WHITE PAPER

THE MONASH/C2ZERO REAL CARBON PRICE INDEX

realcarbonindex.org

BEI CUI, UMMUL RUTHBAH, ROGER COHEN, JAN AHRENS, and NGA PHAM

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EXECUTIVE SUMMARY

Regulators and governments around the world have been using carbon pricing to discourage greenhouse gas emissions since the early 1990s. However, carbon prices – and the mechanisms for implementing them – vary widely between jurisdictions, making it difficult to measure and analyse carbon pricing on a global level.

To try to fill the information void, researchers at the Monash Centre for Financial Studies, in partnership with carbon market specialists C2Zero and SparkChange, have constructed the world's first global carbon price index. Based on mandated carbon prices set by regulators and governments, the Real Carbon Price Index (RCPI) provides a weighted composite measure of the physical price of carbon across all jurisdictions, and tracks its evolution over time. The index provides a valuable new technical resource to help governments, academics, investors and others measure how well – or otherwise – nations are progressing collectively in the battle to halt the warming of the planet. As declared by Dr Roger Cohen, founder and CEO of Sydney-based start-up C2Zero at the project launch: "Our ambition is to make the Real Carbon Price Index the global benchmark for carbon pricing. This will shine a spotlight on global decarbonisation efforts, showing whether real action is being taken, and who is taking it."

The Real Carbon Price Index sits at the top of a hierarchy of carbon price indices constructed by the Monash/C2Zero team, with each sub-index tracking a specific dimension or aspect of carbon pricing. The sub-indices provide important nuance and detail reflecting the complexity and diversity of the many carbon pricing systems that have evolved globally since the first scheme was launched in Finland in the early 1990s. The indices are divided into five main groups:

1. **The Real Carbon Price Index** This provides the most comprehensive weighted measure of global carbon prices, accounting for all carbon prices and all emissions from all jurisdictions. It includes both emissions subject to carbon prices and emissions with no price – the latter being counted in the index using a price of zero. This index enables an overall global carbon price and price history to be determined, reflecting the global value of carbon, dating back to 2013.

2. **The Aggregate Real Carbon Price Index** A subset of the Real Carbon Price Index (above), this index and its sub-indices exclude emissions from regions that do not set a carbon price. These indices can be grouped in various ways including by region, by instrument type or by pollutant or polluting activity. An example of this is the Aggregate Real Carbon Tax Rate, which covers all jurisdictions for which a carbon tax is levied.
   Both the Real Carbon Price Index and the Aggregate Real Carbon Price Index represent the (current or historical) global price of carbon. This means that as carbon markets change structurally – such as when a new jurisdiction introduces an emissions trading scheme or a carbon tax – there will be a discontinuous (or step) change in the carbon price in the relevant index.

3. **The Rebalancing Real Carbon Price indices** These indices cover the same 'universe' as the Aggregate Real Carbon Price indices. The main difference is that periodically, these indices are rebalanced to reflect constituent changes (additions/deletions) and changes in the scope or coverage of their constituents. These indices do not reflect a pure 'price' of carbon over time; rather, they reflect the change in the value of a (real or hypothetical)

For more information, please contact:
Monash Centre for Financial Studies | Monash Business School
Email: mcfsinfo@monash.edu – Tel: +613 9903 8310
This white paper is available on our website.

basket of instruments that underlie the relevant index. The rebalancing methodology for these indices is analogous to the rebalancing that takes place in traditional equity and other market indices.

4. **The Investable Real Carbon Price indices** are a subset of the rebalancing group (above), with the index universe limited to emissions for which a tradeable instrument exists. These indices are further filtered for liquidity and price discovery, and rebalanced periodically as the investable market evolves. These indices should be physically replicable by holding the underlying basket and by following the prescribed rebalances as they occur.

5. **Specialist indices and analytics** Indices and measures not included in the first four groupings fall into this category. Examples include dispersion measures for the Real Carbon Price Index; measures to rank price and scope of emissions globally; measures and metrics to rank countries and regions; different weighting schemes, index subsets covering other forms of emissions (for example farming or aviation) and specific pollutants (such as methane or nitrous oxide).

This document has been prepared as a guide for investors, academics and others to the first iteration of the Real Carbon Price Index. The document includes a detailed description of the nature of each index and the methodology behind it. As the project evolves, more indices and detail will be added to the project website. For further details and the most up-to-date information, go to https://www.realcarbonindex.org

THE INDEX TEAM

Monash University	**C2Zero**	**SparkChange**	**Support team**
Dr Bei Cui	Dr Roger Cohen	Jan Ahrens	Professor Deep Kapur (Monash)
Dr Ummul Ruthbah			Chris Cruzado (C2Zero)
Dr Nga Pham			Thomas Lingafelter (C2Zero)

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1. CONVENTIONS

When referring to pollution, greenhouse gases and greenhouse gas emissions, the terms carbon dioxide (CO_2), carbon dioxide emissions, carbon dioxide equivalents (CO_2e) and at times just carbon are used interchangeably. Technically, the correct terms are carbon dioxide equivalents and CO_2e.

2. OVERVIEW

Carbon pricing started in the early 1990s, when Finland become the first jurisdiction in the world to formally adopt a scheme mandating a price on carbon pollution. Although many countries and regions have followed Finland's lead, jurisdictions with mandated carbon prices today remain in a minority, and only about 21 per cent of global greenhouse gas emissions are covered by a carbon price – either through emissions trading or a carbon tax.

Setting a price on carbon has a single overriding aim: to create a financial imperative for organisations to consider the cost of emitting carbon (or polluting) in their operations and activities. As such, carbon pricing aims to provide an incentive for organisations to cut emissions. While all carbon pricing schemes require polluters to pay to pollute, emissions trading schemes have the additional attribute of financially rewarding some organisations for abating pollution.

From its starting point just over three decades ago, carbon pricing has evolved slowly and disparately into today's somewhat fragmented array of schemes globally, with many different mechanisms and inconsistent levels of pricing, compliance and enforcement. Carbon prices vary enormously, from as high as US$139.66 per tonne in Sweden[1] down to as little as US$0.078 in Poland and to zero in the many jurisdictions that do not set a price on carbon. The scope of emissions covered within individual systems is as fragmented as the pricing, with no uniformity about which forms of pollution and polluting are covered.

Encouragingly, amid increasing global pressure to reduce emissions, a degree of convergence in the design and pricing of schemes is becoming apparent. The ultimate endpoint would be a uniform global carbon price, which would mean the cost of polluting becomes independent of location or activity, and the reward for abatement would be consistent and universal. However, complexities around measurement, compliance and enforcement, as well as political and other factors, may mean this may never be fully realised.

Due to the highly disparate nature of existing carbon pricing schemes, measuring and analysing them in aggregate has been difficult. To try to overcome the inherent challenges, researchers at the Monash Centre for Financial Studies – in collaboration with carbon focused businesses C2Zero and SparkChange – have developed the world's first global carbon price index. Based on mandated carbon prices set by regulators and governments around the world, the Real Carbon Price Index (RCPI) provides a notional composite global price of carbon which, like other financial indices, can be tracked over time (Exhibit 1). In combination with its various sub-indices and related source material for interpretation and analysis, the Real Carbon Price Index delivers a powerful new tool to researchers, investors and others seeking to draw meaningful conclusions about the disparate, but growing collection of carbon pricing schemes globally.

