggest that the number of links and connections as well as the volume of credits exchanged will pick up in the coming years. Using the terminology described in the introduction, there are encouraging signs for greater integration of global carbon markets, specifically for markets for credits via new connections. However, much work remains to be done to ensure that the institutional and technical infrastructure supporting integration is in place, particularly in developing countries.

2.4. Review of latest ETS linking developments

The global carbon market landscape includes several compliance markets which are currently linked:

- EU ETS and Swiss ETS since 2020;
- California and Québec Cap-and-Trade Programs since 2014;
- An evolving set of US states participating in the Regional Greenhouse Gas Initiative (RGGI) since 2009;
- Tokyo Cap-and-Trade Program and Saitama ETS since 2011.

This section reviews the developments in these links over the last few years and assesses the outlook for links that may take place in the future.[12]

As the oldest and one of the largest emissions trading systems in the world, the EU ETS has been at the centre of many important linking events since 2005. In recent years, the link with the Swiss ETS has worked well. The departure of the UK from the European Union in 2020, which resulted in the UK withdrawing from the EU ETS in 2021, was a major shock to which the linked systems proved resilient.

One important implication of the link between the Swiss and the EU systems is that the relevant goods produced by Swiss companies will be exempt from the EU's CBAM when reporting obligations begin in 2023, followed by compliance obligations to surrender CBAM certificates for emissions associated with imports following suit from 2026. This is an important benefit of the linking. It obviates the urge to intervene in order to level the playing field and address the perceived or real concerns of producers whose competitors are subject to regulation under different ETSs.[13] Given the flexibility that the EU-Swiss linking agreement provides, the Swiss government has decided not to introduce an equivalent border mechanism at least until 2026.[14] An additional and relatively minor technical development in relation to the operation of the link has been the increased frequency with which the distinct registries of the two systems are aligned to reflect allowance transactions, changing from twice monthly in 2022 to twice weekly in 2023.[15]

12 Table 9.1 in ICAP (2021) provides a more detailed account of the key linkage events between 2005 and 2021.

13 The topic of "competitiveness and carbon leakage" is a key theme of LIFE COASE and was explored in the "First International Conference on Ex-Post Evaluation of Emission Trading". See Chapter 3 of this report for a summary of the presentations and discussions that took place. See https://fsr.eui.eu/event/international-conference-on-ex-post-evaluation-of-emission-trading/ for further details.

14 The following press release by the Swiss Federal Council (in French) provides additional details: https://www.admin.ch/gov/fr/accueil/documentation/communiques.msg-id-95765.html

15 The following news article provides additional details on this change: https://climate.ec.europa.eu/news-your-voice/news/2023-arrangement-execution-transfers-between-emission-trading-registries-eu-and-switzerland-2022-11-29_en

Looking ahead, there are two tracks at the end of which future links to the EU ETS may become operational. First, the UK and EU may decide to link their ETSs. Since the UK ETS is modelled after the EU ETS and given the experience of UK regulated entities with the EU ETS, the technical hurdles to linking are relatively easy to overcome. Both jurisdictions have ambitious and comparable net-zero targets enshrined in law, making legal and economic hurdles relatively easy to tackle as well. The political will also appears to be in place as expressed in Article 392.6 of the EU-UK Trade and Cooperation Agreement of December 2020 stating "The Parties shall cooperate on carbon pricing. They shall give serious consideration to linking their respective carbon pricing systems in a way that preserves the integrity of these systems and provides for the possibility to increase their effectiveness."[16] The recent divergence between EU and UK allowances prices and divergent policy developments, are however making a future link more complicated.

Second, the EU decided to set up a separate ETS for buildings, road transport, and small industry, hereafter EU ETS2, to complement the (existing) EU ETS which covers energy, industry, aviation, and the maritime sectors. The EU ETS2 will start operations in 2027 or 2028, depending on energy price developments prevailing at the time. The flexible start date is an acknowledgement by the EU Commission of the social and political sensitivities around heating and transportation costs. These may have important ramifications for the public acceptability of the EU ETS2 and carbon pricing more broadly.[17] Similarly, one of the main reasons for a separate system is the high uncertainty regarding the price of allowances in the EU ETS2, particularly relative to the price of allowances in the EU ETS at the time. The EU Commission probably wanted to avoid this uncertainty creating price volatility in the EU ETS. However, the EU recognizes that a linked or integrated system would be more cost-efficient.[18] The reformed EU ETS Directive tasks the EU Commission to assess by October 2031 – once the EU ETS2 is fully established – the feasibility of integrating the sectors covered by the EU ETS2 into the EU ETS (European Union, 2023).

A related issue is the future of German and Austrian national ETSs. These two systems are already in force and broadly cover a very similar set of regulated entities to those which will be covered by the EU ETS2. Whether the two countries will opt-in different sectors to the EU ETS2 or continue operating separate or possibly linked systems to the EU ETS2 remains to be seen. The risk of potential double regulation will likely be an important consideration for the EU Commission and these member states when making their decisions.

The resilience of the link between the California and Québec cap-and-trade programs, similar to the link between the EU and Swiss ETSs, was tested by the departure of an important linking partner, Ontario, in 2018. With the aid of joint and individual workshops, both programs are in the process of evaluating potential amendments to the regulations that underpin their cap-and-trade programs as well as the link between them.[19] There will be further consultations on the topics which have significance for the linked system and where amendments will need to be considered jointly. These include cap setting towards

16 The full agreement text is available at https://commission.europa.eu/strategy-and-policy/relations-non-eu-countries/relations-united-kingdom/eu-uk-trade-and-cooperation-agreement_en

17 The topic of "Social impacts and acceptability of emission trading" is another key theme of LIFE COASE and was explored in the "First International Conference on Ex-Post Evaluation of Emission Trading". See Chapter 3 of this report for a summary of the presentations and discussions that took place. See https://fsr.eui.eu/event/international-conference-on-ex-post-evaluation-of-emission-trading/ for further details.

18 We suggest distinguishing between linking and integrating to account for the possibility that linking can also have restrictions, for example, on the direction or magnitude of allowance flows from one system to the other.

19 Additional details can be found at: https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program/cap-and-trade-meetings-workshops

carbon neutrality; price control and market oversight mechanisms; and the approach to offsets, Carbon Capture and Storage (CCS) and removal technologies. The jurisdictions are expected to publish draft regulations and documents for stakeholder feedback with the intention of adopting the amendments in summer 2024.

