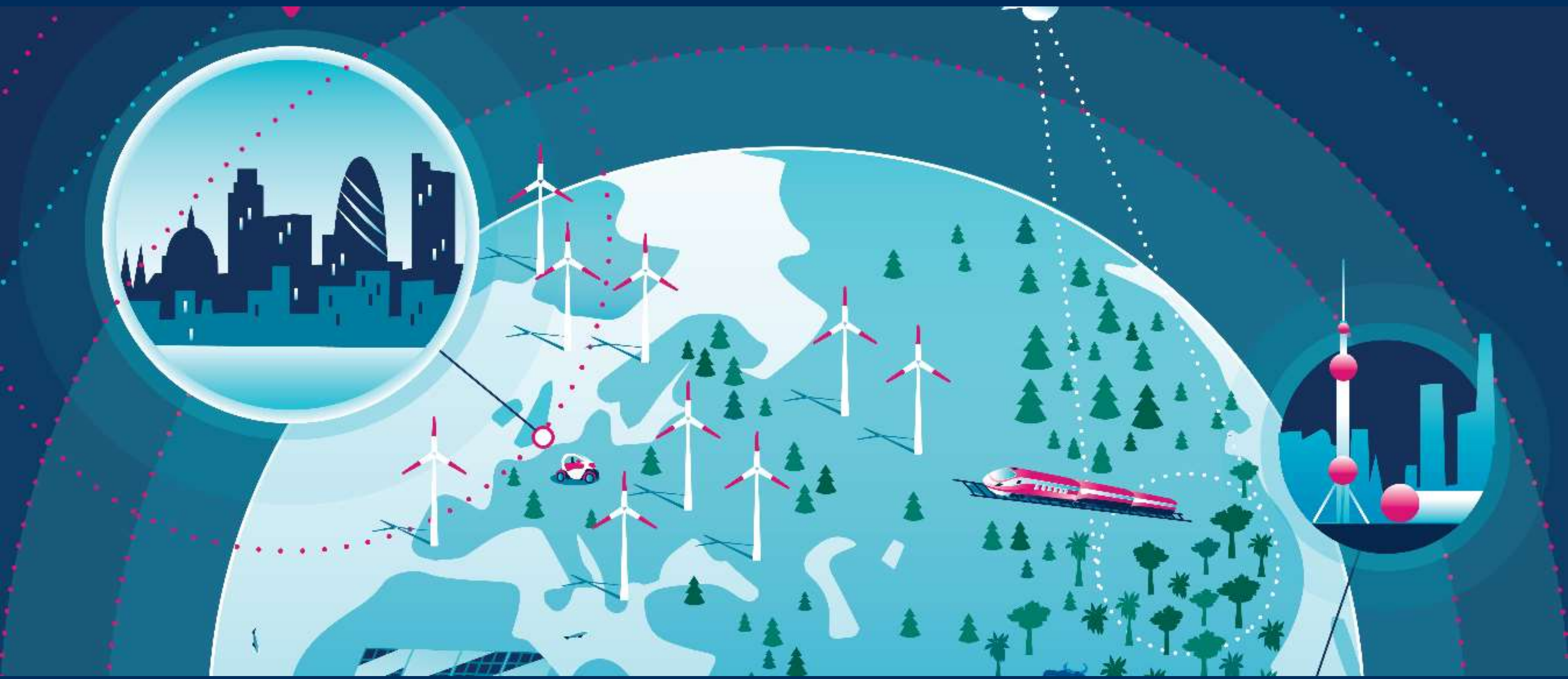
# Market stability measures



Design, operation and implications for the linking of emissions trading systems

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# Summary for Policymakers

Jurisdictions are increasingly adopting market stability measures (MSMs) to help manage unexpected market shocks in emissions trading systems (ETSs). These MSMs provide predictable responses to unexpected circumstances and help ensure that carbon prices and quantities of emissions reductions are aligned with policy goals. This includes supporting low carbon investment by reducing the risk of very low carbon prices and increasing ETS acceptance by avoiding excessive costs.

This paper presents a compilation of two reports that consider the operation of MSMs and analyse the potential implications of these measures for ETS linking. These papers are as follows:

— Understanding price and quantity based MSMs, outlines the findings of a detail literature review and expert interviews regarding the design and operation of these measures
— The impacts of linking ETS with MSMs, presents qualitative analysis and first of the kind modelling to consider the potential implications of these measures for ETS linking

We find that MSMs have become an essential part of ETS design, with all major ETS operating worldwide adopting some form of measure. Our review investigates MSMs proposed or implemented in eight global jurisdictions: the EU; South Korea; California-Quebec; the North-eastern US states in the Regional Greenhouse Gas Initiative (RGGI); Australia; New Zealand; Chinese regional carbon markets; and Tokyo-Saitama's city-level carbon market.

For each jurisdiction, we provide an overview of the key ETS characteristics before considering in detail the design of MSMs. A comprehensive review of existing literature is complemented by practitioner interviews to identify the circumstances that led to market intervention, the processes taken to give effect to the intervention, and the factors considered under discretionary interventions. Subsequently, we detail the functioning of MSMs and evaluate the impact of these interventions on the functioning of markets, including spot and forward prices.

From this analysis, we identify five observations from the comparison of MSMs implemented to date:

1. Inflexible regulatory processes can delay policy makers' response to changed circumstances, which may necessitate the introduction or reform of MSMs.
2. Implementing MSMs through auctions is a common and relatively simple approach.
3. Rule based MSMs increase price predictability and refine market price expectations.
4. MSMs that entail a permanent supply response alter emissions budgets and affect realised ambition levels.
5. Linking ETS requires compatibility in the design of MSMs, with all linked system taking steps to coordinate MSMs to avoid potential adverse impacts.

MSMs can make carbon markets function better, but they also increase their complexity in a manner that makes ETS linking challenging. The second section of our paper finds that, in all cases, jurisdictions should look to coordinate their MSMs if they are going to link to ensure markets interact smoothly and avoid adverse consequences. The potential interactions of MSMs is influenced by the design of MSMs and the relative size of carbon markets.

Any ETS with an unbound MSMs, such as a hard price floor and/or ceiling, should not be linked to others unless MSMs are first aligned. Unbound MSMs come with a variety of risks, which can undermine the functioning of markets and lead to large flows of funds between systems. Bound MSMs limit the potential scale of response and therefore pose a lesser risk to market functioning after linking.

When linking a smaller ETS with a larger ETS, the MSM of a smaller ETS should be removed, or coordinated with that of the larger ETS. In many cases the MSM of a smaller ETS will prove ineffective after linking, as market developments in the larger ETS dominate demand across the linked markets. MSMs that use top-up fees or subsidies applied to a proportion of emissions may be effective, but still likely require coordination.

When linking ETSs of similar size, MSMs in both ETSs can continue to operate effectively in certain circumstances. However, it is still better to coordinate to ensure markets continue to function well. The interactions that must be considered differ based on the types of MSMs being linked:

- If linking an ETS with a price based MSM, such as the California price floor and price ceiling, and an ETS with a quantity based MSM, such as the Market Stability Reserve in the EU ETS, it is important to coordinate to avoid them working in opposite directions. Because these MSMs are triggered by different metrics, it is possible that one may inject allowances while the other is removing them, simply shifting funds and allowances from one to the other.
- If linking two ETSs with quantity based MSMs, coordination is needed to use the appropriate quantity metric is used. The number of allowances banked in each system can differ for arbitrary reasons, meaning a joint measure of allowances in circulation should be used and rules for injecting or removing allowances aligned.
- If linking two ETSs with price based MSMs, there are fiscal consequences for having different trigger levels. Different triggers (ceiling and floor prices) may reflect different preferences for price levels, but if introduced independently they can also have large fiscal and distributional impacts.

We also find that there are several other features of ETSs which will determine how they will interact after linking. These include:

- determinants of demand, which are choices made by jurisdictions that underlie the demand curve in a jurisdiction and result in certain market attributes. For instance, decisions regarding ETS scope and overlapping policies will affect demand and trade flows.
- market attributes, which are the characteristics of carbon markets that effect equilibrium outcomes regarding price and quantity and the gains from trade that can be expected. Carbon markets differ in their volatility, liquidity and market concentration, which will affect how markets interact and the way in which MSMs operate in linked systems.
- governance, which are the set of rules that move beyond pure economic factors but nonetheless effect the interactions of linked markets. For instance, reporting timeframes may need to be aligned for quantity based MSMs to operate, while parties may also wish to agree rules for future policy changes.

These findings all suggest that linking ETSs with MSMs will require significant coordination, and hence a high degree of trust between linking partners. As an alternative to full linking, parties could consider restricted linking to maintain greater autonomy and independently effective MSMs. However, this will also reduce many of the advantages of linking. Similarly, as government's preferences may change over time, this implies that clear rules for delinking are established to ensure this process is smooth.

Table 1 sets out a checklist of questions that should be considered before linking ETSs:

*Table 1.* Summary: a pre-linking checklist

| Question | | Considerations |
|---|---|---|
| Are you linking: | one or more ETSs with an unbound MSM? | Do not link unless aligning your MSMs |
| | with a much larger ETS? | Remove or coordinate your MSM to avoid excessive costs or an ineffective MSM within your own system |
| | an ETS with a bound price based MSM with an ETS with a bound quantity based MSM? | Coordinate to ensure your MSMs do not operate in contradictory directions, and to share information on allowance holdings across all linked systems |
| | two ETSs with bound quantity based MSMs? | Coordinate to ensure MSMs are responding to the joint number of allowances held across linked systems, and manage |
| | two ETSs with bound price based MSMs? | Ensure you understand the fiscal impacts of having different trigger prices, it is still better to coordinate |
| Have you considered: | other aspects of policy design? | ETS scope and overlapping policies will affect demand and trade flows |
| | the attributes of carbon markets? | Carbon markets differ in their volatility, liquidity and market concentration, this can affect how markets interact and the way MSMs operate |
| | alternatives to full linking? | Consider restricted linking to reduce your exposure, if parties wish to maintain greater autonomy and independently effective MSMs |
| | delinking? | Clear rules are required to ensure delinking is smooth, and may prove particularly important if an ETS with a quantity based MSM is involved |

*Source: Vivid Economics*

# Understanding price and quantity based market stability measures

# 1 Introduction

Markets for abstract commodities, such as emissions allowances, can be volatile and unpredictable. This unpredictability has multiple drivers, but the two central drivers are difficulties forecasting emissions trajectories given changes in circumstances (Lina & Ackva, 2018), and the perfectly inelastic emissions allowance supply cap set by conventional emissions trading systems (ETSs). The first driver relates to the impact of unexpected market shocks, primarily affecting demand. For instance, the economic slow-down following the global financial crisis drove down demand for allowances and carbon prices around the world. The fixed emissions cap of an ETS means that allowance supply is perfectly inelastic which means that the effect of demand volatility is fully reflected through changes to price.

Over time, these challenges have led all long-standing carbon markets to adopt some form of market stability measure (MSM). Price fluctuations over time are desirable, as this transmits information on abatement costs to market participants. However, excessive price volatility or prices falling too low can reduce low-carbon investment, while excessively high prices can have negative economic, political, and social impacts. As such, jurisdictions have introduced MSMs to help support the credibility of long-term price signals and mitigate the risk of shocks resulting in severe impacts on market outcomes (PMR, 2016). Jurisdictions have used various mechanisms to stabilise markets and mitigate potential imbalances in supply and demand that can cause prices to spike or crash. These MSMs fall into two broad categories:

— *Quantity based instruments* are market interventions triggered by allowance surplus thresholds; and
— *Price based instruments* are market interventions triggered by allowance price thresholds.

This report assesses the MSMs implemented by major emissions trading systems (ETS) operating worldwide. The review investigates MSMs proposed or implemented in eight global jurisdictions: the EU; South Korea; California-Quebec; the North-eastern US states in the Regional Greenhouse Gas Initiative (RGGI); Australia; New Zealand; Chinese regional carbon markets; and Tokyo-Saitama's city-level carbon market.

For each jurisdiction, we provide an overview of the key ETS characteristics before considering in detail the design of MSMs. A comprehensive review of existing literature is complemented by practitioner interviews to identify the circumstances that led to market intervention, the processes taken to give effect to the intervention, and the factors considered under discretionary interventions. Subsequently, we detail the functioning of MSMs and evaluate the impact of these interventions on the functioning of markets, including spot and forward prices.

The remainder of the review is structured as follows:

— Section 2 reviews the EU's purely quantity based instrument planned for implementation;
— Section 3 reviews the price based instruments that jurisdictions have implemented;
— Section 4 reviews the price- and quantity based instruments implemented by jurisdictions; and
— Section 5 provides a comparative assessment of the various MSMs implemented.

The details cited in the following section were correct as at the time of drafting in 2019, some minor details regarding the design and operation of MSMs may have changed in the period since. These insights were supported by numerous interviews with experts across key jurisdictions, as discussed further in Box 1 below.

*Box 1.* Insights in this report have been developed with the help of numerous expert interviews

We interviewed experts from jurisdictions around the world to draw further insights regarding the design, implementation, and impacts of implemented MSMs. The interviews involved nine experts from a variety of institutions ranging from the private sector, to non-governmental organisations (NGOs), to government agencies. Experts often shared knowledge and insights into the MSMs of multiple jurisdictions. These interviews provided focused discussions to elicit the experts' perspectives on the design and intention of MSMs, implementation and revision processes, and practical experiences and stakeholder reactions.

This report includes their insights throughout to add context and detail to the findings of the literature review. Most experts have first-hand experience in implementing these mechanisms or have devoted significant time researching them. The insights resulting from interviews either support findings from the literature or reveal nuances not published in academic or grey literature. In particular, they revealed process-related considerations such as implementation challenges and the motivations behind specific policy designs.

# 2 Quantity based instruments

The EU is the only jurisdiction operating an MSM triggered solely by quantity based market imbalances. This section provides an overview of the EU ETS, discusses the process that led to the implementation of this stability measure, details its functioning, and reviews evidence regarding its expected impact on the market.

## 2.1 The EU ETS, backloading and the Market Stability Reserve (MSR)

The EU ETS is the cornerstone of the EU's climate policy, and an integral part of a wider EU-level climate and energy policy suite developed to achieve emissions reduction targets. The EU 2030 climate and energy framework sets three targets for 2030:

1. cut greenhouse gas (GHG) emissions by at least 40% compared with 1990 levels;
2. increase renewable energy consumption to at least 32% of final energy consumption; and
3. improve energy efficiency by at least 32.5% (European Commission, 2018a).

The EU ETS currently covers almost half of the GHG emissions in its 31 participating national jurisdictions. It operates across the 28[1] EU Member States and three[2] European Economic Area-European Free Trade Association (EEA EFTA) states. In its third phase (2013-2020), the ETS covers some 11,000 energy-intensive installations in industry, electricity generation and intra-EU airline flights, accounting for 45% of all GHG emissions in covered countries (European Commission, 2017b). The emissions cap for 2018 is approximately 1.9 Gt$CO_2$e (European Commission, 2018c). In November 2018, the price of allowances varied between €16/t$CO_2$e (tonnes of carbon dioxide equivalent) and €20/t$CO_2$e.

The EU ETS began in 2005 and has seen major changes in policy over its three phases of operation. Table 2 illustrates how the coverage of the EU ETS has changed across its three phases. Phase I (2005-07) included power generation and energy-intensive industries and only one GHG: $CO_2$; Phase II (2008-12) added $N_2O$, from nitric acid production; Phase III (2013-20) expanded sectoral and GHG coverage further. Certain small facilities can opt out of the ETS if they are subject to regulation which achieves equivalent emissions reductions as expected under the ETS. Smaller facilities include those with emissions less than 25 kt$CO_2$e per year and/or combustion plants with thermal-rated input below 35 MW, and hospitals (European Commission, 2015b). Allowance banking was not permitted from Phase I to Phase II; however, unlimited banking was introduced from Phase II onwards.

[1] Austria, Belgium, Bulgaria, Croatia, Republic of Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the UK.

[2] Iceland, Liechtenstein and Norway.

*Table 2.* The EU ETS has expanded the sectors and GHGs covered throughout its phases

| Phase | Sectors covered | GHGs covered |
|---|---|---|
| Phase I (2005-07) | — Power generation<br>— Energy-intensive industries | — $CO_2$ |
| Phase II (2008-12) | — Power generators<br>— Energy-intensive industries<br>— Nitric, adipic, and glyoxylic acids production | — $CO_2$<br>— $N_2O$ from nitric, adipic, and glyoxylic acids production |
| Phase III (2013-20) | — Power generators<br>— Energy-intensive industries<br>— Nitric, adipic, and glyoxylic acids production<br>— Commercial aviation within EU ETS countries | — $CO_2$ from power generation, energy-intensive industries and commercial aviation<br>— $N_2O$ from nitric, adipic, and glyoxylic acids production<br>— Perfluorocarbons (PFCs) from aluminium production |

*Source: European Commission (2017c)*

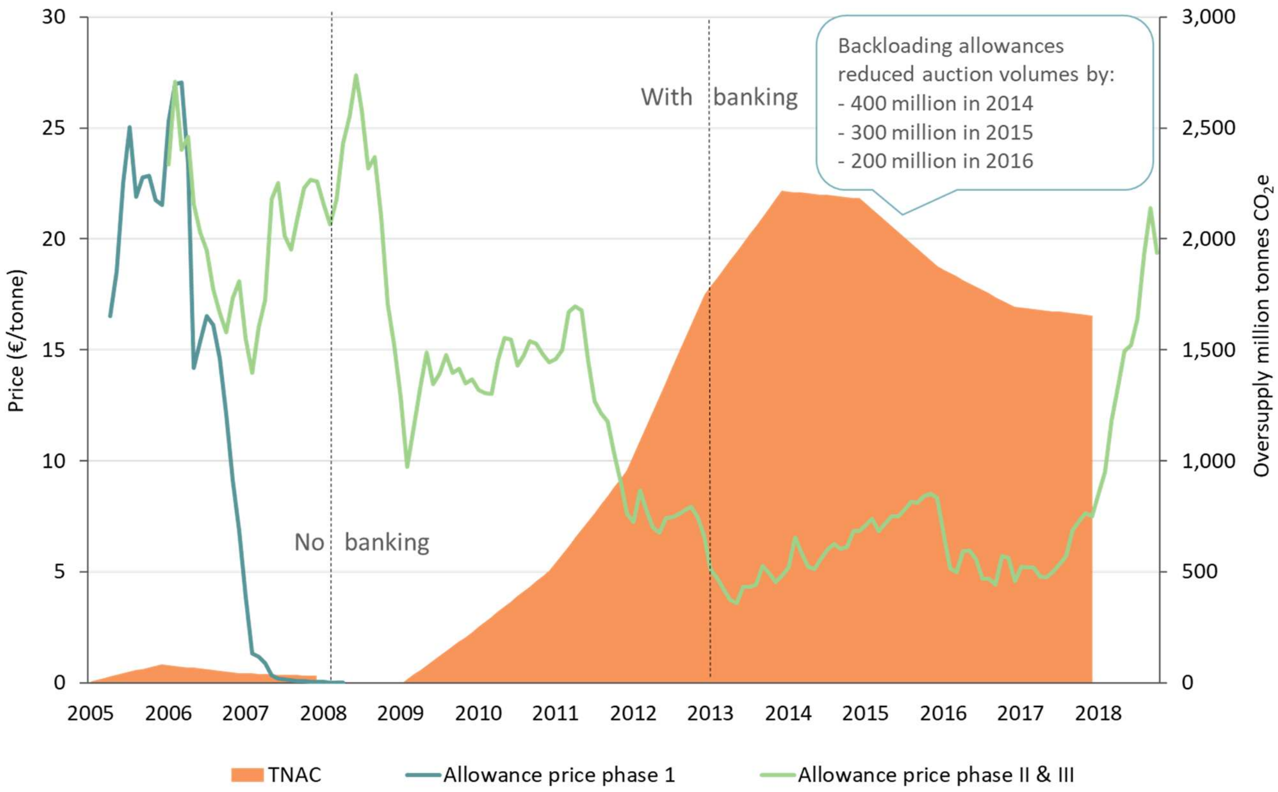
**The final years of Phase III of the EU ETS (2019-20), and Phase IV (2021-30), will see further important policy changes.** In 2019 a quantity based MSM, the Market Stability Reserve (MSR), began operation with the aim of supporting the optimal functioning of the EU ETS. In Phase IV, environmental stringency will be enhanced by an increase in the annual decline of the emissions cap from 1.74% (approximately 38 $MtCO_2e$ per year) to 2.2% (approximately 48 $MtCO_2e$ per year). Phase IV will also introduce a more targeted approach to identifying sectors at risk of carbon leakage and will increase the flexibility of free allocation rules to greater align allocation with current output. Two new funds will be established to support the low-carbon transition in energy-intensive industrial sectors (the Innovation Fund) and the energy sectors of jurisdictions reliant on older, fossil fuel technologies (the Modernisation Fund) (European Commission, 2017a).

**Given that the EU ETS is a regional ETS, the MSMs it implements may interact with unilateral policy decisions made by Member States or other regional entities.** For example, in 2013, the UK unilaterally implemented a carbon price floor (a price based instrument) for its electricity sector. Annex 2 discusses the implementation process, functioning, and practical experience of this instrument.

### 2.1.1 Implementation process

**Following the European double-dip recession, an extended period of low allowance prices and the large allowance surplus sparked a lengthy debate on EU ETS reform.** The large allowance surplus developed due to several factors, but mainly as a result of the reduction of economic activity following the financial and economic crises and the inflow of close to 1.5 billion Clean Development Mechanism offset credits. As the surplus increased, prices of EU allowances fell to below €5/$tCO_2e$, with depressed demand and a hangover of excess supply resulting in prices remaining below €10/$tCO_2e$ for most of the period from 2012-18. These price levels were widely considered by academics and policymakers to be too low to facilitate significant low-carbon investments, leading to pressure for policy intervention. Over the last year, prices have recovered to reach over €20/$tCO_2e$, due in part to expectations of reduced supply following the introduction of the MSR (as discussed below). Figure 1 shows the historical carbon price path in the EU ETS and the cumulative oversupply of allowances.

*Figure 1.* The banking of a large allowance surplus depressed EU allowance prices over much of Phase III




*Notes:* *The total number of allowances in circulation (TNAC) reflects the allowance surplus and is determined each year as the total allowances issued minus the allowances surrendered for compliance, taking into account international credits used for compliance and allowances already in the reserve (European Commission, 2015b).*

*Source:* *Vivid Economics*

In response to low prices, in 2013-14 the EU legislators agreed to 'backload' 900 million allowances over the period 2014-16, to temporarily reduce oversupply by removing allowances from auction. Backloading resulted in the gradual decline of the allowance surplus over 2014-17. However, the large number of surplus allowances meant that prices remained low, which bolstered support for a longer-term solution.

The MSR is the primary mechanism to manage allowances surpluses in the long term. The EU ETS intends for the MSR to serve as an important stabilisation mechanism that will help the EU reach its 2030 emissions reduction target and help the ETS deliver a credible investment signal to reduce emissions in a cost-efficient manner (European Commission, 2018b). The European Parliament and the Council define the role of the MSR as follows:

*'In order to address that problem and to make the EU ETS more resilient in relation to supply-demand imbalances, so as to enable the EU ETS to function in an orderly market, a market stability reserve"*

*DECISION (EU) 2015/1814*

**Before the European Commission decided to propose the introduction of the MSR, several other options to stabilise the market were considered.** The 2014 impact assessment accompanying the proposal for the MSR assessed the impact of a one-off cancellation of allowances, the introduction of a mechanism to permanently retire some allowances from Phase III, and a mechanism that would retire allowances in combination with the MSR (European Commission, 2014b). It was concluded that while permanent allowance retirements could address the immediate market imbalance and benefit from simplicity, they would fail to increase the resilience of the EU ETS to future shocks, which is a central objective of the MSR (European Commission, 2014a).

### 2.1.2 Functioning

**The MSR is a rule based mechanism that seeks to address market imbalances by making allowance supply flexible to the number of unused allowances banked in the system:**[3]

— it includes rule based adjustments of allowance supply in response to allowance surplus thresholds, these rules are set out in Table 3 below; and
— from 2023, it will include the invalidation of all allowances in the reserve in excess of the previous year's auction volumes

*Table 3.* The rules for the MSR adjust auction volumes in light of the allowance surplus

| Total number of allowances in circulation (TNAC) | Change in auction volume by transfers into or from the MSR | Special conditions |
|---|---|---|
| Greater than 833 million | Reduced by 12% (24% over 2019-23) | - |
| Less than 400 million | Increased by 100 million allowances | - |
| - | Increased by 100 million allowances | If for more than six consecutive months the carbon price is more than three times the average carbon price during the two preceding years—even when the total number of allowances in circulation is more than 400 million—the allowances will also be released from the reserve. This safeguard would be in addition to measures taken under Article 29a of the ETS Directive,[4] which allows for moderately increasing the auction supply with allowances from the new entrant reserve in the event of a marked price increase over a six-month period. |

*Source:* (European Commission, 2014b)

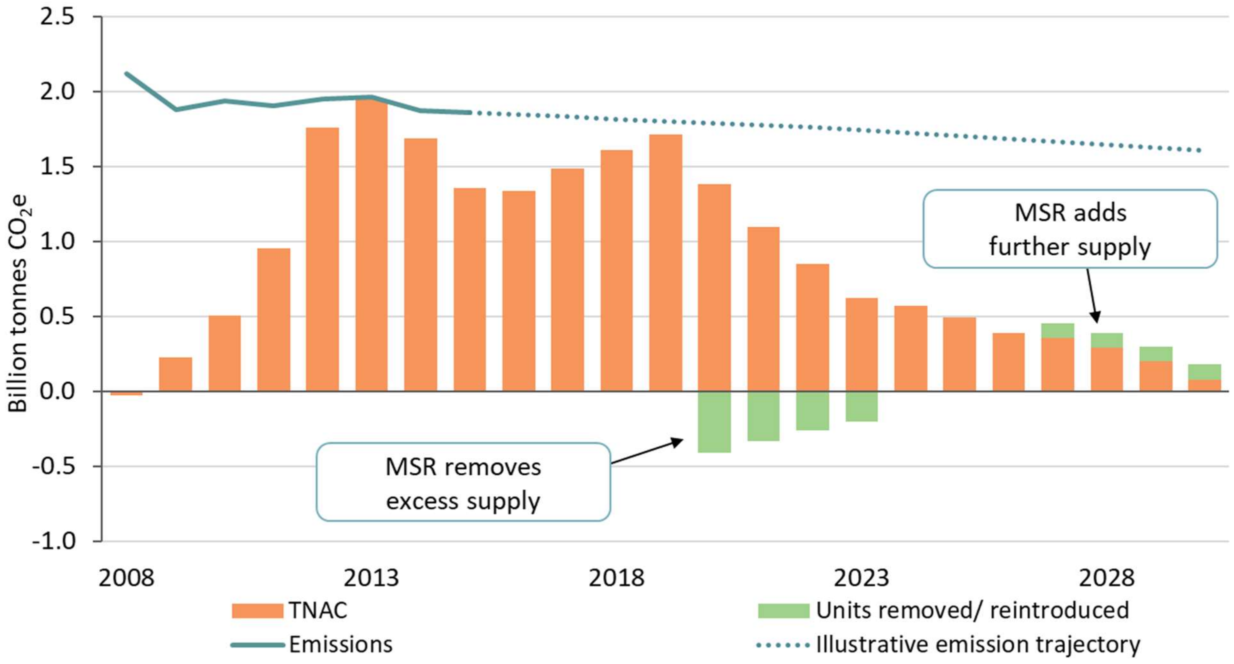
**The MSR began operation on 1 January 2019 and is initially seeded with the 900 million allowances backloaded in 2014-16.** In 2019, this will be supplemented by close to an additional 400 million allowances to be withheld from auction, based on the total number of allowances in circulation (TNAC), a measure of the surplus (European Commission, 2018d). The MSR will also include further unallocated Phase III allowances from reserves set aside for the New Entrants Reserve, and allowances unallocated due to facility closures or production capacity changes. The European Commission expects between 550-700 million Phase III allowances

[3] The TNAC in a given year is defined as 'the cumulative number of allowances issued in the period since 1 January 2008, including the number issued pursuant to Article 13(2) of Directive 2003/87/EC in that period and entitlements to use international credits exercised by installations under the EU ETS in respect of emissions up to 31 December of that given year, minus the cumulative tonnes of verified emissions from installations under the EU ETS between 1 January 2008 and 31 December of that same given year, any allowances invalidated in accordance with Article 12(4) of Directive 2003/87/EC and the number of allowances in the reserve' (European Commission, 2015a, p. 3).

[4] Directive 2003/87/EC, amended by Directive2009/29/EC.

to remain unallocated by 2020 (European Commission, 2015c). Quemin & Trotignon (2019) estimate there to be 581 million unallocated Phase III allowances.. The MSR is expected to significantly reduce allowances surpluses, Figure 2 provides an illustrative example to illustrate the potential functioning of the MSR over time.

*Figure 2.* Illustrative example of MSR's impact on the supply of allowances




*Note:* *This illustrative figure does not include the impact of backloaded allowances being injected into the MSR.*

*Source:* *Vivid Economics*

From 2023, the MSR may alter the long-term allowance supply in the EU ETS by invalidating allowances held in the MSR in excess of the previous year's auction volume. From 2023 onwards, if the volume of allowances held in the MSR exceeds the total volume of allowances auctioned in the previous year (approximately 57% of the annual cap), any excess allowances will be invalidated. This will affect the overall emissions budget available to ETS sectors, and therefore the total level of emissions within the EU. The invalidation mechanism will also mean that overlapping climate policies in covered sector may affect EU ETS-wide GHG emissions (Beck & Kruse-Andersen, 2018; Quemin & Trotignon, 2019; Perino, 2018).

Stakeholder engagement informed decisions regarding the specific scale of the MSR's interventions. Stakeholders suggested that a reduction of auction volume by 12% of the surplus in the event of oversupply, and an increase in annual auction volumes by 100 million allowances in the event of undersupply reflect reasonable adjustments to maintain orderly market functioning. At the same time, EU legislators recognised that these values should be regularly reviewed – and revised if necessary – to incorporate learning from implementing the MSR. These rates of allowance withdrawal or injection are fundamental to the effectiveness of the MSR and determine how quickly it responds to future shocks. This requires calibration so that the MSR responds proportionally to shocks while ensuring that annual adjustments are not too large such that the risks of unintended impacts increase (European Commission, 2014b).

The MSR aims to address several market failures that flourish under uncertainty. Underinvestment in emissions reductions may occur due to divergence between optimal private and social discount rates, myopia, and suboptimal responses in conditions of uncertainty and complexity. The MSR's rule based structure is more predictable than ad hoc interventions such as the backloading decision in Phase 3. To the extent that these rules provide a more predictable price path, this will reduce the market uncertainty and mitigate a significant barrier to low carbon investment.

### 2.1.3 Expected impact

The MSR was designed to reduce the impacts of shocks and to put upward pressure on allowance prices in the near term. The MSR aims to improve the resilience of the EU ETS to unforeseen future demand shocks and the impacts of complementary policies. Importantly, the MSR's objective is to also improve market certainty, thereby fostering low-carbon investment (European Commission, 2014a). Recent amendments to double the feeding rate for allowances into the MSR for the first five years seek to increase the MSR's near-term impact. While estimates diverge, most market analysts agree that the MSR is likely to contribute to increasing allowance prices, with forecasts estimating that prices may reach €35-€40/t$CO_2$e over 2019-23 (Garside, 2018). However, these estimates are highly sensitive to assumptions (Ferdinand, 2018). By raising prices in the near term and reducing future price uncertainty the MSR is expected to lower the risk associated with low-carbon investment. The reduction of uncertainty has the potential to increase efficiency of mitigation pathways, however there remains debate in the academic literature regarding the likely impact of the MSR with some finding price increases attributable to the MSR may be modest (Beck & Kruse-Andersen, 2018; Perino & Willner, 2017a; Quemin & Trotignon, 2019), and other suggesting price volatility increases (Perino & Willner, 2016; Richstein, Chappin, & de Vries, 2015) which could hamper investment incentives (Perino & Willner, 2017b).

The expectation of the MSR''s 2019 start date was accompanied by rapid EU allowance price rises in 2018, reaching peaks not seen in a decade. This rapid price rise, illustrated in Figure 1 above, also saw some price volatility, for instance with EU allowance prices fluctuating between €18/t$CO_2$e and €26/t$CO_2$e over a five-day period in September 2018 (Vitelli, 2018).

While there is some divergence in estimates, analysts expect a significant quantity of allowances to be invalidated from the reserve after 2023. This invalidation will reduce overall emissions in the EU and help to ensure that oversupply does not threaten long-term emissions reductions. Some analysts estimate that the auction volume in 2023 will be around 484 Mt$CO_2$e, while the MSR could be close to 2,982 Mt$CO_2$e, leading to the invalidation of around 2,500 Mt$CO_2$e in 2024 alone and potentially around 3,000 Mt$CO_2$e over Phase IV as a whole (Ruf & Feuchtinger, 2017). Burtraw & Keyes (2018) estimate an annual allowance invalidation of around 2,000 Mt$CO_2$e in 2023, and around 3,500 Mt$CO_2$e in total by 2030. Perino & Willner (2017a) estimate that around 1,700 Mt$CO_2$e will be invalidated, while Beck & Kruse-Andersen (2018) and Quemin & Trotignon (2019) expect substantially more allowances to be invalidated, with estimates varying based on firm myopia, future demand shocks and abatement technology scenarios.

*Box 2.* Key takeaways from the EU's MSR

The EU introduced a quantity based MSM, the Market Stability Reserve (MSR), in 2019. The instrument will:

— reduce annual auction volumes by 12% (24% over 2019-23) by drawing allowances into the MSR if the cumulative surplus exceeds 833 million allowances;
— increase auction volumes by 100 million allowances by injecting allowances from the MSR if the surplus falls below 400 million allowances or allowance prices over a six-month period are three times higher than the preceding two years' average levels; and
— from 2023 onwards, invalidate allowances in the MSR above the previous year's auction volumes.

The MSR was introduced as a structural solution to the challenge of allowance oversupply and high levels of banking.

— The economic shock from the 2008 international financial crisis, followed by the European debt crisis which, in combination with large inflows of international credits, led to a significant oversupply of allowances and declining prices.
— While the European Commission introduced a backloading system to shift 900 million allowances to later phases of auctioning, a more permanent solution was required to increase the robustness of the EU ETS in response to unexpected demand shocks.

Prevailing market perspectives expect the MSR to solve supply and demand imbalances, strengthen the allowance price, and accelerate emissions reductions in the EU ETS.

— The expectation of the MSR's 2019 implementation was met with increased allowance price volatility in 2018 against the backdrop of expected future increases in prices.[5]
— While exact estimates differ, most market analysts expect the MSR to absorb significant volumes of allowance surplus over the first few years of operation, with estimates of a total MSR volume in 2022 ranging between 2.0 and 3.0 Gt$CO_2$e.
— Invalidating surplus allowances above threshold levels from 2023 onwards will reduce the EU's overall emissions and reduce the long-term impact of allowance oversupply.

[5] The EU ETS experienced record levels of price volatility in September 2018, moving from close to €26/tCO2e to around €18/tCO2e over five days (Vitelli, 2018).

# 3 Price based instruments

Most MSMs are price based instruments, having been implemented in several jurisdictions. This section details price based MSMs in California-Quebec; the North-eastern US States of the Regional Greenhouse Gas Initiative (RGGI); New Zealand; Tokyo-Saitama; and Australia. For each jurisdiction, the review provides an overview of the carbon market, discusses the process that led to the implementation of the instruments, details their functioning, and reviews their actual impact and practical experience.

## 3.1 California-Quebec (Western Climate Initiative), soft price collar

California's ETS began in 2013 and is now in its third compliance period (2018-20), covering 85% of all the state's GHG emissions. Initially, it covered only entities in the industry and power sectors, which accounted for 48% of the state's emissions. Industrial facilities were included if they emitted more than 25 kt$CO_2$e per year, which covered producers of electricity, cement, glass, iron and steel, lime, hydrogen, nitric acid, pulp and paper, petroleum, and oil and natural gas (CARB, 2011). After 2015, it was expanded to cover retail sales of mineral transport fuels (such as gasoline, diesel, and natural gas), which in 2014 accounted for 37% of the state's emissions (CARB, 2017b). The ETS currently covers 450 entities representing 85% of emissions, with a 2018 emissions cap of 358.3 Mt$CO_2$e. The state targets an emissions reduction of 46% below 1990 levels in 2030 (200.5 Mt$CO_2$e) (CARB, 2018b). Industry receives free allocation based on benchmarks and provides additional allocation to sectors at risk of carbon leakage; the electricity sector receives free allowances but must sell them at auctions and transfer revenues to consumers (CARB, 2018b).

Quebec's ETS also began in 2013, now being in its third compliance period (2018-20) and covering 85% of the province's total GHG emissions. The first compliance period covered just electricity generation and industrial facilities emitting more than 25 kt$CO_2$e per year. Subsequent phases included coverage of distribution and import of fuels used in transport, buildings and small and medium-sized enterprises (SMEs) for fuel distributors of over 200L (ICAP, 2018a). The Quebec ETS covers 132 entities, accounting for 85% of Quebec's total emissions. In 2018, the total cap was 59 Mt$CO_2$e and will decline to 44 MtCO2e in 2030 to reach an emissions reduction target of 37.5% relative to 1990 levels. Industry receives free allocations based on benchmarks and historical output, while full allowance auctioning takes place in the electricity sector.

California and Quebec linked their ETS in late 2014. This linked carbon market became known as the Western Climate Initiative's (WCI) regional cap-and-trade programme. California's ETS programme design contains a general requirement to explore opportunities for linking with other carbon markets, including the need to undertake a public process to amend the regulation to allow for the mutual acceptance of ETS compliance instruments. CARB staff worked closely with the WCI from its inception and undertook significant public consultation to develop template ETS design features that could facilitate linking. The objective of linking these carbon markets was to enable gains from trade as a result of wider emissions reduction opportunities and a more liquid market (CARB, 2012a). The WCI ETS also briefly included the membership of Ontario in 2017 (Climate Solutions Group, 2017), although Ontario left the WCI regional cap-and-trade in 2018 (McCarthy, 2018). Box 3 discusses how California and Quebec dealt with divergent ETS design aspects when linking their ETS.

*Box 3.* When linking ETS, California and Quebec addressed limited divergent design aspects

While the California and Quebec ETS were similar and based on the model developed by the WCI, divergent design features in a few key areas were harmonised in preparation for linking:

- separate auctions;
- varying auction reserve price levels, exchange rates, and rates of increase;
- California's purchase limit exemption for electricity utilities; and
- allowance price containment reserve (APCR) arrangements.[6]

Linking resulted in California and Quebec implementing new, joint allowance auctions. Previously, the two jurisdictions hosted separate allowance auctions. However, upon linking, the two jurisdictions introduced quarterly joint auctions wherein compliance entities in both markets could bid for allowances simultaneously. This ensured that auctions would result in a single allowance price formed across the linked ETS (CARB, 2012b).

Joint auctions introduced an auction reserve price that was the higher of the two jurisdictions' existing inflation-adjusted auction reserve price. Given that the two jurisdictions use different currencies, linking required that each jurisdiction adjust its auction reserve price for local inflation. To account for multiple currencies in the joint auctions, each auction is accompanied by a prior notice (the business day before the auction) stipulating an official auction exchange rate (CARB, 2015). The two reserve prices are then converted into an inflation-adjusted common currency and the joint auction uses whichever reserve price was higher. This ensures that no linked jurisdiction would be selling its allowances below its stipulated floor price due to currency exchange rate fluctuations (CARB, 2012b).