The Real Carbon Price Index sits at the top of a hierarchy of indices devised by the RCPI team, covering the price of carbon across the entire globe and all emissions for which data is available. Jurisdictions and emissions for which there is no carbon price are included in the index, with a price of zero applied to their carbon emissions. Other index groups in the hierarchy include the Aggregate and Rebalancing indices, which include only jurisdictions that set a carbon price. Under each parent index are sub-indices, using the same methodology but for a specific subset (such as a region or a type of pricing scheme). The Investable indices – a subset of the Rebalancing indices – are filtered for liquidity and other parameters to ensure they are physically replicable. Specialist categories include thematics, various measures and metrics, specific forms of pollution, price dispersion and more.

Over time, the RCPI family will be developed further and broadened in response to feedback and changes in carbon pricing schemes globally.

3. CARBON PRICING MECHANISMS

The main pricing mechanisms used globally are:

- Carbon taxes
- Market-based emissions trading schemes (ETS), sometimes referred to as cap-and-trade (CaT) schemes

Additionally, there are numerous voluntary mechanisms that apply a price on carbon. Predominantly packaged in the form of carbon credits – where realised or unrealised carbon abatement[2] is priced and traded – these schemes allow for voluntary offsetting of pollution. Offsetting schemes are fragmented and often unregulated, with wildly differing prices (Carney, 2021; TSVCM, 2021). These are not included in any of the Monash/C2Zero Real Carbon Price indices. There are also instances of specialised offsets and allowances used across specific industries and sectors (for example large-scale generation certificates [LGCs] issued by the Australian Government for certain renewable energy generation projects[3]). These too are not included in the Real Carbon Price indices.

After Finland introduced the first carbon tax regime in the 1990s, other European countries – including Poland, Norway, Sweden, Slovenia and Denmark – quickly followed with similar schemes. But since 2000, as more jurisdictions worldwide have introduced carbon taxes, disparities between tax rates have grown. Currently, 35 jurisdictions impose carbon taxes. Sweden, Liechtenstein and Switzerland have had the highest carbon tax rates during the past five years, with prices ranging from seven to ten times the global average.

[1] As at October 2021

[2] Carbon credits and offsets come in many forms which are linked to carbon abatement to varying degrees (and not always without controversy). These are not discussed in this paper.

[3] http://www.cleanenergyregulator.gov.au/RET/Scheme-participants-and-industry/Power-stations/Large-scale-generation-certificates

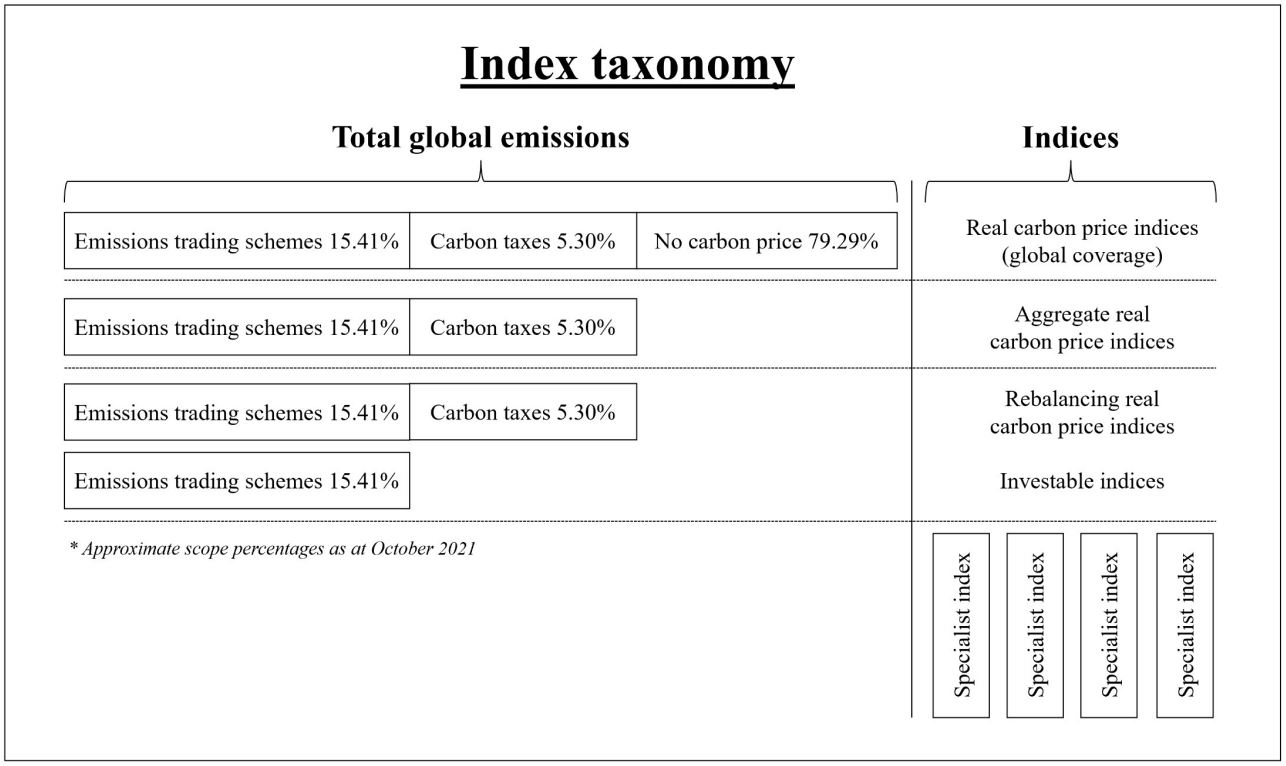

Exhibit 1: Index Taxonomy.

Fuel excise taxes, though applied to carbon-emitting activities, are not included in the scope of the Monash/C2Zero indices as they are typically levied to cover road usage or other purposes, rather than being motivated by climate objectives.

The main alternative to a carbon tax is a cap-and-trade emissions trading system. Emissions trading schemes now operate in 29 subnational jurisdictions around the world, according to the World Bank Carbon Pricing Dashboard, and cover 16.1 per cent of global GHG emissions. Currently, ETS prices range from US$1.10 per tonne of CO_2e to around US$67 per tonne. The difference between a carbon tax and an ETS is that the former sets a fixed price on pollution, whereas the latter controls the absolute level of emissions permitted and allows the market to set the carbon price.

4. EVOLUTION OF THE GLOBAL REAL CARBON PRICE

4.1. Carbon taxes through the decades

In January 1990, when Finland introduced the world's first carbon tax, its tax rate was initially set at just US$1.75 (€1.12) per tonne of CO_2 emitted, and the scheme accounted for just 0.1 per cent of global emissions (Khastar, Aslani, & Nejati, 2020; Sumner, Bird, & Dobos, 2011; World Bank, 2021a). Since 1990, however, Finland's carbon price has significantly increased – by 2021 it was about US$72 (€62) per tonne (World Bank, 2021a).