Both California and Québec participate in the Western Climate Initiative (WCI) that provides a regulatory framework for cooperation and implementation of compliance carbon markets. Another member jurisdiction of WCI is the US State of Washington, which launched its Cap-and-Invest Program in January 2023. The State has made a preliminary decision to pursue linking Washington's cap-and-invest carbon reduction program to those in California and Québec. The three jurisdictions will now begin discussing a linking agreement and the required revisions to program regulations. This process is expected to take at least a year during which further input from the public will be sought. Any eventual program linkage will therefore not happen before 2025.[20]

RGGI is the first compliance carbon market in the US. Having started operations in 2009 with linked emissions trading programs in 10 participating states, its membership evolved over time. New Jersey withdrew from the Initiative in 2011 and re-joined in 2020. Virginia joined the Initiative in 2021 becoming its 11th member. However, significant opposition to the State's participation in RGGI is ongoing and it may leave at the end of 2023.[21] Attempts in Pennsylvania and North Carolina to join have not been successful so far. In Pennsylvania, where the program was due to start in July 2023, the regulation underpinning RGGI is being challenged in courts and the State will not enforce it until the case is concluded.[22] The Senate in North Carolina approved legislation in May 2023 to prevent the State's participation in RGGI, ending a two-and-a-half-year quest by environmental groups pressuring the State to join RGGI.[23] These developments notwithstanding, the participating States are undertaking the third major review of the Model Rule informed by modelling results and input from stakeholders.[24] The review is expected to conclude in December 2023.

By the standards of its European and North American counterparts, the link between the two baseline-and-credit systems of Tokyo and Saitama in Japan has been functioning relatively uneventfully. The outlook for the linked system will be heavily influenced by the implementation of the GX Plan, a ten-year roadmap for carbon pricing adopted by Japan's Cabinet which includes initial arrangements for a mandatory ETS at the national level from 2026.

20 Additional details can be found at: https://ecology.wa.gov/blog/november-2023/stronger-together-the-promise-of-connecting-north-america-s-clean-energy-leaders

21 Additional details can be found at: https://icapcarbonaction.com/en/news/virginia-prepares-regulation-repeal-ets-and-withdraw-rggi

22 Additional details can be found at: https://icapcarbonaction.com/en/news/update-pennsylvania-court-enters-injunction-temporarily-halting-rggi-link

23 Additional details can be found at: https://icapcarbonaction.com/en/news/north-carolina-legislature-defeats-hope-joining-rggi

24 RGGI website defines the Model Rule as the "set of regulations that form the basis for each RGGI state's CO_2 Budget Trading Program." The current version of the model rule can be accessed at https://www.rggi.org/sites/default/files/Uploads/Design-Archive/Model-Rule/2017-Program-Review-Update/2017_Model_Rule_revised.pdf

3. Ex-Ante Modelling Assessments of Emissions Trading

3.1. Introduction

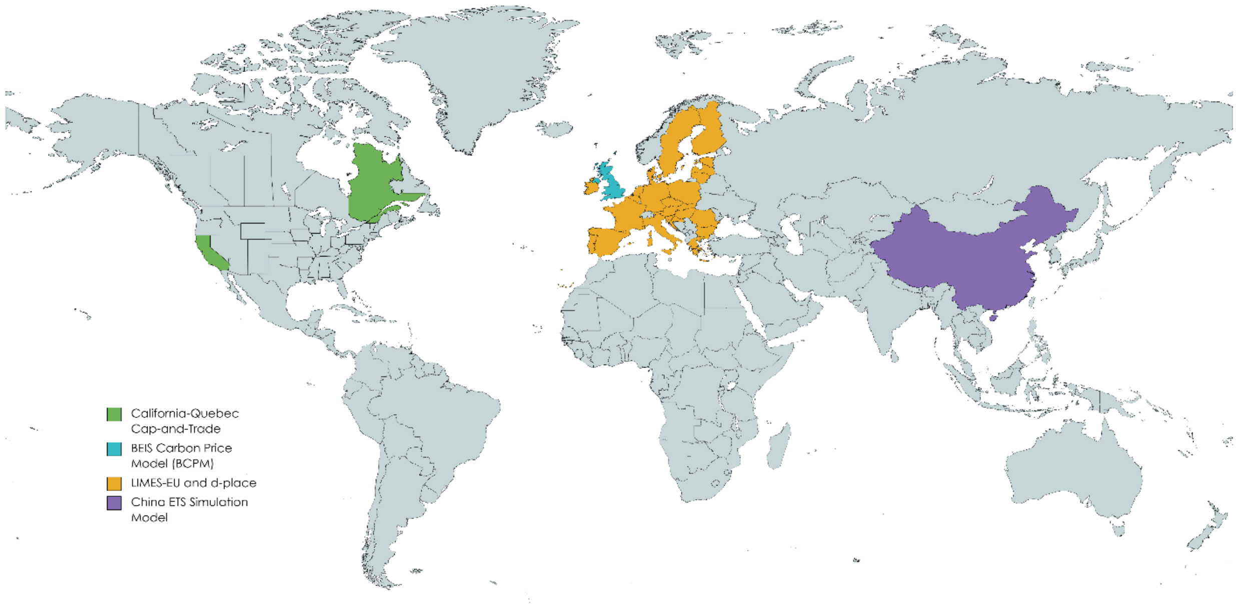
The first annual workshop on ex-ante assessment of emissions trading took place on Monday 5 June 2023.[25] This chapter presents the main takeaways and insights from this workshop.[26]

The workshop was devoted to the comparison of selected macro-economic models simulating the development of the EU ETS and other major emissions trading systems. It convened experts from five organisations that operate carbon market models – academic institutions as well as carbon market analysts. The regions covered by the carbon markets which they analyse are shown in Figure 3.1.

The workshop discussed the model types, implementation details, and core assumptions employed in the analysis of carbon prices from models around the world. More specifically, it took stock of the diversity of approaches, provided insights on the operation, and expected challenges of the respective carbon markets, and identified the main drivers affecting the price dynamics of carbon prices until the end of this decade and beyond. In preparation for the workshop, all participants took part in a survey and provided a short model fact sheet, information about future carbon prices, and an assessment of what they view as the main price drivers in 2030/2050, depending on the model focus.

At a time when emissions trading systems are increasing in number and face similar issues, only a few comparisons of ex-ante models exist. The goal of this workshop on the ex-ante assessment of emissions trading was to step up the benefits of knowledge sharing and mutual learning by collecting scientific evidence from different emissions trading systems worldwide.