California amended its purchase limit rules for electricity utilities when linking with Quebec.[7] Initially, California exempted electricity utilities from purchase limit rules as they were required to consign all of their allocated allowances to auction with the resulting value required to be used to benefit consumers. Upon linking with Quebec, Californian regulators instituted a 40% purchase limit for utilities, as this was large enough for utilities to meet compliance obligations while lifting the exemption removed the perceived inequity between utilities and other compliance entities (CARB, 2012b).

The linked California-Quebec ETS retained separate APCR arrangements but have aimed to keep the price tiers consistent across jurisdictions. In the event of the APCR being triggered, entities can purchase allowances only from their own jurisdiction's APCR. As these reserves are separate, there is no need to fully harmonise tier prices. However, the APCR sales will still be scheduled for the same day and the reserve sales have the same structure, escalation rates, and starting prices.

As California and Quebec are subnational jurisdictions, they may be affected by national policymaking in their respective countries. For example, Canada recently announced its Pan-Canadian Framework (PCF), which will

[6] The APCR is an allowance reserve that is released to contain prices in the event of price spikes and is discussed in detail in Section 3.1.2.

[7] Purchase limits are the maximum volume of allowances that any single entity or group of entities can purchase at quarterly auctions.

introduce a federal carbon pricing backstop to jurisdictions that fail to introduce a carbon pricing mechanism of sufficient stringency, as discussed in Box 4. This functions in a manner similar to a national carbon price floor and could interact with the operation of subnational ETS; however; it remains unclear if and how this interaction may unfold. While the stringency of Quebec's ETS is currently above that necessitating federal intervention, their remains a theoretical potential for future intervention.

*Box 4.* Canada's proposed federal carbon pricing backstop

Canada aims to enforce a minimum benchmark level of carbon pricing across all provinces and would supplement a low-stringency provincial ETS by providing a price floor. The federal government plans to strengthen nationwide climate action by implementing a carbon pricing system in jurisdictions that do not have carbon pricing systems aligned with the national benchmark. This mechanism applies in jurisdictions without carbon pricing and would also supplement systems that do not meet benchmark levels. The pricing backstop could 'top up' low-stringency jurisdictions by expanding sources covered or increasing the stringency of the provincial carbon price. The backstop would include two components: a carbon levy on fossil fuels; and an output based pricing system for large industrial facilities. Rates for each fuel are set to be equivalent to CA$10/t$CO_2$e in 2018, increasing by CA$10/t$CO_2$e annually until reaching CA$50/t$CO_2$e in 2022 (Government of Canada, 2017).

The federal government plans to implement the federal carbon pricing backstop in seven Canadian provinces in 2019, despite legislative challenges. The government recently confirmed plans to implement the backstop in Ontario, New Brunswick, Manitoba, Saskatchewan, Yukon, Nunavut, and Prince Edward Island. However, certain backstop relief will be provided to Yukon and Nunavut (Chachula, Gilbert, & McInerney, 2018). However, the legislative implications and mechanics of implementing the federal carbon pricing backstop on top of provincial ETS that are determined to be below the benchmark are currently unclear (Bishop, 2018; Rabson, 2017). In particular, Ontario and Saskatchewan have mounted legal challenges to the federal carbon pricing backstop, arguing that the federal government does not have the jurisdiction to regulate GHG emissions (Canadian Press, 2018).

The WCI carbon market also allows entities to use offsets for compliance, primarily to help contain costs. In California, entities may use eligible offsets for up to 8% of their compliance obligations,[8] but recent amendments stipulate that from 2021 the quantitative limit will drop to 4% and offsets will be eligible only if they deliver environmental benefits to California (ICAP, 2018i). In Quebec, entities may use offsets for up to 8% of their compliance obligations from five types of domestic offset projects (ICAP, 2018a).[9] The linking of the California-Quebec ETS resulted in offsets eligible under either scheme being available for all regulated entities (Vaiciulis, 2013).

The WCI carbon market has implemented MSMs, using a soft price floor and a soft price ceiling. Both California and Quebec use an auction reserve price as a soft price floor to mitigate the risk of carbon prices falling too

[8] Eligible offsets are those derived from six domestic project types: US forests; urban forests; methane management from livestock; ozone-depleting substances projects; mine methane-capture projects; and rise cultivation projects (ICAP, 2018i).

[9] The five types of eligible domestic offset projects are: methane-destruction projects in manure storage facilities; landfill gas capture; ozone-depleting substances projects; methane-capture and flaring projects from mine drainage systems; and methane-capture and flaring projects from mine ventilation systems (ICAP, 2018a).

low. To provide confidence to the market that prices would be contained within a certain range, and to prevent unexpected price spikes, an allowance price containment reserve (APCR) mechanism was developed. This reserve sets aside a portion of allowances under the cap for injection into the market if the allowance price exceeds any of three tiers (IETA, 2018a).

### 3.1.1 Implementation process

Both MSMs (soft price floor and soft price ceiling) were introduced to reduce risk, from different perspectives:

- risks to low-carbon investment from prices falling too low; and
- risks to industrial competitiveness and costs from prices rising too high.

The auction reserve price was introduced to ensure a minimum level of allowance prices to maintain emissions reduction incentives. The implementation of a minimum auction price reflects the design recommendation of an initial WCI cap-and-trade design report (WCI, 2008). The auction reserve price mechanism was recommended to reduce the impact of a potential early oversupply of freely allocated allowances. Based on the experience of early EU ETS phases, the risk of an oversupply of allowances was particularly salient: stakeholders in these jurisdictions interpreted the lessons from the early part of the EU ETS as showing that caps could be too high, emissions could be overestimated, and market behaviour in response to unlimited banking could be uncertain. The auction reserve price design operating in RGGI also served as a form of guidance for WCI policy-makers.

The soft price ceiling APCR was introduced to reduce risks for market participants and to stimulate market liquidity. The soft price ceiling intends to mitigate risk and improve confidence for market participants by stipulating that if prices rise beyond a certain level, a limited number of additional allowances will be provided at three fixed-price steps. This limits the impact on entities from unforeseen market shocks that could cause allowance prices to spike, as allowance price increases would be dampened beyond the three fixed-price steps. The Californian Emissions Market Assessment Committee described the role of the APCR as an allowance price safety valve and an instrument to mitigate excessive volatility in the event of short-run shocks. The soft price ceilings also aimed to limit the returns to speculative trading on low-probability, high-impact events, and the returns to strategic market manipulation (Bailey, Borenstein, Bushnell, & Wolak, 2012).

California's approach to price containment drew on previous experience with short-run price shocks in the Regional Clean Air Incentives Market (RECLAIM). RECLAIM is a NOx emissions cap-and-trade regulation that began in 1994, covering Los Angeles and Orange counties. In 2000, an electricity crisis in California required more polluting local power plants to ramp up generation, which caused a rapid demand increase for NOx emissions allowances and vintage 2000 average allowance prices to spike from $15,000/ton in 1999 to over $40,000/ton in 2000. Subsequent amendments to RECLAIM temporarily removed large power generators from the market and mandated that they introduce emissions controls, reduced allocations to achieve NOx reductions, and implemented a price protection mechanism that paused annual allocation reductions if the past year's average annual allowance price exceeded a certain level (EPA, 2006).

### 3.1.2 Functioning

The California and Quebec ETS operates a soft price collar with:

- a minimum auction price; and
- an APCR in each jurisdiction.

Minimum auction price

California and Quebec set a minimum price for their joint auctions, which acts as a hard price floor in auctions and a soft price floor for the secondary carbon market. The minimum auction reserve price requires that if auction bids are below the reserve price, allowances are not sold. Table 4 details the minimum auction price over all years of operation of the California-Quebec cap-and-trade programme; it was set at US$10 in 2012 and increases annually by 5% plus inflation. The 2018 minimum price is US$14.5 (IETA, 2018a; WCI, 2018b). An auction exchange rate is published to convert to the two currencies, and the WCI joint auction reserve price uses the higher of California's or Quebec's reserve price (WCI, 2018a). The minimum price is a hard price floor for the auctions themselves but a soft price floor for the carbon price facing covered entities. The secondary market price can fall below the minimum auction price, but as allowances would not be sold at quarterly auctions below this level, this would temporarily limit supply and help support the recovery of secondary market prices back to the level of the reserve price. In 2016, the secondary market price fell below the minimum auction price over April-July for around 140 cumulative days of trading (Busch, 2017a). This resulted in some allowances offered for sale in quarterly auctions not being sold at the minimum auction price (discussed more in Section 3.1.3). Allowances that are unsold at joint auctions due to the reserve price are returned to auction after two consecutive auctions result in a settlement price above the auction reserve price (WCI, 2018b).[10]

Allowance Price Containment Reserve (APCR)

The APCR is a soft price ceiling that offers three equal-sized tiers of fixed-price allowances when quarterly auction clearing prices equal or exceed 60% of the lowest price tier . The price trigger levels are the same for both California and Quebec, rising annually by 5% plus inflation, with Quebec's levels converted into CA$ using an official exchange rate.[11] For the remainder of this section prices are presented as US$. 0 illustrates the three APCR price tiers over each year of operation. If quarterly allowance auction prices equal or exceed 60% of the lowest APCR price tier,[12] this triggers a subsequent reserve sale auction where a fixed number of allowances for each jurisdiction at each price tier will be offered to the market.[13] This works as a soft price ceiling, as only a fixed number of allowances are distributed for sale, but the market prices for allowances in the secondary market can still rise above the price tiers, even after the extra allowances have been offered to the market (Québec, 2014).

[10] Quebec environment ministry stakeholders noted that the rate of reintroduction is set to a maximum of 25% of the volume of allowances otherwise offered for sale at auction to avoid reintroduction resulting in a temporary oversupply.

[11] The WCI attempts to avoid potential mismatch between California and Quebec's APCR price trigger levels due to exchange rates by estimating price levels in California, accounting for its inflation rate, and then converting to CA$ using the most recent available daily exchange rate (IETA, 2015b). However, exchange rate volatility in California and Quebec over the year after the publishing of the Annual APCR Notice could lead to entities in different jurisdictions facing different effective APCR tiers. The effect of this is limited as each jurisdiction's APCR allowances can be used only by entities in that jurisdiction, and thus complete harmonisation of tier price levels is not a hard requirement (CARB, 2012b).

[12] However, Quebec stakeholders in the ministry for the environment suggested in interviews that the price trigger in Quebec is more qualitative and provides greater discretion in implementing APCR auctions when it is believed they are required.

[13] Quebec's regulation refers to these as sales by mutual agreement of the minister (Quebec, 2018).

*Table 4.* APCR tiers in the California-Quebec regional cap-and-trade programme

| Year | Auction reserve price | Effective APCR trigger price | APCR Price Tier 1 | APCR Price Tier 2 | APCR Price Tier 3 |
|---|---|---|---|---|---|
| 2013 | 10.7 | 24.0 | 40.0 | 45.0 | 50.0 |
| 2014 | 11.3 | 25.4 | 42.4 | 47.7 | 53.0 |
| 2015 | 12.1 | 27.1 | 45.2 | 50.9 | 56.5 |
| 2016 | 12.7 | 28.5 | 47.5 | 53.5 | 59.4 |
| 2017 | 13.6 | 30.4 | 50.7 | 57.0 | 63.4 |
| 2018 | 14.5 | 32.6 | 54.3 | 61.1 | 67.8 |

*Note:* *All units are US$/allowance.*

*Source:* *Vivid Economics*

**California and Quebec have separate APCRs containing non-tradeable reserve allowances that can be used only for local entities' compliance.** Since the introduction of the APCR, each year California has set aside 40.6 million allowances for sale at each APCR tier (121.8 million in total), while Quebec has set aside 6.7 million allowances for sale at each APCR tier (20 million in total) (CARB, 2017a). In 2018, the total APCR available in the WCI was therefore close to 41% of the total 347 million allowances available for auction. In California, if the final-tier APCR allowances are exhausted, CARB may offer for sale up to 10% of allowances borrowed from future budget years (CARB, 2018e). Each jurisdiction's reserve allowances are available only to covered entities in that jurisdiction, and allowances injected from the reserve can be used only for compliance and are not tradeable (Québec, 2014). This reflects the fact that the allowance reserve measures were not fully harmonized when the two jurisdictions linked. All reserve transactions are handled by WCI Inc. Both California and Quebec's APCRs were designed to be filled by diverting a small percentage of allowances each year from the respective caps of California and Quebec over 2013-20, as illustrated in Table 5.

*Table 5.* Allowances are diverted to California and Quebec's APCRs in proportion to their ETS caps

| Compliance period | % of annual allowance budget diverted to the APCR | Year | Annual allowances diverted to Californian APCR ($MtCO_2e$) | Annual allowances diverted to Quebec APCR ($MtCO_2e$) |
|---|---|---|---|---|
| 1st (2013-14) | 1% | 2013 | 1.63 | 0.23 |
| | | 2014 | 1.60 | 0.23 |
| 2nd (2015-17) | 4% | 2015 | 15.78 | 2.61 |
| | | 2016 | 15.30 | 2.53 |
| | | 2017 | 14.82 | 2.44 |
| 3rd (2018-20) | 7% | 2018 | 25.08 | 4.13 |
| | | 2019 | 24.24 | 3.98 |
| | | 2020 | 23.39 | 3.83 |

*Source:* *Vivid Economics based on IETA (2014)*

**Quebec's APCR rules provide slightly more discretionary power than California's.** Once price thresholds are breached in California, CARB must implement the APCR mechanism and the auction of the additional allowances must occur six weeks after the initial auction that broke price thresholds (EDF, 2012). However, in Quebec, the regulation is less prescriptive on APCR auction dates and merely limits the number of APCR auctions possible to four per year. Further in Quebec, under specific circumstances of low availability of allowances, the Minister of Sustainable Development and Environment can temporarily lend APCR allowances to provide free allocations to emissions-intensive and trade-exposed (EITE)-covered entities. As such, Quebec's soft price ceiling allows for more discretionary power than California's.

### 3.1.3 Actual use and practical experience

Minimum auction price

**The auction reserve price has supported prices on the secondary market by withholding auction supply.** Figure 3 shows the allowance price and auction reserve prices between 2012 and 2016. Since 2014, the allowance price has been at or slightly above the auction reserve price, illustrating the impact of the soft price floor. In 2016, political challenges to the Californian cap-and-trade led to policy uncertainty which caused prices to decline below the auction reserve price (CleanTechnica, 2018). However, as these challenges were resolved the allowance price reverted to above the auction reserve levels (Profeta, 2017). When secondary market prices dropped below auction reserve price levels between April and June 2016, significant volumes of allowances were unsold. From February 2016 to February 2017, 183 $MtCO_2e$ of allowances went unsold at auction, or about 50% of the allowances offered for sale in each quarterly auction.[14] This helped prevent secondary prices from declining further and since May 2017 no allowances have gone unsold in auctions. Allowances withheld at auctions have been gradually returned to the market by increasing the volume of allowances offered at subsequent auctions. From 2021, all allowances that have remained unsold for 24 months will be moved into the APCR.

*Figure 3.* The auction reserve price effectively supported California allowance prices


*Source:* *Vivid Economics*

[14] For comparison, in 2015 no allowances went unsold and the average proportion of qualified bids relative to allowances offered for sale stood at 1.18.

The California-Quebec ETS experienced enduring allowance oversupply resulting in the secondary market price-tracking the auction reserve price for extended periods. This was driven by a combination of the impact of overlapping command and control policies,[15] low demand relative to cap size given subsequent economic conditions, and uncertainty over the post-2020 policy (Cullenward & Coghlan, 2016). Another significant factor is the accumulation of banked allowances. California's ETS has generated a significant surplus of banked allowances, which reflects emissions having fallen faster than expected.

The allowance oversupply is a concern that is being monitored by academics and regulators. Some academics suggest that this allowance bank could constrain future carbon costs and subsequently reduce mitigation incentives (Burtraw, Keyes, & Zetterberg, 2018). Busch (2017b) recommends that a permanent downward cap adjustment could offset the impact of the high level of banked allowances without introducing additional volatility in the market through rule changes and without harming private holders of banked allowances. However, Burtraw (2018) suggests that a large allowance bank may help incentivise further carbon market linking, as California's bank could effectively function as a cost-containment reserve for any linked jurisdiction. The oversupply has been noted by CARB and the post-2020 amendments to the ETS (AB 398) compel the regulator to evaluate and address concerns of overallocation over 2021-30 (California Legislature, 2017). However, final decisions from four public workshops resulted in CARB staff not proposing banking rule amendments or any changes to post-2020 allowance budgets (CARB, 2018e).[16]

Allowance Price Containment Reserve (APCR)

Stakeholder concerns about future potential cost increases stimulated amendments to the APCR. To date, allowance prices have remained well below the APCR tiers; indeed, auction prices have never risen above 40% of the first APCR tier. Nevertheless, Californian stakeholders have expressed concern that the APCR may be insufficient to contain costs if secondary market allowance prices rise quickly (IETA, 2014; CARB, 2018d). These concerns are particularly pertinent given that California has expanded the role of the ETS as a driver of state-wide mitigation relative to other policies and measures over consecutive scoping plans, through expanded coverage and tightened caps. Over 2021-30, the cap-and-trade programme will aim to generate 236 $MtCO_2e$ in emissions reductions, 38% of total targeted reductions(CARB, 2017b). The legislative amendments of AB 398 require CARB to establish a price ceiling cost-containment measure while considering the objective of avoiding adverse impacts on households and businesses; the potential environmental and economic leakage; and the cost per metric ton of GHG emissions to achieve the state-wide GHG emissions reduction targets (CARB, 2018d, 2018f).

As such, from 2020, California will amend the APCR and transform its final tier into a hard ceiling, meaning that unlimited allowances will be offered at this price, to supplement its containment reserve approach.[17] Figure 4 illustrates the width of the current WCI price collar between the reserve price and the APCR tiers and how amendments from 2021 will lower the APCR tiers and make the top tier a hard price ceiling. The price ceiling would be set at US$65 in 2021 (approximately US$61 in 2018 dollars), while the first and second tier would be set at the halfway point and three-quarter point, respectively, between auction reserve price and

[15] For example, California's Low Carbon Fuel Standard mandates emissions intensity reductions for transport fuels, and the Renewables Portfolio Standard mandates requires electricity providers to procure a set percentage of energy from renewable sources.

[16] Amendments made for the post 2020 period therefore left the minimum auction price unchanged, but strengthened the APCR mechanism, as discussed in the subsequent section.

[17] Previously, the state planned to continue the sale of all reserve allowances under a single tier and a price of US$75.43 + inflation in 2021 (CARB, 2018e).

the price ceiling (CARB, 2018e). These more distributed price triggers from 2021 aim to mitigate price volatility more effectively, particularly the risk of sudden price spikes (Schatzki & Stavins, 2018).

*Figure 4.* Amendments to the APCR will impose a lower, narrower price collar, with a hard price ceiling in tier 3

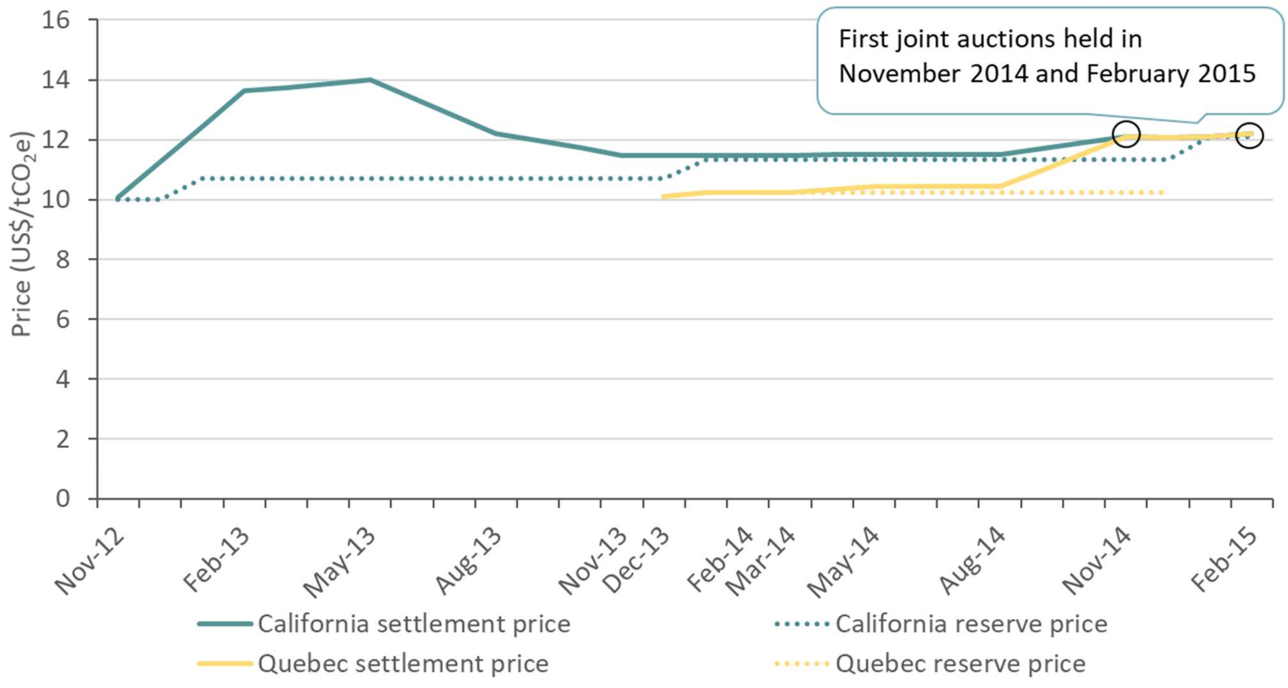

*Source: Vivid Economics, based on CARB (2018c)*

Linking impacts

**Linking raised Quebec's auctioned carbon price, largely due to joint auctions utilising California's higher auction reserve price.** Before the start of Quebec's ETS, ex ante modelling estimated that Quebec's unlinked carbon price would be higher than California's due to a power sector dominated with renewables and fewer low-cost emissions reduction opportunities(WCI Economic Modelling Team, 2012). Due to the significantly larger size of California's ETS (six times the size of Quebec's market), linking was predicted to result in Quebec's allowance price tracking California's lower price (CARB, 2012b). In practice, Quebec's settlement allowance prices were consistently around US$1-US$2 lower than California's, prior to the beginning of joint auctions (EIA, 2015).[18] After linking, the WCI joint auctions utilised the higher of the two auction reserve prices, adjusted by an auction exchange rate to reflect the multiple currencies (WCI, 2014). As Figure 5 illustrates, this resulted in allowance prices tracking Californian ETS prices, which was to be expected considering the relative sizes of the carbon markets.

[18] The differences between ex ante modelled impacts and actualised impacts reflect both a general finding in the literature of carbon prices being lower than expected (Burtraw et al., 2018), and assumptions in the specific model used by the WCI Economic Modelling Team, such as not taking into account the impact of free allocations on allowance prices.

*Figure 5.* Quebec's auction allowance price effectively rose after linking with the Californian ETS




*Source: Vivid Economics based on CARB (2018a) and Environment Quebec (2018)*

The WCI ETS's swift action after Ontario's announcement to de-link helped ensure market stability. The auction immediately following Ontario's de-linking from the WCI ETS resulted in full market clearance and very little unexpected or undesired outcomes. On the day of Ontario's announcement to de-link, the WCI temporarily suspended the allowance accounts of all Ontario's trading entities.[19] This prevented the dumping of excess allowances onto the market and resulted in secondary market prices stabilising quickly. This reflects the market's confidence in the WCI, robust ETS design, and the effectiveness of decisive market intervention (Sutter, 2018). In interviews, Quebec stakeholders noted that market participants broadly supported the immediate actions taken to protect their assets and investment value.

[19] The revoking of Ontario's ETS resulted in CA$2.8 billion worth of allowances purchased by Ontario entities with uncertain value (MOECC, 2018). However, Ontario has developed a plan to compensate such entities which were previously required to participate under the programme (MOECC, 2019)

*Box 5.* Key takeaways from California-Quebec's soft price collar

The linked California-Quebec ETS implement a soft price collar comprising an auction reserve price and an allowance price containment reserve (APCR).

- The auction reserve price acts as a hard price floor in joint auctions,[20] not selling any allowances below the reserve price level,[21] and a soft price floor for the broader market, as the secondary market price may fall below the reserve price level.
- The APCR offers a limited number of allowances into the market for sale when auction allowance prices breach at least 60% of the lowest of three threshold levels. This functions as a soft price ceiling as only a limited volume of allowances are released at each price threshold, and the secondary market price can still exceed price thresholds.
- California and Quebec have separate APCRs which sell non-tradeable reserve allowances to locally regulated entities, and Quebec's APCR provides for slightly more discretionary power.

California-Quebec's soft price collar was introduced to mitigate risks of allowance prices falling too low to stimulate low-carbon investment or too high as to compromise industrial competitiveness.

- The auction reserve price was introduced to mitigate the risk of allowance oversupply leading to low allowance prices. This risk was salient given oversupply in the EU ETS and RGGI's earlier introduction of an auction price floor as part of its auction design.
- The APCR was meant to limit risks to entities or unexpected allowance price spikes and increase market certainty while increasing liquidity, which was a salient risk from the previous NOx emissions trading programme in California (RECLAIM).

The California-Quebec auction reserve price has supported lower-end market prices, but discussions are ongoing to determine whether enduring oversupply requires a structural solution.

- The auction reserve price helped maintain California-Quebec allowance prices over 2014-17, with declines below the reserve price self-correcting in response to withheld auction supply.
- When secondary market prices dropped below auction reserve price levels between April and June 2016, this was accompanied by significant volumes of allowances going unsold. In 2016, 130 $MtCO_2e$ of allowances went unsold at auction, around 42% of the total allowances offered for sale. For comparison, in 2015 no allowances went unsold and the average proportion of qualified bids relative to allowances offered for sale stood at 1.18.
- However, the auction reserve price is less effective at solving the current enduring oversupply of allowances as a result of cap overestimation, high banking levels, the impact of overlapping policies, and post-2020 instrument design uncertainty.
- To correct this, WCI jurisdictions are exploring the potential need for a more structural solution.

California-Quebec stakeholders have challenged the effectiveness of the current APCR design, which has resulted in significant amendments to its post-2020 design.

- Despite prices remaining well below APCR trigger levels, Californian stakeholders have expressed concern over the adequacy of the APCR in the event of future price shocks, arguing that it would not be sufficient given its limited number of reserve allowances.
- AB 398 has legislated that from 2021, a hard price ceiling will replace the top tier of the APCR, and the price triggers for supplying further units will be reduced for the price ceiling and APCR tiers.

## 3.2 The Regional Greenhouse Gas Initiative (RGGI), soft price collar

The Regional Greenhouse Gas Initiative (RGGI) began in 2008 and is now in its fourth control period (2018-20), covering power sector emissions responsible for 20% of total $CO_2$ emissions across nine north-eastern US states. States participating in RGGI include Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. New Jersey recently announced plans to re-join RGGI (having left in 2012), but the requisite negotiations mean the state will likely be a full member again only in 2020 (French & Muoio, 2018). Power sector facilities in these states are covered by RGGI if their electricity generating capacity is greater than 25 MW. Allocation to facilities is largely determined through quarterly auctions, with 93% of allowances sold at auction during the third control period (2015-17) (ICAP, 2018j; RGGI, 2019).[22] In 2018, the initial total emissions cap was 82 million short tons of $CO_2$, which was reduced to 60 million short tons[23] of $CO_2$ to account for privately banked allowances over the first and second control periods.[24] The cap declines annually by 2.5% until reaching 56 million short tons in 2020 as agreed by RGGI states through RGGI Inc. processes (RGGI, 2018g). The most recent auction was December 2018 and resulted in a clearing price of US$5.9/t$CO_2$ (US$5.4/short ton $CO_2$) (RGGI, 2018b). RGGI also has an active secondary market with both compliance and third-party investors eligible to trade.

RGGI allows the use of offsets for compliance, subject to certain quantitative and qualitative limits. Regulated entities may use offsets for up to 3.3% of their compliance obligations in any given control period. Offsets must be derived from one of three emissions reductions project categories outside the capped power sector but within the nine regulated US states.[25] The three eligible offset project categories are emissions reductions from (RGGI, 2017b):

- landfill methane capture projects;
- forestry projects; and
- avoided agricultural methane projects.

RGGI has implemented a soft price collar using two price based MSMs and will introduce a third in 2021. To mitigate the risks of carbon prices falling too low, RGGI has a minimum auction floor price that acts as a soft floor for the market. In the event of prices becoming too high, RGGI has a soft price ceiling (a Cost Containment Reserve (CCR)) that injects a predefined volume of allowances into the market in the event of allowance prices breaching certain thresholds. From 2021, RGGI will introduce another soft price floor mechanism (an Emissions

[20] A technical auction reserve price is a central feature of sound auction design in the presence of a liquid secondary market. In EU ETS auctions, a technical reserve price is set (unknown to bidders) by the auction platform in consultation with the auction monitor based on prevailing market prices before and during the close of the bidding window. This ensures that auction prices do not settle significantly below the market price thereby distorting the carbon price signal. In the event that auction prices settle below this technical auction reserve price, the auction is cancelled and the volume of offered allowances will be returned to the market by distributing them evenly over subsequent auctions scheduled on the same platform (European Commission, 2015b)

[21] Allowances that remain unsold at joint auctions are returned to auction after two consecutive auctions result in a settlement price above the auction reserve price (WCI, 2018b). When returning allowances to auction, they are limited to 25% of the amount originally scheduled for auction, to avoid another auction resulted in unsold allowances (CARB, 2012b). From 2021, allowances that remain unsold after 24 months will move to the APCR.

[22] A limited amount of allowances are also held in separate accounts for states to distribute according to state-specific programmes.

[23] 1 short ton is equivalent to 0.90718 metric tonnes (EIA, 2017)

[24] Two cap adjustments have been made to account for banked allowances. The first adjustment reduced annual emissions caps each year over 2014-20 by around 8.2 million short tons of $CO_2$; in aggregate equivalent to the total privately held bank of 2009-11 (RGGI, 2014a). The second adjustment reduced the annual emissions cap each year over 2015-20 by around 13.7 million short tons of $CO_2$; in aggregate equivalent to the total privately held bank of 2012-13 (RGGI, 2014b).

[25] Prior to the 2017 review, additional eligible offset project categories included reductions of sulphur hexafluoride, afforestation activities, and end-use efficiency measures (RGGI, 2018e).

Containment Reserve (ECR)) that withdraws a predefined volume of allowances in the event of allowance prices falling below certain thresholds.

### 3.2.1 Implementation process

RGGI has taken an iterative approach to implementing MSMs, following its regular programme reviews.

- The minimum auction reserve price was part of the initial RGGI design;
- The CCR was introduced in 2014 after a programme design review in 2012; and
- The ECR was developed through a review of the RGGI design that began in 2015.

The minimum reserve auction price was introduced to reduce the impact of potential allowance oversupply. During deliberations on the initial RGGI design, participating states agreed to use auctions as the primary mechanism to distribute allowances with auction price floors to manage prices, in line with recommendations made in an accompanying study on best-practice auction design (Holt, Shobe, Burtraw, Palmer, & Goeree, 2007). Stakeholders note that programme designers were aware of the difficulties in accurately setting emissions caps and thus used an auction reserve price to reduce the risk that low prices could drastically reduce revenues. This insight proved wise as RGGI faced a significant oversupply of allowances relative to actual emissions levels during the first (2009-11) and second (2012-14) control periods (Ramseur, 2017). This was largely the result of the technological breakthrough of fracking, which increased natural gas supplies and contributed to natural gas prices falling by 46% over 2005-11 (ADB, 2016; Murray, Maniloff, & Murray, 2015).[26] Low natural gas prices resulted in gas-fired generators outcompeting emissions-intensive coal-fired generators, and electricity sector emissions fell rapidly. As demand dropped, auction reserve prices limited the fall in market prices by withholding allowance supply.

Cost controls in RGGI initially relied on an expanded offset supply, but in 2014 this was substituted by the CCR which aimed to ensure greater market stability. RGGI's (2005) Memorandum of Understanding (MoU) among states contains text referring to the potential to implement a safety valve to stabilise the market in the event of high prices (initially at US$10). This safety valve would increase offset supply by widening the eligibility of offsets to projects outside of the RGGI states and relaxing quantitative limits upon allowance prices breaching the trigger level (RGGI, 2006). However, the RGGI programme's 2012 review concluded that the safety valve mechanism would be ineffective at controlling costs if the emissions cap was binding, and recommended that this be substituted with the CCR to increase RGGI's flexibility in the event of escalating allowance prices (RGGI, 2013a). The 2012 review based its conclusions on emissions and electricity modelling, macroeconomic modelling, and stakeholder engagements (RGGI, 2018a).

RGGI's 2017 programme review recommended the introduction of an ECR from 2021 as a way to increase emissions reductions in the event of lower-than-anticipated emissions reduction costs. The review found that complementary policies in RGGI states had been significant drivers of emissions reductions as states had made longer-term emissions reduction commitments that relied on emissions reductions in the electricity sector. Consequently, total emissions levels have continuously trended below the cap level (RGGI, 2017c). The review found that more ambitious emissions reductions could be pursued at a low cost, through the introduction of the ECR and other design amendments such as increasing the post-2020 CCR trigger levels.

[26] This effect was concentrated in RGGI due to its sole focus on the power sector and the dynamics of the East coast electricity market, where natural gas displaced coal-fired electricity generation.

While economic analysis was often used to inform decision-making, the design of price stability mechanisms was primarily determined through political negotiation. Interviews with a leading policymaker involved in these negotiations revealed that decisions on market stability instruments and the level of the price triggers (collar) were predominantly determined by political negotiation and reflect the palatability of different price levels rather than explicit economic considerations. This reflected a desire for RGGI's price collar to help provide greater certainty in auction revenues for the RGGI state governments.[27] RGGI Inc. was established to coordinate between participating states, to serve as the single point of contact for carbon market participants, and to help mediate state-level disagreements. RGGI Inc. is a non-profit organisation with the sole mandate to manage the RGGI market and its board of directors is comprised of public sector representatives from each RGGI state. Changes to the design of RGGI are made by consensus; however, unequal negotiating power between states means that some have greater influence on policy design.

### 3.2.2 Functioning

RGGI operates a soft price collar for the purposes of market stability, with three specific instruments implemented or planned:

- a minimum reserve auction price;
- the cost containment reserve (CCR); and
- (from 2021) the emissions containment reserve (ECR).

RGGI's MSMs also interact with policies imposed by individual states. For example, New York's Independent System Operator (NYISO) recently proposed implementing a carbon price fee (initially proposed at US$50/ short ton $CO_2$) to top up to RGGI's settlement price, as discussed in Box 6 (ICF, 2018). This type of unilateral sub-regional policy reduces demand and drives down prices (See Annex 2 for a similar interaction of the UK's carbon price floor and the EU ETS), thereby increasing the likelihood that the auction reserve price will bind.

[27] RGGI's uses significant shares of auction revenues to support energy efficiency programmes. RGGI States have discretion as to how much of their auction revenue they re-invest. 55% of total RGGI 2016 investments (and 58% of cumulative investments) directed to energy efficiency programmes (RGGI, 2018f).

*Box 6.* Sub-regional MSMs can interact with the regional ETS design: NYISO's potential carbon price fee

NYISO has proposed a carbon fee on electricity generation to further support New York's decarbonisation goals. New York has policy goals to achieve annual electric efficiency savings of 3% and to source at least 50% of its energy demand from renewable generation (Montalvo & Loiacono, 2018). The NYISO proposes to apply a carbon fee to commitment, dispatch, and settlement prices, while applying a correction for electricity imported or exported out of state (similar to a border carbon adjustment). Adjusting the fee to account for electricity imports and exports aims to reduce potential competitive distortions and avoid emissions leakage. It would function by applying a carbon charge on imported electricity and providing a credit on exported electricity (NYISO, 2018). Initial impact analysis suggested that the carbon fee would have a minor effect on customer costs due to offsetting factors such as increasing renewables penetration, lower transmission and congestion costs, rebate credits and lower renewable energy credit prices (Newell, Tsuchida, Hagerty, Lueken, & Lee, 2018). The NYISO suggests that the earliest this proposal could be implemented is midway through 2021 (Walton, 2018).

Minimum Auction Reserve Price

The minimum auction reserve price acts as a hard price floor for auctions and a soft price floor for the market. The minimum auction reserve price ensures that if auction bids are below the reserve price, allowances are not sold. The reserve price was implemented from the beginning of RGGI in 2008, at US$1.86 per allowance adjusted annually for inflation or, if the price was higher, 80% of the current market price (RGGI, 2008).[28]

The 2012 programme review simplified the auction reserve price from 2014 onwards. The auction reserve would be set at US$2.00 in 2014 and increase each year by 2.5% without consideration of inflation (RGGI, 2017b). This amendment also removed reference to a reserve price based on current market prices (RGGI, 2013b). The 2018 reserve price reached US$2.20. The secondary market price can fall below the minimum auction price, but as allowances are withheld at auction, this reduces supply and supports prices.

Cost containment reserve (CCR)

The CCR is a single price tier soft ceiling that provides limited additional allowances in auctions if the settlement price breaches an annual price threshold. The objective of the CCR is to contain the cost of allowances in the event of rapidly escalating prices. First implemented in 2014 at US$4, the CCR trigger price increases each year according to different rules over each phase, as detailed in Table 6. Over 2015-18, the CCR was stocked annually with 10 million allowances which were additional to annual cap levels (RGGI, 2018d). From 2021, the CCR price trigger level will increase by 7% in each subsequent year and its volume will comprise 10% of the annual regional cap.

[28] The prevailing current market price was defined as a volume-weighted average of transaction prices reported to RGGI states and taking into account prices reported publicly through reputable sources (RGGI, 2008).

*Table 6.* RGGI CCR price trigger thresholds increase at different rates over several time periods

| Year | CCR price trigger (US$/short ton $CO_2$) | Annual CCR price trigger increases |
|---|---|---|
| 2014 | 4.00 | Over 2014-17, the CCR trigger price level increases by US$2.00 each year |
| 2015 | 6.00 | |
| 2016 | 8.00 | |
| 2017 | 10.00 | |
| 2018 | 10.25 | Over 2018-20, the CCR trigger price level increases by 2.5% |
| 2020 | 10.77 | |
| 2021 | 13.00 | From 2021, the CCR trigger price level starts at US$13.00 and increases by 7% until 2030 |
| 2025 | 17.03 | |
| 2030 | 23.89 | |

*Source: Vivid Economics based on RGGI (2017a)*

The triggering of the CCR occurs if the initial auction settlement price exceeds the CCR price trigger level, resulting in CCR allowances being made available during the same auction.[29] If the initial auction settlement price is greater than the CCR trigger price, then CCR allowances are released in the same auction until the final clearing price equals the CCR trigger price, or the CCR is exhausted—in which case the final clearing price is the bid price of the marginal bid. When the CCR is triggered, the CCR trigger price acts as a reserve price for the auction (RGGI, 2017b). This reflects the soft nature of the price ceiling as only a limited number of additional allowances are made available, and the price can still rise above the price trigger level both in the auction and in the secondary market.

In the event that the CCR trigger price is breached, RGGI states receive differing proportions of CCR allowances in the auction (RGGI, 2018d). These proportions are similar to the auction shares of each state, with New York and Maryland together eligible for almost 62% of CCR allowances, as shown in Table 7.