Currently, 20 European countries have carbon taxes ranging from US$0.078 per tonne in Poland to US$139.66 per tonne in Sweden. A further eight countries outside Europe have also introduced carbon taxes: Canada, Mexico, Colombia, Argentina and Chile from the Americas, Japan and Singapore from Asia, and South Africa. This makes a total of 27 national jurisdictions that are covered by some form of carbon tax. In total, these programs accounted for approximately 2.93 Gt of CO_2 emissions in 2021, representing 5.4 per cent of global GHG emissions. This coverage is set to increase, with national carbon tax incentives under consideration for Senegal and Côte d'Ivoire (World Bank, 2021a). In addition, there are eight subnational carbon tax programs covering five regions in Canada and three in Mexico, accounting for 0.06 Gt of CO_2 emissions, or 0.1 per cent of the global total. Other subnational programs are under consideration in the Canadian province of Manitoba, the Mexican state of Jalisco, the Catalonia region of Spain and Hawaii (World Bank, 2021a).

Japan's national carbon tax program, introduced in 2012, is among the most comprehensive in the world – covering all fossil fuels for all sectors – and accounts for a greater share of global emissions coverage than any other national or subnational tax initiative. Covering 1.01 Gt of CO_2 emissions, it represents 1.82 per cent of global GHG emissions (Hofbauer Pérez & Rhode, 2020; World Bank, 2021a). This is due in part to Japan being the world's 7th largest emitter of GHG, with 90 per cent coming from energy-related activities (Timperley, 2018).

4.2. Emission trading schemes through the decades

Under emissions trading schemes (ETS) – sometimes referred to as a cap-and-trade schemes – governments (or regulators) typically allocate or auction emission allowances to polluters, with a 'cap' or upper limit on the quantity of emissions allowed within the system.

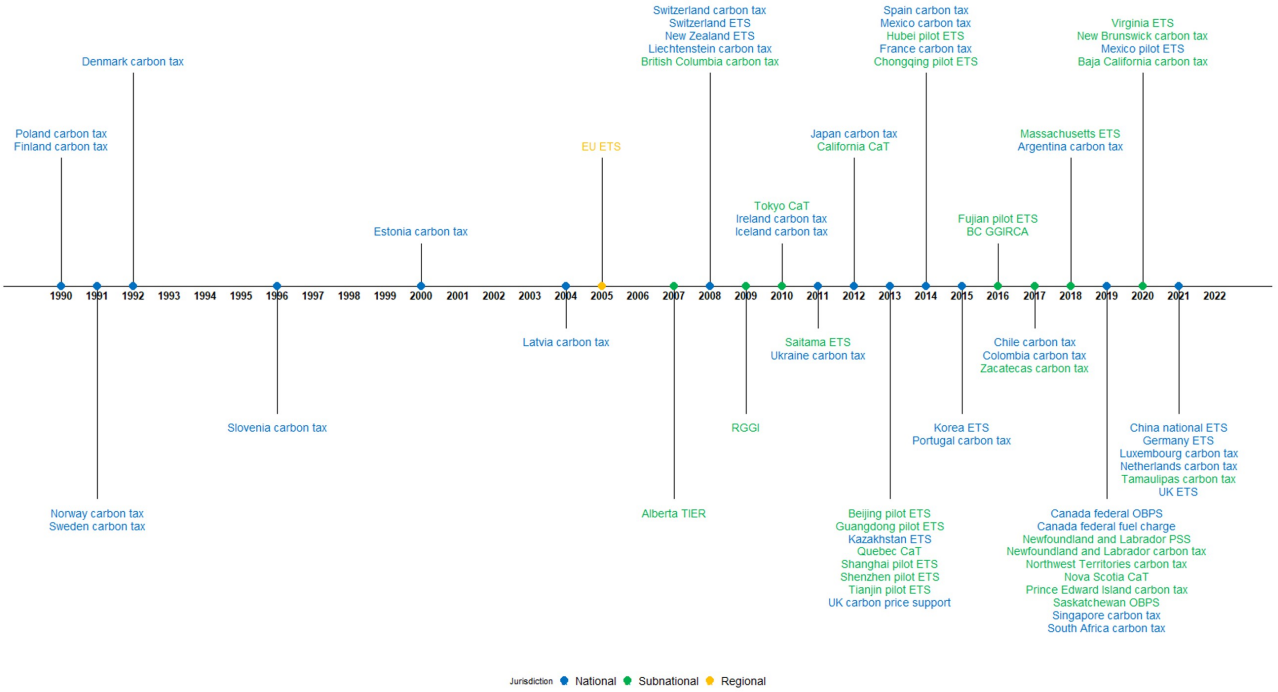

Exhibit 2: The evolution of carbon pricing - Data source: World Bank (2021b).

Participants can trade allowances among themselves, either buying them to cover their polluting activities or selling surplus allowances to other polluters. Over time, emissions caps are lowered, in effect forcing companies collectively to reduce their emissions through investment in sustainable technologies.

The various schemes are characterised by many similarities – and many differences – that are not covered in full detail in this document. For more information, see (for example) ETS Detailed Information by ICAP (2021b).

One of the first emissions trading schemes was the European Union's, launched in January 2005. It covers emissions from industrial facilities including power plants, steel plants, oil refineries and cement factories across the 25 EU member countries. Nearly all pollution permits were allocated for free during the initial phase (Kate, 2020).

The introduction of the EU ETS led to a significant increase in the percentage of emissions covered by carbon pricing globally, from approximately 0.45 per cent in 2004 to 5.33 per cent in 2005, with the EU scheme accounting for 4.91 per cent of global GHG emissions (World Bank, 2021a). However, at the time of its launch, the system was heavily oversupplied with allowances, resulting in a low, sub-optimal carbon price that did little to discourage emissions (Kate, 2020). Since then, the scheme has been amended in each phase to control the oversupply of allowances and ensure higher, more robust carbon prices to achieve emissions reduction targets. The most notable change was the introduction in 2019 of the Market Stability Reserve, a mechanism established to reduce the surplus of emission allowances in the market (European Union, 2021). These Phase 3 changes led to dramatic increases in the price of EU allowances from around US$6 in April 2013 to around US$67 in October 2021.