Figure 3.1. Models presented or reviewed[27] at the workshop with their corresponding institutions and carbon markets covered



25 The programme and other details of the workshop may be found at https://fsr.eui.eu/event/workshop-on-ex-ante-assessments-of-emissions-trading/

26 A first version of the next two chapters, including the replies to a questionnaire sent beforehand to selected modellers, can be found in the following deliverable of the project LIFE COASE: https://fsr.eui.eu/wp-content/uploads/2023/10/Deliverable-5.1_Summaries-of-Workshop-and-Conference-2023.pdf

27 In the case of the EU ETS, the answers to the questionnaire for the models Refinitiv and ERMES were reviewed prior to the workshop although these models were not presented during the event.

3.2. The carbon market coverage of ex-ante models

The models presented during the workshop can be divided into those which focus on the EU ETS and those that study non-EU carbon markets, namely, the California and Québec Cap-and-Trade (C&T), China ETS and UK ETS. The five regions' emissions account for 17.4 $GtCO_2$, i.e., 46% of the world's total emissions. The range of emissions covered by each of the carbon markets by its jurisdiction vary between 28 and 74%, while the emissions covered altogether represent 17% of the world's total CO_2 emissions (ICAP, 2023).

The two models covering the EU were LIMES-EU and d-PLACE.[28] Despite the differences in their approach, both models have a very clear policy focus to assess the most recent reforms implemented by the European Commission, particularly those related to the EU Green Deal. The presentation of the d-PLACE model included an analysis of the potential impact of new sectors within the EU ETS, e.g., the option of having an ETS that covers all sectors of the economy. The analysis of the LIMES-EU model focused on the role of the Market Stability Reserve (MSR) in further tightening the EU ETS cap and the required sharp decrease in emissions. This approach highlights the objective of the power sector being almost fully decarbonised by 2030, while decarbonisation of the energy-intensive industry would become more important after 2030. Both studies emphasised the urgency of exploring alternative policy designs for the EU ETS after 2030 as the models predict that the last allowances would be issued by 2040. This implies that the EU ETS will see important structural changes in the next decade. The system could be jeopardised due to the risk of illiquidity and price distortions. In that sense, the scenarios evaluated with d-PLACE already provide some insights on the effects of expanding the EU ETS by, for instance, merging it with the EU ETS2 for buildings and road transport.

The smaller or less mature carbon markets outside the EU face different challenges compared to the EU ETS. A common issue stands out across non-EU systems: the overallocation or excess of allowances in these markets. In the case of the California and Québec C&T, the initial coverage planned during the early stages of the market was used for the allocation of allowances. This initial coverage was however more ambitious than the implemented coverage, leading to overallocation. Another factor reinforcing overallocation in the California-Québec system is the presence of offsets (up to 4% of emissions in Québec and 8% in California). The UK ETS, created after Brexit, also faces overallocation due to its too generous cap. This cap was set by taking the UK's share in phase IV of the EU ETS. Besides not being in line with the UK's net-zero strategy, this cap has recently proven to be excessive as emissions in 2022 (111 $MtCO_2$) were already below the 2030 cap (117 $MtCO_2$). Although it is not possible to assess ex ante whether the Chinese ETS, with a proposed tradable performance standard (TPS), will also face overallocation, a 'typical' C&T system could lead to abatement at lower costs. A TPS system implicitly subsidises output (Fischer, 2001), which compromises cost-effectiveness relative to C&T.

Besides the particularities of each system, the models also highlighted different main features and approaches. The differences between the models were revealed by the responses to the survey questionnaires.

In terms of methodology, all the models except for the California-Québec model are single-agent optimisation models, and most of them follow mainly a top-down approach. Although optimisation models following a top-down approach constitute an efficient tool for long-term planning and provide high-level

28 Contributions from two EU models (Refinitiv, ERMES), which were not presented at the workshop but answered to a survey, are also included in this document.

policy assessment, they generally struggle to capture market dynamics. This can be tackled by complementing such models with bottom-up approaches, but the implications of assuming a single agent and a perfectly rational central planner still constitute a limitation to analyse markets with such a wide range of heterogeneous actors.

Linkage to other carbon markets, as discussed in chapter 2, is not yet within the features of the models presented. The only one considering a linkage is LIMES-EU, which assumes that the EU and UK ETS will be linked in the short-term. Until recently, both systems showed a remarkable consistency, which might indicate very similar abatement costs as well as investors' hedging behaviour. However, the UK Allowance (UKA) price has recently dropped significantly. This might hinder a linkage in the short-term, despite the EU and UK agreement for cooperation. In other systems, such as those in California-Québec and China, potential linkage between existing systems is currently not under consideration.

Depending on the model's main purpose, either perfect or limited foresight is assumed. Assuming complete information for the long-term is a useful but limiting simplification. Indeed, carbon and energy markets both face increasing uncertainty, not only from market dynamics (e.g., fuel prices), but also from regulatory and policy developments. Traditionally, there is a tendency among organisations developing benchmark scenarios (i.e., computing the theoretically optimal prices to drive the energy transition) to assume perfect foresight. However, recently, there has been an increasing interest in capturing market imperfections and investors' behaviour, thus assuming limited foresight. All the optimisation models presented, except the California-Québec model, have at least this feature as an alternative model configuration. The debate remains on the appropriate time horizon to apply. There is also a discussion on the extent of the impact of an increase in environmental policy stringency on policy credibility and, ultimately, on actors' farsightedness.

Besides addressing the particularities of the different systems (e.g., unlike typical cap and trade systems, the Chinese carbon market relies on TPS), the models cover different sectors of the economy. In some cases, the model sectors are not included within the respective carbon market studied. For instance, the d-PLACE model covers all sectors of the economy. It follows a top-down approach based on a CGE model coupled with a detailed energy sector model (MEESA). This allows the evaluation of the impact of the EU ETS on other sectors of the economy and associated differences in the impacts on them.

Assessing carbon leakage impacts, e.g., resulting from the implementation of the CBAM in the EU, requires more extensive and substantial modelling as regions beyond the scope of the carbon market need to be included.