*Table 7.* CCR allowances that each RGGI state may be offered upon the triggering of the CCR auction

| State | CCR allowances available in 2018 | % of total CCR |
|---|---|---|
| Connecticut | 647,461 | 6.5% |
| Delaware | 457,658 | 4.6% |
| Maine | 360,137 | 3.6% |
| Maryland | 2,270,433 | 22.7% |
| Massachusetts | 1,613,968 | 16.1% |
| New Hampshire | 521,869 | 5.2% |
| New York | 3,893,277 | 38.9% |
| Rhode Island | 160,987 | 1.6% |
| Vermont | 74,210 | 0.7% |
| Total | 10,000,000 | 100% |

*Source: Vivid Economics based on RGGI (2018b)*

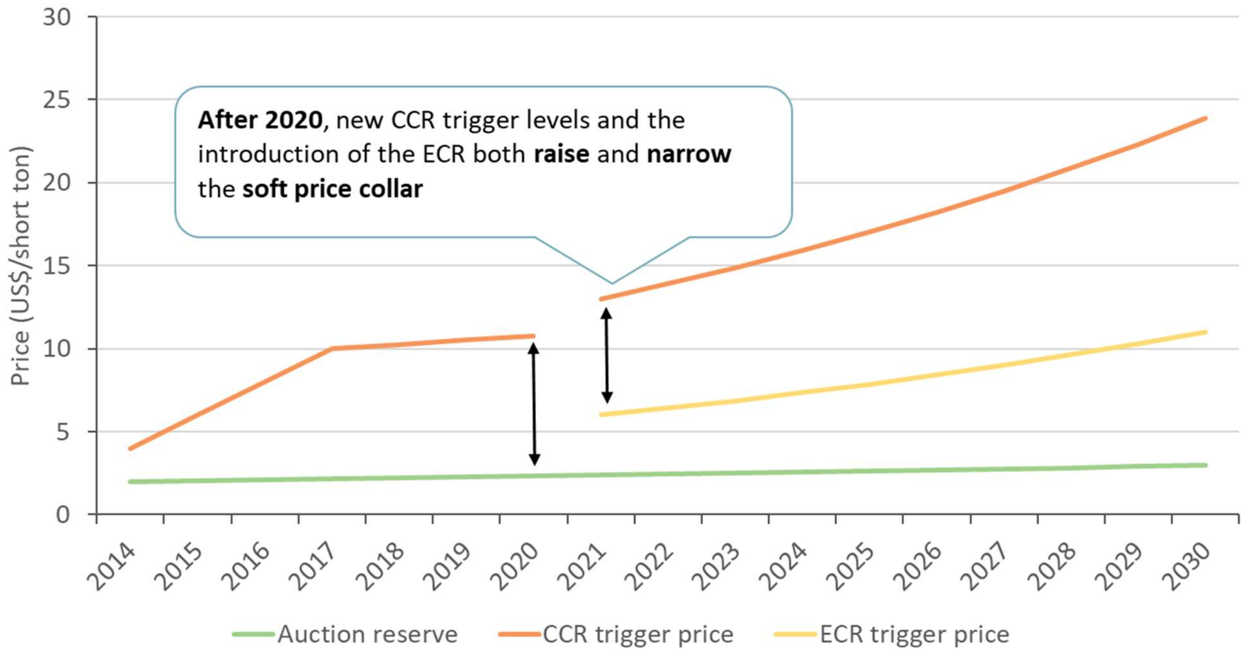
## Emissions containment reserve (ECR)

[29] This contrasts with the California and Quebec reserve auctions which occur sometime after the initial auction settlement price breaches the price threshold level.

From 2021, the ECR will withdraw a predefined allowance volume from auctions if prices fall below the predetermined price threshold level. The ECR will supplement the auction reserve price and aims to effectively narrow the soft price collar. It will function by withholding auction allowances to support prices, in the event that demand for allowances would result in an auction settlement price below the ECR trigger price (RGGI, 2017a). This instrument is an example of a price-responsive supply adjustment that aims to make the carbon market behave more like usual commodity markets, where supply decreases as prices fall (Burtraw, 2017). The ECR is triggered at US$6 in 2021 and this threshold increases by 7% each year until 2030 (RGGI, 2017b). When the ECR is triggered, participating RGGI states reduce the number of allowances at auctions by 10% of their auction budgets for the year.[30] The withheld allowances are permanently removed from the market, such that the ECR reduces the overall cap. The ECR is a soft price floor as allowances can still sell at a lower price than the ECR trigger price, both in auctions and in the secondary market. Importantly, while the ECR can potentially reduce the size of the privately held allowance bank, it does so while respecting private investment and not interfering with overall incentives for banking.

The post-2021 CCR and ECR introduce a higher and narrower price collar relative to the price collar of 2014-20. Figure 6 illustrates that the amendments for RGGI after 2020 impose a step increase in the price collar, both raising its soft maximum price level and narrowing its soft lower price through the introduction of the ECR.

*Figure 6.* The post-2021 amendments both raise and narrow the RGGI soft price collar




*Source:* *Vivid Economics based on RGGI (2017a)*

### 3.2.3 Actual use and practical experience

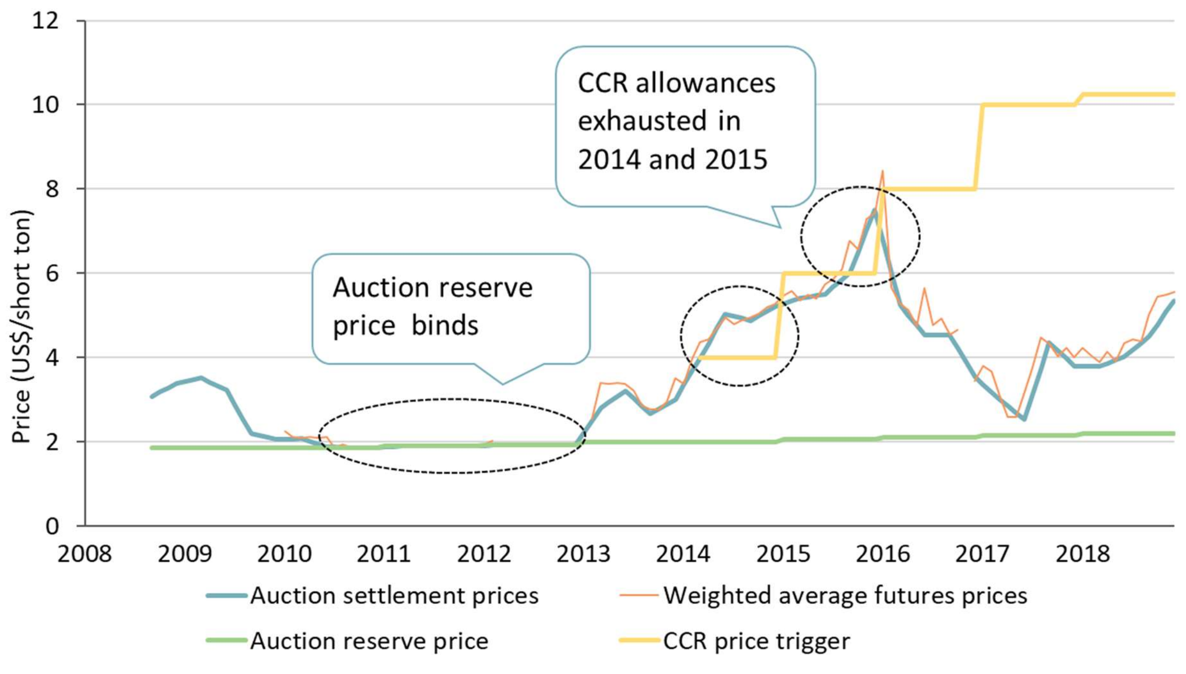
The minimum reserve price effectively supported allowance prices in the presence of early oversupply challenges. Figure 7 shows auction prices between 2009 and 2018. The minimum reserve price was binding

[30] Currently Maine and New Hampshire do not intend to implement an ECR, meaning that the total volume of withheld allowances would be slightly less than 10% of the total RGGI auction volume (RGGI, 2017a). Interviewed stakeholders, however, suggest that this decision may be revisited in the near future.

between 2010 and 2013. The auction reserve price resulted in a cumulative of 169 million short tons of $CO_2$ going unsold over this period. These allowances were not returned to the market and RGGI made a decision, ex post, to invalidate these allowances at the end of the compliance period (RGGI, 2013a), permanently reducing supply. The reserve price has been crucial in RGGI by ensuring that prices did not fall to zero, thereby guaranteeing some returns to innovation, maintaining expectations of future carbon prices, and raising around US$1 billion when prices were at the floor level that helped fund related programme measures (Burtraw, 2017).

**The CCR has been highly influential in determining price levels in RGGI's market after 2012 revisions to the programme's design.** As discussed in Section 3.2, unexpected technological innovation led to significant allowance oversupply and an ad-hoc downward adjustment in RGGI's annual emissions caps for 2014-20 (RGGI, 2014b). This increased market confidence and led to rising allowance prices (Ramseur, 2017). The rising auction prices eventually triggered the CCR in March 2014, when all 5 million allowances (its 2014 limit) were sold and prices went on to exceed the CCR trigger level. This occurred again in September 2015 when all 10 million allowances were sold. The auction price subsequently fell below the trigger threshold due to a combination of the CCR, an accumulation of banked allowances accompanying a fall in emissions, and uncertainty regarding the Clean Power Plan and the 2017 RGGI update (IETA, 2018b).

*Figure 7.* Both the reserve price and the CCR have affected the auction price in the past




*Notes:* *Auction settlement prices reflect linear interpolations between quarterly auction settlement prices.*

*Source:* *Vivid Economics*

**The introduction of the CCR was a significant factor in reducing secondary market allowance price volatility, with the ECR expected to further stabilise prices.** RGGI's market monitor report for 2014 indicates that the historical volatility of futures prices and the option-implied volatility fell gradually over 2013-14, with the introduction of the CCR being a key explanatory factor (RGGI, 2015). The reserve allowance mechanism contains volatility both directly and indirectly:

- *Directly*: the CCR reduces volatility by releasing additional supply above threshold allowance price levels, while the ECR achieves this by reducing supply below allowance price thresholds(RGGI, 2018c);
- *Indirectly*: this soft price collar reduces the likelihood that prices will settle far outside of the managed collar in future auctions, which limits upward speculation on prices (RGGI, 2015)

*Box 7.* Key takeaways from RGGI's soft price collar

**The Regional Greenhouse Gas Initiative (RGGI) implements a soft price collar, with an auction reserve price, a cost containment reserve (CCR), and from 2021 an emissions containment reserve (ECR).**

— The auction reserve price acts as a hard price floor in joint auctions, not selling allowances if bid prices settle below the reserve price, and a soft price floor for the market as a whole, as the secondary market may fall below the reserve price level.
— The CCR is a single-tier soft price ceiling that provides limited additional allowances in auctions if the settlement price breaches an annual price threshold. In contrast to the APCR of California-Quebec, the CCR allowances are additional to the cap and are available immediately in the auction if the price trigger is breached. All RGGI states receive allowances roughly proportional to their cap from a single CCR.[31]
— From 2021, the ECR will withdraw a predefined allowance volume from auctions if prices fall below the predetermined price threshold level.

**The RGGI MSMs have been implemented based on iterative market reviews; however, political negotiation was a key driver of the final price levels chosen.**

— The minimum reserve auction price was introduced from the beginning of the ETS to reduce the impact of potential allowance oversupply. This was a particularly salient issue during the development of RGGI due to the earlier EU ETS experience with initial oversupply.
— Initially, cost controls in RGGI relied on an expanded offset supply, but after a 2012 programme review, this was substituted in 2014 by the CCR which aimed to provide greater market stability.
— Further, a 2017 programme review found that stronger-than-expected emissions reductions opened the possibility for additional low-cost mitigation and recommended the implementation of the ECR and the raising of the CCR price threshold.
— However, interviews with a policymaker involved in RGGI decision-making emphasised that political negotiations were central to determining acceptable price levels.

**RGGI's MSMs have been effective in maintaining prices and reducing volatility.**

— Over 2010-13, RGGI's auction reserve price mitigated a decline in allowance prices.
— Overhauls in RGGI's design led to the emissions cap being tightened over 2014-20, which contributed to price rises from US$2.7/t$CO_2$e to US$4.7/t$CO_2$e over the course of 2014.
— In 2014 and 2015, RGGI's CCR helped reduce the impact of price spikes by providing 5 million and 10 million, respectively, additional allowances (from outside the cap) at auction.
— Reports show the CCR further limited price volatility both directly (by providing additional allowances above certain price thresholds) and indirectly (by limiting the likely price spread and reducing speculative trading).

[31] While in California-Quebec, the APCR auctions are separate auctions held six weeks after the initial auction that breached the price threshold.

## 3.3 New Zealand (NZ ETS), transitional soft price floor and price ceiling

New Zealand's ETS has been operational since 2008 and covers 51% of the country's gross emissions across all sectors. New Zealand is targeting a 30% reduction in GHG emissions by 2030 relative to 2005 (ICAP, 2018g) and is preparing to adopt a Net Zero Carbon target for 2050. The main policy instrument used to achieve this is the NZ ETS. The NZ ETS covers almost all emissions from fossil fuel combustion, industrial processes, and waste, and it applies compliance obligations for deforestation while awarding credits for afforestation activities. The coverage of the NZ ETS has gradually expanded over time and the point of regulation is generally upstream (ICAP, 2018g). In 2008, it included forestry and land-use emissions; in 2010 it expanded to include energy, industry and liquid fuels, and eventually included waste and synthetic emissions in 2014. 49% of New Zealand's emissions are from agricultural sources that are not currently covered by the ETS. Nitrous oxide and methane emissions from agriculture generate reporting obligations but do not yet face compliance obligations; however, the government is investigating how to cover the agriculture sector under the ETS (Leining & Kerr, 2018). The NZ ETS provides output based free allocations to 26 EITE activities: 90% free allocation to highly EITE sectors, and 60% free allocation to moderately EITE sectors (ICAP, 2018g). Entities may bank unlimited allowances but cannot borrow from future phases. Recent allowance prices in the NZ ETS market have been close to NZ$25.

Allowance auctioning does not currently take place, although this will be introduced in the future. The NZ ETS currently has no absolute cap on emissions and does not auction allowances, although legislative arrangements allow for the implementation of auctioning (ICAP, 2018g). As no auctioning has yet been implemented in the NZ ETS, domestic supply and allowance prices were initially set in 2008 by linking with international markets. In 2017, New Zealand decided to develop and introduce an auctioning mechanism that would be developed in principle by 2020 (Leining & Kerr, 2018).

The NZ ETS implemented two transitional price based MSMs to contain costs for compliance entities:

- a discounted allowance price for non-forestry sectors; and
- a price ceiling.

### 3.3.1 Implementation process

The NZ ETS was initially fully linked to the international offset (Kyoto) market, but global oversupply led to domestic challenges and hence led to de-linking in 2015. The ETS initially had a two-way link with the Kyoto market for international offsets, with some qualitative limits but no quantitative limits. This international link was used both to set domestic prices and provide NZ compliance entities with access to least-cost mitigation. However, this made the NZ ETS vulnerable to the global oversupply of Kyoto units and the price crash following the financial crisis. In 2012 the NZ governments announced that they would be de-linking from the Kyoto market, with officially delinking in mid-2015. In 2017, the government stipulated that any future allowance of international offsets in the NZ ETS would be accompanied by quantitative limits (Leining & Kerr, 2018).

New Zealand's price based MSMs were introduced as transitional measures in 2009, after an initial review suggested ETS design amendments would be valuable. Amendments were introduced to reduce competitiveness impacts and, support economic growth, provide a smoother transition for compliance entities, and protect against price volatility while maintaining flexibility to respond to potential changes in the international climate policy framework (Ministry for the Environment, 2009). These amendments introduced a one-for-two reduced-price period for non-forestry entities over 2010-12,[32] to moderate system costs during a time of economic recession (Leining & Kerr, 2018). This was combined with a hard price ceiling for all sectors, which aimed to assist firms in the early stages of market development and maturation and manage extreme price volatility (Emissions Trading Scheme Review Committee, 2009). The ceiling price was set at an estimated level of a future international carbon price, such that the competitiveness of NZ industry relative to international jurisdictions would be secured (Stroombergen, Schilling, & Ballingall, 2009). Both of these MSMs were introduced as transitional measures, but were extended indefinitely following a 2011 review (Spears & Hao Ming, 2016).

### 3.3.2 Functioning

The NZ ETS price stability measures entail a direct allowance price discount and a price ceiling.

- The one-for-two allowance price discount for non-forestry entities ensures that they need surrender only 1 NZU for every 2 $tCO_2e$ emitted.
- The price ceiling is set at NZ$25/NZU and reflects the price at which participants can purchase an unlimited number of allowances for immediate surrender. As such, the secondary market price can rise above the ceiling level, if there are expectations of regulatory amendments raising (or removing) the future ceiling price, or on account of the fact that fixed-price allowances can be used only for compliance and not traded or banked, making them less valuable than other allowances.

### 3.3.3 Actual use and practical experience

New Zealand's link to the Kyoto market meant that this market set domestic prices rather than using government auctioning. This aimed to support liquidity and guard against price volatility (Leining & Kerr, 2018). However, it also left the ETS vulnerable to shocks in the international market, as shown in Figure 8. As the Kyoto market crashed over 2010-13, this dragged down allowance prices in the fully linked NZ ETS. It also led to a significant volume of banked allowances (Stevenson, Comendant, Niemi, & Murray, 2017).

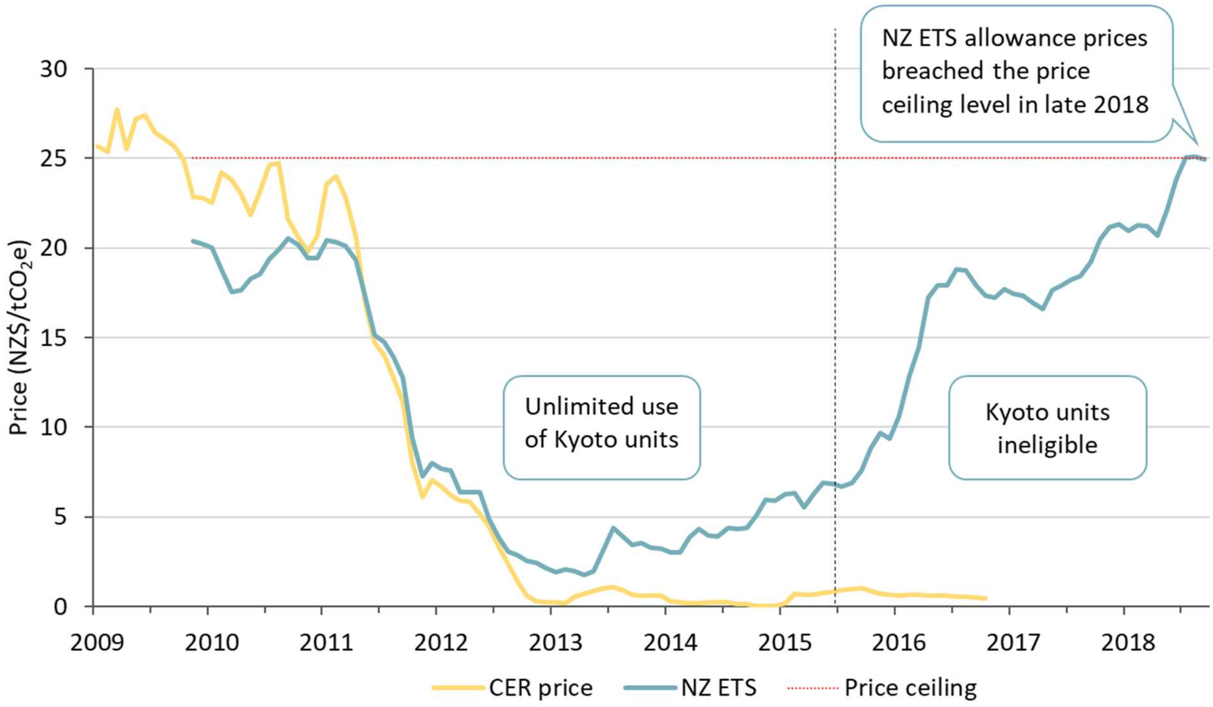
In 2012, the New Zealand government announced that it would be de-linking from the Kyoto market, which led to a steady rise in domestic prices. Figure 8 shows how the announced de-linking supported prices. However, this divergence of prices also led to increased banking of allowances as entities arbitraged price differentials. In 2018, banked allowances reached around 127.8 million units, or 4.5 times the 2017 volume of units entities surrendered for compliance (28.6 million units) (Leining & Kerr, 2018). The in-principle decision to impose quantity limits on any future link with international markets seeks to limit the potential for the domestic market to be severely impacted by international market disruptions.

NZ ETS prices have recently continued to increase and breached the price ceiling level in late 2018. Figure 8 also illustrates the recent rise in allowance prices. These breached the ceiling level in September 2018 and have since remained around that level. The gradual rise in prices suggests this may be a natural consequence of a market with greater maturity and expectations of increased regulatory stringency. The price ceiling is likely to be below the level required to stimulate investment in line with NZ's commitment to a net zero target (Kazaglis et al. 2017), and is expected to be adjusted in forthcoming legislative amendments. The 2017 review

[32] Interviewed experts in the NZ Ministry for the Environment explained that forestry was excluded from the one-for-two discount largely due to the fact that the forestry sector generated offset credits at a non-discounted rate. Therefore, it would not have made sense to provide a discount on forestry sector emissions but instead provide full prices for sequestered emissions.

of the ETS (discussed below) found that the regulation had not yet significantly increased private sector investment (Ministry for the Environment, 2017).

*Figure 8.* De-linking from the international Kyoto market led to a rise in NZ ETS allowance prices




*Note:* *Certified Emission Reductions (CERs) are the predominant Kyoto Protocol emissions unit traded*

*Source:* *Vivid Economics based on Carbon Forest Services and ICE*

The 2015/16 ETS review and recent government announcements have resulted in decisions to phase out the one-for-two discounted price compliance option, introduce a cost containment reserve and investigate a price floor.

— Over 2017-19, each tonne of emissions has become available for sale at incrementally smaller discounts each year. This resulted in allowance prices for sale at 50% discount in 2016, 33% discount in 2017, 17% discount in 2018, and 0% discount in 2019. Correspondingly, free allocations to non-forestry entities have increased as the discounted compliance price phased out (Ministry for the Environment, 2016).

— The review also resulted in plans to develop a cost containment reserve (CCR from 2020 (MFE, 2019). Interviewed experts noted that details - such as the timing of CCR auctions, price thresholds, and the source of allowances - are still being decided. The revision of the NZ$25 price ceiling reflects an expectation that NZ$25 is not sufficient to achieve New Zealand's nationally determined contribution (NDC) targets (Ministry for the Environment, 2018b). The CCR mechanism can ensure the credibility of the price signal while protecting against unexpected price spikes. Ministry stakeholders noted that a CCR was chosen given the flexibility of the mechanism and the potential for it to be more conducive to future ETS linking as its design aligns to measures used in North American carbon markets. The CCR provides flexibility by allowing prices to move above targeted ceiling prices in response to very high demand; this provides greater certainty in emissions levels while still providing price stabilisation.

— The government will investigate the introduction of a price floor to support low-carbon investment (Ministry for the Environment, 2018a). Government stakeholders noted that feedback from ETS participants suggested the need to ensure regulatory predictability in its next phases.

*Box 8.* Key takeaways from New Zealand ETS hard price floor and ceiling

The New Zealand ETS's link with the Kyoto market provides a lesson as to how shocks can transmit through linking partners and how small jurisdictions may be more vulnerable

- Initially, the NZ ETS was fully linked to the Kyoto market which set domestic prices in the absence of local allowance auctioning.
- However, with a global oversupply of Kyoto units, this link pushed NZ ETS prices down.
- To stem the decline of NZ ETS prices, New Zealand de-linked from the Kyoto market in 2015, NZ ETS allowance prices have risen steadily since the government's announcement of the de-linking of the NZ ETS and the Kyoto market.

New Zealand implemented cost containment measures in the form of a discounted allowance price option and a price ceiling.

- The one-for-two allowance price discount for non-forestry entities ensured the need to surrender only 1 NZU for every 2 $tCO_2e$ emitted.
- The price ceiling is set at NZ$25/NZU and reflects the price at which participants can purchase an unlimited number of allowances for immediate surrender. Allowances provided at the ceiling price are not bankable or tradeable.
- These measures were implemented to help entities contain costs in the event of high prices.

Recently, allowance prices have breached the initial price ceiling level and a programme review has called for MSMs to be amended.

- Allowance prices have risen since the announcement to de-link from the Kyoto market in 2012 and, after reaching the price ceiling level in September 2018, have since remained around this level. This price ceiling has recently been temporarily breached, reflecting restrictions on the use of price ceiling units, and (accurate) speculation that the price ceiling would be removed.
- Recent reports indicate that this price ceiling level is too low to stimulate the investment in low-carbon technology that would be required to place New Zealand on a path to net zero emissions.
- The 2015/16 ETS review resulted in the decision to gradually phase out the discounted price compliance option, develop (in-principle) a new price ceiling, and introduce an absolute ETS cap and allowance auctioning.

New Zealand has just announced proposed changes to its ETS design, including replacing its price ceiling with a CCR and investigating the introduction of a price floor.

- This mechanism was seen as the best option to support the credibility of a price signal trajectory by mitigating the risk of sudden price spikes. The CCR also provides greater market flexibility and may provide the potential for linking to other carbon markets of similar design.
- The amendments aim to increase the predictability of the regulatory environment and, as such, the Ministry for the Environment will also investigate the benefits of a price floor mechanism.

## 3.4 Tokyo-Saitama, linking and limited allowance supply adjustments

The Tokyo and Saitama are subnational systems that linked in 2011 and cover $CO_2$ emissions from energy consumption from buildings and factories in the commercial and industrial sectors. The Tokyo ETS began in 2010 and now covers 20% of all Tokyo's $CO_2$ emissions, while the Saitama ETS began in 2011 and now covers 18% of Saitama's $CO_2$ emissions (ICAP, 2018d). Currently in its second phase (2015-19), the Tokyo ETS comprises three five-year compliance phases, and will help achieve the city's goal to reduce GHG emissions by 25% in 2020 relative to 2000 levels (IETA, 2015c). The Saitama ETS is now in its second phase (2015-19),and it supports Saitama's goal of a 21% reduction in GHG emissions in 2020 relative to 2005 levels (ICAP, 2018d). Both ETS cover the direct and indirect $CO_2$ emissions from buildings and factories in the commercial and industrial sectors that consume more than 1,500 kl of crude oil equivalent per year, representing 1,232 entities in Tokyo and 600 entities in Saitama. Unlimited banking is permitted across compliance periods and aims to increase price stability (ICAP, 2018e). Both ETS grandfather allowances at the beginning of the compliance period for all compliance years to all covered entities (Ministry of the Environment, 2012; TMG, 2010).

Tokyo and Saitama have several types of offset credits that entities can use for compliance (ICAP, 2018e).

- Small- and mid-size facility credits reflect emissions reductions from non-covered small- and medium-sized facilities and can be used for compliance without limit.
- Outside Tokyo/Saitama, credits are generated from emissions reductions from large facilities beyond the covered jurisdictions and these can be used for up to one-third of entities' compliance obligations.
- Renewable energy credits (REC) sourced from electricity generated onsite from renewable sources can be used without limit. RECs can be issued for renewable electricity generated when it is included in a facility's calculation of total emissions from energy-related activities (TMG, 2015).
- Additionally, Saitama allows forest absorption credits for emissions reductions from forests within the Saitama Prefectures. These are valued at 1.5 times the value of regular credits and can be used without limit (ICAP, 2018d).

### 3.4.1 Implementation process

The Japanese subnational ETS are designed to demonstrate the effectiveness of emissions trading in Japan, with market stability an important outcome. The Tokyo Metropolitan Government (TMG) acknowledged early on that establishing a stable carbon market, and signalling the effectiveness of the policy instrument, required mechanisms to prevent 'abnormal trading price surges' (TMG, 2010, p. 25). As such, the TMG planned to mitigate the risk of such price volatility through introducing measures that would increase the supply of allowances in the event of market fluctuations.

Stakeholder engagement has influenced ETS design and implementation. This was informed by a process that considered scientific studies, experiences of ETS around the world, and stakeholder views. These stakeholders comprised community groups, industries, local government municipalities, NGOs, academic institutions, and energy suppliers. Stakeholder perspectives were generated through public opinion surveys, online questionnaires and stakeholder meetings (Centre for Public Impact, 2016).

### 3.4.2 Functioning

The Tokyo and Saitama ETS have sought to promote market stability through the linking of their systems and MSMs that provide limited increases in allowance supply at high prices.

Tokyo's ETS and Saitama's ETS are linked: entities in one jurisdiction can use excess credits generated in the other for compliance. Tokyo entities can use both excess credits generated from emissions reductions in Saitama ETS large facilities, and small and mid-size facility credits issued in Saitama, and vice versa (ICAP, 2018e). Tokyo and Saitama's emphasis on buildings may limit future linking to other international schemes due to potential framework incompatibilities (IETA, 2015c). However, Santikarn et al. (2018) note that differences in gas and/or sector coverage do not necessarily pose technical issues for linking.

Tokyo and Saitama also have discretionary authority to increase the supply of compliance credits in the event of high allowance prices. Tokyo's ETS allows for the TMG to implement measures to increase credit supply in the event of excessive prices. Similarly, Saitama's ETS allows for an increase in credit supply in the context of extreme price changes. For example, the TMG can increase the supply of small and mid-size facility credits, promote emissions reductions and renewable energy to effectively increase credit supply, or use the solar energy bank to sell additional credits (TMG, 2010, 2015). Additional measures to expand allowance supply may be utilised if scarcity remains; however, there are no clear rules regarding intervention triggers and the measures that may be taken under these circumstances in either ETS. This therefore provides for a discretionary mechanism to influence allowance supply in response to high, but undefined, prices. However, the TMG is required to publicly disclose the decision to intervene in the market and must take into account the opinions of trading experts (TMG, 2015).

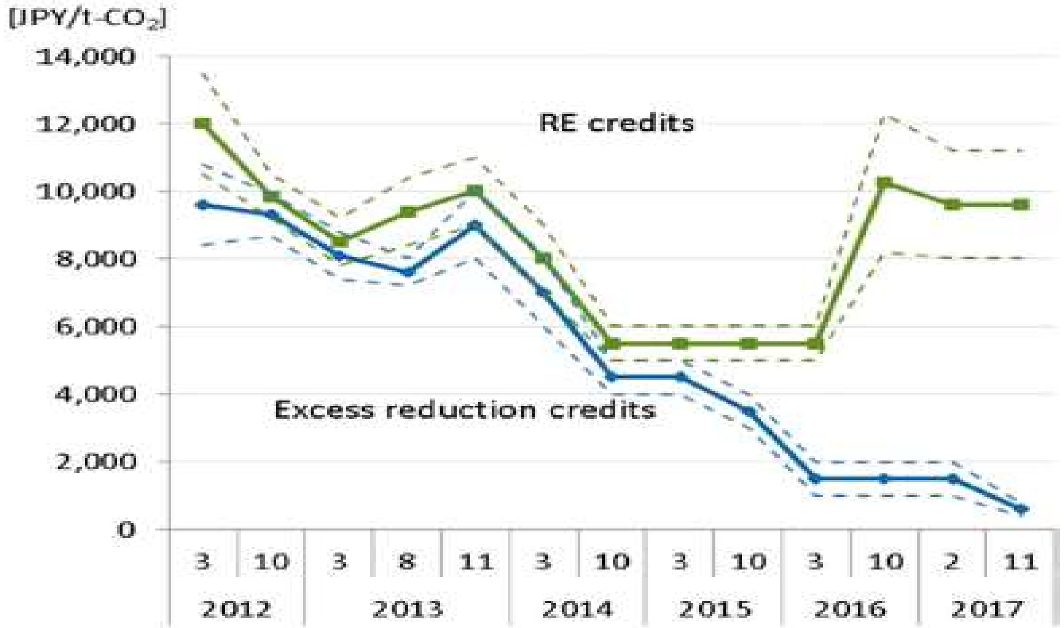
### 3.4.3 Actual use and practical experience

Tokyo has experienced significant emissions reductions under Phases 1 and 2 of the ETS. In 2016, annual emissions declined by 26% from 16.5 $MtCO_2e$ in 2010 (TMG, 2018). However, much of this reduction cannot be attributed to the ETS as other drivers were key, with similar emissions reductions evident outside of the Tokyo region. These drivers included the energy efficiency audits included in the ETS roll-out, energy use and emissions reductions following the 2011 earthquake and Fukushima disaster, and the expansion of LED lighting technologies (Wakabayashi & Kimura, 2018).

The Tokyo ETS has seen falling credit prices and low liquidity, partly due to an allowance oversupply. The Tokyo government does not auction credits and does not set explicit limits on prices. Further, there is no open market for carbon credits and transactions are negotiated individually through an agency (TMG, 2015). Figure 9 illustrates that credit prices have been declining since 2012, and participants interviewed in Wakabayashi & Kimura (2018) highlighted that current prices may be too low to stimulate low-carbon investment. Low liquidity in the Tokyo ETS was experienced as most entities directly reduced their own emissions, suggesting a current oversupply of allowances (Wakabayashi & Kimura, 2018). Low liquidity also results from limited emissions coverage, and restrictions on allowance trading which mean that entities can sell emissions allowances only after they achieve their abatement targets (ADB, 2016).

The link between Tokyo and Saitama has resulted in few credit transfers between jurisdictions to date. Only 14 credit transfers were made during the first compliance period (2011-14): eight transfers from Tokyo to Saitama, and six transfers from Saitama to Tokyo (ICAP, 2018d).

*Figure 9.* Renewable energy (RE) and excess reduction credit prices in the Tokyo ETS have seen an overall declining trend




*Source:* *Wakabayashi & Kimura (2018)*

*Box 9.* Key takeaways from Tokyo and Saitama's ETS linking and allowance supply adjustments

Tokyo and Saitama have linked ETS and MSMs that allow for limited allowance supply adjustments.

- Tokyo's ETS is linked to the Saitama ETS, with entities from either jurisdiction able to use excess credits generated in the other jurisdiction for compliance.
- Tokyo and Saitama have discretionary authority to increase the supply of compliance credits in the event of high allowance prices. This can involve interventions including the regulatory authority increasing the supply of small and mid-size facility credits, promoting emissions reductions and renewable energy to effectively increase credit supply, using the solar energy bank to sell additional credits, or relaxing limits on the mutual use of credits between Tokyo and Saitama.

Tokyo's ETS has experienced falling credit prices and low liquidity and the link with Saitama has seen low volumes of allowance exchanges across jurisdictions.

- Tokyo's ETS allows three types of offset credit to be used for local compliance. Prices for these allowances diverge and have been declining recently. The TMG does not auction credits or set explicit price limits on credits.
- Low liquidity levels were evidenced as many entities complied with their obligations through their own emissions reductions, indicating a potential oversupply of allowances.
- The first compliance period of the Tokyo-Saitama linked ETS observed only 14 credit transfers between the two jurisdictions.

## 3.5 Australia (CPM), top-up carbon price floor and hard price ceiling

Australia operated a fixed price ETS, the Carbon Pricing Mechanism (CPM), between 2012 and 2014. The CPM placed a fixed price on emissions starting at AU$23/t$CO_2$e,[33] with the intention to transition to a floating price ETS from 2015 (CER, 2015). The CPM covered over 60% of Australia's GHG emissions, including emissions from electricity generation from power stations, other stationary energy generation, landfill waste, industry, and some transport (Banerjee, 2012; CER, 2015). Facilities included under the CPM were those emitting more than 25 kt$CO_2$e per year or landfill facilities emitting more than 10 kt$CO_2$e per year (Australian Government, 2011; C2ES, 2011). Banking of allowances was not permitted during the fixed price phase of the ETS (but would have been during the flexible price phase), and borrowing from the following year was limited to 5% of an entity's compliance liability (IETA, 2013).

Australia's CPM planned to introduce two price based MSMs:
— a hard price floor and ceiling for the allowance price; and
— a top-up carbon price floor for international offsets.

The hard price floor and the top-up carbon price floor for international offsets were repealed as part of a negotiated arrangement to link with the EU ETS, and never came into effect.

### 3.5.1 Implementation process

The CPM was introduced in the 2011 Clean Energy Act and was intended to introduce a flexible price with a price floor and ceiling from 2015. The Act gave a legal basis to measures that would help Australia meet its obligations under the Kyoto Protocol and achieve its targeted reduction of emissions to 80% below 2000 levels by 2050. The Australian Clean Energy Regulator was established to administer the CPM (Australian Government, 2011). The 2007 National Greenhouse and Energy Reporting (NGER) Act mandated the reporting of GHG emissions and energy consumption from 2009, thereby supporting the implementation of the carbon pricing instrument (Australian Government, 2017; C2ES, 2011). The CPM was designed with a fixed price for the first three years before transitioning to an ETS with a flexible price floor and a hard price ceiling. However, the hard price floor and the top-up carbon price floor for international offsets were repealed as part of a negotiated arrangement to link with the EU ETS, and never came into effect.

### 3.5.2 Functioning

The CPM commenced with fixed allowance prices over the period 2012-15, which was intended to transition to a flexible price ETS with a price ceiling in the period 2015-18. Prices for the first three years were set at AU$23/t$CO_2$e (2012), AU$24.15/t$CO_2$e (2013), and AU$25.4/t$CO_2$e (2014). From 2015, the CPM would become an ETS with a flexible price and would include a price ceiling set at AU$20/t$CO_2$e above the international carbon price, rising by 5% annually (Banerjee, 2012). The price ceiling was scheduled for removal from 2018, with access to international markets planned as a cost containment measure (IETA, 2013).

The initial fixed price and proposed hard price ceiling was set drawing on modelling of carbon price scenarios and political negotiations. The fixed price level was based on modelling that suggested the initial carbon price consistent with Australia's emissions reduction targets should be in the range of AU$20- AU$30/t$CO_2$e, with negotiations in the Multi-Party Climate Change Committee agreeing a starting price of AU$23/t$CO_2$e (Peel,

[33] This is about €18.5/t$CO_2$e using average annual exchange rate for 2012 from OFX (2017).

2014). The choice of ceiling level was informed by ex-ante modelling combined with estimates of future international carbon prices. The economic modelling investigated the potential impacts of various carbon pricing levels on output, household welfare, and emissions, taking into account the impact of design elements such as free allocation and rebates (Australian Government Treasury, 2011).

During the operation of the flexible price period, Australia also planned a price floor and a top-up carbon fee for international offsets but later moved away from this design. This flexible price period also contained a price floor, set at AU$15/t$CO_2$e and rising by 4% per year (C2ES, 2011). The CPM did not accept international offsets in the fixed price phase, but allowed entities to use local Kyoto-compliant Carbon Farming Initiative credits for up to 5% of their compliance obligations (The Australian Government, 2011). However during the flexible price period, it was planned that EU allowances and international offsets could be used to cover up to 50% of an entity's compliance obligations,[34] subject to qualitative conditions (Peel, 2014). To reach the planned price floor, the government planned to impose a top-up fee on international offset units at the time of their surrender, if their price was below the floor level (Jotzo, 2012). However, this system posed significant implementation challenges, such as difficulties in calculating an appropriate top-up fee in a dynamic fashion, requirements from entities to be able to hedge price risks, and the need to maintain emissions reduction incentives while safeguarding revenues from domestic permit sales (Jotzo & Hatfield-Dodds, 2012).

### 3.5.3 Actual use and practical experience

While the price floor and ceiling were not implemented, they sought to balance the dual concerns of ensuring competitiveness and providing incentives for emissions reductions. The price ceiling sought to ensure that domestic industries did not face high carbon prices relative to international levels. Similarly, the price floor aimed to provide greater certainty for the low-carbon investment, while providing investors the flexibility of using international credits (Jotzo, 2012). Significant implementation challenges were experienced in trying to operationalise the top-up carbon price floor, with interviewed policymakers suggesting that this added unnecessary complexity that created significant risks for the functioning of the ETS. In particular, the dynamic top-up price approach was likely to have created opportunities for arbitrage between emissions units, and/or incentives for side-payments to reduce effective liabilities.