As of 2021, the EU ETS covers 31 national jurisdictions, and accounts for 3.14 per cent of global emissions. The scheme has provided inspiration for the development of emissions trading in other countries and regions, including China's new national ETS which accounts for the largest share of global GHG emissions – 7.38 per cent. A further eight emissions trading schemes are operating nationally in Canada, New Zealand, South Korea, Switzerland, Kazakhstan, Germany, the United Kingdom and Mexico (a pilot scheme). These programs cover 5.58 Gt of CO_2 emissions, or 10.3 per cent of global GHG emissions. This coverage is set to increase with a further 10 national initiatives under consideration across South America, the Middle East, Eastern Europe and Asia (World Bank, 2021a). In addition, a further 19 ETS initiatives are operating in 29 subnational jurisdictions, accounting for 1.43 Gt of CO_2 emissions, or 2.6 per cent of the global total. Eight of these programs operate in the Chinese provinces of Hubei, Guangdong, Tianjin, Beijing, Chongqing, Shanghai, Shenzhen and Fujian, and are part of China's pilot ETS program. The coverage of subnational ETS programs is expected to grow, with three initiatives scheduled to be introduced in North America and another six under consideration across North America and East Asia (World Bank, 2021a).

Another significant scheme is the subnational cap-and-trade system for California and Quebec, known as the Western Climate Initiative (WCI). Established in 2014, it allows companies to buy and sell emission allowances on each other's carbon markets. The combined markets of the WCI and the Regional Greenhouse Gas Initiative (RGGI) – a joint initiative of several eastern US states – account for 1.06 per cent of global GHG emissions (World Bank, 2021a). The Canadian province of Nova Scotia also introduced an ETS in 2018. A timeline track-

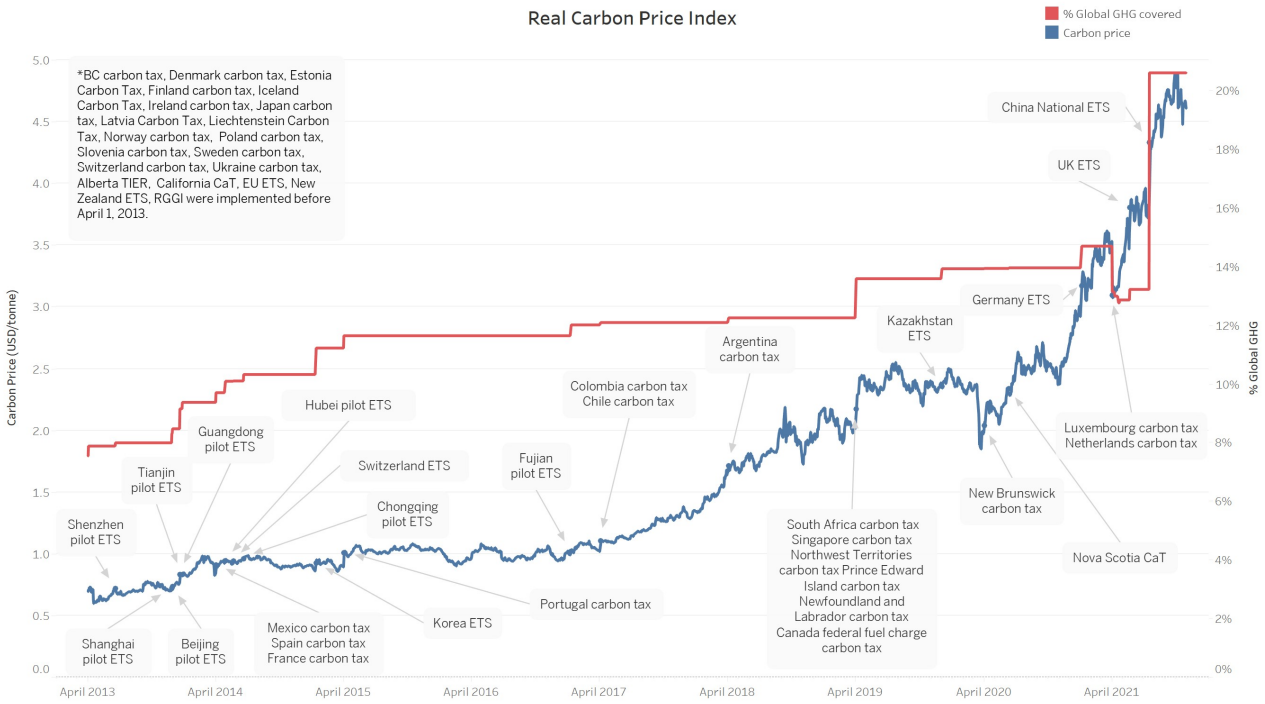

Exhibit 3: The Real Carbon Price Index April 2013 - October 2021.

ing the introduction of these schemes in various jurisdictions is included in the Exhibit 2 above.

5. THE REAL CARBON PRICE INDEX FAMILIES

The Monash/C2Zero team have developed a hierarchical family of indices (Exhibit 1). At the top of this hierarchy is the Real Carbon Price Index (RCPI). Of all the indices, the RCPI provides the most comprehensive measure of global carbon prices, representing all carbon prices and all emissions from all jurisdictions globally. It includes both emissions subject to carbon prices and those with no price – the latter are included in the indices using a price of zero. The index allows the calculation of a global carbon price and its evolution over time (adding dispersion and other measures), as well as provides tools for interpretation and analysis. Benchmarking and tracking of the performance of various jurisdictions relative to each other and to the whole world can also be quantified, as can relative performance (including the identification of leaders and laggards).

Relativities across jurisdictions, activities and even individual polluters via the price they pay for polluting can be tracked and compared. Global carbon prices can also be used as a reference for policy makers, new entrants and others when seeking a benchmark for setting their own carbon prices.

5.1. Simplifications, limitations and assumptions of the RCPI

- The RCPI includes only carbon taxes and mandatory emissions allowances (which are regulated at a governmental level).
- The index does not include voluntary carbon credits offsets and certain specialist allowances.
- ETS instruments are included at auction or market price even though some are provided for free.
- The index does not include carbon border taxes.
- Where spot prices are not available for an ETS, auction prices or futures levels may be used to derive a spot price.
- Where daily prices are not available, they are kept constant at the last observed price.

5.2. The real carbon price index - Tracking carbon prices from 2013

Due to the absence of comprehensive and reliable data from the early years of carbon pricing in Europe, the Monash/C2Zero Real Carbon Price Index shows the evolution of the global aggregate carbon price from a starting point of 2013. By this time, the carbon price index 'universe' comprised 20 national, regional and subnational jurisdictions. In subsequent years, the scope covered by the index has increased, as has the number of instrument constituents.

As of April 2021, 65 national, subnational and regional jurisdictions had implemented a carbon tax or carbon ETS (World Bank, 2021b). Our indices cover 51 of those jurisdictions. We exclude the other 14 jurisdictions due to the lack of available data. For example, for the three Mexican subnational jurisdictions - Baja California, Tamaulipas and Zacatecas, either the scope or the tax rates were not available, prompting their exclusion from the index. The emissions covered by the UK Carbon Price Support overlap 100% with EU ETS and are hence excluded from the index. Of the 30 jurisdictions with an ETS, only 19 for which data are available are included in the index. Note that, Kazakhstan ETS was implemented

in 2013, but data for this ETS is available from only December 2019. Therefore, Kazakhstan entered the index in 2019, not in 2013.

As shown in Exhibit 3 (above), the Real Carbon Price Index has increased dramatically since the starting point, from US$.069 in 2013 to US$4.61 by the end of October 2021 – more than a 550 per cent increase. Most of the increase occurred after 2017 and was driven primarily by carbon price increases in Europe.