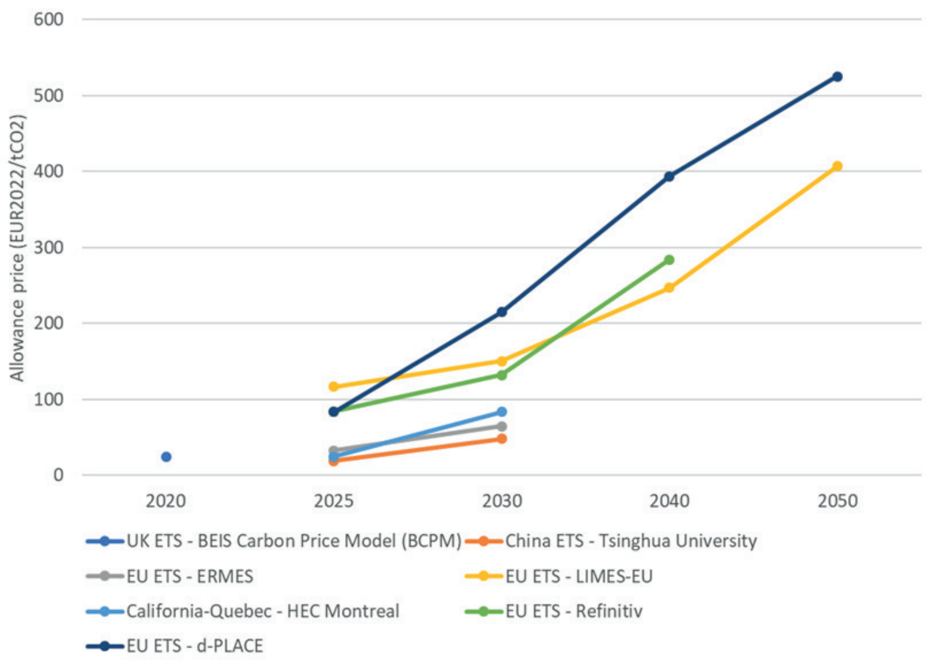
3.3. Carbon price forecast

In terms of predicted prices, the survey further revealed an overall increasing trend across jurisdictions, with predicted prices of non-EU ETSs remaining at a lower level than EU prices (see Figure 3.2). European Union Allowance (EUA) prices increase from 84-117 EUR/tCO_2 in 2025 to 407-526 EUR/tCO_2 by 2050. The price range increases as a result of the uncertainty regarding abatement costs, EU ETS coverage scope and overlapping policies. The price in non-EU jurisdictions also follows an increasing trend, but at a substantially lower level: from 19-25 EUR/tCO_2 to 48-84 EUR/tCO_2. The UKA prices will increase from 13 to 31 EUR/t between 2021 and 2024.

It is difficult to identify the main factors explaining such price differences. Differences might stem from the systems' scope. Although all of them comprise the power sector and at least a substantial part of industry, non-European systems have a larger scope, as they include buildings and road transport. A larger coverage makes it more difficult to estimate an appropriate cap. In addition to differences in scope, the overallocation of allowances keeps prices at a low level (e.g., during the EU ETS phase III, prices were below 10 EUR/t from 2013 to 2017).

Another explanation for the differences in projected prices is the lack of maturity of some of the carbon markets. A special case is the UK ETS, which covers the same sectoral scope as the EU ETS but does not have a market stability mechanism. Despite having the experience of being part of the EU ETS, it seems to be currently going through a transition period after Brexit. The very large cap with respect to current emissions appears to be having an effect on UK allowance prices. This lack of ambition is highlighted by the BCPM model results.

Figure 3.2. Carbon prices in each model and jurisdiction. [Note: the BEIS estimation of the UK allowance price is an average of the price between 2021 and 2024.]



4. Ex-Post Evaluation of Emissions Trading: Distributional and Competitiveness Effects

4.1. Introduction

Carbon pricing has long been economists' favoured tool of carbon emissions reduction. As noted above, it is increasingly being applied, both as carbon taxes and through ETSs. However, carbon prices are still typically low, and well below both mainstream estimates of the Social Cost of Carbon (SCC) and the carbon prices estimated to be required to meet the temperature targets of the Paris Agreement.

Two main barriers to carbon pricing recur increasingly in the relevant literature: fears about negative impacts on the competitiveness of businesses if carbon prices are imposed unilaterally at the national level; and concerns about fairness, especially in relation to low-income households and individuals. These were the major themes of the first annual conference on ex-post assessment of emissions trading which took place on Tuesday 20 June 2023[29].

The purpose of the conference was to identify the latest policy-relevant studies on ex-post assessments of emissions trading, with a special focus on distributional effects (section 4.2) and competitiveness (section 4.3). Section 4.4. concludes.

4.2. Distribution and Fairness

The distributional issues related to carbon pricing are largely driven by perceptions of 'fairness' – to self, to others and in respect of governmental procedures for its introduction (Steckel, 2023). Most obviously, such issues can be considered between different income groups, e.g., between the richest and poorest groups (vertical distribution), but also looking at 'hardship cases' within different groups (horizontal distribution). Governments obviously have the option of changing the first-order distributional effects from carbon pricing by making transfers within or between groups, perhaps using the revenues from the carbon price, or by using the revenues in different ways. What they do with the revenues, and how they do it, is important not just for the distributional outcome but also for perceptions of procedural fairness.

On average, low-income households are likely to be disproportionately affected by carbon pricing, but it is also crucial to recognize significant disparities within income groups. Factors like rural or urban residence, the energy efficiency of homes, car ownership and commuting requirements all influence how households are impacted. Governments need to choose wisely how to spend the revenues. There was a clear preference for green investments, such as energy-efficient renovations, rural transport initiatives, and electric vehicle adoption. These not only reduce long-term costs for households but also contribute to climate targets. Direct income support to households, in contrast, may not be as effective.

A meta-analysis of the literature by Steckel (2023) finds that carbon pricing is more progressive in poorer countries, when it is applied to transport, and when its wider economic effects are taken into account.

Between groups, the key variable that determines whether the first-order effects of carbon pricing are regressive is expenditure on carbon-based energy. In richer countries, such energy expenditure is normally a higher proportion of poor households' expenditure than for rich households, so that the first-order effects are regressive, but this is not true for poorer countries. Analysis using Steckel (2023)'s dataset, that excludes North America and most European countries, finds that carbon pricing is not regressive for the Sub-Saharan African countries except South Africa, for Latin American countries except Peru, and for most Asian countries, including China and the countries of South and South-East Asia, although there are regional differences within countries, and the effects in individual countries depend crucially on the design of the carbon pricing. Policy-relevant studies of carbon pricing therefore need to take regional and local differences into account.