*Box 10.* Key takeaways from Australia's Carbon Pricing Mechanism's top-up price floor and hard price ceiling

Australia's ETS included a hard allowance price floor and ceiling and a top-up carbon price floor; however, the CPM was repealed in 2014, prior to their implementation.

- While prices were fixed during 2012-15, the Australian Carbon Pricing Mechanism aimed to introduce a flexible ETS phase from 2015 with two MSMs.
- A planned carbon price floor would impose a surrender top-up fee on international offsets, should their price be below the floor level. However, this faced significant implementation challenges that led the government to move away from this design.
- The flexible price phase would implement a hard price ceiling, at AU$20/t$CO_2$e above the international carbon price, to mitigate potential competitiveness impacts on local industry.

[34] The quantitative limit was set at 50% of an entity's liability, of which only 12.5% could be sourced from non-EU credits.

# 4 Price- and quantity based instruments

South Korea and several of the Chinese regional pilot ETS have implemented MSMs that combine price- and quantity based instruments, generally reflecting broad discretionary powers. This section details MSMs in Korea and the Chinese regional pilot ETS, providing an overview of each carbon market, the processes that led to the implementation of these measures, details of their functioning, and a review of their actual impact and practical experience.

## 4.1 Korea ETS, discretionary market stability measures

The Korean ETS (K-ETS) covers entities' direct and indirect emissions, representing 70% of national GHG emissions, and is now in its second phase with a 2018 cap of 540 $MtCO_2e$. The K-ETS covers entities' direct and indirect GHG emissions.[35]

- Phase 1 of the K-ETS (2015-17) focused on developing a market with stable operation. During this phase, all allowances were allocated for free, with the majority of the cumulative 1.69 $GtCO_2e$ cap allocated using grandfathering, but the phase also allocated a small volume of allowances using benchmarks developed for refineries, cement, and aviation.
- Phase 2 (2018-20) strives for effective national emissions reduction and now covers 591 businesses, representing 70% of national GHG emissions. This phase is reducing free allocation levels and increasing the use of benchmarking, while allowing international credits for local compliance.
- Phase 3 (2021-30) aims to strengthen the K-ETS to become the main instrument to achieve Korea's NDC mitigation targets. It will expand the use of auctioning to around 10%, increase the use of benchmarking and, importantly, allow third parties to trade allowances.

The K-ETS allows unlimited banking and restricted borrowing within ETS phases. Borrowing allows entities to use future compliance years' allocations, often with some limitations. In Phase 1, borrowing was allowed for up to 10% (increased to 20% in 2016 and 2017) of an entity's compliance obligation. In the first year of Phase 2 borrowing was limited to a maximum of 15% of an entity's compliance obligation and, from 2019, the maximum allowable borrowing rate will be a function of entities' past borrowing activity (ICAP, 2018f).

### 4.1.1 Implementation process

The K-ETS has limited participation in its carbon market, with secondary market trade currently restricted to a small set of entities. In Phases 1 and 2, only compliance entities and three public banks (Industrial Bank of Korea, Korea Development Bank, and Korea Export/Import Bank) can trade allowances. Furthermore, only spot products can be traded during Phases 1 and 2.[36]. Only three types of tradeable spot products are currently offered: Korean Allowance Units (KAU), Korean Credit Units (KCU), and Korean Offset Credits (KOC):

- KAUs are allowances that the K-ETS allocates to installations and can be used for compliance;
- KOCs are certified emissions reductions from offset projects external to the K-ETS; and
- KCUs are converted KOCs that can be used for compliance under the K-ETS (Yoo, 2018).

[35] A unique feature of the K-ETS is that it covers both direct emissions from electricity generators and indirect emissions from downstream entities' electricity consumption. This is because electricity prices in Korea are regulated by the government and would not automatically adjust to provide a pass-through carbon cost signal to downstream users to incentivise efficient electricity consumption. One challenge for this design is that it entails double-counting electricity emissions and may exacerbate poor economic conditions (ADB, 2018).

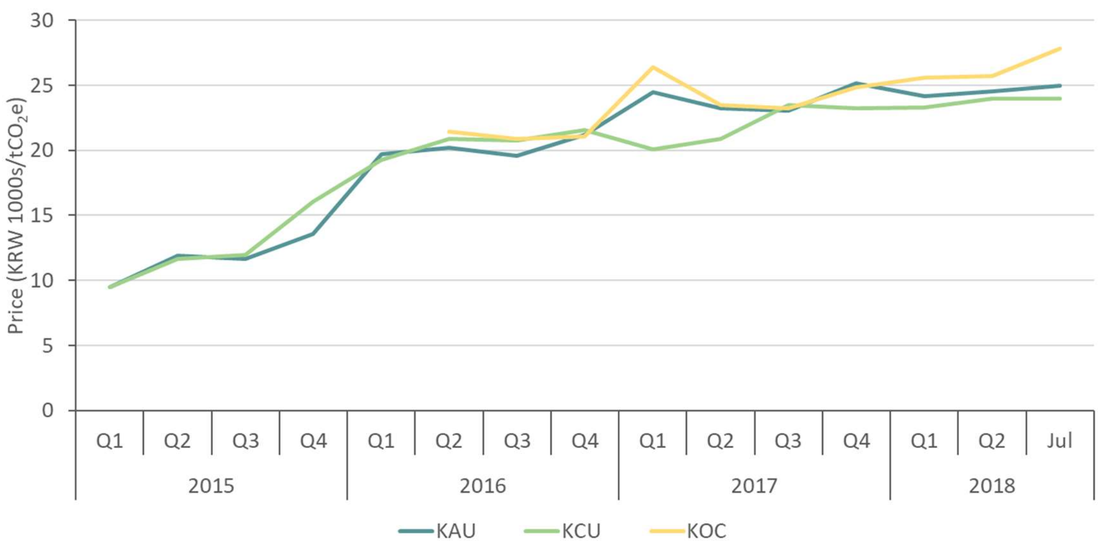
[36] From Phase 3 onwards, third parties (including individuals) will be eligible to trade in the market and derivative trading will be introduced

**Offsets can be used for compliance subject to certain limits.** In Phase 1, domestic offset credits could be used for up to 10% of an entities compliance with phase 2 and 3 expanding offset allowance to include international offset credits from domestic companies up to 5% (ICAP, 2018f).

**MSMs in Korea were designed and implemented against the backdrop of low market liquidity and rising allowance prices.** From 2015 to March 2017, 539 $MtCO_2e$ were allocated to covered entities, but the cumulative traded volume was only 19 $MtCO_2e$, with the majority of trading being in KOC offset units (Kim, 2017). Korea's turnover ratio, an indicator of market liquidity,[37] was only 0.05% over 2015-17, while the same indicators in the EU, RGGI, and California post-2014 all stood above 15% (Narassimhan et al., 2017). Liquidity may be constrained by high levels of free allocation relative to short-term compliance needs and the market currently only using spot products and not allowing third-party trading. Trading has also tended to be concentrated just before annual compliance deadlines. In a survey conducted by the Greenhouse Gas Inventory and Research Center (GIR) in 2017, 70% of 164 respondents stated that they had not yet experienced carbon trading after two years of K-ETS operation (Acworth, 2018a).

**In 2018 K-ETS allowance prices were among the highest in the world for any operational ETS** (World Bank, 2018). In 2015, allowance prices started at around KRW 9,000 and more than tripled over the first three years of operation to reach a peak of KRW 28,000 by mid-2018, as shown in Figure 10.[38] This price trend was the same across KAUs, KCUs, and KOCs (Kim, 2017). Expectations of rising future allowance prices may exacerbate low market liquidity by incentivising entities to hold surplus allowances rather than trade them, particularly if the rate of expected price increase is greater than entities' internal rate of return.

*Figure 10.* Quarterly average carbon prices have risen quickly since the start of the K-ETS




*Source:* *Vivid Economics based on KRX/GIR data*

[37] The turnover ratio is the ratio of total allowances traded in the secondary market and total allocations issued.

[38] This reflects prices beginning around €8 in 2015 and rising to close to €26 in 2018.

### 4.1.2 Functioning

The K-ETS authority may implement several forms of MSMs:

- It can use a market stability reserve (MSR) that can inject/withdraw allowances due to supply and demand imbalances or rapid increases in the carbon price. During Phase 1, 14 $MtCO_2e$ of allowances from under the emissions cap were drawn into this reserve to support market stability (ICAP, 2018f).
- The K-ETS authority may impose minimum (70%) or maximum (150%) emissions allowance holding limits.
- The K-ETS authority may also increase or decrease the borrowing limit or offset limit, or establish a temporary a price ceiling or price floor (Korea Ministry of Environment, 2012).

The legislation defines price- and quantity based circumstances under which the K-ETS authority can activate MSMs. The circumstances that can trigger intervention are defined for both upper and lower thresholds, and legislation requires the authority to publicly specify the grounds on which it intends to intervene in the market (Korea Ministry of Environment, 2012):

- *Upper threshold criteria:* when the average trading volume of the last month is at least double the larger of either the average trading volume of the same month in the preceding two years, and, the allowance price of last month is at least double the average emissions price in the previous two years; or
- *Lower threshold criteria:* when the allowance price of the last month is lower than 60% of average price from past two years, or, when it is impracticable for businesses eligible for allocation to trade allowances due to lack of supplies of allowances in markets, due to low trading levels.

The implementation and duration of Korea's MSMs remain largely discretionary, although work is currently under way to increase transparency and predictability through more detailed rule based criteria. At present, rules to trigger market intervention entail subjective judgements, particularly in terms of what determines impracticability to trade allowances. This provides the K-ETS authority discretionary control over market intervention. Similarly, the K-ETS legislation states that the authority may cease intervention 'when [it] deems that the objective of market stabilization is achieved' (Korea Ministry of Environment, 2012). The rules based approaches being investigated should reduce the subjectivity of interventions.

### 4.1.3 Actual use and practical experience

To date, the K-ETS authority has intervened on four occasions in response to rapidly rising prices, using both verbal signals and allowance injections.

- In June 2016, after the KAU price breached 21,000 KRW,[39] the K-ETS authority made 0.9 $MtCO_2e$ of allowances available through an auction with a price floor significantly below the market level, but only 0.27 $MtCO_2e$ of the additional supply was purchased.
- In late January 2017, rising prices (a 36.2% increase in one month) led the K-ETS authority to verbally signal that they might introduce banking limits. This induced entities to sell allowances on the market, in anticipation of allowances above a holding limit potentially being invalidated.
- In November 2017, rising market prices led to a verbal indication that the K-ETS authority could implement a potential MSR release.
- In mid-May 2018, the K-ETS authority released, through auction, 5.5 $MtCO_2e$ from the MSR to help short entities with Phase 1 compliance that were struggling to find allowances in the market. The auction reserve

[39] This is about €16.50 using exchange rates as of February 2019.

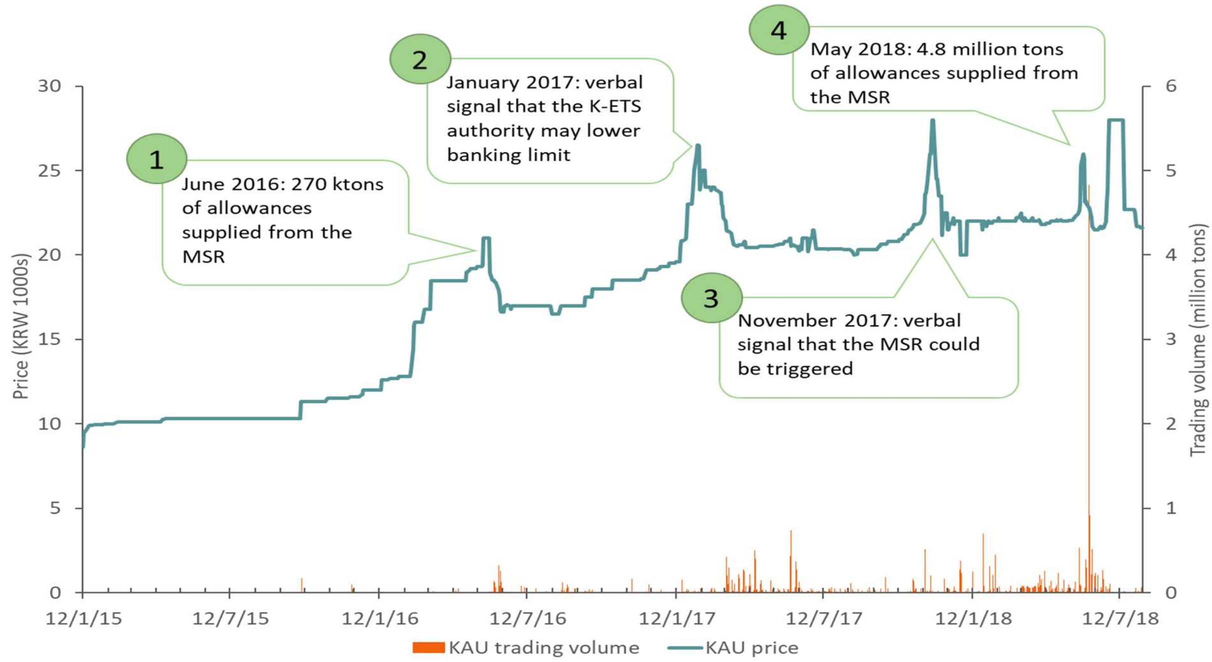
price was based on recent market prices (ICAP, 2018h),[40] and 4.8 $MtCO_2e$ were purchased by entities (Acworth, 2018a).

All implemented interventions led to a temporary fall in allowance prices and stimulated trading. 0 over page, shows the development of daily prices and trading volumes for KAUs in the K-ETS and illustrates the impact of the four market intervention events. Each intervention reduced allowance prices and stimulated trading volumes. The first intervention led to prices falling by 21%; the second by 22.3%; the third by 24.5%; and the fourth by 20% in ten days. Further price spikes in late June 2018 accompanied the publication of the 2030 national GHG road map, reflecting industry's concern over the tightening of climate policy (Acworth, 2018a). Significant price reductions resulting from announcements suggest that prices are not only a function of the demand-supply balance but also of expectations and banking choices (Acworth, 2018b). However, these impacts were only temporary as price spikes soon reoccurred after each intervention. A Korean policy expert interviewed for this study suggested that the uncertainty of discretionary interventions was a contributing factor to enduring volatility.

Recently liquidity has been improving, with the trade of KAUs growing. As illustrated in Figure 12 over page, annual credit trading increased from 5.7 million trades in 2015 to 31 million trades in 2018 (by July). In particular, KAU trading has grown in proportion, reflecting 7% of total trades in 2015 and 95% of cumulative trades by July 2018 (Yoo, 2018). Further, from 2019 the K-ETS will introduce a 'market maker' institution to improve market stability and enhance liquidity (ICAP, 2018f; Kim, 2017). Its main purpose will be to provide selling offers to short entities that are unable to address shortages in the market. 5 $MtCO_2e$ of allowances will be reserved for this purpose. An interviewed Korean policy expert added that post-2020 revisions to increase market access to third parties and introduce new trading products may also increase liquidity.

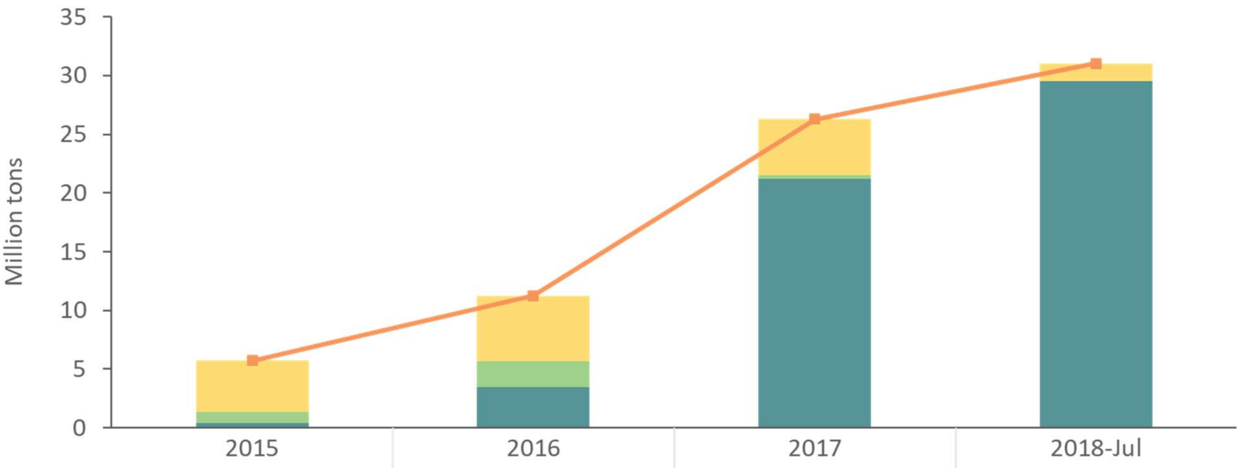
[40] The formula used to determine the auction reserve price uses recent average prices: ( (average price over past three months) + (average price of last month) + (average price over past three days) / 3) (ICAP, 2018h).

*Figure 11.* The four Korean market interventions had a direct impact on allowance prices and market liquidity




*Source:* *Vivid Economics based on KRX (2018)*

*Figure 12.* Trading volume, particularly in KAUs, has increased since the beginning of the K-ETS




| | 2015 | 2016 | 2017 | 2018-Jul |
|---|---|---|---|---|
| KOC | 4.4 | 5.6 | 4.7 | 1.5 |
| KCU | 0.9 | 2.2 | 0.3 | 0.0 |
| KAU | 0.4 | 3.5 | 21.2 | 29.5 |
| Total | 5.7 | 11.3 | 26.3 | 31.0 |

*Source:* *Vivid Economics based on KRX/GIR data*

Korea's ETS held its first auction in January 2019 and sold all offered allowances at prices 2% higher than the secondary market price. Seven entities participated, with four companies winning all 550,000 KAUs at a settlement price of KRW 25,500.[41] In 2019, 7.95 $MtCO_2e$ will be offered for auction, with 0.55 $MtCO_2e$ offered monthly in the first, third, and fourth quarters, and 1 $MtCO_2e$ offered monthly in the second quarter (ICAP, 2019). A Korean policy expert noted that the increase in second-quarter auction volumes is intended to accommodate an expected increase in demand near compliance deadlines. Korean auctions include a technical auction reserve price to ensure efficient functioning, similar to the EU ETS auctions.

*Box 11.* Key takeaways from the Korea ETS discretionary MSMs

**The K-ETS authority has significant discretion regarding its use of MSMs, which were designed to mitigate low market liquidity and rising prices.**

— The K-ETS authority can use a market stability reserve (MSR) that can inject/withdraw allowances due to supply and demand imbalances or rapid increases in the carbon price. During Phase 1, 14 $MtCO_2e$ of allowances were drawn from this reserve to support market stability.
— The K-ETS authority may impose minimum (70%) or maximum (150%) emissions allowance holding limits relative to an individual entity's covered emissions levels.
— The K-ETS authority may also increase or decrease the borrowing limit or offset limit or establish a temporary price ceiling or price floor.

**The legislation defines price- and quantity based circumstances under which the K-ETS authority can activate MSMs; however, implementation remains relatively discretionary.**

— The legislation defines criteria for when a market stability intervention can be triggered, while providing some discretion for the K-ETS authority to interpret these criteria:
  - *upper threshold criteria:* based on larger-than-average trading volumes *AND* higher-than-average prices;
  - *lower threshold criteria:* lower-than-average prices *OR* low liquidity leading to trading impracticability.

**To date, the K-ETS authority has used its powers to inject new supply on two occasions and has also used verbal signals to counteract market excess on two other occasions.**

— In 2016 and 2018 additional allowances were provided to the market to mitigate rising prices.
— Verbal signals to the market were sent twice in 2017—one indicating a potential change to holding limits, and the other indicating a potential release of allowances from the MSR.
— Each intervention led to lower allowance prices and stimulated trading, though the impact appears to have been transitory
— Liquidity has been improving recently, with growing trade in Korean Allowance Units (KAUs).

[41] This is about €20 using exchange rates as of February 2019.

## 4.2 Chinese regional pilot ETS, mixed market stability measures

In 2013, China launched eight regional pilot ETS that each trial slightly different MSM designs. These pilots (five at the city level and three at the provincial level) were developed to provide practical insights to the government to inform the development of the national ETS. The major characteristics of each of the regional ETS are detailed in Table 8 . While each pilot ETS has design nuances, their MSMs are either price based or quantity based measures.

All regional pilots include banking measures and limited use of domestic offsets. Hubei only allows banking for allowances that have been traded at least once, while Shanghai allowed only one-third of banked allowances from the first phase to be used in its second phase (2016-18). None of the other ETS impose banking restrictions. All regional ETS allow for offsets to be used for compliance, with slight variations in quantitative and qualitative limits. In particular, Fujian focuses on forestry credits and increased the quantitative limits, from 5-10% of compliance for companies that use both China Certified Emission Reduction (CCER) and Fujian Forestry Certified Emission Reduction (FFCER) credits (ICAP, 2018b). The other pilots allow the use of CCERs for between 5-10% compliance, with varying levels of local project requirements (Wang, 2016).

China has now begun the implementation of its national ETS, although no decisions have yet been made on what MSMs will be used. The national ETS will eventually help achieve China's goal of reducing the carbon intensity of GDP by 40-45% in 2020 relative to 2005 levels (IETA, 2015a). It will cover $CO_2$ emissions from the following sectors: petrochemicals, chemicals, building materials, iron and steel, non-ferrous metals, paper production, power (including power generation and grid), and aviation. The Phase 1 (2017-19) annual emissions from covered entities is estimated at 3-5 $GtCO_2e$ per year. Only firms that consumed more than 10 kilotons of standard coal equivalent (ktce) per year, in any of the years between 2013 to 2015, will be included in the ETS (ICAP, 2017; Swartz, 2016). The national ETS's first year of operation focuses on market infrastructure development and trading simulations will begin from 2019, and from 2020 the market will be deepened and expanded. The Chinese Ministry for Ecology and Environment is currently developing MSMs to prevent price spikes and reduce the risk of market manipulation, although there are no details yet (Stoerk, Dudek, & Yang, 2019). The choice of future MSMs will be important given the widespread expectations that China's national ETS will experience rising prices from 2020 to 2025, with significant divergence in opinion over the levels (Slater et al., 2018).

Overlapping policies in China may also influence carbon price levels in the ETS. The 13th Five-Year Plan for Energy Development has a range of energy consumption and production targets for 2020, including a total energy consumption cap of 5 gigatonnes of coal equivalent (Gtce), a cap of 58% of coal use in primary energy consumption, a goal of at least 15% of non-fossil fuel energy consumption, and individual targets for specific energy generation technologies. China has also set a goal for reducing the energy intensity of its economy by 15% in 2020, relative to 2015 levels (Tianjie, 2017). Policies such as these that overlap with the objectives of an ETS can influence carbon price levels (World Bank, 2016).

*Table 8.* Overview of China's eight regional pilot ETS

| Regional ETS | GHG coverage | 2020 emissions intensity reduction target relative to 2015 | 2019 carbon price level (US$/t$CO_2$e) | MSM(s) |
|---|---|---|---|---|
| Beijing (2013) | 45% of city's direct and indirect $CO_2$ emissions | 20.5% | 8.8 | — price based allowance reserve |
| Chongqing (2014) | 40% of city's direct and indirect GHG emissions | 19.5% | 1.0 | — price stabilisation measures<br>— limited trading of free allocation |
| Fujian (2016) | 60% of the province's $CO_2$ emissions | 19.5% | 4.4 | — price- and quantity based allowance reserve |
| Guangdong (2013) | 60% of the province's $CO_2$ emissions | 20.5% | 2.8 | — auction floor price<br>— price based allowance reserve |
| Hubei (2014) | 35% of the province's $CO_2$ emissions | 19.5% | 4.1 | — auction floor price<br>— price based allowance reserve<br>— exchange limits day-to-day price fluctuations between -10% and +10% |
| Shanghai (2013) | 57% of city's direct and indirect $CO_2$ emissions | 20.5% | 4.4 | — price based stabilisation measures |
| Shenzhen (2013) | 40% of the city's direct and indirect $CO_2$ emissions | 45% (relative to 2005) | 1.5 | — price based allowance buy-back<br>— price based allowance reserve |
| Tianjin (2013) | 55% of city's direct and indirect $CO_2$ emissions | 20.5% | 1.8 | — price- and quantity based allowance reserve |

*Source: International Carbon Action Partnership (ICAP) and IETA (2015a)*

### 4.2.1 Implementation process

China's regional pilot ETS represents an experimental approach to testing different carbon price and MSM designs. The pilot ETS aim to provide experience and information for the design and implementation of the national ETS. Pilots were selected to provide a diverse portfolio of regions/cities in terms of economic development, sectoral composition as well as emission profiles, such that the impact of carbon pricing on different regions of the country, and the impact of different designs would, be better understood when implementing the national ETS (The Climate Group, 2013). Pilots were also implemented through a staggered approach such that lessons learned could be applied to subsequent pilots. The objective of the experimental approach is to reinforce China's capacity and confidence in the use of market based measures (Li & Healy, 2018).

Regional pilot MSMs have built on the experience of the EU ETS and other regional pilots, as well as stakeholder engagement and research. A China policy expert interviewed for this study suggested that the design of Beijing's MSM influenced the design of subsequent pilot ETS, particularly Hubei and Fujian. Oversupply and low prices in the EU ETS were also motivating factors in introducing MSMs in the pilot ETS. In addition, engagement with industrial stakeholders and abatement costs analysis informed the volume of allowance reserves and the levels of price thresholds.

### 4.2.2 Functioning

The Chinese regional ETS trialled several MSMs (ICAP, 2018b; IETA, 2015a). This subsection describes the general functioning of mechanisms across two main categories:

- price based mechanisms; and
- a combination of price- and quantity based mechanisms.

Beijing, Hubei, Shanghai, Guangdong and Shenzhen have largely price based MSMs.

- Beijing has a fully price based MSM and sets a soft price floor and ceiling. The Beijing Development and Reform Commission (DRC) can inject additional auction allowances if the weighted average price exceeds a price trigger of US$22/t$CO_2$ for ten consecutive days and can buyback allowances if the market price falls below US$3/t$CO_2$. The annual reserve for cost containment is set at 5% of the total annual cap (Zhang, 2015).
- Hubei implements an auction floor price (IETA, 2015a), and diverts 8% of its annual allowance cap to a stability reserve that can be used for market intervention if the price breaches low or high thresholds more than six times in a 20-day period. The reserve can be used for market intervention by buying or selling allowances. Intervention can also be justified in the event of supply and demand imbalances or liquidity issues. In Hubei, price fluctuations are also directly controlled by the exchange limiting day-to-day price fluctuations to between -10% and +10%.
- Shanghai has discretion to implement secondary market price stabilisation measures to ensure prices do not vary more than 30% in one day, including imposing holding limits or suspending trading (Wang, 2016).
- Guangdong's auction floor price was initially US$9/t$CO_2$ in 2013 and was then lowered to US$4/t$CO_2$ and increased each subsequent quarter in increments of US$1/t$CO_2$. In 2016 the floor was set at 80% of the weighted average allowance price from the past three months. Guangdong's exchange does not allow prices to vary by more than 10% in one day (Wang, 2016).
- The Shenzhen ETS has symmetric mechanisms to manage the market in the event of prices falling too low or rising too high. The Shenzhen DRC has an allowance reserve (2.4 Mt$CO_2$e) from which fixed price

allowances can be sold if the ceiling price is triggered. It may also buy back up to 10% of the total allowance allocation if it determines market prices are too low (Wang, 2016).

Fujian, Chongqing and Tianjin have MSMs that can be triggered by both price and quantity thresholds.

— Fujian has an allowance price reserve that can be triggered by price or quantity considerations. The Fujian DRC reserves 10% of the cap for market intervention when price exceeds thresholds for ten consecutive days, or when it judges there are demand and supply imbalances, or when liquidity issues arise. The Fujian DRC can also buy back allowances when prices are considered too low.
— In Chongqing, the Carbon Emissions Exchange may undertake stabilisation measures in response to general market fluctuations and entities are restricted to selling less than 50% of their free allocation.[42]
— Tianjin also has an allowance reserve that can be used to inject (withdraw) allowances to (from) the market in the event of general market fluctuations.

### 4.2.3 Actual use and practical experience

The carbon prices in regional ETS have been determined significantly by non-market forces such as regional governments or local companies with large allowance market power. For instance, in the 2018 China Carbon Pricing Survey, government intervention was widely seen as the second most influential factor in determining prices (second only to cap-setting and allocations) (Slater et al., 2018). As a result, carbon prices in the different regions in 2014 varied from US$3.3/t$CO_2$ to US$8.8/t$CO_2$ (Duan, Wu, & Kadilar, 2015). Table 8 shows that this variability in carbon price levels is still evident in 2019, with prices ranging from US$1.5/t$CO_2$ to US$8.8/t$CO_2$.

The Chinese regional governments retain significant discretionary power to implement MSMs. One China policy expert noted that the lack of written policy often allows the government to react in an ad hoc fashion to evolving circumstances. In some cases, auctions can be introduced in supply emergencies; the government can buy back an undetermined number of allowances; or it can use its close relationship with traders to influence market behaviour.

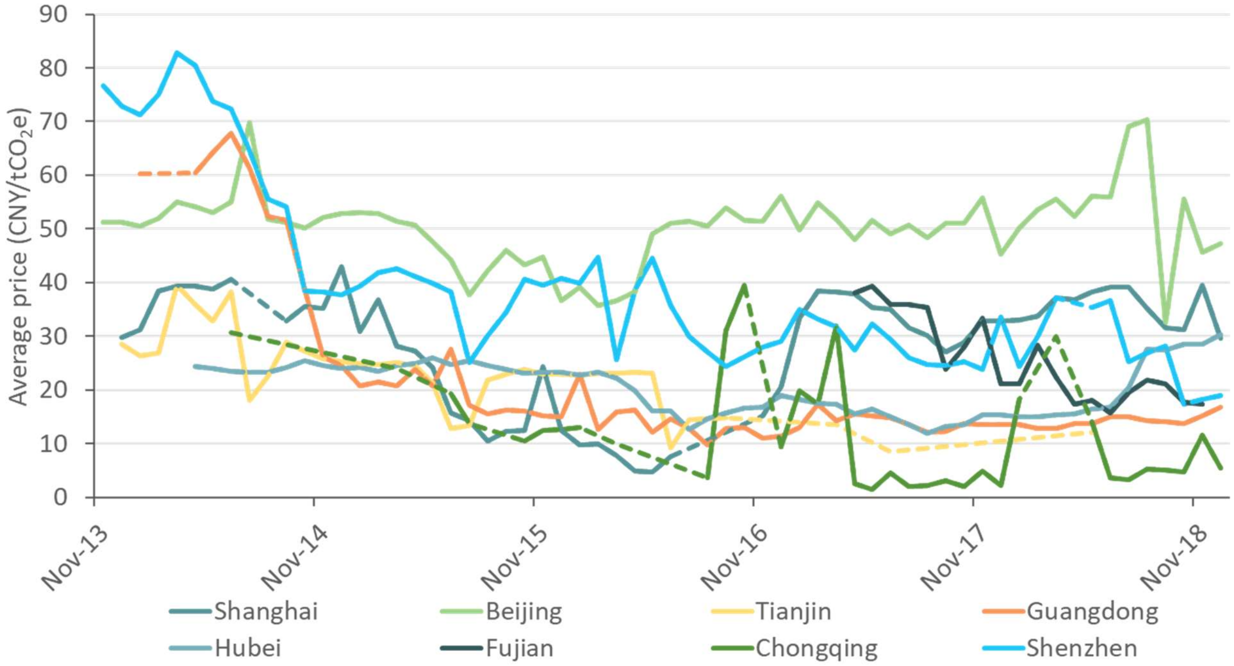
Overall, experience across the pilot ETS shows low liquidity and high price volatility (Li & Healy, 2018).

— In Shenzhen, Shanghai, Beijing, Guangdong and Tianjin, over-the-counter transactions account for most trade, while online trading is dominant in Hubei and Chongqing. Low liquidity has been a key issue across pilots and has resulted in many pilots encouraging greater participation of individuals, institutional investors, and foreign companies. Nonetheless, liquidity remains low, with the turnover ratios for Guangdong, Shanghai, and Shenzhen at only 0.54%, 1.48% and 2.12%, respectively—far lower than those of the EU, California and RGGI, which were all above 15% after 2014 (Narassimhan et al., 2017).
— Most pilot ETS have also experienced high price volatility alongside low overall prices, as shown in Figure 13. This may be the result of low transparency and information uncertainty, combined with few low-cost hedging tools via futures, options and other derivative products.

However, liquidity in the pilot markets has improved each year. A China policy expert noted that in the first few years of the ETS, almost 90% of trading was undertaken one month prior to the compliance date. However, this has recently fallen to below 50%. This may be attributed partly to increasing familiarity with ETS rules and increasing participant sophistication in terms of capacity to forecast their own emissions and allowance requirements.

[42] General market fluctuations can reflect either significant price volatility or supply and demand imbalances.

*Figure 13.* Over 2013-18, most Chinese regional pilot ETS have experienced significant carbon price volatility




*Note:* *Average monthly prices are volume-weighted, dashed lines represent months without trading.*

*Source:* *Vivid Economics based on Tanjiaoyi (2019) and Californiacarbon (2019)*

*Box 12.* Key takeaways from the Chinese regional pilot ETS mixed MSMs

China's eight regional pilot ETS reflect an experimental approach to, among other things, trialling different MSM designs.

— Beijing, Shanghai, Guangdong, and Hubei have MSMs that are price based.
— Shenzhen, Chongqing, Fujian, and Tianjin have MSMs that can be triggered by both price and quantity thresholds.

The Chinese regional ETS have exhibited low market liquidity and high price volatility.

— Allowance prices have generally risen near compliance deadlines and most ETS experienced high price volatility, potentially reflecting low transparency and information uncertainty, combined with few low-cost hedging tools via futures, options and other derivative products.
— Low liquidity has been a key issue and has resulted in many pilots opening up markets beyond spot allowances and to entities beyond compliance firms, thereby encouraging greater participation of individuals, institutional investors, and foreign companies.

# 5 Comparative assessment of market stability measures

This section compares MSMs implemented in ETS across the world. We first synthesise common findings across jurisdictions; this relates to design features (mainly the treatment of banking, borrowing and offsets) and the objectives of MSMs. Next, we identify the ways in which MSMs differ and offer key lessons from a comparison of implemented measures.

The ETS in the jurisdictions reviewed in this report have largely similar designs across three central features which also play a role in market stability and price management: banking, borrowing and the use of offsets. All ETS allow some form of banking but either do not allow no for borrowing or impose strong restrictions and they also all allow some level of offsets. Box 13 provides further details on these characteristics, and Annex 1 provides fact sheets on jurisdictions considered in this report.

*Box 13.* Globally, ETS have similar banking, borrowing, and offset design provisions

| *Banking* | *Borrowing* | *Offsets* |
|---|---|---|
| Unlimited banking is permitted in all ETS, except for California-Quebec, Hubei and Shanghai:<br>— California-Quebec has holding limits for banked allowances, in 2018 this was 12.3 million allowances (3% of the 2018 cap) in excess of each participant's compliance obligation(CARB, 2018c);<br>— Hubei only allows banking of allowances that have been previously traded;[43]<br>— Shanghai allows only one-third of allowances banked from the 2013-15 phase to be used per year in the 2016-18 phase. | Borrowing is not permitted except in Korea and the former Australian ETS:<br>— In Korea, borrowing is allowed but restricted to a between 10-20% of an entity's compliance obligation, and in the future this limit will be a function of past borrowing behaviour;<br>— In the (former) Australian CPM, borrowing from a year in advance was to be limited to 5% of an entity's future compliance obligation. | All ETS allow the use of offsets, with varying quantitative and/or qualitative limits:<br>— Most ETS limit offsets to 10% or less of an entity's compliance obligation;[44]<br>— ETS will often limit offset eligibility to domestic projects or specific project types. |

Implemented MSMs differ across six central characteristics:

1. Policy intent relates to whether the measure aims to support or contain prices, or whether it focused on managing excessive short-term fluctuations. Most jurisdictions now have MSMs that act as a collar, to both support and contain prices

[43] This measure of allowing allowances to be banked only once they have been traded at least once may reflect an ambition to increase market liquidity.

[44] Australia's CPM planned to allow international offsets for up to 50% compliance; Tokyo-Saitama ETS allow unlimited use of certain offsets; and New Zealand previously allowed unlimited use of Kyoto offsets.

2. Decision criteria relates to whether the method and scale of intervention is specified by rules, or whether it allows for discretionary judgement by the regulator. Rule based measures are the prevailing norm, with discretionary measures only implemented in Korea, Tokyo-Saitama, and certain Chinese regional pilots.
3. Intervention triggers relate to whether a measure is triggered by price- or quantity based criteria/thresholds. Most jurisdictions implement MSMs that have price triggers. Only the EU, Korea, and some Chinese regional pilots implement measures that have a quantity trigger.
4. Bounds of intervention determine whether limits apply to MSM responses. Unbound interventions refer to measures which impose an unlimited response, for instance, a hard price ceiling, whereas bound interventions impose a limited response, for instance a cost containment reserve which can be fully exhausted and may see prices rise above the trigger price. Bound and unbound intervention occur at a similar frequency across jurisdictions.
5. Breadth of intervention relates to whether MSMs cover all ETS emissions or only a subset of emissions. Nearly all MSMs have been implemented to cover all emissions under an ETS, with only the UK and New Zealand imposing measures on a subset of emissions.
6. Impact on covered sector emissions budget can either be permanent or temporary. There is a fairly even split between measures that imply a temporary supply adjustment and those that imply a permanent supply adjustment. However, recently more measures have been introduced that entail some element of permanent supply adjustments.