A drop in scope recorded in April 2021, and a subsequent increase after three months in July, can be explained by events in China. Some of the emissions covered by the Chinese regional schemes were allocated to the China National ETS, reflecting a decline in the scope of the existing jurisdictions by 1.54 per cent. The national ETS came into operation only in July 2021, increasing the overall scope of the index.

6. AGGREGATE REAL CARBON PRICE INDEX

The main distinguishing feature of the Aggregate Real Carbon Prince Index is that, unlike the Real Carbon Price Index (above), it excludes emissions from jurisdictions with no carbon price; it only covers emissions subject either to a carbon tax or emissions trading scheme. It can also be divided into sub-indices and, like the Real Carbon Price Index, will exhibit price discontinuities when the constituents enter or exit the indices, or there is a change in scope of emissions covered.

Significantly, the Real Carbon Price Index and the Real Carbon Aggregate Price indices respond differently to new entrants to the carbon pricing market. In almost all cases, a new entrant to the former will cause a discontinuous increase in the index price. This is because a zero component (such as a country with no carbon price) becomes non-zero. In the latter index, the same new entrant can cause a discontinuous (single step) change either way – up or down – in the index price. This will depend on the carbon price of the new entrant relative to the index price at the time it is included. This was evident at the start of 2021 when China instituted a national ETS[4].

Currently, the physical carbon price is still zero for approximately 78.5 per cent of global emissions. Many of the world's biggest polluters – including India, Russia, Iran, Saudi Arabia, Iran and Australia (accounting collectively for about 19 per cent of global emissions) – have no carbon price in place.

As new jurisdictions launch carbon prices, this will be reflected in the Real Carbon Price Index and the Real Carbon Aggregate Price Index as a step or discontinuous change (a zero component is replaced by a non-zero value). An example of such a step change can be seen in Exhibit 3, with five new jurisdictions covering 1.76 per cent of global emissions entering the index on 1 April 2019 with a non-zero price.

7. REBALANCING REAL CARBON PRICE INDICES

These are subsets of the Aggregate Real Carbon Price Index which are rebalanced periodically to reflect changes in the underlying constituents or constituent weights due to a change in scope of emissions they cover. Rebalancing follows the methodology for traditional stock and other securities indices, such that the index value is unchanged immediately before and immediately after a rebalance event.

By definition, rebalancing indices do not include any jurisdiction without a carbon price – they draw exclusively from the same 'universe' as the Aggregate Real Carbon Price Index.

7.1. Differences between Aggregate Real Carbon Price indices and rebalancing indices

Although the aggregate indices and the rebalancing indices derive from the same universe, they differ in several ways.

- The aggregate indices reflect the evolution of a carbon price over time. As new constituents enter or exit these indices, discontinuous (or step) changes occur in the indices.
- The rebalancing indices reflect the behaviour of a theoretical basket containing the underlying constituents. When there is a constituent change (addition, deletion or change in scope/weight), the basket – and hence the relevant index – rebalances to reflect the change. These indices do not track the price of carbon.
- The rebalancing indices are normalised so that there is no discontinuity (step change) across a rebalance.
- The Real Carbon Price Index and the Aggregate Real Carbon Price Index (and its sub-indices) do not rebalance in the same way as the rebalancing indices. Rather, changes in the former two reflect the evolution of the relevant carbon price. Thus, when a new jurisdiction introduces a carbon price, the Real Carbon Price Index and the Aggregate Real Carbon Price indices will show a discontinuous step change, as a constituent with a zero contribution becomes non-zero. Similarly, when there is a scope change to an existing constituent, the indices will adjust discontinuously (in a single step) to reflect the change.

7.2. Investable indices

A subset of the rebalancing indices, the investable indices track baskets of instruments that can be physically replicated and traded, and for which transparent price data is available. To ensure investability, the index universe is confined to jurisdictions covered by emissions trading schemes, and therefore excludes those with a carbon tax. The universe is further screened and filtered to ensure that:

- There is a liquid secondary market.
- Constituents are tradeable – and independent market participants (which are not necessarily polluters) are able to buy and sell these allowances. There may be certain restrictions on their activity, but not to prevent them from holding these allowances.

[4] See https://www.realcarbonindex.org/indices

- There is a transparent and discoverable price (either directly available or directly referable to the price of another instrument with a transparent and discoverable price).

The rebalancing methodology used for the aggregate indices is also applied to the investable indices.

8. LIMITATION OF THE INDICES

It is important to note that 'perfect' indices and index calculations are extremely difficult if not impossible to achieve. This is due to many factors, including:

- Data is not always available or may be incomplete.
- Price transparency varies across instruments and schemes.
- Instruments vary and are not fungible.
- Conditions on ownership, holdings and holding limits, market participation, secondary market activity and other issues vary across schemes.
- In some jurisdictions, emissions allowances are allocated at no cost to certain parties. This is not considered or incorporated in any of the Monash/C2Zero indices – except in the form of a note that carbon prices would be lower than those calculated if this were accounted for.
- Border taxes are not included.
- There may be instances of double counting where two or more schemes operate in one jurisdiction. For example, some emissions in Norway, Ireland, Finland, the Netherlands, Denmark, Sweden, Estonia, Slovenia and Latvia are covered by both the EU ETS and individual carbon taxes. Data on these overlaps are not available for all jurisdictions.
- Where a spot price for emissions allowances is not readily available, primary market auction prices or futures prices may be used to derive spot prices.

9. PRICING AND PRICE SOURCES

Pricing and price sources are not available from a single source. Price disclosure varies across markets and instruments, and prices for certain instruments are not necessarily available daily.

Carbon tax rates in local currency units (LCUs) and United States dollars (US$) are collected from the World Bank's annual State and Trends of Carbon Pricing reports, the Carbon Pricing Dashboard, and various government websites[5].

ETS carbon prices are sourced from various market data providers including Bloomberg, Refinitiv and Wind, as well as various government websites. The data sources for each ETS carbon price are listed in Exhibit 4. Liquid spot prices (where available) are used for ETS carbon pricing. For jurisdictions whose ETS spot prices are not available, ETS auction prices, or prices adjusted from ETS futures, are used. In the event that no new prices for a particular jurisdiction are available, the index will continue to be calculated based on the last available prices.