Within groups, there can be huge variation in the first-order effects of carbon pricing. For example, while in Vietnam the median effect on the poorest quintile was 2.4%, 5% of that quintile experienced an effect of more than 7% – and it is often different characteristics across groups (e.g., rural vs urban, or

29 The programme and other details of the conference, including the presentations, may be found at https://fsr.eui.eu/event/international-conference-on-ex-post-evaluation-of-emission-trading/

car ownership, as noted above) that generate the largest political impacts. In Latin American countries, while in the majority of countries energy expenditure was the most important variable in explaining the impacts of carbon pricing, for Costa Rica, the Dominican Republic, Guatemala and Mexico, the key explanatory variables were car ownership and cooking fuel. Unintended consequences from carbon pricing or subsidy reform can also be important, as when the removal of fossil fuel subsidies for clean cooking fuels causes a resumption of reliance on biomass for cooking, with its negative health and environmental effects. However, the first-order effects, within groups, between different characteristics, and unintended consequences vary so much according to the context that generalisations are not helpful, and each case needs to be assessed in its own right.

Much the same is true when governments seek to compensate for distributional effects through tax reform or social transfers, when much depends on the existing structure of taxation and the coverage of social transfer schemes. In each case, it is possible to design a system that is progressive overall, but which still misses out non-negligible proportions of the poorest and worst affected households. When transfers are used, a targeted transfer will be more beneficial for the majority of low-income households but will exclude certain 'hard-to-reach' poorer households, while a universal transfer, such as a lump sum per person or household, will be more inclusive. That said, where lump sum distribution has been tried, evidence from Canada suggests that people have an inaccurate perception of what sums they are actually receiving, and their perceptions tend to align more with their political orientation than with the reality of the situation and strongly affect the social acceptability of policies. Governments which wish to use carbon pricing should put effort into communication about what they are doing, and why and how they are using the revenues.

An interesting result on an alternative use of the revenue is that in some cases compensation schemes can be made twice as progressive by using (some of) the revenues to invest in basic infrastructure (e.g., electricity, sanitation, water) for the poor. However, the time lags for the investment benefits to become apparent may not help with the immediate acceptability of the carbon pricing measure.

Fairness and distributional issues are key to public perceptions, and social acceptability more generally, of carbon pricing. Apart from issues of cost, some of those who oppose carbon pricing do so because they do not perceive it to be effective, although levels of support can be increased by devoting the revenues to 'green spending', and, perhaps, by avoiding the use of the term 'tax' and levying the carbon pricing upstream.

The EU's Social Climate Fund (SCF) is a prime example of an instrument that seeks to address distributional issues arising from carbon pricing, since it will channel part of the revenues from the EU ETS to support vulnerable groups affected by rising energy or transport costs. The fund, which is meant to come into force in 2027, allows for temporary direct income support and for investments in energy efficiency, renovation of buildings, clean heating, and cooling as well as low-emission mobility including public transport. Some major challenges persist with regard to revenue spending and the SCF. For example, more data and indicators are needed to identify individuals most at risk of being impacted by rising energy and transport costs.

One approach to carbon pricing in climate policy which has so far not won the support of policymakers is a mandatory global policy that applies to all countries. Yet a global survey, reported on by Fabre (2023), finds high levels of support for such policy, whether this entails dividing up the global carbon budget between countries on the basis of their population, or levying a global tax on millionaires to finance sustainable development in low-income countries. Focusing specifically on the Global Climate

Scheme (GCS), an emission trading system in which a basic income is paid to all people out of the proceeds of emission auctions, regression analysis by Fabre (Fabre et al., 2023) finds a modest level of global support, with generally stronger support in European countries than in the USA. This support is broadly replicated for a whole range of other policies that would result in redistribution from richer to poorer countries to enable climate action in those countries. Moreover, further tests applied to the regression analysis suggest that this support is sincere, that it is not the result of social desirability bias, and that the GCS would not be unpopular electorally. A remaining question is why such stated support has not yet translated into actual global policies along these lines. There is as yet no clear explanation as to why this is the case.

Another survey reported by Funke et al. (2023) examined differences in perceptions and attitudes in relation to carbon taxes and emissions trading, with the former hypothesised as being more salient to consumers and, perhaps, government, and the latter more relevant to businesses. Relative support for these two instruments varies in different European countries, but overall stands at about 40% for each. Preliminary work reported by Funke (Funke et al., 2023) correlated the support for each instrument across a wide range of characteristics and perceptions, some of the most significant of which are reported here.

For example, the possession of a college degree was positively correlated with support for a carbon tax but slightly negatively correlated with emission trading. Concern about climate change was, perhaps unsurprisingly, positively correlated with support for both tax and trading, with tax showing the more positive correlation. There was a positive correlation, too, between carbon pricing (both tax and trading) and those with a green voting preference, with tax again showing the stronger correlation. Those with liberal voting preferences showed a positive correlation with support for trading but a negative correlation with support for a tax. The belief in a strong role for government in the net-zero transition correlated with support for both tax and trading, with tax again the slightly stronger correlation. While perceptions that the instrument was easy to evade was correlated negatively with support for an ETS as expected, it was surprisingly correlated positively with support for a tax. Support for both instruments was correlated positively with perceptions of trust in government, but only for trading with perceptions of trust in business. Support for both instruments was also positively correlated (trading more than tax) with perceptions of equitable burden sharing, but only support for trading was correlated with perceptions that the instruments increased the government budget. Support for both instruments was strongly correlated (trading more than tax) with perceptions of both their effectiveness in reducing emissions and their positive effects on innovation. On the negative side, support for both instruments was negatively correlated (tax more than trading) with perceptions that they increased the cost of living and had a negative effect on the economy. Perhaps as a result of this, support for both instruments was negatively correlated with those in the lowest income tertile. Comparing a carbon tax and the EU ETS directly, the most significant effects of a shift from a carbon tax to trading were perceived to be increased fairness of both burden sharing and ease of evasion, and lower effectiveness of emission reduction, negative effects on the economy, increases in the cost of living and increases in the government budget.

EU governments receive significant revenues from the EU ETS: revenues from auctions, 50% of which are intended to be invested in decarbonisation, and funds from the 10c derogation applicable to some countries to help them modernise their electricity sectors. Poland was the largest EU recipient of derogation 10c funds. Sobkiewicz and Kobyłka (Kobyłka et al., 2023) evaluated the impact of these funds in Poland from 2012-2020, focusing particularly on their impact on the level of investment and the development of infrastructure in the context of the energy transition and the achievement of sustainable development objectives.

The evaluation showed that the auction revenues were not invested in ways that brought about significant additional decarbonisation, and there were few investments in infrastructure. The 10c derogation funds financed 378 projects, but 82% of these were focused on coal-fired plants, and only 1% involved investment in renewables. Nor did the derogation funds fulfil the other required objectives of these funds, namely that they should contribute to diversification of the supply mix and should not cause distortion in the power market. These funds were allocated to the coal-fired power sector and resulted in a negligible (1%) increase in renewables. Neither funding source was therefore effective in contributing to the objectives for which they had been established. It may be that the changes to the regulations after 2020 will lead to an improvement in the way these funds are being used. At the same time, carbon prices in these systems are becoming both higher and more volatile, and this introduces both uncertainty for businesses in the business cycle and potential risks for the financial system.