Table 9 over page, compares how MSMs in reviewed jurisdictions vary across these characteristics

*Table 9.* Characteristics of MSMs implemented in ETS around the world

| Jurisdiction and MSM | Trigger for intervention | | Decision criteria | | Intent of market stability mechanism | | | Bounds of intervention | | Breadth of intervention | | Impact on emissions budget | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Price | Quantity | Rule based | Discretion | Price support | Contain price | Market stability | Unbound ('harder') | Bound ('softer') | All covered emissions | Subset of emissions | Temporary | Permanent |
| **Europe** | | | | | | | | | | | | | |
| EU—Market Stability Reserve (MSR) | | | | | | | | | | | | | |
| **Americas** | | | | | | | | | | | | | |
| WCI—Auction reserve price | | | | | | | | | | | | | |
| WCI—Allowance price containment reserve | | | | | | | | | | | | | |
| RGGI—Auction reserve price | | | | | | | | | | | | | |
| RGGI—Cost containment reserve | | | | | | | | | | | | | |
| RGGI—Emissions containment reserve | | | | | | | | | | | | | |
| **Asia-Pacific** | | | | | | | | | | | | | |
| Korea—Powers of intervention | | | | | | | | | | | | | |
| NZ ETS—One-for-two price discount | | | | | | | | | | | | | |
| NZ ETS—Ceiling (fixed price option) | | | | | | | | | | | | | |
| Australia CPM—Floor (top-up charge) | | | | | | | | | | | | | |
| Australia CPM—Ceiling | | | | | | | | | | | | | |

| Jurisdiction and MSM | Trigger for intervention | | Decision criteria | | Intent of market stability mechanism | | | Bounds of intervention | | Breadth of intervention | | Impact on emissions budget | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Price | Quantity | Rule based | Discretion | Price support | Contain price | Market stability | Unbound ('harder') | Bound ('softer') | All covered emissions | Subset of emissions | Temporary | Permanent |
| Tokyo—Credit supply increases | ✓ | | | ✓ | | ✓ | ✓ | ✓ | | ✓ | | | ✓ |
| **China (pilots)** | | | | | | | | | | | | | |
| Beijing—Price based allowance reserve | ✓ | | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | | ✓ | |
| Chongqing—Powers of intervention | ✓ | ✓ | | ✓ | | | ✓ | ✓ | | ✓ | | ✓ | |
| Fujian—Allowance reserve | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | ✓ | |
| Guangdong—Auction reserve price | ✓ | | ✓ | | ✓ | | | ✓ | | ✓ | | ✓ | |
| Hubei—Auction reserve price | ✓ | | ✓ | | ✓ | | | ✓ | | ✓ | | ✓ | |
| Hubei—Price based allowance reserve | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | ✓ | |
| Shanghai—Auction reserve price | ✓ | | ✓ | | ✓ | | ✓ | ✓ | | ✓ | | ✓ | |
| Shenzhen—Allowance buy-back reserve | ✓ | | | ✓ | ✓ | | ✓ | | ✓ | ✓ | | ✓ | |
| Shenzhen—Cost containment reserve | ✓ | | | ✓ | | ✓ | ✓ | | ✓ | ✓ | | ✓ | |
| Tianjin—Allowance reserve | ✓ | ✓ | | ✓ | | | ✓ | ✓ | | ✓ | | ✓ | |

*Note:* *Green squares represent the characteristic in operation for the relevant market stability measure*

*Source:* *Vivid Economics*

Five general observations arise from the comparison of market stability measures implemented to date:

1. Inflexible regulatory processes can delay policy makers' response to changed circumstances, which may necessitate the introduction or reform of MSMs.
2. Implementing MSMs through auctions is a common and relatively simple approach.
3. Rule based MSMs increase price predictability and refine market price expectations.
4. MSMs that entail a permanent supply response alter emissions budgets and affect realised ambition levels.
5. Linking ETS require compatibility in the design of MSMs, with all linked system taking steps to coordinate MSMs to avoid potential adverse impacts.

Inflexible regulatory processes can delay policy makers' response to changed circumstances, which may necessitate the introduction or reform of MSMs. All MSMs considered have evolved in response to local changing circumstances, but, in some cases, rigid legislative or policy processes have delayed necessary changes. For example, the formal review and legislative amendments required to adjust the NZ ETS's price ceiling have meant that NZU prices have recently tracked the ceiling price, despite a general view amongst policy makers that price increases are needed to reach an appropriate price trajectory. Constraining prices at this level may inhibit desired low-carbon investment; however the ceiling will remain in place throughout 2019.[45] Given the potential long lead-time for changes, jurisdictions such as the EU, California and the RGGI states have introduced regular reviews of the functioning of their markets and the operation of market stability mechanisms. New Zealand also intends to introduce a more flexible market stability mechanism, and more frequent reviews of ETS operation in forthcoming legislative amendments.

Implementing MSMs through auctions is a common and relatively simple approach. Most ETS implement MSMs through primary auctions. The EU's MSR alters auction volumes; California-Quebec and RGGI use auction reserve prices and offer reserve allowances to implement price controls through auctions; and Korea and some Chinese pilot ETS offer additional allowances through auctions, with New Zealand also considering a similar approach. Introducing MSMs through auctions is simpler than regulating secondary markets, as the auctions pertain to a subset of entities and sales events occur less frequently. However, some other jurisdictions have implemented MSMs outside of auctions. For example, some Chinese pilot ETS exert direct control over secondary exchanges by imposing volatility limits; the Tokyo-Saitama ETS retains the option to increase credit supply through various means; and the Australian CPM had planned to implement a top-up fee on international offsets but moved away from this when the design proved impractical.

Rule based MSMs increase price predictability and refine market price expectations. Triggers based on well-defined rules allow market participants to anticipate interventions in advance and adjust expectations and behaviour accordingly. Such behaviour change accompanied the announcement of the introduction of the rule based measures of RGGI's CCR, and New Zealand's pathway to de-linking from the Kyoto market. Conversely, triggers based on discretionary considerations may not send a sufficient signal for the market to adjust behaviour or expectations, particularly where criteria for intervention are inadequately defined. In these cases, interventions may have short-lived impacts, as appears to have been the case in in Korea's ETS, where the regulatory authority had to implement two interventions and send two verbal warnings to stabilise prices over 2016-18.

[45] New amendments to the NZ ETS cost containment measure will introduce increased flexibility and frequent ETS reviews, while providing the new Climate Commission a clear mandate to provide recommendations on ETS targets and mitigation progress.

MSMs that entail a permanent supply response can affect levels of realised ambition. Measures can be designed to provide either a temporary or a permanent supply response. In California-Quebec and Korea, for example, MSMs provide a temporary supply response: allowances that are unsold at auction are returned to the market in subsequent auctions, while allowances in the APCR are sourced from the annual caps of a combination of years. When coupled with a permanent supply response, MSMs alter emissions budgets. For example, the EU ETS MSR and RGGI's ECR can invalidate allowances, and therefore tighten the overall stringency of the ETS in response to low demand. This effectively increases the ambition of the ETS which may feed through to the jurisdiction-wide emissions target. Conversely, RGGI's CCR contains allowances from outside the cap and, when triggered in response to high demand, increases overall emissions and reduces ETS stringency. In 2018, the CCR could have effectively raised emissions in covered facilities by up to 17%, reducing the ambition of the ETS and possibly reducing the ability of jurisdictions to achieve long run emissions targets. While temporary supply responses may be easier to introduce, permanent supply responses may elicit more behaviour change.

To date, all jurisdictions that have linked ETS have acted to coordinate MSMs, with the exception of top-up charges levied on a subset of emissions. California and Quebec's linking was accompanied by a move to joint auctions with a single reserve price, as well as coordination on issues such as the treatment of exchange rates, inflation, operationalisation of APCR arrangements, and purchase limit rules (see Box 3). Similarly, the Tokyo-Saitama linked ETS utilise symmetric MSMs, and all RGGI states operate joint auctions with the same reserve price and CCR price thresholds. MSMs automatically propagate across linked systems, with potentially large impacts on market and environmental outcome. As such, linking requires compatibility of these measures (Santikarn et al., 2018). Additionally, aligning price collars can be difficult considering that the collar levels are often determined politically and reflect specific local concerns. This is particularly the case when measures differ in terms of the permanence of the supply adjustment they entail (Burtraw et al., 2013). The impact of MSMs will also vary depending on the type of linking arrangement sought. Restricted linking can limit the potential propagation of impacts across linked ETS, but also can reduce the economic benefits of linking. However, some jurisdictions have implemented (or propose to implement) top-up charges on a subset of emissions in linked ETS arrangements.[46] Such unilateral actions may impact market outcomes for linked partners, and may require mechanisms to address these cross-border impacts.

[46] The UK imposes a top-up charge on power sector emissions covered under the EU ETS, while New York plans to implement a top-up charge for its power sector emissions covered under RGGI.

# The impacts of linking ETS with market stability measures

# 1 Introduction

As jurisdictions ratchet up ambition to reach NDC targets, carbon prices are expected to rise and linking will become an increasingly important avenue to reduce abatement costs. To achieve Paris goals carbon prices will need to rise to between US$50-100/t$CO_2$ by 2030 (Stern and Stiglitz, 2017).[47] International cooperation in carbon markets has the potential to reduce the costs of reaching 2030 mitigation targets by 32 per cent and 2050 mitigation targets by 54 per cent (World Bank, 2016).[48] As such, linking is likely to become an increasingly important avenue to facilitate cost-effective mitigation.

However, linking ETSs is technically and politically challenging and in recent years has been made more complex by the proliferation of market stability measures (MSMs). Experience of linking to date suggests several aspects of policy need to be made compatible. Design features such as banking and borrowing, cap setting, the choice of full or partial linking and a range of other technical and policy details all require a degree of coordination between the linking jurisdictions. The proliferation of MSMs further complicates interactions between linked systems, creating challenges for establishing provisions to link (and delink).

This project seeks to build understanding of the interaction of carbon markets that utilise MSMs. As shown in Task 1, MSMs are now the norm and vary widely in their design, creating complexity for assessing their operation when markets are linked. This report builds on the research undertaken for Task 1 to develop a taxonomy of MSMs based on the international experiences of carbon markets. This is complemented by expert assessments of ETS design choices and market attributes that are relevant to the functioning of (linked) carbon markets.

This report uses a typology framework to generate qualitative and quantitative insights on the interaction of MSMs under various linking arrangements. In this report we seek to build understanding of these interactions using typologies, that act as generalised representations of carbon markets which can be used to assess a wide variety of potential interactions. Typologies help by identifying the most important characteristics for the functioning of markets and assessing these interactions, thus providing tractable insights that can be applied into the future. The qualitative insights have been developed through extensive discussions and workshops with academic experts, European Commission officials, and other carbon market experts. The quantitative modelling of ETS linking builds off the model developed by Doda & Taschini (2016)[49] and extends it with the support of the authors to account for different forms of linking and linking ETSs with different MSM designs.

The remainder of the report is structured as follows:

- Section 2 details the development of ETS typologies;
- Section 3 outlines qualitative findings from our analysis;
- Section 4 provides an overview of the modelling approach;
- Section 5 outlines the key findings from the modelling exercise; and
- Section 6 concludes with key implications for policy makers.

[47] Stern N. and Stiglitz J. (2017) Report of the High-Level Commission on Carbon Prices, World Bank Washington DC

[48] World Bank. (2016). State and Trends of Carbon Pricing 2016. Washington DC. https://doi.org/10.1596/978-1-4648-0268-3

[49] Doda, B., & Taschini, L. (2016). Carbon dating: When is it beneficial to link ETSs? Baran Doda and Luca Taschini September 2015 Centre for Climate Change Economics and Policy the Environment (No. No. 234)

# 2 Developing ETS typologies

While each ETS is different, some share common characteristics which can be used to help us identify how they might interact when linked.

This section develops ETS typologies that reflect the range of existing and potential characteristics and designs of carbon markets, and linking arrangements between these markets. These ETS typologies seek to capture the key differences between carbon markets operating in different contexts and how these effect the way in which they operate and interact. The full typologies include two subcomponents:

— *ETS archetypes:* representations of ETSs that vary according to relative market attributes and choice of MSMs;
— *policy choice sensitivities*: policy choices that are non-essential to an archetype ETS but are of interest as they can influence market outcomes under the linking or close cooperation of systems.

We assess the extent to which the full range of potential market attributes and policy choice variables influence the operation of carbon markets under linking. Market attributes are variables inherent to a given country or jurisdiction, such as economic structure, the design of non-climate policies and general governance frameworks. In contrast, policy choice variables reflect specific ETS design choices that are within a policy maker's immediate control.

To define archetypes, we identify the range of likely variability in carbon markets that is relevant for policy makers to understand the implications of linking. As such, the archetypes are defined based on the market attributes or policy choices where there is observed heterogeneity (differences), and where this heterogeneity would substantively affect the operation of carbon market links.

Table 10 represents a qualitative assessment of various market attributes and policy choice variables on carbon market outcomes. The assessment found that relative market size and relative abatement cost (for a given cap stringency) are the key market attributes across implemented ETSs that are likely to have a significant impact on ETS linking. Other market attributes will be considered but in less detail, such as volatility in the secondary market and the correlation of economic activity between ETS. These attributes shed light on the potential economic gains from linking but are less relevant for determining interactions of carbon markets specific to MSMs. Our policy assessment found that the choice of MSM is the major consideration in the interaction of carbon markets under linking. Other policy choices, such as the use (and restriction) of offsets and choice of cap type will be considered in less detail, as these vary less across jurisdictions and overlap with other policies considered.

Those market attributes and policy choice options not considered in detail, are nonetheless addressed through modelling of sensitivities or through qualitative analyses.

— Sensitivities are considered regarding economic volatility, the correlations of economic activity between linking partners, design of offsets, and choice of cap types.
— We also provide a qualitative discussions of the impact of other market characteristics such as market liquidity, or variations in allocation, scope or temporal flexibility provisions.

*Table 10.* We find that three variables exert the most influence over the interaction of carbon markets

| Market attribute or policy choice | Variable | Method of assessment of impact | Justification for approach |
|---|---|---|---|
| Market attribute | 1. Relative ETS market size | Included in archetype | Determines if ETS is a price maker/taker under linking |
| | 2. Relative ETS cost | | Determines if ETS has upward or downward price impact under linking |
| | 3. Volatility | Market attribute sensitivities | Effects economic impact of linking |
| | 4. Correlation of economic activity between ETS | | Effects economic impact of linking via gains from trade |
| | 5. Market liquidity | Qualitative analysis | Effects economic impact of linking but difficult to model, liquidity is only expected to be a problem in small ETS. |
| | 6. Market concentration (number of firms, market power) | Limited qualitative discussion | Impact negligible given concentration in operational carbon markets |
| | 7. Complementary, overlapping, countervailing policies | | Impact is proxied through ETS cost variable |
| | 8. Ease of rule-change processes (legislative complexity) | | Difficult to quantify, partially proxied through volatility variable |
| Policy choice | 9. Market stability measure | Included in archetype | Key policy variable to be tested in project |
| | 10. Offsets | Policy choice sensitivities | Relevant for price formation and market functioning, can be proxied through typologies as this is effectively a form of linking. |
| | 11. Cap type (e.g. absolute vs. intensity) | | Impact on price formation easily represented in models |
| | 12. Allocation (auctioning and types of free allocation) | Qualitative analysis | Limited impact on market functioning, but important for economic and distributional issues |
| | 13. Scope and coverage | | Impact of different coverage on linking is proxied by market size and cost |
| | 14. Temporal flexibility (Banking/borrowing) | | Relevant for market functioning, but alignment of approaches across ETS means this provides little analytical value |
| | 15. Cap level | Limited qualitative discussion | Impact of different cap choice is given by market size and cost |
| | 16. Monitoring, reporting, and verification protocols | | Impact negligible given common standards implemented |
| | 17. Revenue recycling rules | | Negligible on market functioning |

*Notes:* *Green rows reflect variables explicitly included in ETS archetypes; orange rows reflect variables included as policy choice sensitivities for the modelling of the typologies; non-coloured rows reflect variables that will be assessed through separate qualitative analysis of varying levels of detail*

*Source:* *Vivid Economics*

**The design of MSMs will have a major impact on the interaction of ETSs under linking.** As such, in defining archetype carbon markets we consider how these MSMs can vary across their six central characteristics discussed in task 1:

- **Policy intent** relates to whether the measure aims to support or contain prices, or whether it focused on managing excessive short-term fluctuations.
- **Decision criteria** relates to whether the method and scale of intervention is specified by rules, or whether it allows for discretionary judgement by the regulator.
- **Intervention triggers** relate to whether a measure is triggered by price or quantity based criteria/thresholds.
- **Bounds of intervention** determine whether limits apply to MSM responses.[50]
- **Breadth of intervention** relates to whether MSMs cover all ETS emissions or only a subset of emissions.
- **Impact on covered sector emissions budget** can be temporary or permanent (e.g. if reserve allowances are taken from outside the cap or allowances are permanently invalidated when taken from the market).

**Of these six characteristics, only the latter four are relevant for modelling.** The first two criteria are not relevant as the use of discretionary interventions cannot be systematised for modelling purposes, while policy intent is relevant to initial policy design but is less relevant for subsequent operation.

*Table 11.* MSMs vary across six central design characteristics

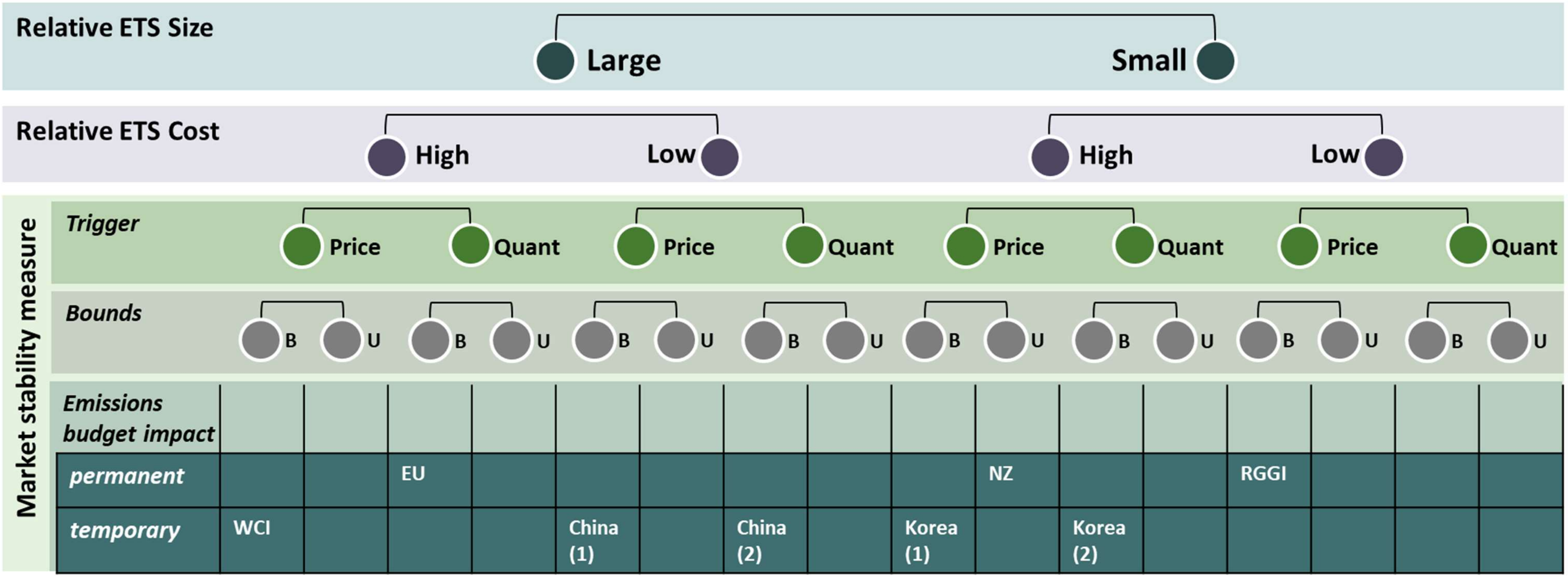
| Policy intent | Decision criteria | Intervention trigger | Bounds of intervention | Breadth of intervention | Impact on emissions budget |
|---|---|---|---|---|---|
| — Price support | — Rule based | — Price | — Bound (limited) response (quantity or price) | — All ETS emissions | — Temporary |
| — Price containment | — Discretionary | — Quantity | — Unbound response | — Subset of ETS emissions | — Permanent |
| — Managing excessive fluctuations | | | | | |

*Source: Vivid Economics*

**Taken together, this means that our ETS archetypes capture potential variation in carbon markets regarding their relative size, relative cost, and the design of MSMs.** These archetypes also capture the variation that exists in all rule based MSMs implemented to date. We consider MSMs that have lower thresholds triggers, upper threshold triggers, or both. This reflects the recent trend to implementation of collar mechanisms that aim to mitigate both upside and downside price or quantity risks. This variation is depicted in Figure 14, over page.

[50] Unbound interventions refer to measures which impose an unlimited response, for instance, a hard price ceiling, whereas bound interventions impose a limited response, for instance a cost containment reserve which can be fully exhausted and may see prices rise above the trigger price

*Figure 14.* Our archetypes vary by relative size, relative costs, and design of MSM




Note: *All MSMs can also apply to either full ETS emissions or a subset of ETS emissions. Mapping of operational ETS is illustrative only, China and Korea appear twice due to degree of discretion in Chinese subnational pilots and the K-ETS; Bounds: B – bound; U – unbound. All MSMs can either apply to full ETS emissions or a subset of ETS emissions. New Zealand intends to shift from its current fixed price option to a cost containment reserve once auctioning has been introduced.*

Source: *Vivid Economics*

We define ten central carbon market archetypes to form the ETS typologies each of which can be combined with several policy choice sensitivities. These archetypes, defined in Figure 15 over page, can be loosely mapped onto existing or potential future ETS and reflect a wide variation in possible carbon market designs. As such, these archetypes represent interesting cases to assess the impacts of MSMs and linking. For completeness, this includes one archetype with a discretionary based MSM (1b) and two archetypes of ETSs without MSMs.

MSMs will affect how carbon markets operate under linking. MSMs will propagate across linked markets, and this can impact either market outcomes or the effectiveness of the MSM after linking. As such, MSMs have been identified as a potential barrier to linking, however there is limited understanding of how these measures might interact. Further, different types of linking will affect these interactions and should be considered explicitly.

As such, we will consider the interaction of ETS typologies when they are linked in three ways:

- *full linking* arrangements imply unrestricted mutual recognition of allowances across jurisdictions. This is the most common form of linking and allowances from all linked systems can be used in any jurisdiction for compliance (e.g. the link between the California and Quebec ETSs);
- *restricted linking* relates to the scenario where there is partial or conditional recognition of allowances across jurisdictions. This type of linking can impose certain quantitative limits on the amount of allowances from another jurisdiction that can be used by entities (e.g. the 10 per cent limit on the use of offset units in the K-ETS), or it can impose a uni-directional flow of allowances across jurisdictions (e.g. the formerly proposed one-way link between the Australian and EU ETSs);
- *multijurisdictional linking* is any linking arrangement that involves more than two jurisdictions. This can be indirect linking (where two jurisdictions are linked through a third, mutual jurisdiction), or direct linking. Multijurisdictional linking can also comprise various permutations of full or restricted linking among all considered jurisdictions (e.g. the EU ETS as it operates across the EU, EFTA, and Switzerland).

*Figure 15.* We define ten core ETS archetypes

| Attributes | | 1a<br>Small ETS, price MSM | 1b<br>Small ETS, discretionary quantity MSM | 1c<br>Small ETS, hard price MSM | 2<br>Small, low cost ETS, price MSM | 3a<br>Large ETS, quantity MSM | 3b<br>Large ETS, quantity MSM + subset coverage floor | 3c<br>Large ETS, price MSM | 3d<br>Large vanilla ETS | 4a<br>Large, low cost ETS with price MSM | 4b<br>Large, low cost vanilla ETS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ETS Size** | | Small | Small | Small | Small | Large | Large | Large | Large | Large | Large |
| **ETS Cost** | | High | High | High | Low | High | High | High | High | Low | Low |
| **Market stability measure (MSM)** | *Trigger* | Price | Quantity | Price | Price | Quantity | Quantity | Price | NONE | Price | NONE |
| | *Bounds* | Bound | Bound | Unbound | Bound | Bound | Bound | Bound | | Bound | |
| | *Criteria* | Rule-based | Discretion | Rule-based | Rule-based | Rule-based | Rule-based | Rule-based | | Rule-based | |
| | *Supply adjustment impact** | Temporary | Temporary | Permanent | Permanent | Permanent | Permanent | Permanent | | Temporary | |
| | *Breadth* | All | All | All | All | All | Subset | All | | All | |

**Additional policy choice sensitivities:** offset limits; allocation

*Source:* *Vivid Economics*

# 3 Qualitative findings

This section presents the qualitative findings on the interaction of MSMs once linked. These findings are supplemented by quantitative modelling of the impact of linking ETSs with different MSM designs, for which the methodology is discussed in Section 4 and the findings are presented in Section 5.

The following subsections consider the interaction of price and quantity based MSMs in ETS, and then other policy, market and governance aspects likely to impact the functioning of linked ETSs with MSMs. These qualitative insights first cover the central determinants of the interactions between MSMs in linked ETSs in Section 3.1: differences in relative size and MSM design.[51] The discussion then focusses on the impact of additional variables that Table 10 identified for qualitative assessment, in section 3.2.

## 3.1 Interactions of MSMs in linked ETS

This section considers the interactions of linked ETSs of different size and MSM design. While in isolation MSM design can be considered independent of ETS size, when linked the relative size of ETS becomes a key determinant of the impact of MSMs. Below we outline the potential interactions between different types of MSM, while a quantitative analysis of these relationships is provided in section 5.

### 3.1.1 Linking smaller and larger ETS

When ETSs are linked, their relative size becomes a crucial factor for determining how they interact. For a smaller ETS, linking with a larger, stable, and compatible ETS may address concerns regarding market stability that removes the need for independent MSM. In some cases, upon linking a smaller ETS may wish to retain its MSM if it has different preferences for prices or market stability. However, below we demonstrate that maintaining an MSM in the smaller ETS may be ineffective, or risks having adverse impacts.

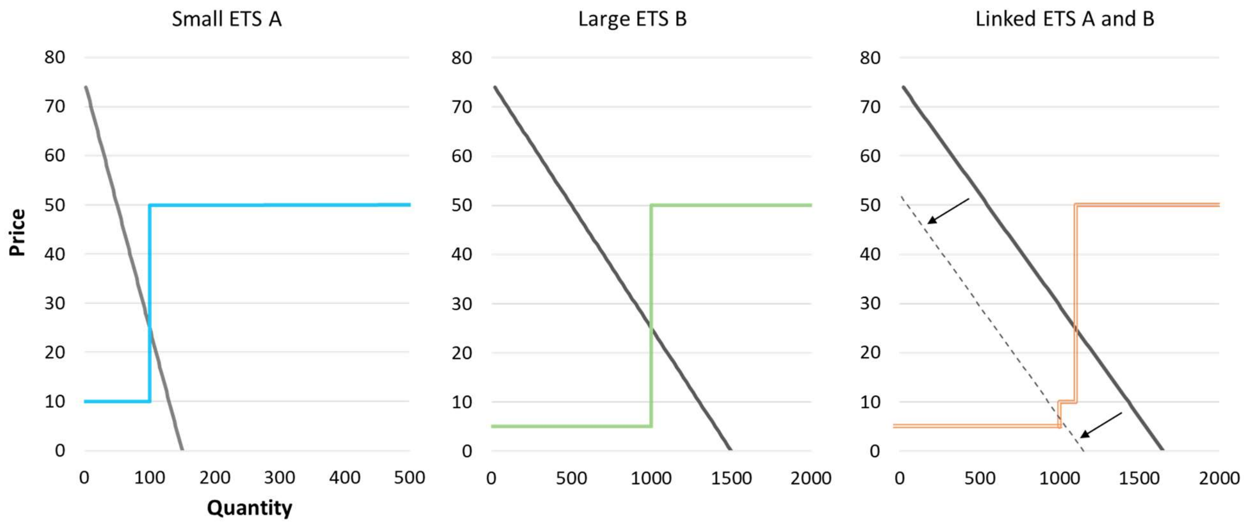
The design of MSMs has a major influence on how smaller and larger ETSs interact under linking. For instance, a price based MSM that uses a minimum or maximum price at auctions will have a different effect from a price based MSM where the regulator directly intervenes in the secondary market (for instance through buy backs). In the case of an auction based mechanism, the scale of intervention is bound by the number of allowances available for auction in the implementing jurisdiction. However, for an unbound (hard) price based MSM the intervention could involve a much larger number of allowances, drawn from across both jurisdictions. This means using an auction based MSM can limit the potential scale of intervention.

Figure 16 shows supply curves for a (smaller) jurisdiction A and (larger) jurisdiction B alongside the supply curve operating across the joint market once these jurisdictions are linked. Both jurisdictions operate independent price based MSMs implemented through auctions, which means that once they are linked the supply curve becomes kinked. We can see that jurisdiction A's auction reserve (at a price of 10) has a far less pronounced impact on the supply curve than jurisdiction B's auction reserve (at a price of 5), given its much smaller market size. In turn, when the joint market is faced with a large demand shock, jurisdiction A's price floor is rendered ineffective, and the joint market price falls below its intended lower price bound. While this

[51] Differences in relative cost are considered throughout and are the proximate driver of the dynamics discussed.

example shows the operation of price based MSMs for simplicity, this dominance of the MSM in a larger jurisdiction is equally true in the case of quantity based MSMs implemented through auctions.

*Figure 16.* The auction reserve price of a small ETS is ineffective given shock in larger ETS



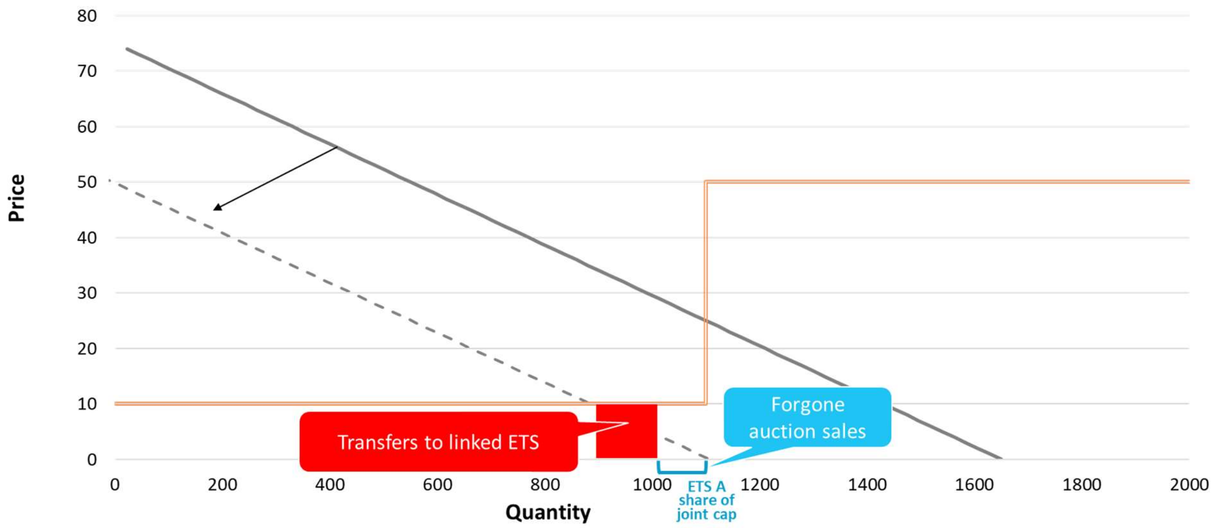

*Source: Vivid Economics*

We now consider an alternative MSM design, with jurisdiction A instead implementing an MSM directly through the purchase of allowances, as shown in Figure 17 over page. In this case jurisdiction A has a small ETS (ETS A), but is seeking to link with a large ETS (ETS B). Jurisdiction A wishes to maintain a hard price floor and price ceiling after linking by purchasing an unlimited number of allowances at a price of 10 and selling an unlimited amount of units at a price of 50. ETS B has a cap of about 1000 units, while ETS A has a cap of about 100 units. Following a large demand shock, jurisdiction A would need to purchase allowances of a value equal to the size of the red squares shown. The red square represents the quantity adjustment that is needed *in addition* to the withholding of all allowances at auction, in order to reach equilibrium at jurisdiction A's floor price. Given the size of the demand shock Jurisdiction A has to purchase more allowances than its total cap to maintain its targeted price, requiring large fiscal transfers from jurisdiction A to allowance sellers (business or the government) in jurisdiction B.

These dynamics mean that a smaller jurisdiction seeking to implement an independent MSM, must accept that this could lead to very large outflows of funds, or that its MSM may be rendered ineffective. If the smaller party is motivated by the need for revenue from the ETS (in Figure 16) or strongly values keeping its allowance price above the price floor (in Figure 17), then these objectives could be compromised by linking with the larger jurisdiction. It may be possible to maintain differential price incentives through a mechanism that targets total carbon costs, rather than allowance prices like the UK's carbon price floor. These measures use a top-up fee or subsidy applying to certain sectors covered by an ETS. This approach has flow on effects on demand across the joint system and is therefore still likely to need to be coordinated. Given these effects, successful linking requires that these potential impacts be explicitly addressed in linking negotiations.

**In extreme cases, MSMs' trigger levels could be fundamentally incompatible, such as where the lower trigger of one is above the upper trigger of the other.** If two jurisdictions use independent price based MSMs and the lower price trigger of one MSM is above the upper price trigger of the other MSM, then financial flows will occur from the jurisdiction with the binding floor to the one with the binding ceiling, while allowances flow in the other direction. Under bound (soft) interventions, these flows will continue until the legislatively determined supply or demand of either of the MSMs is exhausted. Incompatible trigger levels are a major issue for ETSs with unbound MSMs, as they risk substantial financial flows and allowance transfers. If both ETSs have unbound MSMs with incompatible trigger levels, in theory this leads to an unlimited transfer of allowances and the link will collapse. Further, an MSM that is triggered at a level that is below (above) a hard price floor (ceiling) in the linked-ETS becomes redundant.

*Figure 17.* A smaller ETS linking is likely to be required to abandon its MSM or coordinate with its larger partner




*Source:* *Vivid Economics*

### 3.1.2 Linking ETSs of a similar size

**When linking ETSs of a similar size, jurisdictions may need to adjust existing MSMs or develop a new joint MSM to ensure effective functioning.** The following sections show that for ETSs operating both quantity based and price based MSMs, some degree of coordination is likely to be needed.

#### 3.1.2.1 Linking ETSs with quantity based MSMs

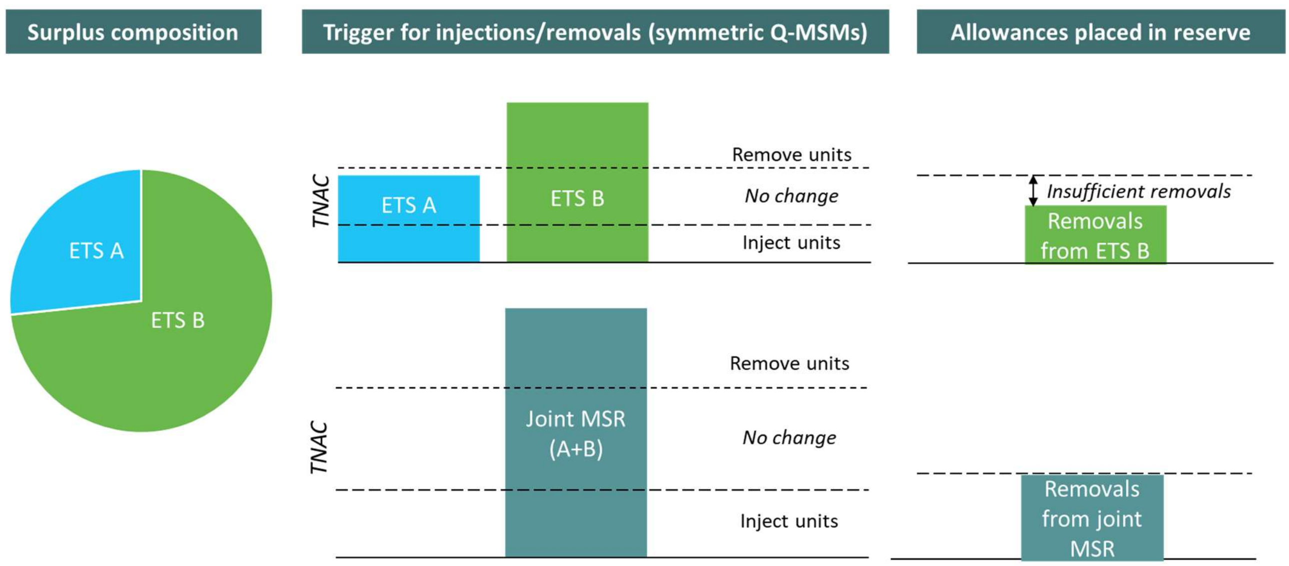
**Quantity based MSMs operate by altering supply based on the number of allowances in circulation in a carbon market.** Quantity based MSMs use measures of allowance holdings to trigger interventions such as the Total Number of Allowances in Circulation (TNAC) used by the EU MSR. In a fully linked system, allowances from each ETS are perfect substitutes. Price and emissions trajectories are therefore driven by the *joint* allowance supply and demand across the linked ETS, meaning that the allowances in circulation from just one ETS are not informative regarding the overall market conditions. This means that the number of allowances being banked *jointly* (the joint bank) across the linked ETS is of key importance.

It is possible that two ETSs with similarly stringent quantity based MSMs may be linked and operate independently, but a joint MSM is likely to be more effective. This is because the sequence of banking allowances in an ETS can be influenced by random or arbitrary factors. A random driver of differences could be differences in secondary market conditions at the time of auction, which could see the composition of allowance-purchasers differing between investors holding units or liable entities buying for within-year compliance across jurisdictions. Alternatively, an arbitrary source of difference could be if a parent corporation directs its facilities to hedge their liabilities in only one jurisdiction's allowances. This in turn can mean that the joint bank has many different potential compositions of allowances from each ETS, regardless of their stringency.

Figure 18 below, shows the impact of linking two identical ETS, operating identical quantity based MSMs, where participants have an arbitrary preference for banking allowances from ETS B. This market is in oversupply and based on the joint surplus in the system a significant number of units should be removed based on policy-makers' preferences regarding the joint bank. Yet looking at the top panel, we see that if ETS A and ETS B are operating independent MSMs, an inadequate number of allowances may be removed from the system. This is because the surplus in ETS A is insufficient to trigger the removal of allowances from its system. However, a joint MSM addresses this issue by considering only the joint bank across these jurisdictions and removing the appropriate number of allowances.

Because of the importance of the joint banking of allowances in driving market outcomes, when linking ETSs of similar size using quantity based MSMs, the measure of allowance holdings should be adjusted. In order to ensure that the joint banking of allowances is being reflected in the operation of the MSM, it is crucial that all (or the vast majority) of the allowances in the linked system are accounted for in the calculation of the surplus.

*Figure 18.* Parties using quantity based MSMs may need to adopt a joint approach as banking can differ arbitrarily

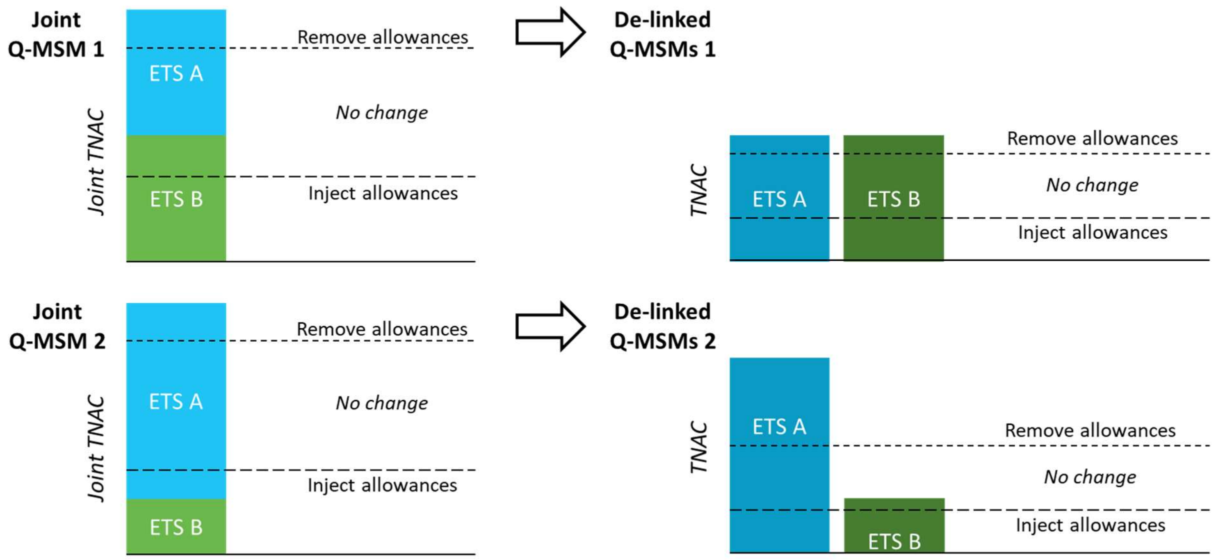



*Source:* *Vivid Economics*

**Along with the redefinition of the surplus, trigger levels could be adjusted to account for the larger size of the linked systems, as could the scale of the response.** Adding or removing a given quantity of allowances has a smaller impact when two or more ETSs are combined to form a larger system, while an intervention specified as a percentage of the total number of allowances in circulation (as is currently the case in the EU ETS) implies that the quantity removed will adjust with the joint size of the linked systems.