Jurisdiction	Pricing Source	Type of price
Alberta TIER	Alberta Government	Fixed price
Beijing pilot ETS	Refinitiv	Spot price
California CaT	Bloomberg	Spot price derived from future prices
China National ETS	Refinitiv	Spot price
Chongqing pilot ETS	Wind/Refinitiv	Spot price
EU ETS	Refinitiv	Spot price
Fujian pilot ETS	Wind/Refinitiv	Spot price
Germany ETS	Government of Germany	Fixed price
Guangdong pilot ETS	Refinitiv	Spot price
Hubei pilot ETS	Wind/Refinitiv	Spot price
Kazakhstan ETS	ICAP, Caspy Commodity Exchange	Auction price
Korea ETS	Bloomberg	Spot price
New Zealand ETS	Bloomberg	Spot price
Nova Scotia CaT	Government of Nova Scotia	Auction price
RGGI	RGGI CO2 Allowance Tracking System (RGGI COATS)	Spot price
Shanghai pilot ETS	Wind/Refinitiv	Spot price
Shenzhen pilot ETS	Wind/Refinitiv	Spot price
Switzerland ETS	Swiss Emissions Trading Registry	Auction price
Tianjin pilot ETS	Wind/Refinitiv	Spot price
UK ETS	Bloomberg	Spot price

Exhibit 4: Carbon pricing and price sources by jurisdiction

10. SCOPE AND COVERAGE

The data on each jurisdiction's coverage of global GHG emission is sourced from the World Bank's Carbon Pricing Dashboard. For seven of the 51 jurisdictions in our index universe – Estonia, Latvia, Liechtenstein, Iceland, Prince Edward Island, Northwest Territories, and the Netherlands – the scope is missing from the dashboard. For these jurisdictions, the scope was estimated from the 'GHG emissions in the jurisdictions (2015)' and 'Share of jurisdiction's GHG emissions covered' on the dashboard's individual jurisdiction pages.

11. SPECIALIST INDICES

11.1. Dispersion indices

These measure the dispersion of each constituent around the index value. They provide a measure of how widely the constituent prices vary, and over time a measure of the convergence of a carbon price. These can be produced for any of the physical carbon price indices as follows:

$$Dispersion\ Index = \frac{variance}{index\ level} \tag{1}$$

Where, index level is the value of the index at any point in time and variance is the cross sectional variance in price across the jurisdictions.

[5]Some jurisdictions with carbon taxes have more than one tax rate (Finland, Norway, Denmark, Iceland, Mexico and Luxembourg). In those cases the highest tax rate is included. Note that the scope data for each of the different tax rates is not available.

11.2. RCPI Carbon Scores

The Monash/C2Zero Real Carbon Price Index (RCPI) Carbon Scores rank the overall effectiveness of different carbon pricing schemes. The score considers both the coverage of individual schemes and their pricing, with a target price of US$75 per tonne of CO_2e applied.

$$RCPI\ Carbon\ Score = \frac{carbon\ price}{\$75} \times \frac{scope\ of\ emissions\ covered}{total\ scope\ for\ country} \quad (2)$$

The US$75 target was chosen because it is the mid-point of the US$50-100 range suggested by the High-Level Commission on Carbon Prices (2017), and it is also the target price mooted by the International Monetary Fund for the carbon price by 2030 to keep global warming under control (Carney, 2021).

A score of 1 or more could mean a country or region is covering 100 per cent of its emissions at a price of US$75 or more or half of its emissions at US$150 (i.e., double the target price).

12. METHODOLOGY

12.1. Currency treatment

Foreign exchange spot rates are sourced from Bloomberg to convert Local Currency Units (LCUs) into US dollars. The index converts all constituents' LCU prices into US dollars using the Bloomberg end-of-the-day exchange rates. If the day is a non-business day, the foreign exchange rates from the previous business day are used. For jurisdictions and years when carbon tax rates in LCUs are not available from the World Bank or government websites, the annual tax rates in US dollars available on the Carbon Pricing Dashboard is used. The exchange rates from the IMF[6] are used to convert them into LCUs, and then Bloomberg's end-of-the-date exchange rate is applied to convert the annual carbon taxes into daily carbon taxes in US dollars.

12.2. Adding or deleting constituents

When a jurisdiction with no carbon price introduces an ETS or levies a carbon tax, this will be included in the index. Where practicable, inclusion will occur at the time the relevant tax or ETS is instigated. Where information about new entrants to the index only becomes available after the launch date, the index may be recast retrospectively. In certain cases, however, recasting will not occur – for example when the retrospective change is below a certain threshold. The Index Committee, guided by this document, will determine whether an index is recast or not.

When a carbon tax is removed, or an ETS is disbanded, the scope for which the tax or ETS applies will be adjusted to have a carbon price of zero. It will then be treated in exactly the same way as jurisdictions with no carbon price are treated in each of the RCPI indices.

[6]The World Bank uses these exchange rates for all currency conversion. https://www.imf.org/external/np/fin/data/param_rms_mth.aspx

12.3. Rebalancing

As discussed above, the Real Carbon Price Index and the Aggregate Real Carbon Price Index (and sub-indices) do not rebalance in the way that traditional market indices rebalance. As the price of index constituents change, the indices will also change to reflect the weighted impact of such changes. Changes to the indices also occur when the scope or coverage of an emissions instrument changes or when a new instrument is added to or deleted from an index. When this happens, the index may change discontinuously (up or down) to reflect the additional scope of new instrument(s).

For example, the Aggregate Real Carbon Price Index value on 15 July 2021 was US$28.38 – reflecting weighted data from 50 jurisdictions covering 13.22 per cent of global GHG emissions. When the China National ETS was added to the index on 16 July 2021, the coverage of the index increased to 20.60 per cent, but its value dropped to US$21.04, as the price in the new jurisdiction was much lower than the average carbon price before its entry. The rebalancing indices will adjust when a new constituent is added, a constituent is deleted or there is a scope change. Weights are adjusted so that the index value before and after the change is continuous. Thus there is no such drop in the corresponding rebalancing index, which has a value of 3.37 before and after the inclusion of the new jurisdiction.

12.4. Index reviews

Periodically and at least annually, the Index Committee will review the indices, the methodologies and constituents and recommend changes if necessary. Where possible, there will be a time lag between the announcement and implementation of changes.

Changes that fall below a materiality threshold will be implemented on a quarterly cycle, or as determined by the Index Committee. Changes that have an impact above this threshold may be implemented outside this cycle. In certain instances, where changes are material, indices may be retrospectively recast to reflect their impact.

Over time, the Index Committee may review and change the underlying index rules in line with developments and changes to the carbon market.

12.5. Extraordinary events

An extraordinary event is defined as any event not covered by the rules or scope of this document, or one for which there is not a documented procedure.

A record of extraordinary events and resulting actions will be kept and updated as necessary.

In the case of such events, the Index Committee will decide how the event is to be handled. The committee will also be responsible for communicating its decision. If the event is considered likely be to be repeated, the decision will be included in these rules as a precedent.

In general, extraordinary changes will be made with reference to precedents and to the rules and methodologies in this document.

12.6. Timing of index reviews and changes

Reviews will generally be conducted every six months (usually in January and July to coincide with legislation updates and World Bank reporting). The exact review dates may vary where dates for release of such information are not specified.

Additional reviews may occur if there are major structural changes to emissions markets – for example, when a new ETS commences.

12.7. Materiality thresholds

Any event that causes a material change to the value of an index or to the scope covered by any index or index constituent will be disclosed and incorporated into the index as soon as possible. Materiality thresholds may differ across indices. The Index Committee may revise or change the materiality thresholds at any time.