A specially constructed model showed that the two main drivers of the ETS price and its associated volatility, in respect of the EU ETS, are 'abatement shocks' (i.e., the trajectory of emission reduction) and 'climate sentiment shocks' as a result of other climate policies (Benmir et al., 2023). Optimality in respect of carbon pricing is achieved when the carbon price follows the SCC. A comparison between this and the ETS price shows that the SCC is a factor of 10 less volatile than the ETS price. A carbon cap rule that adjusts the cap in order to make it as close as possible to the SCC is shown to reduce significantly the volatility in the carbon price from the ETS.

4.3. Competitiveness and industrial transformation

As noted in the Introduction, fears about the loss of economic competitiveness are a major barrier to the implementation of carbon pricing at the national level, in the absence of global harmonised carbon pricing. This economic concern spills over into environmental concern, because if low carbon prices in some regions incentivise the movement of economic activity there, carbon emissions in those regions may increase, offsetting the emission reduction in high-price regions – a phenomenon known as carbon leakage.

The literature cited at the conference on these issues is relatively clear: there is currently little evidence of negative effects from carbon pricing on productivity and employment (Trinks, 2023; Bremer, L. and Sommer, K., 2023); there is very little evidence of carbon leakage (Dechezleprêtre et al., 2019; Martin et al., 2014); and there is some evidence of innovation in terms of directed technological change, which may *increase* competitiveness (Calel, R. and Dechezleprêtre, A., 2016). However, as the caps in emission trading systems tighten, and carbon prices rise, there is nervousness in respect of the EU ETS of larger impacts on competitiveness, especially if energy-intensive sectors have to buy, rather than be freely allocated, their emission allowances in the future, as is foreseen. This has led to the introduction by the European Union of the CBAM[30], with a view to 'levelling the playing field' between carbon-intensive imports and the EU's energy-intensive industry, by charging a levy on imports that reflects the emissions associated with the production of the imports and related carbon pricing of the exporting country.

The EU ETS is of course just one emissions trading system, and in recent years many other such systems have been established, or are under development. Wang (Ruijie, T. et al., 2023) explored emissions reduction in different sectors as a result of the introduction of the ETS in Beijing. Phase 1 of

30 See https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en#:~:text=On%201%20October%202023%2C%20the,importers%20ending%2031%20January%202024.

this ETS ran over 2013-2015 and involved firms with emissions greater than 10 $ktCO_2$. An interesting difference between the introduction of this scheme and that in Europe was that in Europe the criteria for being involved in the scheme were announced well in advance, whereas in China the criteria were only announced immediately before the scheme was introduced, so there was no ‘announcement effect’ before the scheme’s introduction. In Phase 2, from 2016, the threshold for inclusion in the scheme was lowered to 5 $ktCO_2$. By estimating the emissions reduction in affected firms over 2013-2015 Wang (Ruijie, T. et al., 2023) showed that there was significant emissions reduction in industry, but no significant reduction in service sectors, with the reduction among heavy coal users being the largest of all. The main abatement mechanism seemed to be fuel-switching away from coal. A further piece of analysis indicated that the way emission allowances were allocated did not significantly affect emissions, except perhaps among smaller and service sector firms, for whom the transaction costs may have been non-trivial.

Bremer (Bremer and Sommer, 2023) explored many of the same issues, specifically competitiveness (employment and profits) and technology adoption (investments) in relation to Dutch manufacturing firms (actually coherent ‘business units’ in these firms) involved in the EU ETS, split into three cohorts, with Cohort 1 (the most energy-intensive) involved in the ETS’s Phases 1, 2 and 3, Cohort 2 only involved in Phases 2 and 3 and Cohort 3 only involved in Phase 3. The findings of the regressions, which compared the companies in the ETS with matched controls, suggest (using a difference-in-difference [DiD] methodology) that Cohort 1 experienced some initial negative effect on employment in Phase 1, but that this disappeared in Phases 2 and 3, while this effect persisted through the three Phases when using a two-way fixed effects methodology (TWFE) (i.e., methodology matters). Neither method showed significant effects on profits but DiD did show a lasting negative effect on investment, which was absent in TWFE.

The impacts of the EU ETS on industrial competitiveness were also the focus of Cameron (2023), with the addition of the associated risk of carbon leakage. The literature on the risk of carbon leakage is divergent. Theoretical studies suggest that the risk is high, ex-ante modelling finds that it depends highly on input assumptions, such as elasticities, and ex-post evaluations suggest that it is small. It is possible that explanatory factors for this divergence may include the allowance allocation method (e.g., free allocation), the stringency of the policy (with ETS prices being low until quite recently) or the structure (e.g., the degree of monopoly) of the industries concerned. In terms of measuring the risk of carbon leakage, the European Commission’s indicators (trade intensity, emission intensity, and qualitative assessment of threshold cases) have been found to overestimate the carbon leakage risk. The focus of Cameron (Cameron, 2023) was to explore the potential implications of market structure for carbon leakage risk, by using a hypothetical monopolist test for market power (asking whether the profit after a 5% price increase is higher than before the increase) and estimating substitution elasticities for different products (in this case hydraulic cement, clinker, and flat and long steel) over the period 2008-2018. The main results of this estimation suggest, somewhat counter intuitively, that “cement products are more substitutable between countries than steel products; sub-products do not vary substantially in terms of their substitutability”; and that steel is mostly traded in national markets while cement has mostly regional and sometimes global markets. The focus of this paper on substitutability is complementary to a focus elsewhere in the literature on pass-through rates of the value of emission allowances, and an interesting extension of this work would be to link the two concepts.

Arlinghaus (Arlinghaus et al., 2023) focused on the way in which climate policy, especially the EU ETS in Europe, affects the financial sector, given the price volatility of EU ETS allowances and the differential exposure of firms, and therefore banks, to the EU ETS. In Phase 3 of the EU ETS the introduction of the Market Stability Reserve and increase in the Linear Reduction Factor (LRF) in the supply of allowances put upward pressure on the EU ETS price. At the same time, the introduction by the European Central Bank of a Negative Interest Rate Policy (NIRP) in 2013-2014 constituted a shock to the financial sector that was felt differentially by banks, with those with the highest deposits/assets ratios being the most affected. The result is that the most affected banks had a stronger incentive to increase their lending, and the paper analysed whether they did so differentially between ETS and non-ETS firms. The results of the analysis suggest that banks increased their lending in the short run to ETS firms more than to non-ETS firms, and reduced the required collateral for these loans, and their estimated probability of default, for these ETS firms. While the reasons for these results are unclear, one hypothesis is that, in line with the Porter hypothesis, the regulation through the ETS caused ETS firms to increase their innovation and investment.