**Nonetheless a joint quantity based MSM can also face challenges, potentially facing perverse outcomes if ETSs are delinked.** As the joint bank can comprise different combinations of allowances from each jurisdiction, if these ETSs delink then the relative surplus held in each delinked ETSs could be one of many combinations. This could include a large surplus in the domestic ETS and a small surplus in the foreign ETS, a large surplus in the foreign ETS and a small one domestically, or similar surpluses in both as shown in Figure 19 below. In the bottom panel we see a situation where the joint bank is unbalanced, which could have negative impacts after delinking. In this case, the large surplus in ETS A would lead to low prices and the triggering of its MSM. In contrast, ETS B could face high prices as its allowances comprise only a small share of the joint surplus, resulting in relative scarcity after delinking.[52]

*Figure 19.* Differences in holdings can have a large impact if ETS with joint quantity based MSMs are delinked




*Source:* *Vivid Economics*

**Banking behaviour is central to the operation of quantity based MSMs and linking has the potential to make certain banking restrictions ineffective.** If a jurisdiction has banking restrictions and links with a jurisdiction with no banking restrictions, linking may circumvent the banking restrictions in the first jurisdiction as allowances are fungible across both ETS. This means a market participant operating in either of the two systems can choose to bank allowances from the ETS that allows banking, while surrendering allowances from

[52] There are essentially two options for de-linking: either cut the registry link or suspend trading. The notice period or the length of trading suspension influences the potential for de-linking to result in allowances increasing supply in the market.

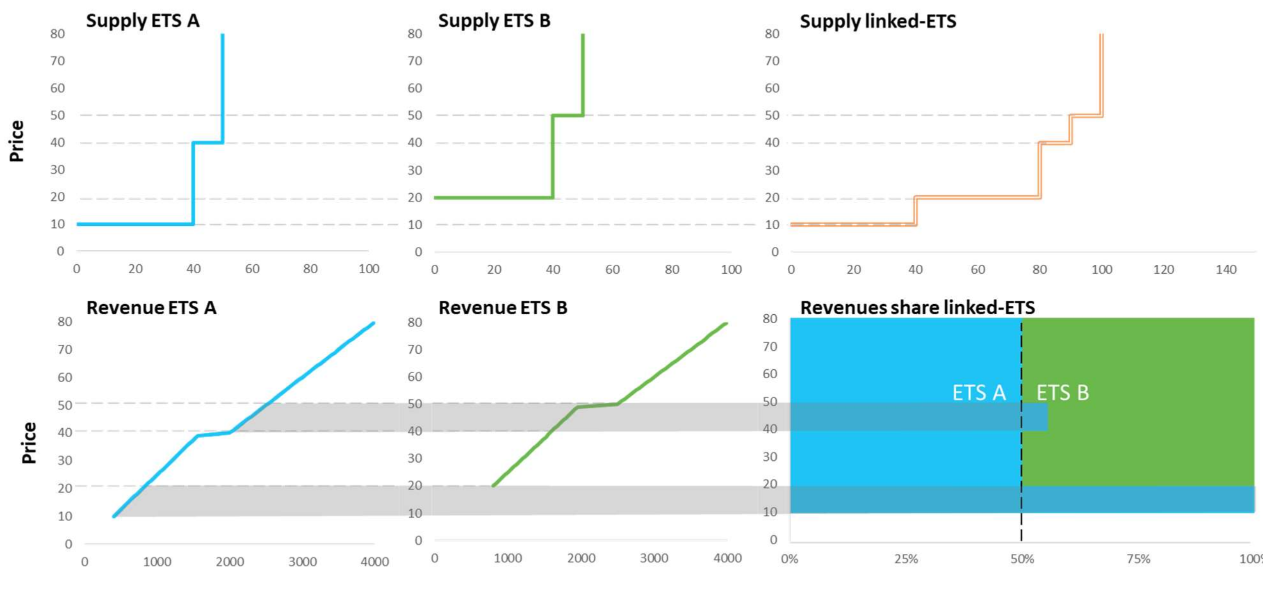
the ETS that chooses to limit banking. This could have implications for the operation of a quantity based MSM if the mechanism does not propagate across the linked system.

#### 3.1.2.2 Linking ETSs with price based MSMs

**Price based MSMs need to be compatible to operate effectively.** Price triggers should be adjusted based on expectations regarding the expected equilibrium price and volatility in the linked system. Bound (soft) MSMs can be combined to establish "stepped" price support and containment levels,[53] however these stepped supply curves can have large fiscal implications.

**Figure 20 shows how the supply curves in ETS A and ETS B reflect their respective price based MSMs.** ETS A has an auction reserve price at a price of 10 and a cost containment reserve (CCR) that releases a limited amount of allowances at a price of 40. ETS B has an auction reserve price at the higher price of 20 and a CCR at the higher price of 50. When linked, these markets effectively have a joint supply curve, created by each jurisdiction's auction reserve and cost containment reserves operating independently (the right hand panel in the top row). However, because price triggers for these MSMs haven't been aligned, linking could have severe distributional consequences. For instance, if demand is low, such that the price is between 10 and 20, then ETS A will receive all auction revenue available while ETS B will sell no allowances and raise no revenue. At prices above 20, the auction revenue is split, however we again see that ETS A receives a larger share of revenues between the price of 40 (where ETS A's CCR is triggered) and 50 (where ETS B's CCR is triggered).

*Figure 20.* Price based MSMs can create a "stepped" supply curve, with price triggers having large fiscal impacts




*Source:* *Vivid Economics*

[53] See for example Roberts and Spence, 1976 and Wood and Jotzo, 2011

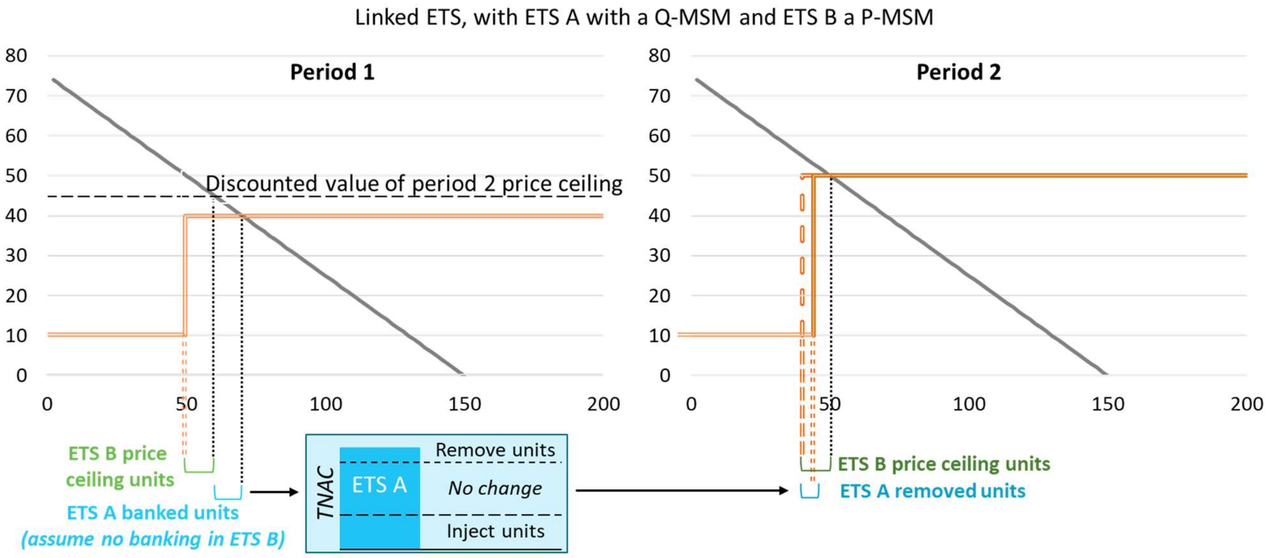
It is important that the highest auction reserve price trigger is below the lowest CCR trigger to avoid MSMs in each jurisdiction having contradictory effects, that is, where one MSM tightens supply while the other MSM loosens it. For instance, if the CCR trigger of one ETS is below the auction reserve price trigger of the other, then the MSM in the first ETS will inject allowances while the MSM of the second ETS removes them. Combining soft price controls in this way again has fiscal impacts as the jurisdiction administering each price step will face the losses or gains in revenue. These same dynamics also hold in unbound price based MSMs making their coordination particularly important, as fiscal and distributional impacts can be much larger.

#### 3.1.2.3 Linking ETSs with price and quantity based MSMs

If jurisdictions are operating price and quantity based MSMs respectively, this may require rules to prevent them from having contradictory effects. Since these MSMs are triggered by different parameters (prices, allowance surplus) situations may arise where one MSM injects allowances while the other removes them, a situation shown in Figure 21 below. Changes to the trigger level may reduce the likelihood of this occurring, however it is preferable for provisions to be put in place to avoid these outcomes.

Figure 8 demonstrates how the operation of MSMs and firms banking behaviour, can lead to contradictory effects. In this case, ETS B has a price based MSM in place with a rapidly increasing hard price ceiling over time. In period 1 ETS B's price ceiling binds at the price of 40, in period 2 it will increase to a price of 50, and there is no banking of allowances from ETS B. Forward looking firms notice the ETS B price ceiling in period 2 and realise they would be better off banking allowances from ETS A in period 1 to reduce their liability in period 2. This purchasing behaviour drives up the price of allowances from ETS A to the point where these allowances are priced at a level equal to period 2 price ceiling in ETS B adjusted for discounting based on firms required rate of return. This leads to significant banking of allowances, with the results that the TNAC in ETS A breaches the upper level required to trigger a removal of allowances from auction in period 2. Thus, in period 2 ETS A is reducing its supply of allowances due to an 'excess' of allowances in circulation, at the same time ETS B is releasing additional allowances to maintain its price ceiling.

*Figure 21.* Linking ETSs with different MSM can lead to contradictory behaviour due to different trigger definitions




Note: *A 'price ceiling unit' is sold by the government on an unlimited basis*

Source: *Vivid Economics*

## 3.2 Other policy, market and governance aspects

This section considers other aspects relevant to linking that are not considered explicitly in the modelling discussed in section 4 below. These are grouped as:

— determinants of demand, which are choices made by jurisdictions that underlie the demand curve in a jurisdiction and result in certain market attributes.

— market attributes, which are the characteristics of carbon markets that effect equilibrium outcomes regarding price and quantity and the gains from trade that can be expected.

— governance considerations, which are the set of rules that move beyond pure economic factors but nonetheless effect the interactions of linked markets.

We consider each of these categories below.

### 3.2.1 Demand determinants

Climate policy decisions will influence the determinants of demand within a carbon market. Policy choices that should be considered as they effect the operation of linked carbon markets include:

— Decisions regarding scope and coverage

— The design and operation of overlapping policies

— Intertemporal flexibility (banking and borrowing)

— Rules regarding secondary market participation

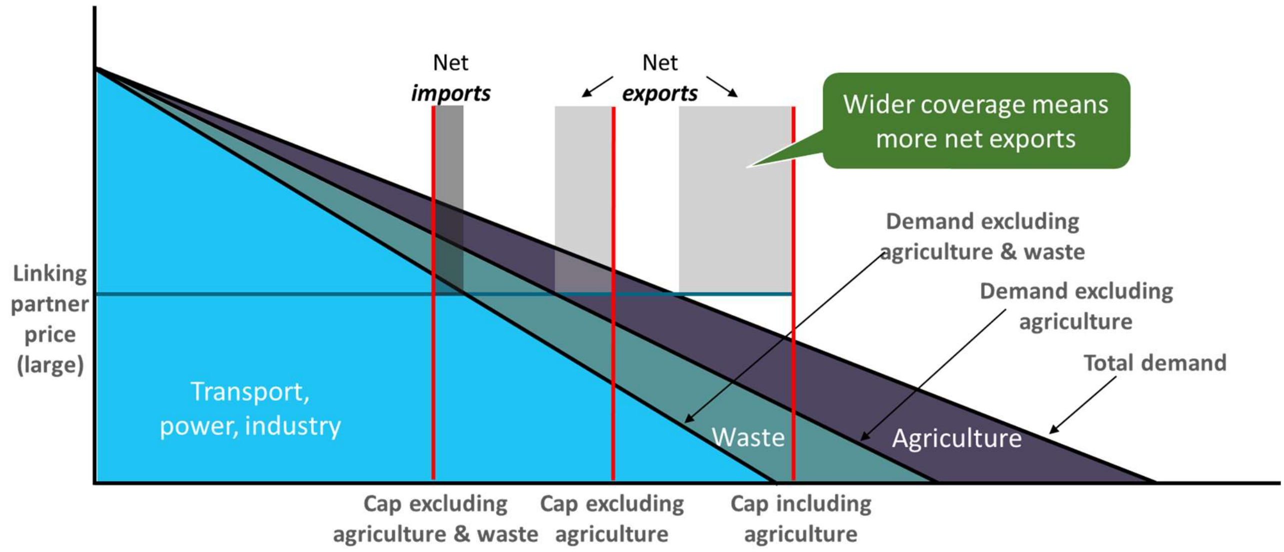
The design of an ETS determines the level and shape of demand. Decisions regarding scope and coverage are particularly important, as these determine what segments of the economy are included in the carbon market.

Different sectors will have different demand attributes, as such scope decisions determine the level and elasticity of demand, as well as costs of mitigation. For instance, we know at low carbon prices, demand for carbon from the road transport sector is less elastic than demand from the industrial or energy sector.

Put another way, decisions on scope and coverage determine which aspects of the economy-wide mitigation demand curve are included within a jurisdiction's carbon market. In general, greater scope and coverage mobilises more mitigation opportunities. This means (assuming credible MRV and enforcement) greater coverage enables greater level of emissions reduction at any given price. Even if mitigation is relatively expensive some additional mitigation will still occur at low prices, for instance due to substitution effects.

Figure 22 below shows what this can mean for outcomes within a linked carbon market. Here we represent decisions of a very small ETS linking with a very large ETS, such that the former is a price taker. The figure is indicative only and does not seek to reflect the likely scale or cost of emissions reductions in a jurisdiction. If this smaller ETS covers all emissions including agriculture and waste, it exports a relatively large number of its allowances to its linking partner. If it does not cover agriculture the amount of exports reduces, while if it does not cover agriculture and waste it becomes a net importer of allowances from its linking partner.

*Figure 22.* Coverage decisions influence the supply-demand balance in linked ETS

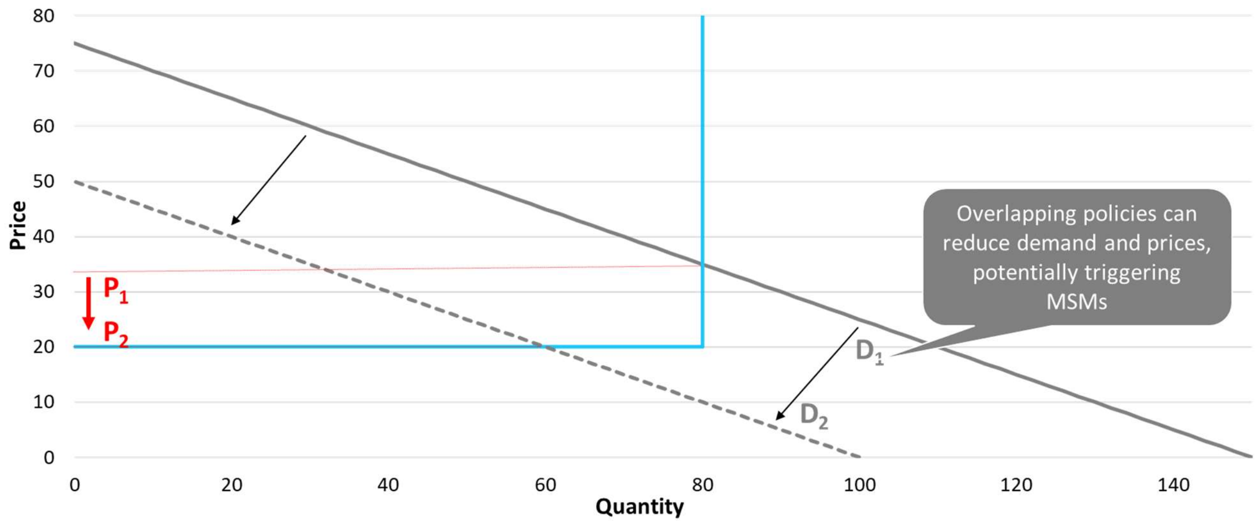



*Notes:* *Cap is set such that the ETS drives a constant level of mitigation in the economy regardless of coverage.*

*Source:* *Vivid Economics*

Overlapping policies can impact demand and therefore may contribute to the triggering of one or more MSMs as shown in Figure 10 below. In this case, an overlapping policy in a covered sector (e.g. electricity) has a major impact on overall demand in the market. This reduction in demand triggers a fall in prices to the price floor level of 20, at which point the auction reserve price binds.

*Figure 23.* Complementary policies can influence demand and the operation of MSMs




*Source: Vivid Economics*

**Given the potential impact of overlapping policies on the linked system, linking partners may seek to actively share information regarding planned policy changes.** This could include a wide range of policies such as the support of renewables, use of nuclear power, mobility policies and a host of other fiscal and sector-specific reforms. These overlapping policies may be implemented by jurisdictions other than those party to the agreement. For instance, in the EU these may be implemented by national governments, rather than the EU which has responsibility for negotiating a link but may not be able to limit member states' overlapping policies.

**Differences in rules regarding intertemporal flexibility (banking and borrowing) can also have important market impacts.** In a full linking scenario, any intertemporal flexibility from one participating ETS is effectively available to the entire market. Hence, if banking (or borrowing) is allowed in one ETS, this effect flows on to the linked system in the same manner as if it were allowed in both. Typically, ETSs allow for banking of allowances but not for borrowing. Borrowing is heavily limited in all ETSs currently operating but has the potential to impact MSMs under linking. Borrowing in particular could undermine the effectiveness of quantity based MSMs, as it can counteract measures to induce scarcity in MSMs where this supply adjustment is temporary.[54] Under an unbound price based MSM, intertemporal arbitrage could induce large scale borrowing of allowances if a government's commitment to keep prices at a given level enables firms to borrow at a below market interest rate (depending on the rate of increase in the price floor). As such, a linking agreement may need to include rules regarding banking and borrowing alongside MSM design.

**Market design determines underlying compliance demand, but the operation of carbon markets is also heavily affected by the participation of other market actors, particularly financial markets.** Restrictions on market participation or on the holding of units can limit the financial markets involvement and potentially reduce market efficiency. Regulation of trade will also affect the products available (e.g. spot only or derivatives), and

[54] For a discussion of this see Perino and Willner, 2016

the prevalence of market misconduct (e.g. commodity or financial product regulations). Finally, the liquidity of the market and sophistication of the financial sector will have a major impact on the financial products available and their tenure. Experiences of ETSs to date make this obvious, with smaller ETSs such as the New Zealand ETS only having over the counter trade, ETSs with participation restrictions like South Korea's ETS having highly illiquid exchange based trade,[55] while as the only large ETSs with open participation, the EU ETS has developed liquid medium tenure (2 to 3 year) futures markets. This suggests that linking need not only make allowances compatible but also ensure that rules governing holding behaviour or market access are compatible. Note that this does not guarantee a proliferation of different financial instruments, with the ability to provide long-tenure futures being a function of market demand.

### 3.2.2 Market attributes

There are several market attributes that create channels of impact on economies after linking. Attributes of interest include:

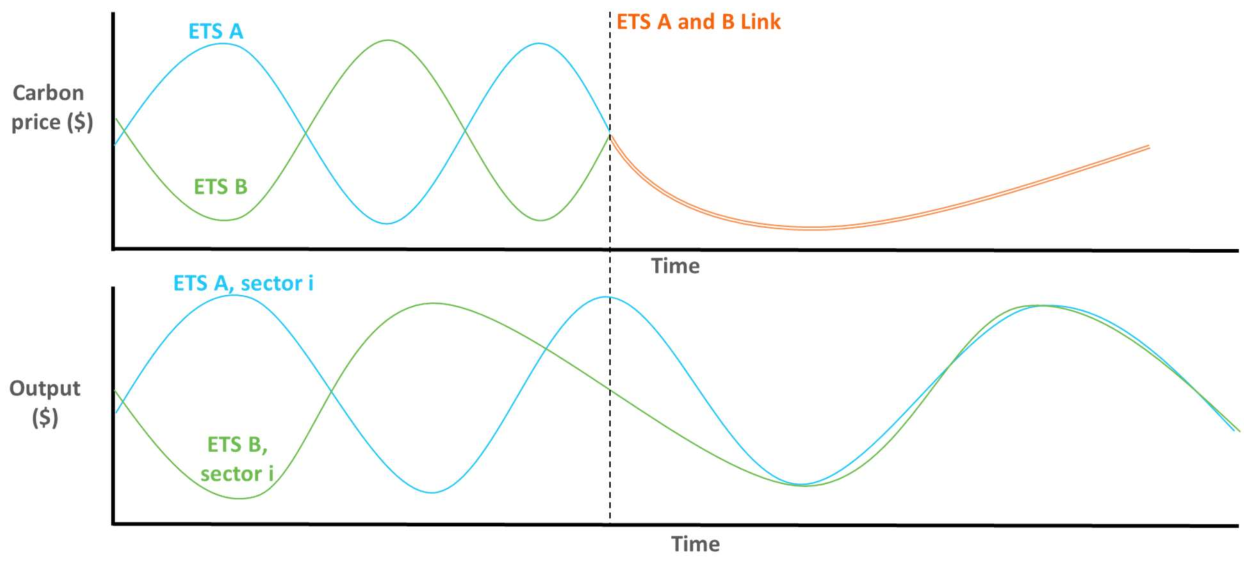
- The correlation of economic activity in linking jurisdiction
- Market concentration of ETS in linking jurisdiction

Under full linking, carbon prices from ETSs will converge, which should make economic activity more correlated across linked ETSs. This simply reflects that by making carbon prices correlated, linking makes a major input cost for certain industries correlated, meaning that the overall economic environment becomes more closely correlated. This is particularly true for sectors where allowance prices are a large share of input costs as the relative impact of correlated prices is greater, or sectors that face intense competition from regions that are not part of the linked ETS.

Figure 24 provides an illustration of how ETS linking could increase the correlation of economic activity in emissions intensive trade exposed sectors, where the carbon price is a larger share of input costs. In this example, carbon prices and economic activity in ETS A and ETS B are at first negatively correlated. Upon linking, the carbon price becomes correlated which has flow through impacts on emissions intensive industry which becomes increasingly correlated across the jurisdictions. Further in this case the carbon price of the larger jurisdiction (ETS A) dominates the linked system, which mean that economic activity in ETS B will shift to become more aligned with that in ETS A.

[55] Relying solely on OTC or exchange based trade can lead to challenges in ensuring smaller/mid-sized firms have access to allowances. This is particularly salient in markets where there are no intermediaries, such as South Korea.

*Figure 24.* Illustrative example of correlation of economic activity in EITE sectors increasing




*Notes:* *Figure for illustrative purposes only, complex dynamics will determine the operation of markets across jurisdictions*

*Source:* *Vivid Economics*

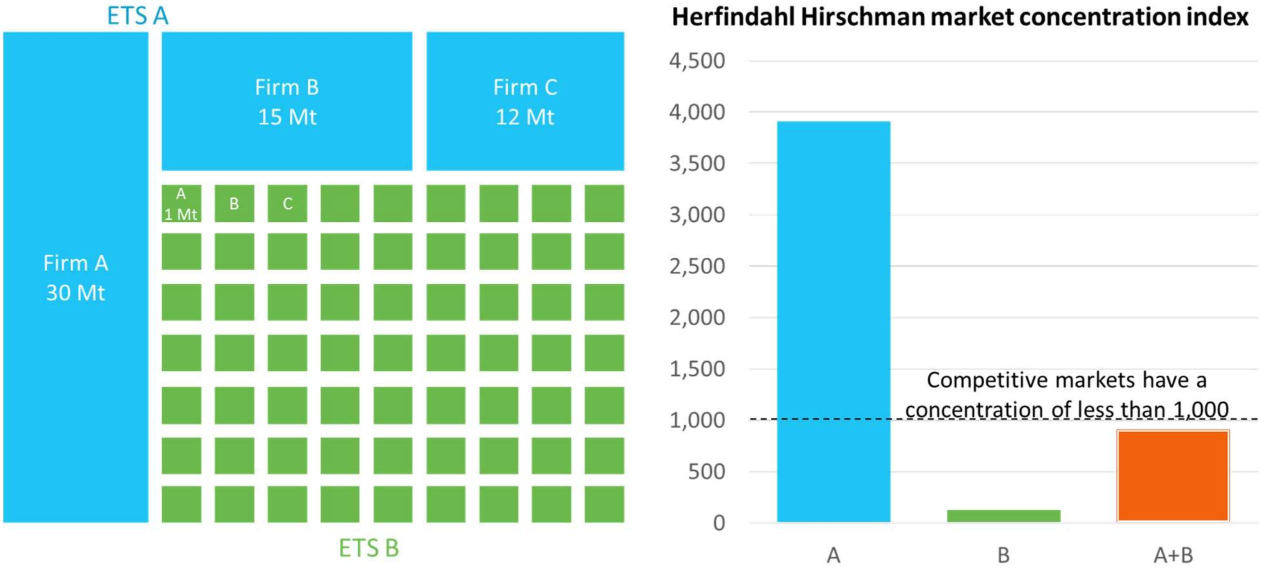
Carbon markets can differ in their level of competitiveness, which is heavily influenced by the degree of market concentration. Linking generally reduces overall market concentration, as increasing the size of the market (by merging two markets) increases the number of regulated entities and tends to reduce the market share of the 'big players'. However, this does not mean that the market concentration of the *linked market* is less than the concentration of *each individual market* prior to linking. While the linked market will always be less concentrated than the *more* concentrated market prior to linking, it could be more or less concentrated than the market that was *less* concentrated before linking.

Market concentration can be measured using the Herfindahl Hirschman Index (HHI). The HHI is commonly used in regulatory economics to identify uncompetitive markets that could be subject to anti-competitive behaviour. The HHI is calculated by squaring the market share of each firm competing in the market and then summing the resulting numbers. A HHI of over 1000 is generally taken to indicate an uncompetitive market.

Figure 25 below demonstrates how market concentration can be affected by linking. It shows an extreme case, where a highly concentrated market (ETS A) links with a very competitive market (ETS B). In this case ETS A has 3 firms dominating the market, while ETS B is comprised of a large number of identical firms. In this case, ETS A has a HHI of nearly 4,000 before linking indicating a highly concentrated market, while ETS B is highly competitive with a HHI of just over 100. The HHI of the linked ETS is just under 1000, indicating that linking has reduced the market power of participants in ETS A. For participants in ETS B, the market is now relatively less competitive but remains below the threshold that would generally indicate a cause for concern.

In ETSs with active secondary markets, the market concentration of liable entities becomes less important, as financial participants will play a major role in the market. Similarly, if the sophistication of firms is correlated to their size and market power, linking might not reduce the risk of anti-competitive behaviour as much as theory suggests, as sophisticated participants engage in more strategic trading.

*Figure 25.* Linking ETSs can reduce or increase market concentration




*Source:* *Vivid Economics*

### 3.2.3 Governance considerations

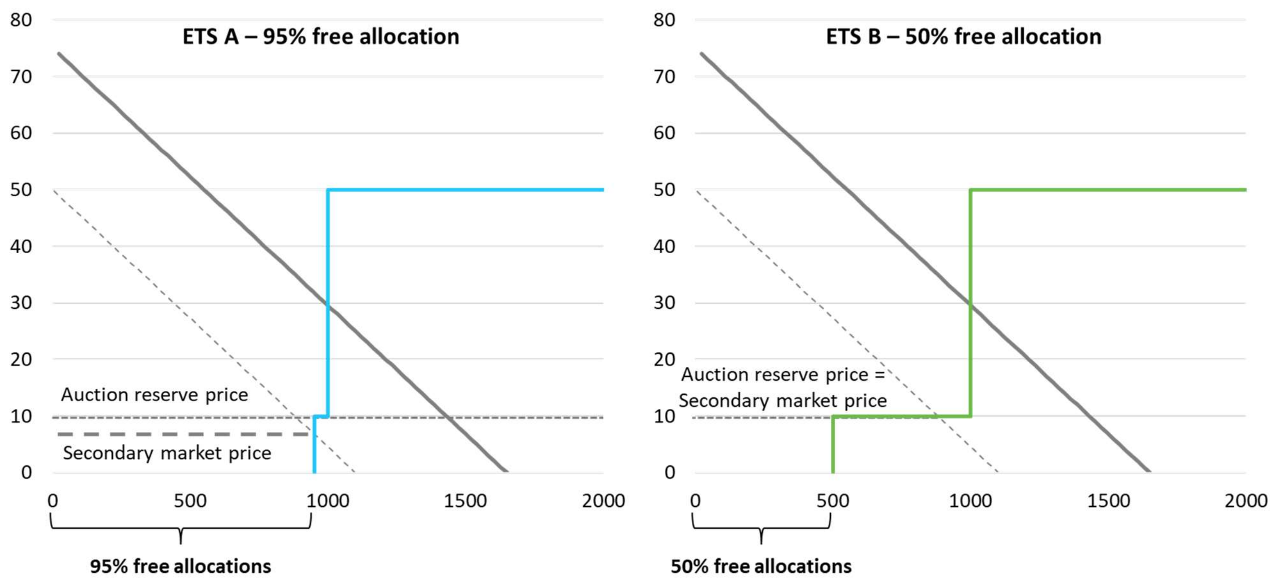
The sections above outline how differences in market design choices can affect the operation of MSMs under linking, however specific governance choices can also have impacts. Here we consider:

— Approaches to implementation of MSMs
— Rules regarding MRV and enforcement
— Coordination of future rule making, and rule changes

Many MSMs use auctioning for implementation (such as auction reserve prices), which means that rules regarding auctions will have flow on effects on MSM operation. In the case of reserve prices, the auction is an integral feature of the MSM and is not directly affected by linking. However, the share of allowances auctioned imposes an effective upper bound on the size of an MSMs intervention in any given year, which in turn limits the impact that can be achieved in the market. Allowance allocations are usually split between auctions and free allocations, which means that high levels of free allocations may undermine the effectiveness of an auction reserve price.

Figure 26 shows how the proportion of freely allocated allowances can affect MSM operation. In this case, ETS A allocates 95% of its allowances for free, while ETS B allocates only 50% for free. When faced with an identical demand shock, ETS A is unable to maintain its price floor, as although it sells no allowances at auction, the large number of freely allocated allowances are still traded, which sees prices fall below its auction reserve price of 10. In contrast, ETS B freely allocates only 50% of its allowances, which means that when it is hit with a demand shock it can maintain prices at the targeted auction reserve price.

*Figure 26.* Excessive free allocations limit the effectiveness of auction reserve prices




*Source:* *Vivid Economics*

To operationalise quantity based MSMs, minimum MRV standards may be required across linked ETSs. Quantity based MSMs are triggered by the number of banked allowances, if jurisdictions operate a joint-MSM, this means that coordinated reporting of allowance surpluses will be needed following linking. This means a minimum degree of transparency will be required for linking quantity based MSMs, as the number of banked allowances may not be directly observable and implementation may rely on common reporting standards and aligned reporting timeframes. Further, sharing information on MRV may also prove important for jurisdictions wishing to ensure progress towards NDC achievement as part of a linking arrangement.

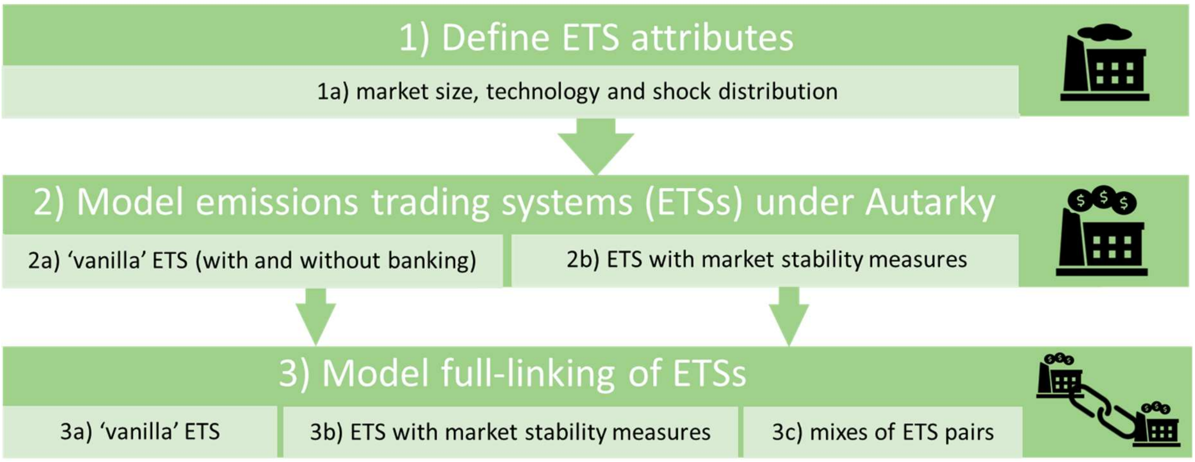
Finally, upon linking it may be wise to establish mutually agreed constraints regarding future policy developments and processes for delinking. In general, linking arrangements should include provisions for managing any policy changes that have an impact on the operation of the joint market. Governance and coordination of future design adjustments would almost certainly need to be agreed for some areas such as cap adjustments, and MSM type, design and stringency. Other policy areas such as overlapping policies and auction design may allow for greater degree of independence. Nonetheless jurisdictions should agree which policies areas require coordination, which do not, and the processes for management disputes and for potential delinking of ETSs in cases of disagreement. When considering delinking having specified rules such as notice periods and clear processes can enable a smoother and more predictable decoupling.

# 4 Methodology for quantitatively assessing interactions between ETS

The modelling approach below supports the assessment of interactions of ETSs with MSMs under linking. This model can represent simple interactions between carbon markets, operating across two periods under linking. Using this model, we assess the interactions between ETS archetypes, which have been developed in parallel to the modelling methodology. In turn, this modelling provides insights regarding how linking ETSs with different MSMs effects market functioning and impacts emissions and prices in carbon markets.

A two-period supply and demand model is utilized to assess the interaction of carbon markets.[56] This model can reflect specific policies, assess the impact of MSMs, assess the impact of linking, and account for intertemporal decision-making. The approach to modelling carbon markets is illustrated in Figure 27. First, we define the attributes of individual ETS, in terms of their relative size, cost of abatement (proxied by technology) and effect of economic shocks. We then model how these ETSs operate independently prior to linking with or without MSMs, and finally we assess the impact of linking combinations of ETSs with MSMs.

*Figure 27.* The modelling methodology follows three broad steps




*Source:* *Vivid Economics*

This section describes our stylised model of carbon market outcomes under linking. The model allows for a coherent quantitative economic analysis of ETS linking in an uncertain world.

— Section 4.1 describes the baseline model of the operation of an ETS;
— Section 4.2 summarises the model's approach to representing ETS MSMs;
— Section 4.3 presents the approach to modelling ETS linking; and
— Section 4.4 discusses how typologies can by mapped to model parameters.

[56] The development of a two-period model was necessitated by the quantity based market stability measure requiring two periods for full implementation: the measure is triggered in period one, and the intervention is implemented in period two.

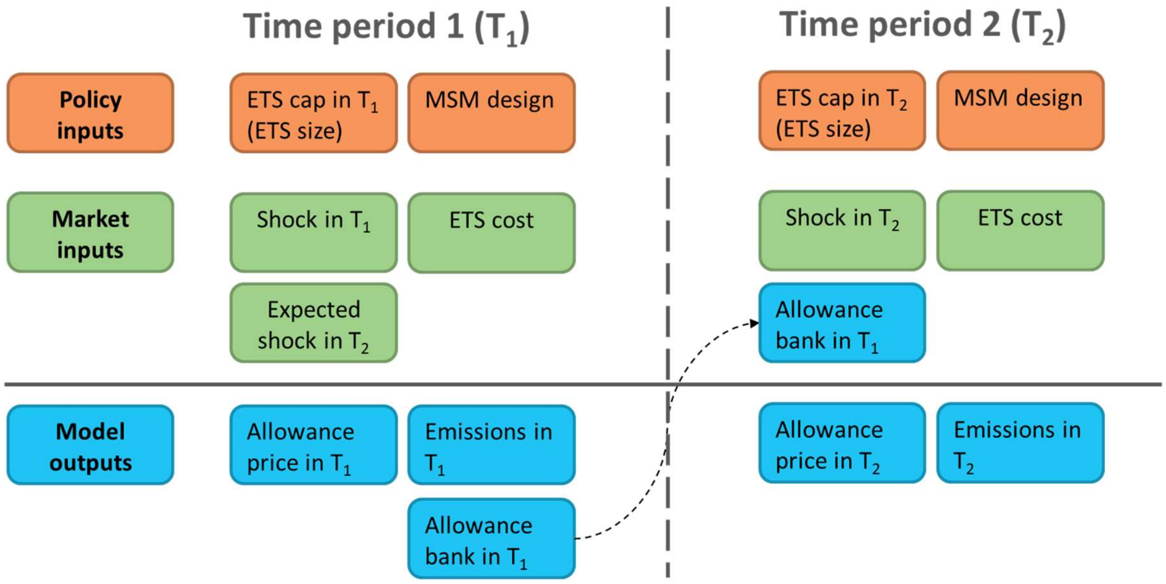
## 4.1 Baseline model of the operation of an ETS

The baseline model estimates an ETS's allowance prices and emissions based on three main drivers:

— ETS size and abatement costs given a specific emissions cap;
— the influence of uncertain shocks; and
— the level of banking across two time periods.

Figure 28 below, presents a schema for the model under autarky, including the possible utilisation of MSMs discussed further in section 4.2 below.

*Figure 28.* Overview of the model




*Source:* *Vivid Economics*

The basic model features an ETS with allowance prices that are determined by the ETS size and market abatement costs given a set emissions cap. The ETS cap constrains jurisdictions' emissions to within the joint cap over the two time periods. Emissions and allowance prices are influenced by the volume of covered emissions, its cap stringency, and the baseline cost of abatement in the jurisdiction combined with the technology stock.[57] Both ETSs size and technology are represented by model parameters that can be mapped onto real-world data. The model makes the standard assumption that emissions abatement is initially relatively cheap but becomes increasingly costly with more stringent policy. This baseline allows for systematic comparisons with more complex ETS designs.

A key feature of the model is that prices are influenced by the occurrence of uncertain shocks. In practice, there is significant uncertainty around the costs of emissions abatement for regulated entities. For example, uncertain events such as technology shocks, changes in prices of factors of production, or weather fluctuations

[57] This reflects the country's flexibility to abate at the margin, and hence their abatement cost.

can have a very large impact on abatement costs. This is modelled as a 'shock' to the marginal cost of abatement that is initially unknown when the policy is designed. The market price of an allowance then reflects the country's marginal cost of abatement, once uncertainty has been resolved.

The model is dynamic with two periods of 'time' and allows banking of allowances between periods. The country has a cap on its emissions for each of the two periods. A period of 'time' can be interpreted, for example, as an ETS compliance period. In each period, the cap is split between allowances that are auctioned to regulated entities and free allocation. The model allows for banking of allowances from period 1 to period 2 but does not allow for borrowing. The volume of allowances banked in period 1 must all be used in period 2. This facilitates cost efficiency over time as regulated entities set emissions in each period to minimise costs given pre-defined emissions cap and expected shocks. The model assumes that the allowance market is competitive and abstracts from transaction costs. The two-period setup is essential for any analysis that incorporates the transferability of allowances over time.