12.8. Recasting or recalculating indices

Whether due to errors, changes to data or other factors, there may at times be a requirement to recalculate one or more indices. This will only be done if the recalculation causes a change that exceeds the materiality thresholds described above.

12.9. Errors or omissions

Although every effort will be made to avoid errors or omissions, it is not guaranteed or represented that the indices will be completely free of them (see the disclaimer and terms and conditions near the end of this document). Once detected, errors or omissions will be rectified as quickly as possible. Where such an error or omission has been present in historical calculations, the relevant indices or products may be recast or recalculated if they exceed a materiality threshold, or if the Index Committee deems that a recalculation or recasting is necessary. There is no warranty that errors and omissions (even where they are known) will be remediated.

12.10. Current constituents

The eligible index constituents must have either a carbon tax or an ETS implemented, an accessible and valid carbon tax and/or ETS price, as well as GHG emission data. As shown in Exhibit 5, the current universe consists of carbon tax prices of 31 jurisdictions and ETS prices of 20 jurisdictions, covering 5.3 per cent and 15.41 per cent of global GHG emissions in 2021, respectively.

13. STANDARDISING FOR COUNTRY/ INSTRUMENT NUANCES

As discussed elsewhere in this document, there is no global standard around pricing greenhouse gas emissions. Price setting methodologies and applicable scope of emissions covered varies widely across jurisdictions. Tax rates differ and each ETS has its own features and nuances. Regulation is not harmonised and neither is compliance and enforcement. Against this backdrop, data used in these indices may not be fully consistent.

13.1. Scope

Generally, the index covers all priced emissions including taxes and levies or costs for emission permits – with the provision that they are directly related to greenhouse gas emissions. This means we do not include taxes on fuels unless they are related to the greenhouse gas emissions of the fuel. We include all greenhouse gases as defined by the IPCC (Slezak & Timms, 2021a, 2021b).

If there are overlaps between carbon pricing policies, the index includes the sum of all prices for the emissions within any overlap, so that the index reflects the true cost of emitting greenhouse gas in the relevant jurisdiction.

The index does not currently include supranational systems such as the CORSIA aviation emissions system, or the International Maritime Organisation's attempt to price carbon emissions from shipping.

13.2. Price

In carbon markets, we use the current spot price of a fully fungible carbon allowance for all emissions covered by the system. This means we also apply the traded price of an allowance to free allocations, and do not include the option to reduce compliance costs, for example, by using offsets.

In jurisdictions with a carbon tax, we use the current tax rate on the date of the index calculation.

There have been instances where a government has chosen a carbon pricing system ahead of any trading taking place. In such instances, emissions are technically covered by an allowance system, but the price is as yet unknown. In such instances, we exclude the emissions covered by this system from the index altogether, which is equivalent to assuming the global average carbon price for these allowances. As soon as these allowances trade for the first time with a publicly discoverable price, the indices include coverage of these emissions at that traded price.

14. COMMITTEES, TEAMS, AND CONTACT DETAILS

14.1. The Index Committee

The governance framework for the Monash/C2Zero Real Carbon Price Index family is overseen by an Index Committee. Recommendations and advice may be sought from various sources including the Research Committee (below) and other parties. While, to the extent possible, this set of rules will determine how the indices work, there will be from time to time issues and instances that fall outside the scope of these rules. When this occurs, the Index Committee will be the ultimate arbiter. All decisions will be made with respect to these rules in both prescription and in spirit.

14.2. The Research Committee

The Research Committee is responsible for overseeing the ongoing production of these indices and validating any new indices or related products. The Research Committee will also, when necessary, provide advice

Jurisdiction	Start date	2013	2014	2015	2016	2017	2018	2019	2020	2021
%Global GHG Covered by Carbon Tax		2.87%	3.40%	3.33%	3.33%	3.52%	3.68%	5.02%	5.03%	5.30%
BC carbon tax	1-Apr-13	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.09%
Denmark carbon tax	1-Apr-13	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.04%
Estonia carbon tax	1-Apr-13	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%
Finland carbon tax	1-Apr-13	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.07%
Iceland carbon tax	1-Apr-13	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%
Ireland carbon tax	1-Apr-13	0.04%	0.03%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%
Japan carbon tax	1-Apr-13	1.77%	1.70%	1.64%	1.64%	1.64%	1.64%	1.64%	1.64%	1.82%
Latvia carbon tax	1-Apr-13	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%
Liechtenstein carbon tax	1-Apr-13	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%
Norway carbon tax	1-Apr-13	0.08%	0.08%	0.09%	0.09%	0.09%	0.09%	0.09%	0.09%	0.09%
Poland carbon tax	1-Apr-13	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%
Slovenia carbon tax	1-Apr-13	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.02%
Sweden carbon tax	1-Apr-13	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%
Switzerland carbon tax	1-Apr-13	0.04%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%
Ukraine carbon tax	1-Apr-13	0.55%	0.49%	0.41%	0.41%	0.41%	0.41%	0.41%	0.41%	0.41%
France carbon tax	1-Apr-14		0.31%	0.32%	0.32%	0.32%	0.32%	0.32%	0.32%	0.32%
Mexico carbon tax	1-Apr-14		0.35%	0.35%	0.35%	0.35%	0.35%	0.35%	0.35%	0.35%
Spain carbon tax	1-Apr-14		0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
Portugal carbon tax	1-Apr-15			0.04%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%
Chile carbon tax	3-Apr-17					0.11%	0.11%	0.11%	0.11%	0.11%
Colombia carbon tax	3-Apr-17					0.08%	0.08%	0.08%	0.08%	0.08%
Argentina carbon tax	2-Apr-18						0.16%	0.16%	0.16%	0.16%
Canada Federal Fuel Charge carbon tax	1-Apr-19							0.29%	0.29%	0.33%
Newfoundland and Labrador carbon tax	1-Apr-19							0.01%	0.01%	0.01%
Northwest Territories carbon tax	1-Apr-19							<0.01%	<0.01%	<0.01%
Prince Edward Island carbon tax	1-Apr-19							<0.01%	<0.01%	<0.01%
Singapore carbon tax	1-Apr-19							0.08%	0.08%	0.08%
South Africa carbon tax	1-Apr-19							0.95%	0.95%	0.95%
New Brunswick carbon tax	1-Apr-20								0.01%	0.01%
Luxembourg carbon tax	1-Apr-21									0.01%
Netherlands carbon tax	1-Apr-21									<0.01%
%Global GHG Covered by ETS		6.50%	6.92%	8.31%	8.31%	8.68%	8.68%	9.02%	9.04%	15.41%
Alberta TIER	1-Apr-13	0.24%	0.25%	0.24%	0.24%	0.24%	0.24%	0.24%	0.24%	0.28%
California CaT	1-Apr-13	0.23%	0.23%	0.69%	0.69%	0.69%	0.69%	0.69%	0.69%	0.65%
EU ETS	1-Apr-13	4.26%	4.06%	4.11%	4.11%	4.11%	4.11%	4.11%	4.11%	3.14%
New Zealand ETS	1-Apr-13	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%
RGGI	1-Apr-13	0.20%	0.20%	0.20%	0.20%	0.20%	0.20%	0.20%	0.20%	0.30%
Shenzhen pilot ETS	18-Jun-13	0.11%	0.11%	0.11%	0.11%	0.11%	0.11%	0.11%	0.11%	0.05%
Shanghai pilot ETS	26-Nov-13	0.32%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.31%	0.19%
Beijing pilot ETS	28-Nov-13	0.16%	0.16%	0.16%	0.16%	0.16%	0.16%	0.16%	0.16%	0.13%
Guangdong pilot ETS	19-Dec-13	0.68%	0.68%	0.68%	0.68%	0.68%	0.68%	0.68%	0.68%	0.30%
Tianjin pilot ETS	26-Dec-13	0.22%	0.22%	0.22%	0.22%	0.22%	0.22%	0.22%	0.22%	0.10%
Hubei pilot ETS	28-Apr-14		0.39%	0.38%	0.38%	0.38%	0.38%	0.38%	0.38%	0.26%
Switzerland ETS	21-May-14		0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Chongqing pilot ETS	19-Jun-14		0.22%	0.22%	0.22%	0.22%	0.22%	0.22%	0.22%	0.04%
Korea ETS	12-Jan-15			0.90%	0.90%	0.90%	0.90%	0.90%	0.90%	0.95%
Fujian pilot ETS	9-Jan-17					0.37%	0.37%	0.37%	0.37%	0.14%
Kazakhstan ETS	2-Dec-19							0.34%	0.34%	0.29%
Nova Scotia CaT	10-Jun-20								0.02%	0.02%
Germany ETS	4-Jan-21									0.74%
UK ETS	21-May-21									0.36%
China National ETS	16-Jul-21									7.38%