Trinks (2023) investigated the possible carbon leakage from carbon pricing, covering 15 industrial sectors and 32 countries over 2000-2014, and using both explicit and implicit carbon prices, with the latter being estimated from other taxes (e.g., fuel duties) or other measures of climate policy, such as standards and regulations. Six dimensions of firm performance (sales revenue, investment, employment, profitability and firm exit) were regressed against these carbon costs, and only employment showed a significant but small reduction, with a USD 50/tCO_2 carbon price leading to a 2.5% reduction in employment. However, the results show considerable heterogeneity across different types of firms, with the greatest effect on employment being shown in small firms most subject to leakage risk, which also showed the largest increase in productivity, while large and capital-intensive firms in covered sectors showed the greatest (but still quite small) increase in investment. Both profit and the probability of exit were hardly affected at all for any type of firm, while the (negative) employment effects and (positive) investment effects were most clearly shown in EU countries. There is thus little evidence in this analysis for adverse economic effects and relocation from carbon pricing, and such small effects as are seen are concentrated in small sub-groups in sectors affected by leakage. One possible explanation for this is that carbon costs over the period were relatively low, and they may therefore have larger effects in the future if they increase significantly, although countervailing policy measures, such as the CBAM may mitigate this.

CBAM was the explicit topic of Wildgrube (2023), which first explored whether CBAM creates a 'level playing field' for the products (iron and steel, aluminium, cement, electricity, hydrogen, ammonia and fertilisers), to which, from 2027, it will apply. In principle, CBAM will equalise carbon costs for the covered products when sold in the EU. However, many other market distortions will remain, including carbon costs in export markets and special financial support in some EU countries for electricity and renewables. Importers may be disadvantaged by CBAM's incidence on imported *products*, whereas the EU ETS applies to *installations*.[31] In fact, given the huge differences that exist in markets in different countries, it may be that the focus on the level playing field is misleading, and may even stand in the way of industrial transformation, which has historically been a characteristic and driver of industrial development. To enable low-carbon transformation in the EU, perhaps, rather than worrying about trade

31 Imported goods in the sectors covered by CBAM will pay a carbon price on emissions associated with imports from 2027, taking into account carbon prices already paid in the country of origin. For the same sectors, free allowances will be phased out in the EU ETS to create a level playing field so European sectors will be exposed gradually to the full carbon price. However, market distortions may persist, as noted in the main text.

effects of carbon pricing, the policy focus should be on installing low-carbon infrastructure, developing low-carbon technologies and providing regulatory certainty. Abroad, it may be that the EU should seek to encourage carbon pricing more flexibly than seeking to equalise carbon costs between its own products and imports in its own markets.

If the focus is to be on industrial transformation, then clearly research has a crucial role to play in the development of technologies and of scenarios as to how such transformation might take place and what it would look like.

Pommeret (2023) is another exploration of the trade effects of a border carbon adjustment (BCA), in the context of a wider piece of work on short-run transition risk from climate policy. Such risk could arise from multiple interacting causes including Keynesian shocks (investment), inflation, input substitutions, stranded assets, labour adjustments (with sectoral heterogeneity), technological change, shocks on competitiveness, sufficiency/sobriety (lifestyle change), critical raw materials, social acceptability, and financial contagion. The focus of this paper was on the last of these, modelling how ambitious climate policies such as a carbon tax and BCA might transmit across borders, with and without financial frictions, leading to difficulties in financing investments. Scenarios explored the impact of an unexpected carbon tax of USD 80/tCO_2 being imposed in the home economy, both with and without financial frictions. Without these frictions, there is carbon leakage and negative economic impacts on the home country's polluting industry, as capital flows abroad and into the green sector at home. Introducing financial frictions exacerbates the negative economic impacts at home, reducing output also in the home non-polluting sector, but also has a negative impact abroad, the carbon tax shock being transmitted through both home and foreign banks, and resulting in a lower capital stock in both the polluting and non-polluting sectors. In this case, there is still carbon leakage, but it is smaller. The imposition of a BCA on foreign polluting goods amplifies all these negative effects but reduces leakage further. A conclusion of the paper is that it seems important to take account of financial sector linkages when assessing the impact of both carbon taxes and BCAs.

Feng (2023) concentrated on the practical details involved in CBAM, specifically on the procedures that might need to be followed by importers of goods in the covered sectors into the EU in order to verify the carbon intensity of their products. For simple products, it might be sufficient simply to calculate the carbon intensity of the power inputs to production. But for complex products, for example from the chemical industry, determining their carbon intensity would involve complex processes of life cycle assessment, involving multiple stakeholders. The complexity means that it is unlikely that a single 'one-size-fits-all' set of guidelines or regulations would be adequate, but at the same time a case-by-case approach may not be manageable. Feng (2023) proposed a "coordinated social governance scheme" involving guidelines from the government, a self-regulated assessment by industry, with professional third-party certification, and social reliance on competitors, NGOs or whistle-blowers within the company to expose poor or inadequate practices.

The USA's Inflation Reduction Act (IRA) seeks to stimulate innovation and boost low-carbon industrial transformation by directing federal spending and tax breaks amounting to $500 billion. Although the IRA was outside the scope of the conference, it may be seen as an alternative means to CBAM of accelerating the clean energy transition, while not disadvantaging domestic industry, although its national content requirements certainly also act as a barrier to trade. Moreover, the internalization of environmental externalities is better addressed by carbon pricing rather than subsidies. Perhaps some combination of carbon pricing and innovation support would be the best approach and would be better still if a single approach could be harmonised across countries. While such harmonisation has been achieved in some health-related sectors, e.g., pharmaceuticals or food standards, it would probably prove more difficult to achieve with carbon abatement.

5. Conclusions

5.1. State-of-play in international carbon markets in 2023

The report has taken stock of developments in an increasingly complex global carbon market landscape and the potential for the integration of different types of markets was assessed. To that end, a stylized characterization of the carbon market has been introduced, and key components and concepts defined.

The landscape of compliance carbon markets, and particularly ETSs, has been changing dynamically with an increase from 13 to 28 ETSs in force over the past ten years. This includes ETSs at regional, national, and subnational levels. These systems can be grouped into five types: point source ETSs for electricity and heat; point source ETSs for all big emitters; point source and downstream regulation of big emitters; ETSs with upstream regulation of small emitters; and comprehensive ETSs. The number of ETSs in force will likely rise over the future years as 8 systems are currently under development and 11 are under consideration.