## 4.2 Approach to MSMs

The next step for the modelling is to represent MSMs within the model.

We model a quantity based mechanism as an adjustment to allowance supply in the second period, in response to the first period's banking volume. This supply adjustment alters the market clearing condition for allowances and impacts the allowance price in the second period. This measure is triggered when the volume of banked allowances in period 1 crosses a threshold (either an upper or lower threshold), as defined by the regulator. If there are 'too many' banked allowances, then the measure withdraws some allowances from auction. Conversely, the measure injects extra allowances if there are 'too few' banked allowances.

We can model several types of price based mechanism, building off a flexible price collar arrangement. Under this collar, when the allowance price breaches an (upper or lower) threshold, this triggers a response by injecting or withdrawing a volume of allowances into the market in the same period. This approach can be used to represent price floors (minimum price), price ceilings (maximum price), or a situation with no price floor or price ceiling by setting the floor at zero and ceiling at an arbitrarily high price. We can model a 'hard' price collar, for which the market price never moves outside the collar range, or a 'soft' price collar, where a limited number of allowances are injected or removed, such that when shocks are sufficiently large the allowance price may still move outside the collar range.

The model can be customised to reflect either absolute or variable price/quantity triggers, and injection or withdrawal volumes. For example, a quantity based measure's allowance withdrawal volume can be set either at a pre-defined volume or calibrated to be a function of the preceding year's auction volumes as per the EU ETS's market stability reserve. However, in Section 5, we focus on only absolute trigger levels.

However, as we are using a two-period model, we can only represent permanent supply responses. Two-period models have the benefit of allowing us to represent and model most variations in the design of MSMs, as their relative simplicity makes the modelling of complex interactions tractable. However, this simplicity comes at the cost of being able to represent more complex dynamic effects that may require multiple periods, such as a temporary supply response.

## 4.3 Approach to ETS linking

The model can model full-linking, one-way quantity-restricted linking and multijurisdictional linking.

We model full linking between two ETSs with different MSMs. Modelling the full linking of ETS archetypes provides useful information regarding the expected changes in allowance prices in each archetype following linking. It also allows for an assessment of how MSMs of different designs (e.g. quantity- or price-triggered, with varying reserve sizes, and varying trigger levels) operate under linking.

We model one-way, quantity restricted linking. Restricted linking implies linking with certain restrictions, such as one-way linking or thresholds on the (net) number of allowances that can be traded across systems.[58]

We model multi-jurisdictional linking through a stepwise process. In practice, more than two ETSs might be linked. If these ETSs do not have MSMs then this is relatively straightforward to model within our set-up. However, if more than two of the ETSs have a variant of a MSM, then there might be interaction effects not adequately captured by the current two-ETS setup of the model. To test this, we model multijurisdictional linking by first modelling a bilateral link between two jurisdictions and then introducing a third jurisdiction that links with the already linked bilateral system.

We propose simplifying assumptions for modelling linking with quantity based MSMs. These measures, such as the EU's market stability reserve, alter allowance supply based on the number of allowances in circulation in the market (in our model the number banked). As discussed in section 3, arbitrary differences in banking behaviour across jurisdictions could affect the operation of a quantity based MSM once ETSs are linked. In defining the quantity trigger for our model, we can think of both a 'domestic' bank where only domestic allowances banked are counted against the quantity trigger, and an 'aggregate' bank, where allowances banked across linked systems are counted. Under full linking, allowances from linked ETSs become perfect substitutes and firms are expected to be indifferent between banking allowances of different types. This means that for a given number of bank allowances in aggregate, it is not possible to predict the composition of domestic and foreign allowances. This is turn means that it is not possible to operationalise a domestic bank without potentially arbitrary assumptions regarding the allowances being banked. As such, we assume an aggregate bank operates when modelling the linking of ETSs with quantity based MSMs.

## 4.4 Mapping typologies to model parameters

The modelling approach can reflect all major aspects of the typologies developed in Section 2 and their interactions given linking. This section provides an overview of how the modelling maps onto the typologies across the three central elements: archetypes, policy choice sensitivities, and linking options.

The modelling outputs allow us to assess how archetypes interact and affect two key outcomes allowance prices and price volatility. We have focussed on allowance prices and volatility as these outcomes are the major point of interest. All other outcome variables such as banking levels, allowance flows across linking jurisdictions, emissions, and auction revenues change linearly in the model with changes in price.

[58] We do not consider exchange rate based restricted linking.

The sections below discuss elements of the model outlined above; further details on the model can be provided on request to the authors.

### 4.4.1 Archetypes

The modelling approach has customisable parameters that reflect differences across the three central archetype attributes.

- *Relative ETS size:* the model defines a parameter ($\omega_i$) that captures the volume of emissions in a system;
- *Relative ETS cost:* the model defines a term that reflects the stringency of the cap as the expected autarky allowance price ($\alpha_i$ - ($\frac{a_{it}+ f_{it}}{\gamma_i}$)); and
- *MSMs:* the model can represent a variety of MSMs, triggered by both quantity or price and with both bound and unbound responses.

### 4.4.2 Policy choice sensitivities

With additional calibration the model developed can provide five policy-choice sensitivity switches in the analysis. When modelling the impact of MSMs or the impact of linking across archetypes, we have the options to also vary each jurisdiction's:

- banking rules across compliance phases;[59]
- initial volatility of shocks;
- persistence of shocks through time;
- correlation of shocks with a potential linking partner jurisdiction; and
- potentially, the proportion of free allocation relative to auctioning.

However, for the modelling results presented in Section 5, we have held most policy choice sensitivities constant across scenarios for ease of presentation and to maximise comparability across scenarios. We hold all sensitivities, except banking rules, constant across modelled scenarios. Banking is not allowed in combinations 4 and 5 to facilitate calculation and presentational simplicity.

### 4.4.3 Modelling calibration

When modelling specific combinations of ETS, we make some common calibrations across the scenarios.

- Linking partners: large jurisdictions are always 4 times larger than their partners, and low-cost jurisdictions have autarky prices that are around ½ that of their partner's;
- MSMs: quantity based MSMs have thresholds that increase under linking in proportion to the expected increase in aggregate bank because under linking, quantity based MSMs are triggered based on the sum of the two linking jurisdictions' banks; price based MSMs have thresholds that remain the same under linking as in autarky; and
- Time and uncertainty: In all scenarios, ETS caps decline by 10 per cent over period 1 and period 2 and demand shocks are modelled as 1,000 simulations of a uniform distribution.

[59] No borrowing is permitted in the model. However, from the literature review in Task 1 of this project it is apparent that borrowing is seldomly permitted in practice.

# 5 Quantitative findings

This section presents results from our modelling of ETS archetypes to demonstrate the impacts of linking ETSs with MSMs. This focuses on the interaction of key features identified in archetypes (size, cost, stability measure design) and our analysis of how these impacts transmit across carbon markets. The results focus on the impact on allowance prices and price volatility as other outcomes such as resulting emissions, banking levels, and allowance imports are determined within the model.

The modelling results first present how the model represents an ETS and builds in complexity to present the results of modelling five specific linking combinations with different MSMs. The results are presented in three steps, increasing in complexity.
- Section 5.1 models the operation of an ETS without MSMs or with a quantity or price based MSM;
- Section 5.2 models linking two ETSs without MSMs, and models linking where an MSM operates in one of the linking jurisdictions; and
- Section 0 models five advanced linking combinations to provide insights on more complex interactions.

## 5.1 Simple case and operation of the MSMs

This section provides an overview of the modelling results for the basic functioning of an ETS. First, we discuss how prices are determined in a simple ETS (without an MSM) influenced by shocks over two periods. Subsequently, we discuss the mechanics of the quantity based MSM and the price based MSM, and detail how these stability measures influence market prices in response to shocks across two periods.

Our model presents the results of ETS allowance prices as a function of actualised market shocks. Figure 29 over page presents results for an ETS without an MSM and without linking across two periods of market operation. Allowance prices in period 1 are linearly correlated to the actualised shock in the jurisdiction. A negative shock implies lower than expected market activity, and thus lower allowance demand and prices. Conversely, a positive shock implies higher than expected market activity and thus higher allowance demand and prices. As such Figure 29 shows prices in period 2 increase on average as future prices are discounted by actors in the current period,[60] but have greater dispersion as they are dependent on the shock outcomes in period 1.

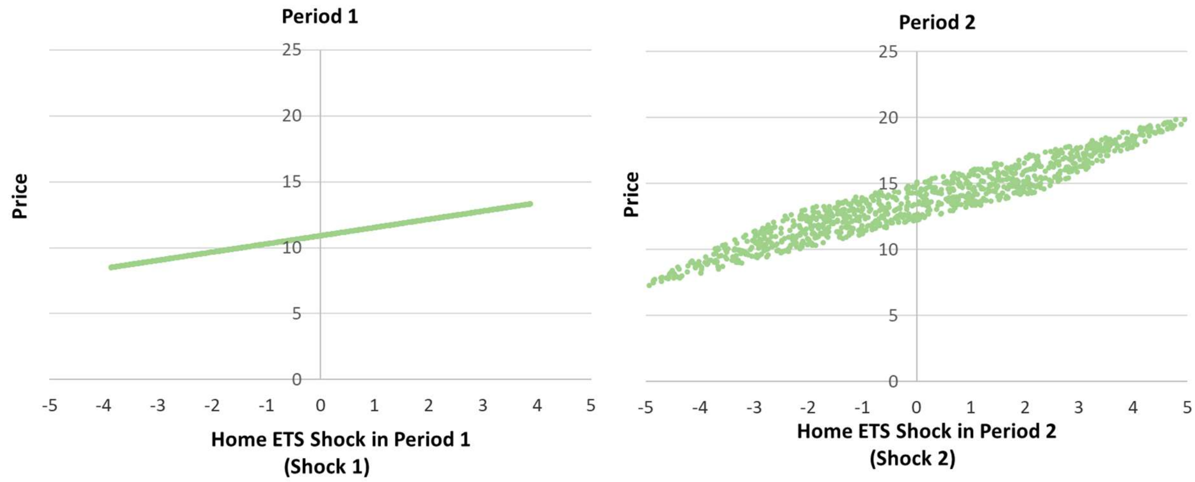
Quantity based MSMs inject or withdraw allowances in Period 2, based on banking levels in Period 1. A quantity based MSM requires two periods to be fully implemented, in Period 1, the actualised banking levels in the ETS trigger the injection or removal of allowances in Period 2. Low levels of banking trigger an injection of allowances in Period 2, which reduces allowance prices. High levels of banking trigger a withdrawal of allowances in Period 2, which increases allowance prices.

Figure 30 presents results for the operation of a quantity based MSM over two periods. It shows that given our calibration of the MSM, when the period 1 shock results in an excess of banked allowances, the removal of these allowances in period 2 pushes prices higher to reach a level above the average for the period.

[60] Across all modelled scenarios, we assume a 10% reduction in ETS caps over period 1 and period 2.

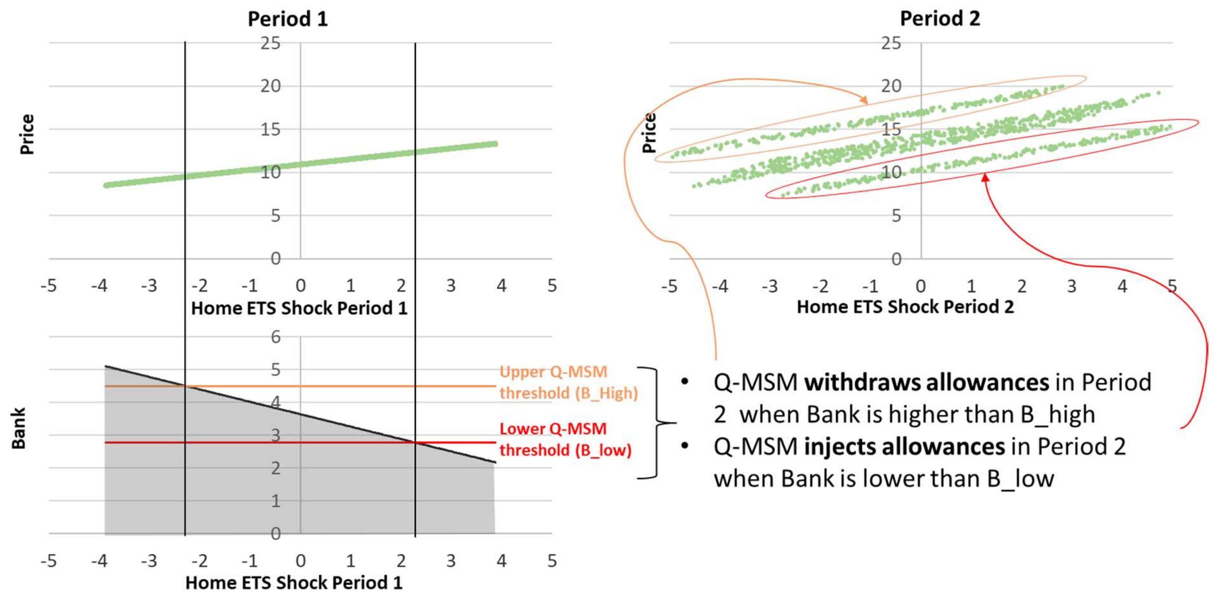
Conversely, when the period 1 shock results in an allowance shortage, the injection of allowances in period 2 results in prices that are below the average for the period.

*Figure 29.* Our model depicts allowance prices in an ETS against market shocks




*Source:* *Vivid Economics*

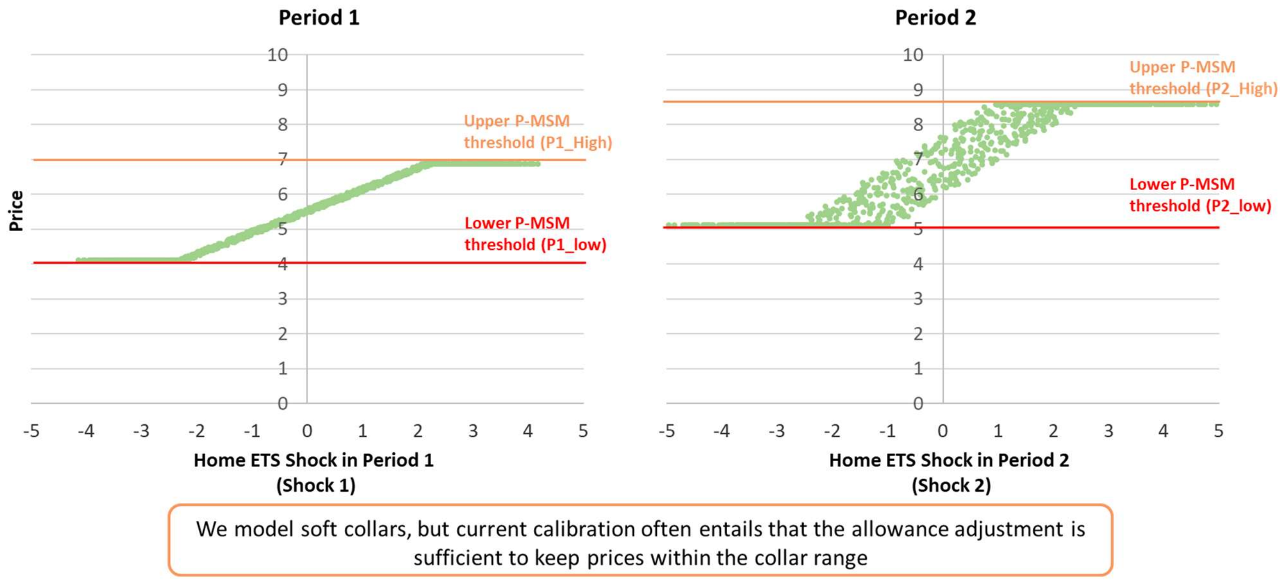
*Figure 30.* Our model depicts quantity based MSMs as being fully implemented over two periods




*Source:* *Vivid Economics*

Soft-collar price based MSMs influence prices in both periods by adjusting allowance supply when prices breach lower or upper thresholds. Figure 31 depicts the model's representation of a price based MSM with allowances injected or removed based on whether prices are initially above or below price triggers. The model depicts soft collars, where allowances equal to up to 5 per cent of the cap are injected or removed. This means that in cases of significant price changes due to linking or shocks, prices may not remain within the collar.[61] Given the relative size of shocks we model, we see that the collar binds across periods 1 and 2.

*Figure 31.* Our model depicts price based MSMs as soft price collars operating in a single period




*Source:* *Vivid Economics*

## 5.2 Results from basic linking combinations

This section discusses results from modelling basic linking combinations. We present the results for linking ETSs with the same size (cap) and costs (expected prices in autarky), then linking ETSs with varying size and costs, and then linking ETSs with varying size and costs and with one jurisdiction implementing a quantity based MSM. The modelling results show the impact of various linking and MSM combinations for a benchmarked 'Home' jurisdiction. Any impact on market outcomes reflects changes in home jurisdiction outcomes, such as allowance price and price volatility.[62] Modelling of the basic linking scenarios shows that in general, linking reduces price volatility.

Figure 32 presents the impact of three basic linking scenarios on prices in the Home jurisdiction:

— A) linking home with an identical ETS: decreases Home's price volatility, but has little impact on average price levels

— B) linking home with a smaller, lower cost ETS: reduces Home's average allowance prices, but has little effect on volatility on the larger Home jurisdiction

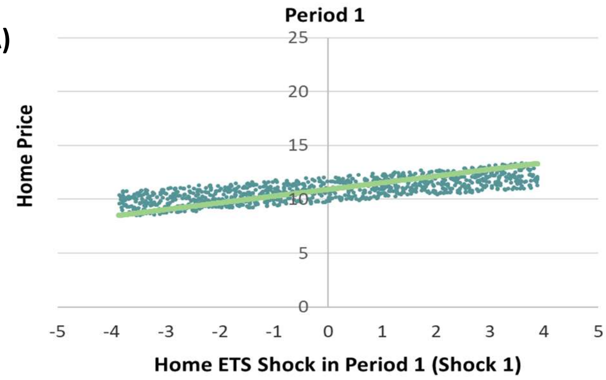
[61] The model is formulated so that when a price based MSM is triggered due to high prices, the upper bound becomes the price floor. Similarly, when a price based MSM is triggered in response to low prices, the lower bound becomes the price ceiling.

[62] Price volatility here is measured as the variance in the distribution of prices.

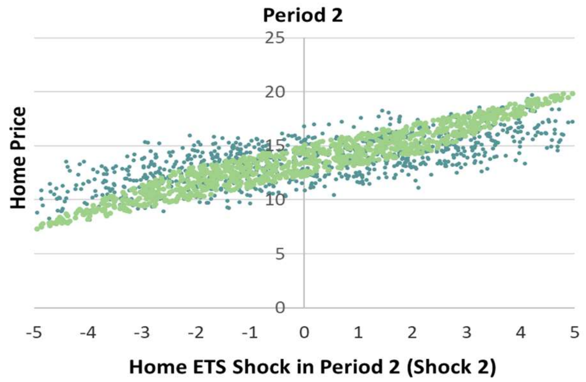
— C) linking home (with a quantity based MSM) to a smaller, lower cost ETS (with no MSM): reduces Home's average allowance prices and volatility. Only period 2 results for this combination are presented.

*Figure 32.* Results from basic linking scenarios

A)

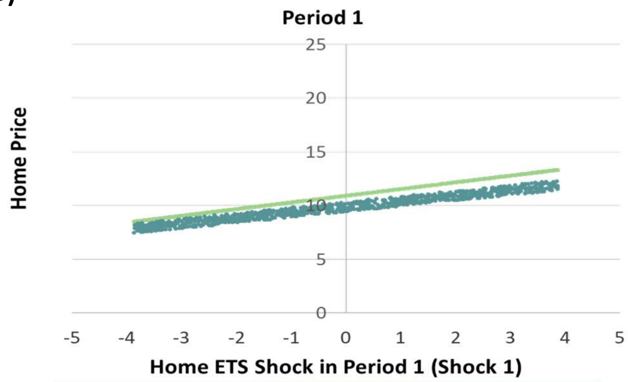



| | Autarky | Linking |
|---|---|---|
| Mean | 10.90 | 10.89 |
| Variance | 1.97 | 1.08 |

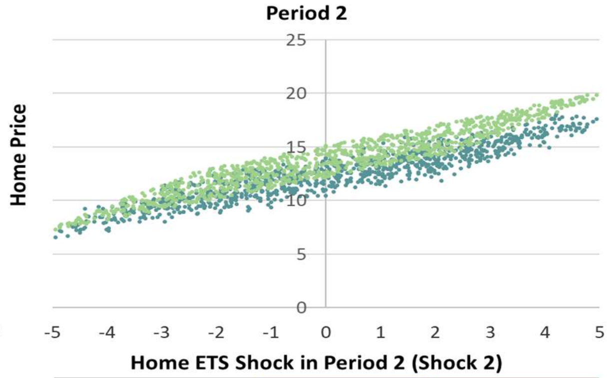



| | Autarky | Linking |
|---|---|---|
| Mean | 13.74 | 13.72 |
| Variance | 7.85 | 4.37 |

B)

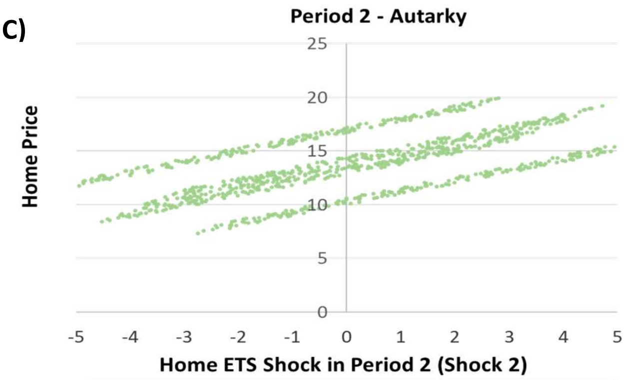



| | Autarky | Linking |
|---|---|---|
| Mean | 10.90 | 9.87 |
| Variance | 1.97 | 1.43 |

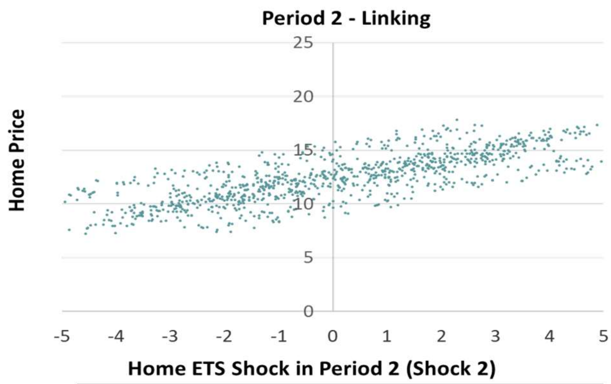



| | Autarky | Linking |
|---|---|---|
| Mean | 13.74 | 12.45 |
| Variance | 7.85 | 5.69 |

C)




| | Autarky |
|---|---|
| Mean | 13.78 |
| Variance | 7.58 |




| | Linking |
|---|---|
| Mean | 12.46 |
| Variance | 4.99 |

Autarky Linking

*Source:* *Vivid Economics*

**The results above align with expectations regarding the impacts of linking.** The results in Panel A demonstrate the benefits from linking ETSs with uncorrelated (or not perfectly correlated) economies, with economic shocks offsetting each other to reduce overall price volatility. Panel B and Panel C show that the impact of linking on volatility is reduced when linking with a smaller ETS partner. These also show the potential for cost reductions enabled by linking with lower cost jurisdictions.

## 5.3 Results from advanced linking combinations

**This section presents the results from five linking combinations, where the 'Home' jurisdiction links with ETS with different characteristics and MSM designs.** The five linking combinations modelled are:

- **Combination 1**: Home **full link** with a smaller, lower cost ETS with a price based MSM;
- **Combination 2**: Home **full link** with a larger, lower cost ETS with a price based MSM;
- **Combination 3**: Home **one-way, quantity limited link** with larger lower cost offset market;
- **Combination 4**: Home (price based MSM) **full link** with a larger, higher cost ETS with a price based MSM; and
- **Combination 5**: Home **multijurisdictional link** with two smaller ETSs with price based MSMs.

**Throughout the five combinations the Home jurisdiction's market size and cost is used as the benchmark**. In combinations 1,2,3 and 5 the Home jurisdiction has a quantity based MSM, while in combination 4, the Home jurisdiction has a price based MSM. The impact of linking on Home's average prices depends on the relative size and cost of the partner. Table 12 summarises the impacts that each linking combination has on the Home jurisdiction's average allowance prices and frequency of its MSM being triggered. Under full linking, allowance prices converge and thus tend towards the prices of their linking partner. The magnitude of the effect is determined by i) the relative size of the partner, and ii) the relative difference in autarky prices.

*Table 12.* Impacts of linking combinations on Home jurisdiction prices and propensity to trigger MSM

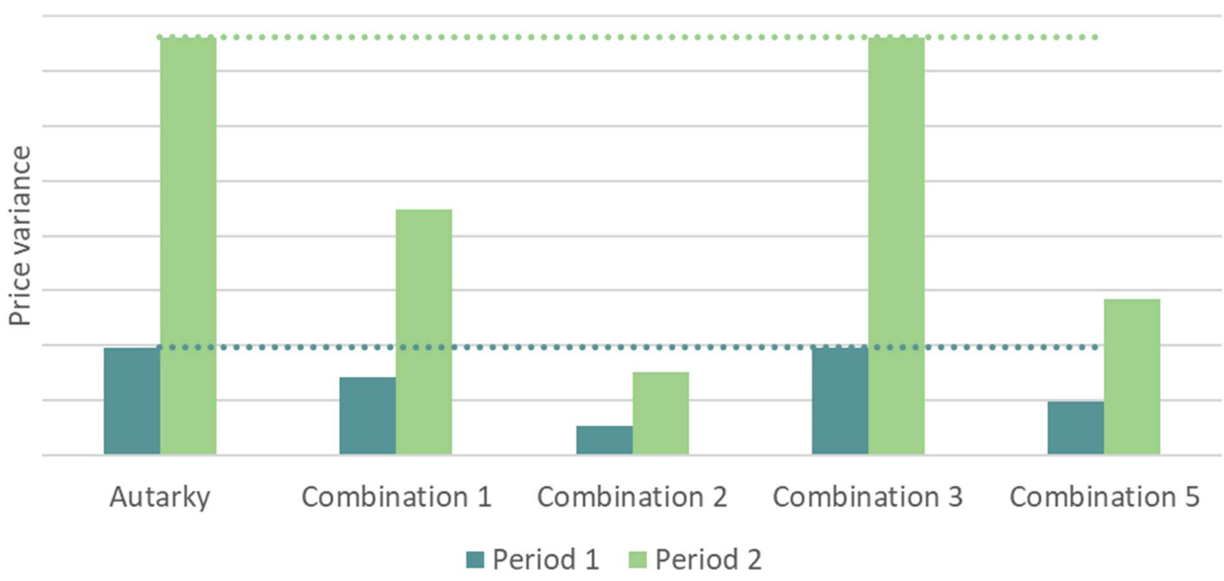
| Combination | Linking type and partner jurisdiction | Linking impact on Home's average prices | Linking impact on Home's frequency of MSM trigger |
|---|---|---|---|
| 1 | full linking with smaller, lower cost ETS with price based MSM. Home has a quantity based MSM. | ↓ | ↓ |
| 2 | full linking with larger, lower cost ETS with price based MSM. Home has a quantity based MSM. | ↓↓ | ↓↓ |
| 3* | quantity-restricted linking with larger, low-cost offset market. Home a has quantity based MSM. | ↓↓ | – |
| 4** | full linking with larger, higher cost ETS with a price based MSM. Home has a priced based MSM. | ↑ | ↓ |
| 5*** | Multijurisdictional link with two smaller, similar cost ETSs with price based MSMs. Home has a quantity based MSM. | ↓ | ↓ |

Note: **In combination 3, the Home jurisdiction may import up to 5 per cent of its cap from the larger, lower cost linking partner. **In combination 4, Home jurisdiction has a price based MSM and both jurisdictions do not allow banking. ***In combination 5, banking is allowed in the Home jurisdiction but not in smaller jurisdictions*

Source: *Vivid Economics*

**Linking appears to reduce price volatility, and the frequency at which the Home jurisdiction's MSM is triggered.** Once ETSs are linked, economic shocks may balance each other out across jurisdictions which reduces overall price volatility and the frequency at which Home's MSM is triggered. Figure 33 compares Home's price volatility (measured as price variance) after linking with partner jurisdictions across combinations, compared to the level of volatility under autarky.[63] In unrestricted linking cases, the Home jurisdiction's price volatility decreases under linking. This is particularly the case for linking with a larger, lower cost jurisdiction in combination 2 where Home's price volatility reduces substantially. An exception is combination 3, where Home has a quantity limited link to a large, low-cost offset type market where we assume offsets are available at a constant price.[64] This means that the Home jurisdiction's volatility remains unchanged after linking, and therefore the frequency at which Home's MSM is triggered is unchanged.

*Figure 33.* Linking generally reduces price volatility in the Home jurisdiction




Note: *Dashed grey and green line reflect the autarky variance levels in period 1 and period 2. Combination four is not included for consistency, as it models a price based MSM rather than a quantity based MSM.*

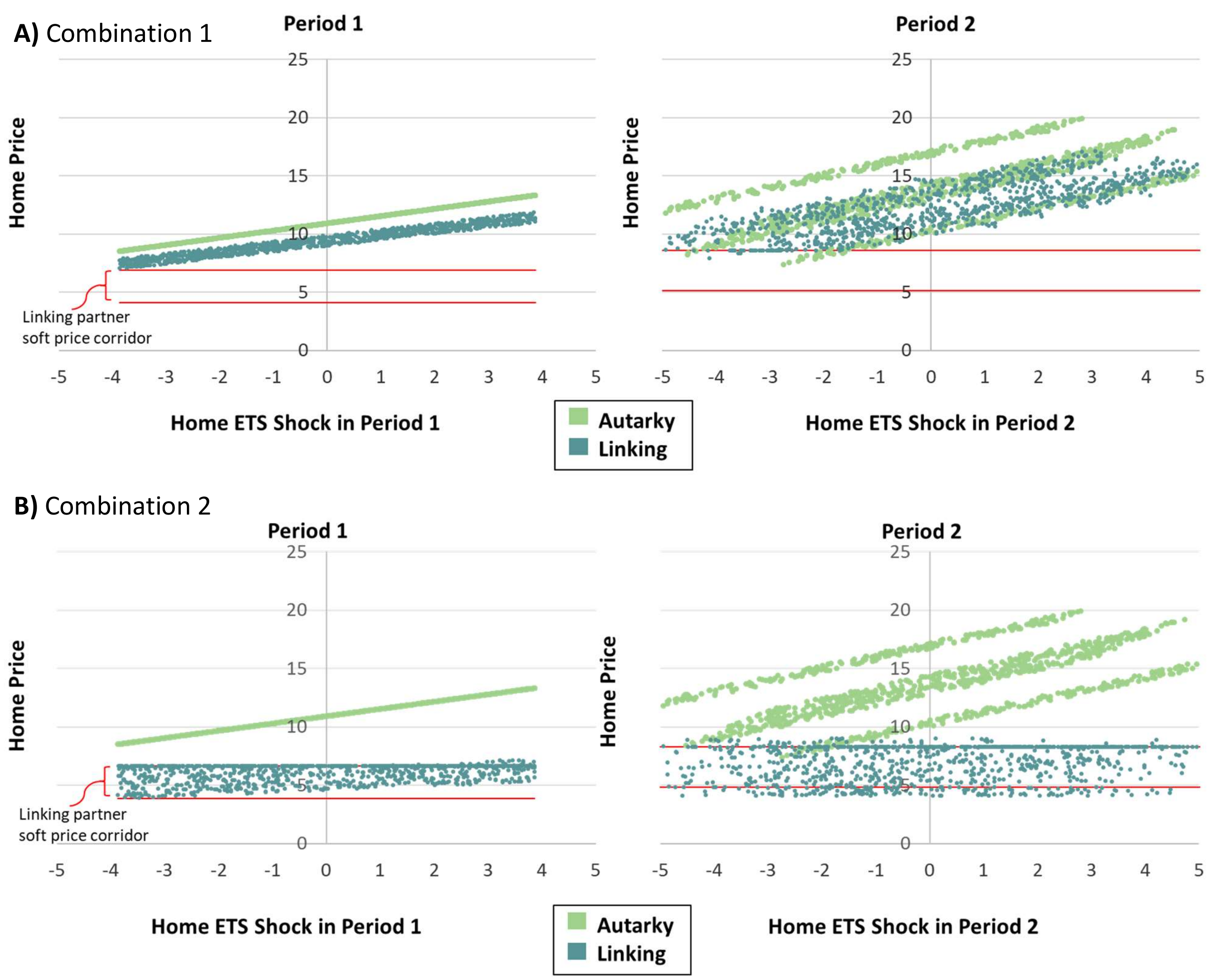
Source: *Vivid Economics*

**The results for combinations 1 and 2 show the importance of market size in determining outcomes under linking.** Figure 34 depicts the impact on the Home jurisdiction's allowance prices from linking to an ETS with a price based MSM that is a) smaller and lower cost, and b) larger and lower cost. In both scenarios, the linking partner's soft price corridor is shown for reference. In combination 1 (panel a), Home is four times larger than its linking partner, and in combination 2 (panel b), Home is four times smaller than its partner.

[63] Combination four is not included as the Home jurisdiction in the autarky comparison reflects a home jurisdiction with a quantity based MSM, whereas combination four describes the linking of two price based MSM jurisdictions.

[64] In combination 3, the large offset market is modelled as having no underlying volatility. When a market is sufficiently large, as in this scenario, it is minimally impacted by shocks with a uniform distribution that does not change with market size. As such, offsets are essentially available at constant prices as the influence of shocks on the offset market yield infinitesimal changes to the offset price.

*Figure 34.* Linking can reduce volatility, but reduces the effectiveness of independent MSMs




*Note:* *Red lines in both panels show the linked partner's price based MSM soft price corridor.*

*Source:* *Vivid Economics*

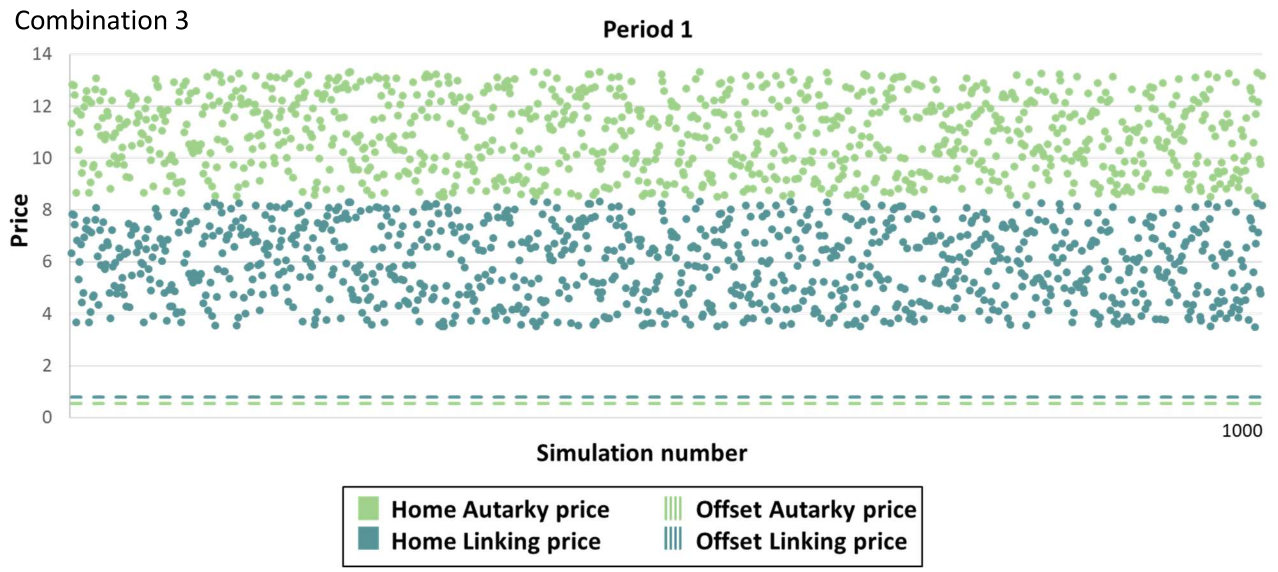
The results show that the MSM of the largest ETS dominates the market outcomes under linking. In both combinations, Home's average allowance price falls, as its linked partner has lower costs. However, when the linked partner is much larger, Home's average allowance price falls significantly.

— In Combination 1, the smaller jurisdiction's price based MSM is ineffective at constraining prices in the linked system to the price corridor in both periods. Prices under linking are closely correlated with the shock in Home jurisdiction in both periods, showing that the larger ETSs price dominates. In period 2, the influence of Home jurisdiction's quantity based MSM outweigh the impact of the price based MSM.

— In Combination 2, the larger jurisdiction's price based MSM generally keeps linked prices within its price corridor in Period 1 and Period 2. However, the distribution of prices in Period 2 relative to the Home jurisdiction's shock, shows that linked prices are being determined predominantly by the shock and price based MSM occurring in the larger linked partner jurisdiction.

**Combination 3 reveals that restricted linking with a low-cost offset type market could bring significant cost-saving potential as shown in Figure 35.** This shows 1,000 simulations of Home jurisdiction allowance prices following a one-way, quantity-restricted link with a large, low-cost market. It illustrates the cost savings that linking with a large offset market could offer. Prices do not converge under this linking scenario, due to the quantity-restricted linking arrangement; Home may only import up to 5 per cent of its cap from its linking partner. Given the significant price differences between the markets, the Home jurisdiction imports the maximum number of allowances permitted under the restricted linking in each run of the simulation. Notably, the offset market itself is so large that its average price only increases marginally from restricted linking. Further, as the offset market is so large and consequently has no underlying volatility, linking to it leaves Home jurisdiction's price volatility, and the implications of its quantity based MSM unchanged. This also shows the potential risks of linking to such a market for maintaining price incentives within the Home ETS. Offset markets effectively act as a source of supply to the Home ETS, which means they act only to reduce prices, which could have negative effects in the event of shocks such as an economic downturn. Offsets markets often have large numbers of allowances in circulation, this could also make linking with an ETS with a quantity based MSM problematic, by introducing a large surplus to the market.