Exhibit 5: GHG emission covered by jurisdictions (2013-2021)

to the Index Committee. Membership of the Research Committee will be determined by the Index Committee. From time to time, members may be appointed to the Research Committee for specific tasks or specific periods. Membership of the Research Committee will be reviewed on an ad-hoc basis and be sanctioned by the Index Committee. At any time, the Index Committee may appoint or remove members of the Research Committee.

14.3. The support team

Additional resources have and may continue to support these indices, including development and maintenance of the website, distribution of the indices and other activities. For further details please visit the website https://www.realcarbonindex.org.

15. PRICING SCHEMAS

15.1. Real Carbon Price indices

This schema applies to all indices for which a real carbon price is calculated.

$$Index\ level = \frac{1}{n}\sum_i w_i f x_i P_i \tag{3}$$

- w_i is the percentage global scope (weighting) of emissions covered by instrument i, including the scope with zero price
- $n = \sum_i w_i + w(no\ carbon\ price) : n = 100\%$ for the global index and otherwise the percentage coverage for relevant sub-indices including the weighting for zero prices
- $\sum_i w_i$ represents the scope or percentage of emissions in the index for which the price is non-zero
- P_i is the price in local currency of instrument i. Note: for tax-based instruments, P_i will be largely static

- fx_i is the relevant foreign exchange rate for converting P_i (the local price) into the index currency

15.2. Aggregate Real Carbon Price indices

This schema applies to all indices for which an Aggregate Real Carbon Price is calculated. This includes ETS-only indices and tax rate indices. This methodology is the same as for the Real Carbon Price Index but does not include terms with a zero carbon price.

$$Index\ level = \frac{1}{\sum_i w_i} \sum_i w_i f x_i P_i \tag{4}$$

- w_i is the percentage global scope (weighting) of emissions covered by instrument i
- $\sum_i w_i$ is the total scope or percentage of emissions included in the relevant index
- P_i is the price in local currency of instrument i. Note: for tax-based instruments, P_i will be largely static
- fx_i is the relevant foreign exchange rate for converting P_i (the local price) into the index currency

15.3. Rebalancing Real Carbon Price indices and Investable Real Carbon Price indices

Where an index is periodically rebalanced, the following schema is applied:

$$Index\ level = \frac{\frac{1}{N} \sum_i C_i L_i f x_i P_i}{\sum_i C_i L_i} \tag{5}$$

- C_i is the adjusted percentage global scope (weighting) of emissions covered by instrument i
  - C_i may be adjusted to reflect accessible coverage (for example in certain instances, to exclude market stability reserves or locked up holdings)
- For certain indices (including the investable indices), L_i is a liquidity adjustment based on the relative liquidity of a market compared to a benchmark (generally the EU for which $L = 1$)
  - Where the EU is the benchmark,

$$L_i = \frac{(average\ traded\ volume)_i / C_i}{(average\ traded\ volume)_{EU} / C_{EU}} \tag{6}$$

- L_i may be set to zero if it falls below a certain threshold (ie < 0.5)
- P_i is the price in local currency of instrument i
- fx_i is the relevant foreign exchange rate for converting P_i (the local price) into the index currency
- N is a normalisation factor giving the index a base value (eg: $1,000$) at a reference date (eg at inception). When the index is rebalanced, N is adjusted so that

$$index\ level\ (post\ rebalance) = index\ level\ (pre\ rebalance) \tag{7}$$

15.4. Specialist indices and analytics

Methodologies for these will be published on a case-by-case basis.

15.4.1. Dispersion Index. The dispersion Index shows whether there has been any convergence in carbon prices across the jurisdictions with a carbon price over time. It is measured as follows:

$$Dispersion\ Index = \frac{variance}{index\ level} \tag{8}$$

For the Aggregate Real Carbon Price Index, this would be:

$$variance = \frac{1}{\sum_i w_i} \sum_i w_i (f x_i P_i - \frac{1}{\sum_i w_i} \sum_i w_i f x_i P_i)^2 \tag{9}$$

and

$$index\ level = \frac{1}{\sum_i w_i} \sum_i w_i f x_i P_i \tag{10}$$

- w_i is the percentage global scope (weighting) of emissions covered by instrument i
- $\sum_i w_i$ is the total scope or percentage of emissions included in the relevant index
- P_i is the price in local currency of instrument i. Note: for tax-based instruments, P_i will be largely static
- fx_i is the relevant foreign exchange rate for converting P_i (the local price) into the index currency

15.4.2. RCPI Carbon Score. This score considers both the coverage of individual schemes and their pricing, with a target price of US$75 per tonne of CO_2e applied.

$$RCPI\ Carbon\ Score = \frac{carbon\ price}{\$75} \times \frac{scope\ of\ emissions\ covered}{total\ scope\ for\ country} \tag{11}$$

Based on current international scientific advice, an RCPI Carbon Score of 1 or more by 2030 is required for the world to have a sustainable existence. Currently, the world score is 0.061[7], with only 20.71 per cent of global emissions covered by carbon prices[8], and prices averaging just around US$22. These figures translate to the world being just above 6 per cent of the way towards meeting sustainability targets for 2030.

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[7] This can also be derived using the Real Carbon Price Index value of US$4.61/US$75 x 100 per cent as at October 2021.

[8] For jurisdictions covered by the Aggregate Real Carbon Price Index.

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