Similarly, there have been important changes in the markets for carbon credits. Over the last few years new domestic and independent crediting mechanisms have entered the stage, and the volume of credits issued doubled from 2018 to 2022. As the mechanisms under the Article 6 of the Paris Agreement are developed further and technical as well as institutional capacity is built in their use, particularly in developing countries, it is likely that new connections to compliance markets will emerge and underpin some greater carbon market integration. However, there is an urgent need for reliable carbon credits, given considerable current scepticism towards them, due to the absence of established guidelines to ensure their quality. Many open questions remain relating to the authorization process, dispute settlement and capacity gaps in developing countries.

The further integration of carbon markets through new links between compliance markets has not been very dynamic. Since each system is tailored to its domestic circumstances, linkage is challenging and is only feasible between markets with similar characteristics. More integrated global carbon markets are theoretically desirable, but two important preconditions for linkage and integration are aligned ambition and consistent market regulations. Many questions arise as to the benefits of linking when these conditions are not met. In the last few years, only the links between the EU and Swiss ETSs, and Virginia's program and RGGI were established. Moreover, the UK left the EU ETS when it exited the EU, and Virginia may leave RGGI soon. There is, however, potential for further linking of compliance markets in the near term, for example between the EU and UK ETSs; Washington and the already linked systems of California and Québec; and Pennsylvania, North Carolina and RGGI. Further ahead, the EU will also need to consolidate its carbon pricing framework once the new EU ETS2 covering buildings, road transport and small industries enters into force. This EU ETS2 will likely replace the upstream systems in Austria and Germany. Future editions of this report will provide updates on these potential links between compliance carbon markets. A focus will also be put on the potential for connections between compliance and voluntary carbon markets. The inclusion of offsets in compliance carbon pricing systems is indeed being discussed as a potential avenue to expand the lifetime of ETSs in the future. Crucially, voluntary carbon credits will also be needed to offset remaining emissions of hard-to-abate sectors.

5.2. Ex-ante modelling assessments of emissions trading

Further improving ex-ante models is an important exercise for academia and policymakers alike. While the models might not be able to reliably predict future carbon prices, they already play an important role in understanding the effects of different policies and design changes.

The models discussed not only showed a wide heterogeneity in approach but also highlighted the different carbon market scopes, maturities, and ambitions. Moreover, there is a growing interest in capturing market imperfections and investor behaviour. On the modelling assumptions, there is a deep reliance of models on MACCs and a strong impact of parameters such as the discount rate on model predictions. This underlines the need for discussion fora, with the inclusion of industry feedback, to continue the comparison of ex-ante modelling, share experiences, and improve the robustness of modelling assumptions and approaches. With the exception of the BCPM model, the extent to which these research models can influence policy-decision making is difficult to measure, but closing the loop between the policy process and modelling work is necessary to enhance the predictability of carbon markets and ultimately improve their credibility in an increasingly dynamic policy landscape.

5.3. Ex-post evaluation of emissions trading

Carbon pricing through emission trading seems to be outpacing carbon taxation as the pricing instrument of choice.

The main research questions and methods related to carbon pricing have not changed much over the years. However, there is a new focus on social aspects, perceptions, and public acceptability, especially in respect of the spending of revenues. CBAM is a new topic of research. There is a general need for better understanding and assessment of the real-world implications of carbon pricing policies, and of the interactions between different policies.

5.3.1 Social dimension of emissions trading

In respect of the distributional impacts of carbon pricing, the key issues seem to be the targeting of compensation schemes, and their communication to ensure that stakeholders, and particularly those most impacted by the schemes, are more aware of them. Notwithstanding evidence of a lack of awareness of carbon pricing and mechanisms for using the revenues therefrom, a global survey suggests widespread majority support for carbon pricing, which leaves the unanswered conundrum why policymakers have so far not succeeded in introducing a global carbon price.

In general, the social aspects of climate and ETS policies are gaining new importance, both in academia and in policymaking. There is a growing awareness that carbon pricing, especially when applied to heating and transportation, can have significant distributional consequences. Without appropriate redistribution of carbon pricing revenues, higher energy and fuel prices and a shift in labour markets may present a particular burden for low-income households. However, it appears that if only a part of the revenues that are generated in ETSs are redistributed to lower-income households, or on a lump-sum basis, carbon pricing can be made distributionally progressive. It is thus an important task of policy instruments seeking a just transition to use ETS revenues to achieve progressive outcomes.

Carbon pricing is likely to raise increasing amounts of money that, spent wisely, can benefit poor households, and accelerate the green transition. Both good design and better communication about social distribution measures are needed.

5.3.2 Competitiveness and carbon leakage

On competitiveness and the low-carbon energy transition more broadly, two very different approaches are being tried in Europe (CBAM) and the USA (Inflation Reduction Act).

There is a long-standing concern that carbon pricing might jeopardize the competitiveness of domestic industries and lead to carbon leakage. This risk arises from the difference in environmental ambition and stringency of climate policies across countries that would negatively impact the competitiveness of firms in countries with more ambitious climate goals, potentially shifting pollution-intensive production to regions with less stringent climate policies. Until now there has been little evidence of carbon leakage as a result of the EU ETS, but there are legitimate fears that this may not be the case as carbon prices increase and energy-intensive sectors have to start paying for their emission allowances. In fact, some recent evidence shows that both production and exports from energy-intensive industries in Europe have declined, while imports have risen, indicating a loss of competitiveness.

Furthermore, the evidence for carbon leakage identifies significant heterogeneity at the sector and firm-level, meaning that different countries, sectors, and firms within those sectors may be affected very differently from the loss of competitiveness that leads to carbon leakage. As a result, policies with flexibility in policy design are essential to tackle these differentiated impacts and to support affected firms that are concentrated in specific geographical areas or sectors.

Despite complexities in its implementation, the EU's introduction of CBAM could represent an initial step in addressing this challenge. The ongoing negotiations surrounding CBAM have already had significant repercussions in other ETSs, including those in the US and China. However, for this instrument to be effective in preventing carbon leakage, the EU's focus should be on safeguarding industries most vulnerable to carbon leakage, with an emphasis on investment rather than compensation measures. In parallel to CBAM, the EU should also intensify efforts in the realm of innovation policy and continue initiatives related to international cooperation, the reduction of fossil fuel subsidies, and the facilitation of trade policies.

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