*Figure 35.* Linking with a low-cost offset market with quantitative restrictions does not reduce volatility




*Source:* *Vivid Economics*

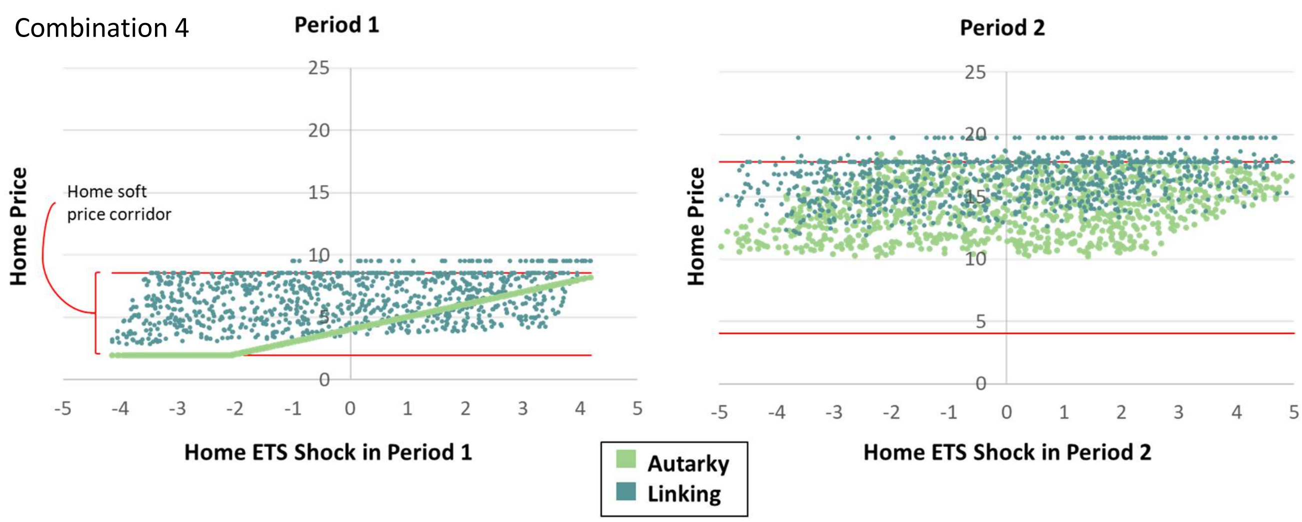
**Combination 4 show that when linking two ETSs with price based MSMs, the shocks in the larger market dominate, and the smaller market's price based MSM becomes less effective.** In this combination the Home jurisdiction is four times smaller, has lower initial costs (expected autarky prices), and a price based MSM with a narrower soft price collar that is within the price collar of its linking partner. The major outcomes when linking with a low-cost offset market are therefore:

— Under autarky, Home's price collar functions effectively; supporting prices in the event of negative shocks in Period 1 and holding prices below the ceiling level in Period 2 in 96.5 per cent of cases.

— When linking, Home's prices shift upwards and their distribution reflect that shocks in their linking partner become the greater determining force for prices, in both periods.

Home's price based MSM keeps linked prices within its corridor under autarky, but prices frequently rise above Home's price ceiling after linking. Home's price ceiling gets breached often but prices never rise above the larger, linked partner's price ceiling. After linking prices are no longer highly correlated with Home's shocks, as shocks in the linking partner propagate to the Home jurisdiction and dominate allowance prices. This shows the reduced effectiveness of a smaller market's MSM after linking. However, linking still benefits the Home jurisdiction by reducing price volatility. Under linking, Home's price volatility reduces by 14 per cent in Period 1 and 33 per cent in Period 2.

*Figure 36.* The larger market dominates when linking two ETSs with price based MSMs




*Notes:* *To simplify modelling banking is not permitted in either jurisdiction for this combination.*

*Source:* *Vivid Economics*

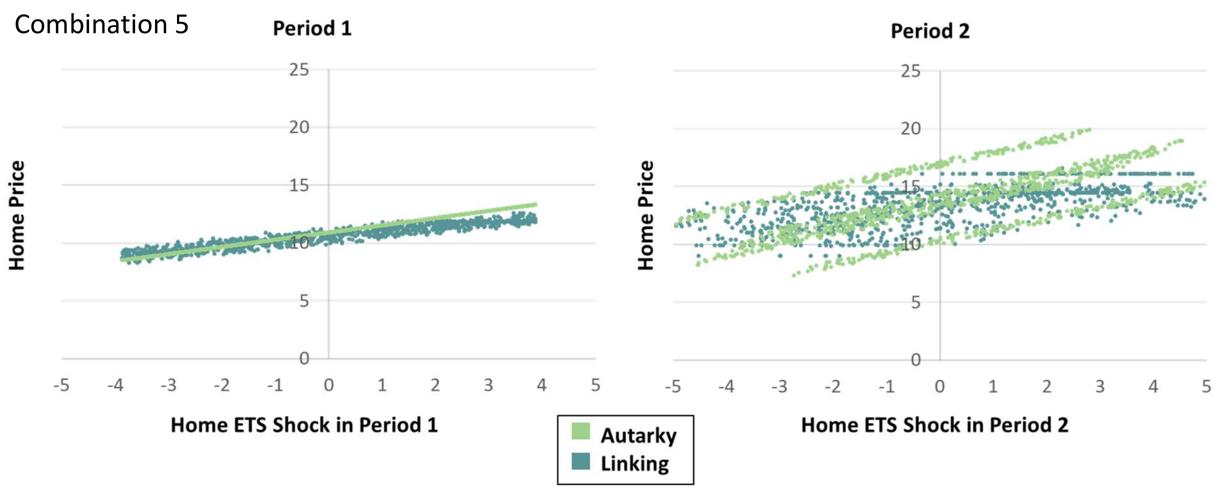
Combination 5 is modelled in a two-step process and assumes the two smaller jurisdictions do not allow banking. First, we assume that the two smaller jurisdictions form a link (Figure 37) and then the Home jurisdiction links to the bilaterally linked system (Figure 38). The linking of the two smaller jurisdictions leads to price convergence between the two systems and a stepped-price collar at either extreme of the revealed shock. The modelling of this combination is limited to the condition that neither of the two smaller jurisdictions allow banking, to simplify calculations.

When Home links with this bilaterally linked system, the variance of prices in the Home jurisdiction falls. Linking leads to Home prices being pulled up in the event of negative shocks and drawn down in the event of positive shocks in period 1. In period 2, the distribution of potential linking prices is significantly tighter for the Home jurisdiction relative to autarky. This tighter distribution of prices is clearly shown in Figure 38. This occurs because the price based MSMs respond to the *actual* shocks in period 2 and therefore reduce variance of prices at the extreme ends of the distribution. This sees prices kept within an even tighter band then would have occurred with the quantity based MSM alone in autarky.

*Figure 37.* Small jurisdictions can have a larger joint impact under multijurisdictional linking


Source: *Vivid Economics*

*Figure 38.* Multilateral linking reduces price volatility at the expense of less direct control over prices




Source: *Vivid Economics*

This result shows, that at least in this model, MSMs in smaller markets may become more effective at managing prices under multijurisdictional linking when combined with a quantity based MSM. However this is only the case because these price based MSMs provide countervailing injections or removals of allowances in period 2, when the quantity based MSM 'overreacts' following a shock in period 1.

This is an example of MSMs having contradictory effects. For instance, when a large positive economic shock in period 1 result in the number of allowances in circulation dropping below the trigger level, this leads to the injection of allowances in period 2. However, if in period 2 there is a large negative shock, then this injection of allowances may be too large, which will drive prices down. If prices fall to a low enough level, then the floor price may trigger in one or more of the price based MSMs. In turn these price based MSMs will begin to remove allowances to counteract the impacts of the allowances being injected by the quantity based MSM. In this example the quantity based MSM is injecting allowances while the price based MSM is removing allowances, but the contrary case could also occur, with the quantity based MSM removing allowances while the price based MSM injects them. This also reflects underlying differences in design, as in this case in the second period the price MSM is reacting to a demand shock that the quantity MSM cannot yet react to, as it reacts in the subsequent period.

By having contradictory effects these MSMs reduce price volatility, but at the cost of potentially large distributional effects. When MSMs operate in a contradictory manner this acts as a wealth transfer from one jurisdiction to the other, with the jurisdiction injecting (selling) allowances profiting at the expense of the jurisdiction removing them (withholding from sale).

# 6 Conclusion

This report outlines key lessons regarding the effects of linking ETSs with MSMs, with considerations spanning a range of policy areas. It shows that to avoid perverse outcomes MSMs should be coordinated or aligned upon linking. Ideally upon linking, jurisdictions would develop a new MSM for the linked system that is tailored to the specific context (e.g. ETS size, cost structure, economic volatility) of the linked ETSs and policy preferences of the participating jurisdictions. However, coordination of existing MSMs may be a more feasible option if political or other constraints on changing ETS-design exist in jurisdictions.

Jurisdictions considering linking have only three options, to retain their MSM unchanged, abandon their MSM or coordinate their MSM with their linking partners. The choice to retain, abandon or coordinate MSMs should be driven by the expected interactions of MSMs post-linking. Specifically, whether the interaction of existing MSMs is expected to undermine the efficient functioning of markets, and the distributional consequences caused by MSMs.

The way in which MSMs interact following linking are determined by parameters across three categories:

1. ETS size, cost and volatility;
2. MSM design compatibility;
3. Other policy, market and governance aspects.

1) Differences in ETS size, cost and volatility

The attributes of ETSs regarding size, cost and price volatility are the drivers that determine the way ETSs interact and subsequently influence the operation of MSMs. Some general lessons can be drawn when linking ETS with different attributes.

A smaller ETS is likely to need to abandon or coordinate its MSM when linking with a larger partner. When two ETSs of significantly different sizes link, the MSM of the larger jurisdiction is likely to dominate. This is likely to render the smaller jurisdiction's mechanism ineffective regardless of whether it is a quantity based MSM or a price based MSM. As such, it is in the smaller jurisdiction's interest to ensure that its MSM is either harmonised or coordinated with the larger jurisdiction's MSM.

An ETS with a quantity based MSM will be more effective if it takes account of the level of allowances banked across linked ETS. If two ETSs link and allowances become perfect substitutes, then it is the joint allowance supply that is most important for determining prices. In this situation a joint allowance surplus can be comprised of many different combinations of home and domestic allowances. This means that calibrating allowance injections and removals to a joint allowance surplus can allow supply adjustments to be more accurately calibrated to supply conditions in the joint market. However, there may be political challenges to redefining a quantity based MSM trigger and resulting changes to auction and reporting rules.

Linking with a lower cost ETS holds significant cost-saving potential but may have fiscal implications that require consideration prior to linking. Linking with a lower cost ETS will reduce allowance prices and revenues, with this impact higher for larger differentials in autarky price and for larger sizes partner jurisdictions. While linking in this case makes achieving abatement targets cheaper, this can also result in significant financial outflows that may be politically challenging and require careful management.

Restricted linking can ensure that jurisdictions retain a degree control over their allowance prices upon linking. For instance, restricted linking could be used to ensure that linking to a much lower cost jurisdiction results in cost savings without having too large an impact on domestic mitigation outcomes or generation of auction revenues.

In most cases linking can be expected to reduce price volatility. If two jurisdictions experience a similar probability and severity of shocks, linking always reduces allowance price volatility. This result occurs regardless of the MSMs implemented in each jurisdiction or the relative differences in ETS cost. This price volatility dampening effect is augmented when linking with a larger partner.

If a partner faces a significantly different distribution of shocks this could result in price volatility increasing under linking. However, this may be unlikely, as emissions intensive industries are likely to be similar across linked ETSs and face similar fundamental demand drivers.

2) MSM design compatibility

There are several ways in which MSMs may be incompatible, which may mean that coordination of MSMs between linked ETSs is necessary.

If ETSs have MSMs with incompatible trigger levels these must be harmonised to ensure that linking does not result in perverse outcomes. If the lower trigger of one MSM is above the upper trigger of the other MSM, these will act in a contradictory manner, with one injecting allowances as the other withdraws them. This undermines the effectiveness of the link and can have potentially large distributional implications.

If an MSM is triggered at a level that is below (above) a hard price floor (ceiling) in the linked-ETS then this MSM will be redundant. If this trigger level is below (above) a soft price floor (ceiling) then it may still come into effect if the other jurisdiction's reserve is exhausted.

Maintaining an unbound (hard) MSM is likely to require agreement from linking partners. Unbound MSMs can have significant impacts on emissions and revenues. Unbound mechanisms can compromise mitigation ambition across ETSs (for a hard ceiling) or may result in significant foregone revenue (for a hard floor).

Bound (soft) price based MSMs can be combined to create "stepped" price support and containment levels, with potential implications for revenue sharing in the linked system. This approach can make supply more responsive to demand changes but must be managed carefully to avoid inequitable revenue impacts.

3) Other policy, market and governance aspects

Other policy, market and governance aspects can interact with the operation of MSMs in a manner that requires consideration before linking.

Policy decisions that can impact the operation of an MSM under linking can include:

— overlapping policies, which can impact demand for allowances. By shifting demand these policies can increase or reduce the likelihood of an MSM being triggered.
— free allocation rules, which can affect the operation of MSMs. More generous allocations could reduce the potential effectiveness of soft price controls implemented through auction reserve prices
— reporting standards and timeframes, which may need to be aligned. To operate a quantity based MSM linked jurisdictions may need to coordinate reporting as otherwise allowance surplus levels are not directly observable.

Linking has implications for other economic attributes across the linked system. For instance, linking can render banking and borrowing restrictions ineffective as allowances become fungible between jurisdictions and can increase the correlation of economic activity between linking jurisdictions and generally reduces the concentration of a linked carbon market.

ETSs with MSMs interact in highly complex ways under linking. This implies that detailed analysis and close collaboration is required to ensure that these interactions do not undermine the overall functioning of these systems.

# Annex 1: Jurisdiction fact sheets

*Figure 39.* Fact sheet: EU

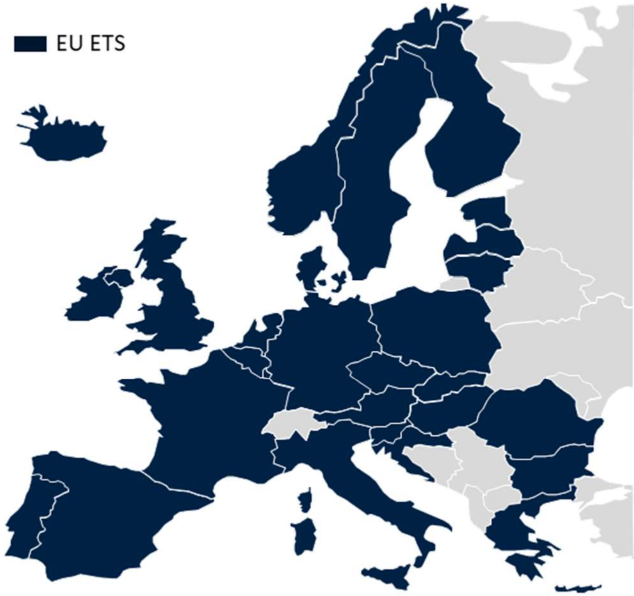
**Economy** GDP (2017): US$ 21.1 trillion Population (2017): 512 million

GHG emissions (2016): 4.3 $GtCO_2e$ (excl. LULUCF)

**ETS** Emissions cap (2019): 1.85 $GtCO_2e$

Recent carbon price: € 23.5/$tCO_2e$ (7 Feb 2019)

| | | | |
|---|---|---|---|
| Sectors | Power, industry, intra-EU aviation | Offset use | Restricted use of CERs |
| GHGs | $CO_2$, $N_2O$, PFCs | Banking/ borrowing | Unlimited banking since 2008, no borrowing |




**Market stability measure(s)**

| MSM | Intent | Trigger | Criteria | Bounds | Supply adjust |
|---|---|---|---|---|---|
| Market Stability Reserve (MSR) | Support price, contain price, and, market stability | Quantity | Rule-based | Bound | Permanent from 2023 onwards |

***Description:***

*The MSR adjusts auction volumes in response to allowance surplus thresholds:*

- *Surplus > 833 million, then auction volume reduced by 12% (24% for 2019-23)*
- *Surplus < 400 million, then auction volume increased by 100 million*

*From 2023 onwards, MSR allowances in excess of the previous year's auction volume are permanently invalidated*

*Source:* *Vivid Economics*

*Figure 40.* Fact sheet: California-Quebec

## Economy

GDP (2017): US$ 3.0 trillion  Population (2017): 48 Million

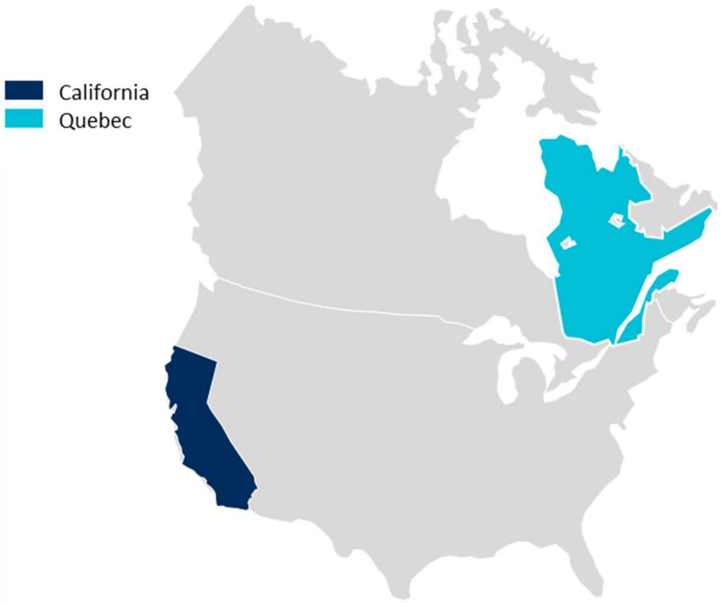
GHG emissions (2016): 506.7 $MtCO_2e$ (excl. LULUCF)

## ETS

Emissions cap (2019): 403 $MtCO_2e$

Recent carbon price: US$ 15.76 (6 February 2019)

| | | | |
|---|---|---|---|
| Sectors | Power, industry, transport | Offset use | Local offsets up to 8% of compliance and qualitative limitations |
| GHGs | $CO_2$, $CH_4$, and $N_2O$ | Banking/ borrowing | Banking limited by a general holding limit, no borrowing |




## Market stability measure(s)

| MSM | Intent | Trigger | Criteria | Bounds | Supply adjust |
|---|---|---|---|---|---|
| Auction Reserve price | Support price | Price | Rule-based | Unbound | Temporary |
| APCR | Contain prices | Price | Rule-based | Bound | Temporary |

***Description:***

- *The auction reserve price acts as a hard price floor in auctions and a soft price floor for the secondary carbon market*
- *The allowance price containment reserve (APCR) is a soft price ceiling offering three equal-sized tiers of fixed price allowances when allowance auction prices equal or exceed 60% of the lowest price tier*

*Source:* *Vivid Economics*

*Figure 41.* Fact sheet: RGGI states

## Economy

GDP (2017): US$ 3.1 trillion | Population (2011): 41 million

GHG emissions (2012): 446 MtCO2e (excl. LULUCF)

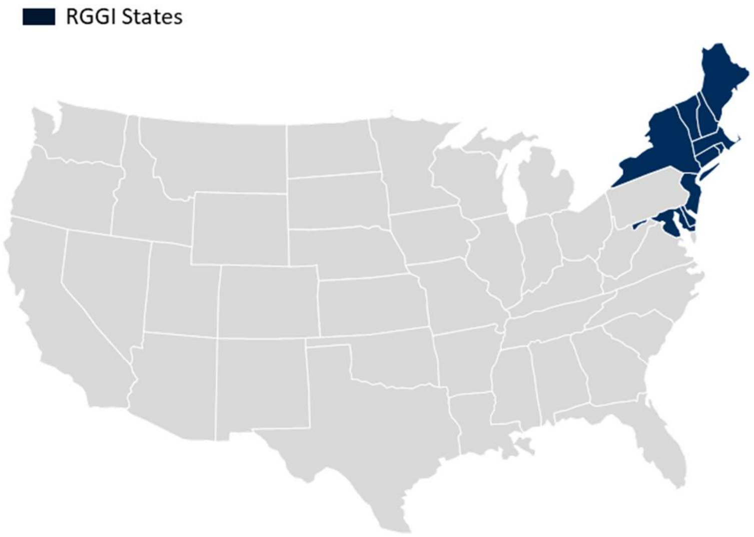
## ETS

Emissions cap (2018): 82 m short tons of $CO_2$

Recent carbon price: US$ 5.5 per allowance (28 December 2018)

| | |
|---|---|
| Sectors | Power |
| GHGs | $CO_2$ |

| | |
|---|---|
| Offset use | Local offsets from RGGI states up to 3.3% of compliance |
| Banking/ borrowing | Unlimited banking, no borrowing |




## Market stability measure(s)

| MSM | Intent | Trigger | Criteria | Bounds | Supply adjust |
|---|---|---|---|---|---|
| Auction Reserve price | Support price | Price | Rule based | Unbound | Permanent |
| CCR | Contain price | Price | Rule based | Bound | Permanent |
| ECR | Support price | Price | Rule based | Bound | Permanent |

***Description:***

— *The auction reserve price acts as a hard price floor in auctions and a soft price floor for the secondary carbon market*

— *The cost containment reserve (CCR) is a single price tier soft ceiling that provides limited additional allowances in auctions if the settlement price breaches an annual price threshold*

— *From 2021, the emissions containment reserve (ECR) withdraws a pre-defined allowance volume from auctions, if prices fall below the predetermined price threshold level*

*Source:* *Vivid Economics*

*Figure 42.* Fact sheet: South Korea

## Economy

GDP (2017): US$ 1.9 trillion Population (2017): 51 million

GHG emissions (2014): 628 $MtCO_2e$ (excl. LULUCF)

## ETS

Emissions cap (2018): 540 MtCO2e

Recent carbon price: 19.3 US$/$tCO_2e$ (9 Aug 2018)

| | |
|---|---|
| Sectors | Power, industry, buildings, transport, waste |
| GHGs | $CO_2$, $CH_4$, $N_2O$, PFCs, HFCs, $SF_6$ (Also covers indirect emissions from electricity consumption) |

| | |
|---|---|
| Offset use | Local offsets up to 10% of compliance, international offsets from local companies up to 5% |
| Banking/ borrowing | Unlimited banking and restricted borrowing between ETS phases |


## Market stability measure(s)

| MSM | Intent | Trigger | Criteria | Bounds | Supply adjust |
|---|---|---|---|---|---|
| Powers of intervention | Market stability | Price and quantity | Discretionary | Bound | Temporary |

***Description:***

— *the K-ETS authority can use an allowance reserve to inject/withdraw allowances in the case of supply or demand imbalances or rapid price spikes*

— *The K-ETS authority may also impose minimum or maximum allowance holding limits, amend borrowing or offset limits or impose temporary price floors or ceilings*

*Source:* *Vivid Economics*

*Figure 43.* Fact sheet: New Zealand

**Economy**

GDP (2017): US$ 197 billion    Population (2017): 5 million

GHG emissions (2016): 78.7 $MtCO_2e$ (excl. LULUCF)

**ETS**

Emissions cap : N/A – no cap or auctioning

Recent carbon price: 25.05 NZ$/$tCO_2e$ ; 17 US$/$tCO_2e$ (28 Jan 2019)

| | | | |
|---|---|---|---|
| Sectors | Stationary energy, industrial processes, transport, waste, forestry | Offset use | Local forestry and other removals generate allowances |
| GHGs | $CO_2$, $CH_4$, $N_2O$, $SF_6$, HFCs and PFCs | Banking/ borrowing | Unlimited banking and no borrowing |


**Market stability measure(s)**

| MSM | Intent | Trigger | Criteria | Bounds | Supply adjust |
|---|---|---|---|---|---|
| 1-for-2 discount *(discontinued)* | Contain price | Price | Rule-based | Unbound | Temporary |
| Fixed price ceiling | Contain price | Price | Rule-based | Unbound | N/A – no cap |

***Description:***

— *The price ceiling, at NZ$25/NZU, reflects the price at which participants can purchase an unlimited number of allowances for immediate surrender.*

— *The price ceiling will be removed when auctioning begins, or no later than 2022, and substituted for a cost containment reserve*

— *NZ has abolished the 1-for-2 price discount which reduced the liabilities of emitters*

*Source:* *Vivid Economics*

*Figure 44.* Fact sheet: China regional pilots

## Economy

GDP (2017): US$ 23.3 trillion

Population (2017): 1.4 billion

GHG emissions (2012): 10.9 $GtCO_2e$ (excl. LULUCF)

## ETS

Emissions cap (2016/17): 1.3 GtCO2e (sum of regional pilots)

Recent carbon price: 3.4 US$/$tCO_2e$ (November 2018 average of regional pilots)

| | | | |
|---|---|---|---|
| Sectors | Largely power, industry, and transport. Sometimes buildings and aviation | Offset use | All regional ETS allow for offsets to be used for compliance, with slight variants in quantitative and qualitative limits |
| GHGs | Most pilots: only $CO_2$<br>Chongqing : $CO_2$, $CH_4$, $N_2O$, HFCs, PFCs, $SF_6$ | Banking/ borrowing | All regional pilots include banking measures, with some limitation in Hubei and Shanghai<br>No borrowing in any pilot |


## Market stability measure(s)

| MSM | Intent | Trigger | Criteria | Bounds | Supply adjust |
|---|---|---|---|---|---|
| Auction reserve prices | Price support | Price | Rule-based | Unbound | |
| Allowance reserves | Market stability | Price & quantity | Rule-based or Discretionary | Mix | Temporary |
| Exchange volatility control | | | | | |

***Description:***

- *The Chinese regional ETS trialled several different market stability measures*
- *Beijing, Hubei, Shanghai, Guangdong and Shenzhen have largely price based market stability measures*
- *Fujian, Chongqing and Tianjin have market stability measures that can be triggered by both price and quantity thresholds.*

*Source:* *Vivid Economics*

*Figure 45.* Fact sheet: Tokyo-Saitama

## Economy

GDP (2014): US$ 1.1 trillion | Population (2015): 17 Million

GHG emissions (2015): 103 $MtCO_2e$ (excl. LULUCF)

## ETS

Emissions cap (2019): 13-15% below base year emissions

Recent carbon price: 6 US$/$tCO_2e$ (1 April 2018)

| | |
|---|---|
| Sectors | Buildings |
| GHGs | $CO_2$ |

| | |
|---|---|
| Offset use | Small, mid-size facility credits, renewable energy credits - unlimited; outside Tokyo/Saitama credits ≤ 33.3% of compliance; forest absorption credits unlimited (Saitama) |
| Banking/ borrowing | Unlimited banking, no borrowing |


## Market stability measure(s)

| MSM | Intent | Trigger | Criteria | Bounds | Supply adjust |
|---|---|---|---|---|---|
| Credit supply increases | Contain price and market stability | Price | Discretionary | Unbound | Permanent |

***Description:***

— *Tokyo and Saitama have discretionary authority to increase the supply of compliance credits in the event of high allowance prices*

*Source:* *Vivid Economics*

*Figure 46.* Fact sheet: Australia

**Economy**

GDP (2017): US$ 1.2 trillion Population (2017): 25 million

GHG emissions (2016): 549 $MtCO_2e$ (excl. LULUCF)

**ETS**

Emissions cap (2012): 382 MtCO2e

Recent carbon price: 23 AUD/$tCO_2e$ (2012)

| | | | |
|---|---|---|---|
| Sectors | Power, industry, waste, and fugitive emissions. | Offset use | Local AFOLU credits up to 5% of compliance; top-up fee on international offsets up to 50% of compliance |
| GHGs | $CO_2$, $CH_4$, $N_2O$, HFCs, PFCs, $SF_6$ | Banking/ borrowing | Unlimited banking, limited borrowing |


**Market stability measure(s)**

| MSM | Intent | Trigger | Criteria | Bounds | Supply adjust |
|---|---|---|---|---|---|
| Top-up charge price floor | Price support | Price | Rule-based | Unbound | Temporary |
| Price ceiling | Contain price | Price | Rule-based | Unbound | Permanent |

***Description:***

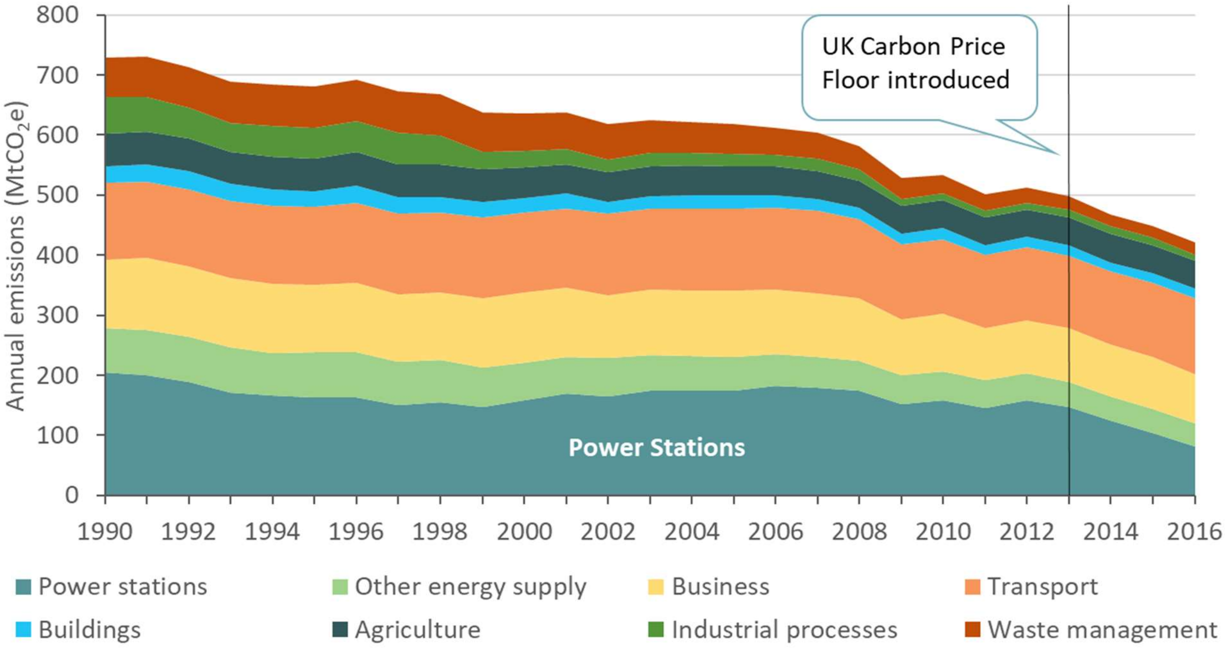
- *The CPM introduced fixed prices over 2012-15 and planned to implement a flexible price ETS with a price ceiling from 2015-18.*
- *During the (intended) operation of the flexible price period, Australia planned a price floor and a top-up carbon fee for international offsets but later moved away from this design*

*Source: Vivid Economics*

# Annex 2: UK, carbon price floor in power generation

**In 2013, the UK introduced a domestic carbon floor price using a top-up charge to drive low-carbon investment and maintain security of supply in the electricity sector.** As discussed in Section 2.1, the EU ETS experienced declining allowance prices from 2008, which motivated the introduction of a domestic carbon price support (CPS) in the power sector to strengthen the signal for investors to support lower carbon generation sources. The power sector has historically been the UK's single largest emitting sector, with emissions averaging one-quarter of total UK emissions over 1990-12. Figure 47 illustrates the trajectory of UK GHG emissions by sector over 1990-2016 and reveals rapid reductions in generation emissions after 2012.

*Figure 47.* Emissions from power generators have been declining sharply since 2012




*Source:* *Vivid Economics based on BEIS (2018b)*

## Implementation process

**The CPS was designed to top up EU ETS prices and improve incentives for decarbonisation of power.**[65] The UK Treasury develops the CPS rates three years before each budget, and it retains all revenues. CPS rates are calculated based on the difference between the targeted UK carbon price and the prevailing market price. Simultaneously, the UK developed an indirect cost compensation support mechanism to reduce the potential competitiveness impacts of the CPS on certain energy-intensive industries (Hirst, 2018).

[65] This was against the backdrop of the UK's commitment to channel £200 billion investment to low-carbon energy by 2020 and a concern over the stability and low level of EU ETS prices (HMRC, 2010). The UK electricity sector was seen as a strong mitigation option given that the economics of switching from coal to gas was relatively straightforward (Newbery et al., 2018).

**The CPS was designed to rise each year until 2020; however, in 2014 the government capped the CPS rate at £18/t$CO_2$ for 2016-20.** Table 13 presents the CPS rates that were initially planned and those that have been implemented since 2013. This CPS rate freeze was explained as a response to EU ETS prices remaining low, causing increasingly divergent carbon costs for UK producers relative to EU producers and hence competitiveness concerns for EITE industries, and introducing a relatively high cost burden for households (Hirst, 2018).

*Table 13.* CPS rates rose steeply from 2013-16, but have recently been frozen at £18/t$CO_2$

| CPS rate (£/t$CO_2$) | 2013-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 |
|---|---|---|---|---|---|---|
| Planned | 4.94 | 9.55 | 18.08 | 21.20 | 24.62 | not planned |
| Implemented | 4.94 | 9.55 | 18.08 | 18.00 | 18.00 | 18.00 |

*Source: Vivid Economics*

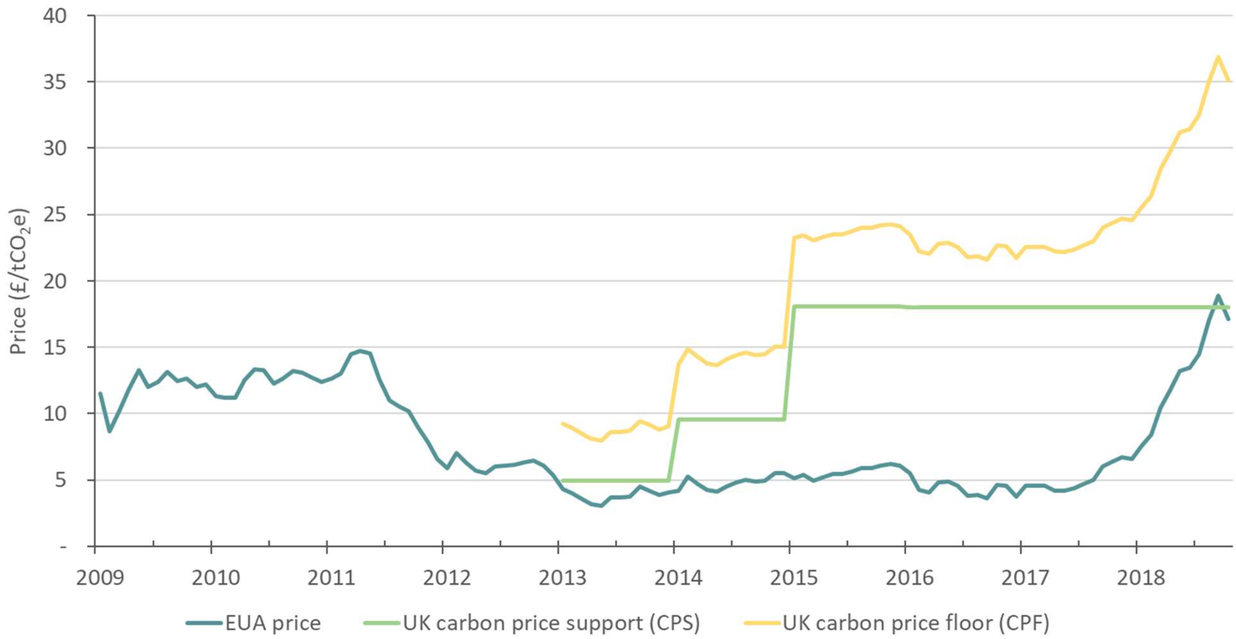
### Functioning

**The CPS supports the EU ETS allowance price in the UK electricity sector by charging fossil fuel electricity generators a top-up fee.** UK electricity generators pay two separate charges: the EU ETS allowance price and a predefined CPS rate that was calculated with the intent of getting the overall carbon price to the level of a targeted floor price.

**The CPS rate is fixed annually and charged in addition to the EU allowance price, which means UK electricity generators still face fluctuating total carbon costs due to fluctuations in EU allowance prices.** Figure 48 shows the evolution of effective UK carbon costs for electricity generators based on CPS rates and the underlying prices of EU ETS allowances from 2009 to October 2018. As can be seen, price fluctuations in the EU ETS are mirrored in the total carbon cost for UK generators.

**The UK government initially planned for the carbon price floor to reach £30/t$CO_2$ in 2020 (Hirst, 2018), but rising EU allowance prices meant that this level was already breached by 2018, as shown in Figure 48.** EU allowance prices rose from below £5/t$CO_2$e in 2017 to reach almost £20/t$CO_2$e in just over a year and a half. This led to an increase in UK carbon costs for generators from around £23/t$CO_2$e to close to £37/t$CO_2$e in this period. This points to a limitation of predefined top-up charges, which lack flexibility in responding to rapid price changes.

*Figure 48.* The CPS supported carbon prices in the UK power sector while EU allowance prices were low over 2013-15




*Source: Vivid Economics based on Hirst (2018) and Quandl (2018)*

## Actual use and practical experience

**The CPS was one of several policies that together succeeded in incentivising investment in low-carbon electricity generation.** Figure 47 above illustrates the acceleration in power sector emissions reductions following the implementation of the CPS in 2013. The impact of the CPS occurred concurrently with other policies such as the EU-wide emissions standards implemented by the 2010 Industrial Emissions Directive (IED) that also likely played a large role in reducing coal-fired electricity generation (BEIS, 2016). The UK used around 33 million tonnes of oil equivalent (mtoe) of coal for electricity generation in 2012, which declined to around 7 mtoe in 2016 (Hirst, 2018). As an indication of this progress, the UK achieved its highest number of hours of electricity generated without coal-fired generation in 2018 (REA, 2018).

**Freezing the CPS rate limited government revenues and dampened the low-carbon investment signal.** Over 2016-17 CPS tax receipts totalled £1 billion, with all receipts to general revenue. However, HM Treasury estimated that the post-2015 CPS price cap would reduce government revenue by £870 million by 2018 (Hirst, 2018). The Committee on Climate Change (CCC) (2014) argues that the CPS freeze may have marginal impacts on dampening the low-carbon investment signal. While CPS rates were never directly legislated, the frequent changes to the CPS provided an inconsistent signal to investors.

**The overall impact of the CPS freeze on EU-wide emissions is unclear.** Ex ante analysis of the UK carbon price floor suggested that the additional abatement induced in the UK power sector could lower the equilibrium price of EU ETS allowances, reduce the efficiency of the EU ETS, and reduce auction revenues to EU ETS member states (Fankhauser, et al., 2011; Sartor & Berghmans, 2011). However, the introduction of the EU MSR could mean that the greater emissions reductions in the UK lead to a greater allowance surplus and the potential invalidation of more surplus allowances after 2023 (Newbery et al., 2018).

*Box 14.* Key takeaways from the UK's power sector carbon price floor

**The UK introduced a carbon price floor for its power sector in 2013 which acts as a top-up charge on the EU ETS allowance price.**

- The price based mechanism works by charging a fixed carbon price support (CPS) fee for power generators' emissions, in addition to the cost they incur in complying with the EU ETS.
- The CPS fee is predetermined and fixed annually, which means that power generators still face fluctuating carbon prices under the EU ETS.
- The UK initially planned for the mechanism to result in the power sector facing total carbon costs (CPS plus allowance price) of £30/t$CO_2$; however, recent increases in allowance prices mean that this level was reached in 2018.

**The UK carbon price floor aimed to increase low-carbon investment in the power sector.**

- The UK's power sector is a significant component of the nation's total emissions.
- The introduction of the carbon price floor aimed to improve the investment environment for low-carbon power generation to meet UK investment commitments.
- The CPS fee was initially designed to increase annually; however, it was frozen from 2016 with the government citing competitiveness concerns for the UK power sector.

**The UK carbon price floor has helped drive emissions reductions in the UK power sector, although its impact on EU-wide emissions is less clear.**

- Increased investment in low-carbon electricity generation from 2013 can be seen in the significant reduction in emissions and increase in fuel-switching in the UK power sector.
- However, the impact of the carbon price floor on EU-wide emissions is less clear.

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# Company profile

Vivid Economics is a leading strategic economics consultancy with global reach. We strive to create lasting value for our clients, both in government and the private sector, and for society at large.

We are a premier consultant in the policy-commerce interface and resource- and environment-intensive sectors, where we advise on the most critical and complex policy and commercial questions facing clients around the world. The success we bring to our clients reflects a strong partnership culture, solid foundation of skills and analytical assets, and close cooperation with a large network of contacts across key organisations.

# Contact us

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