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Contribution of carbon pricing to meeting a mid-century net zero target

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ABSTRACT

A mid-century net zero target creates a challenge for reducing the emissions of emissions-intensive, trade-exposed sectors with high cost mitigation options. These sectors include aluminium, cement, chemicals, iron and steel, lime, pulp and paper and petroleum refining. Available studies agree that decarbonization of these sectors is possible by mid-century if more ambitious policies are implemented soon. Existing carbon pricing policies have had limited impact on the emissions of these sectors because their marginal abatement costs almost always exceed the tax rate or allowance price. But emissions trading systems with free allowance allocations to emissions-intensive, trade-exposed sectors have minimized the adverse economic impacts and associated leakage. Internationally coordinated policies are unlikely, so implementing more ambitious policies creates a risk of leakage. This paper presents policy packages a country can implement to accelerate emission reduction by these sectors with minimal risk of leakage. To comply with international trade law the policy packages differ for producers whose goods compete with imports in the domestic market and producers whose goods are exported. Carbon pricing is a critical component of each package due its ability to minimize the risk of adverse economic impacts on domestic industry, support innovation and generate revenue. The revenue can be used to assist groups adversely impacted by the domestic price and production changes due to carbon pricing and to build public support for the policies.

Key policy insights:

- A country with a mid-century net zero GHG emission target likely will need to implement more ambitious mitigation policies soon for emission-intensive sectors such as aluminium, cement, chemicals, iron and steel, lime, pulp and paper and petroleum refining.
- More ambitious mitigation policies are likely to vary by country and be implemented at different times, creating a risk of leakage due to industrial production shifts to other jurisdictions.
- More ambitious mitigation policy packages, compatible with international trade law, that a country can implement to reduce emissions from these sectors with

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minimal risk of leakage are available but differ for producers whose goods compete with imports in the domestic market and those whose goods are exported.
- Carbon pricing is a critical component of each package due its ability to minimize the risk of adverse economic impacts on domestic producers, support innovation and generate revenue.

1. Introduction

The Paris Agreement objective is to hold the increase in global average temperature to well below 2°C above pre-industrial levels and pursue efforts to limit the increase to 1.5°C above pre-industrial levels. Meeting this objective requires that global CO_2 emissions be reduced to at least net zero about mid-century along with significant reductions in emissions of other greenhouse gases (GHGs). Over 135 countries have a net zero target, over 90% of them with a mid-century or earlier date. Countries will need to implement more stringent mitigation policies to achieve their targets.[1]

Although international coordination of mitigation policies offers economic benefits, policies are likely to vary by country, be implemented at different times and at different levels of ambition. International coordination is inhibited by various factors including the disparate interests of countries that import or export emissions-intensive, trade exposed (EITE) goods. The risk of production shifts to jurisdictions with less costly regulations (leakage) deters unilateral implementation of more stringent mitigation policies.

Carbon pricing – a carbon tax or GHG emissions trading system (ETS) – encourages implementation of emission reductions whose cost per tCO_2e reduced is lower than the tax rate or allowance price. Carbon pricing policies, especially ETSs, can be designed to reduce emissions by EITE sectors with minimal risk of production shifts. In such ETSs, regulated EITE sources receive free allowances, which gives them an incentive to reduce emissions but limits the total compliance cost and incentive to shift production to other jurisdictions.[2]

EITE sectors with high mitigation costs, such as aluminium, cement, chemicals, iron and steel, lime, pulp and paper and petroleum refining, account for 24–34% of global emissions (Bashmakov et al., 2022).[3] A net zero target will require development of new technologies and transformation of the production facilities of those sectors. To provide sufficient time for those developments more ambitious mitigation policies for those sectors need to be implemented soon.

Various policies have been proposed to reduce emissions by these EITE sectors. Since the products of these sectors are internationally traded, any policy must comply with international trade law. Trade law provisions differ for imports and exports, so domestic producers whose goods compete with imports (import-competing) in the domestic market, and producers whose goods are exported, require different policies.

This paper presents policy packages a country can implement to increase the ambition of its policies for EITE sectors. Each package includes one or more policies proposed in the literature together with carbon pricing. Carbon pricing to minimize the risk of adverse economic impacts is a critical component of each package. Carbon pricing also generates revenue the government can use to assist groups adversely impacted by domestic price and production changes.

Since carbon pricing is a key component of each package, the paper first establishes its ability to fulfil the projected role. Sections 2 through 4 discuss carbon pricing, its advantages and limitations and evidence of its effectiveness in reducing emissions and supporting innovation. More ambitious mitigation policies for these EITE sectors that a country can implement on its own with minimal risk of leakage are presented in section 5. Collection and use of carbon pricing revenue are discussed in section 6, while section 7 concludes.

[1]The term ‘country’ is used to mean a country, jurisdiction, region or state depending upon the context.
[2]Non EITE sources must buy allowances.
[3]The focus of the paper is EITE industrial sectors with marginal abatement costs well above the prevailing tax rate/allowance price. There is no accepted term for these sectors. Together with some transportation and agricultural sources they are sometimes called ‘hard to abate’ sectors. EITE is also a broader term in that it covers some industrial sectors with marginal abatement costs lower than the prevailing tax rate/allowance price. The paper uses the term EITE with the understanding that the focus is industrial sectors with relatively high marginal abatement costs.

2. Carbon pricing – key features: advantages, limitations, and international coordination

Carbon taxes and GHG ETSs have been used since 1990 and 2005 respectively (World Bank, 2022). With a carbon tax, the government sets a carbon price but the resulting emission reductions are uncertain while with an ETS the government sets an aggregate emissions limit whose carbon price is uncertain (Pollitt, 2016).[4,5] Stavins (2022) reviews carbon taxes and ETSs in theory and in practice. The performance of different policies, including carbon taxes and GHG ETSs, is assessed by Peñasco et al. (2021).

A carbon tax or allowance price imposes a cost per tCO_2e on regulated emissions. This increases the prices of goods and services in proportion to their GHG emissions intensity and encourages consumers to shift to less emissions intensive alternatives (Bertoldi, 2022).[6,7] In practice features such as exemptions and multiple rates lead to debate as to whether a specific tax is a carbon tax (Haites, 2018).[8] Carbon pricing is becoming more prevalent (Dubash et al., 2022) with 35 carbon taxes and 33 ETSs collectively covering almost 23% of global GHG emissions in effect by January 2022.[9] A tax or ETS can be designed to apply to a wide range of emissions sources. In practice, a tax or ETS typically covers between 10% and 80% of a jurisdiction's GHG emissions with agricultural, forestry, chemical process and non-CO_2 emissions being the most common exemptions (Khan & Johansson, 2022; World Bank, 2022). Several jurisdictions have an ETS and one or more carbon taxes that apply to different sources. These jurisdictions rarely attempt to coordinate these tax rates and allowance prices.

The main advantage of carbon pricing is flexibility; it encourages the regulated sources to implement emission reductions whose cost per tCO_2e is lower than the tax rate or allowance price. It leaves the choice of mitigation measures to affected sources. In addition taxes and auctioned allowances generate revenue for the government, which can be used to address distributional impacts, as discussed in Section 6.

The limitations of carbon pricing instruments are that they:

- Provide limited incentive to implement higher cost (cost per tCO_2e higher than the tax or allowance price) mitigation technologies, such as renewable energy (Bertoldi et al., 2005; Lilliestam et al., 2021), or more costly measures to abate industrial process emissions (Bataille, 2020). The incentive to implement higher cost measures depends on the level of the carbon price, the entity's discount rate and its expectations concerning the future tax rate/allowance price and future costs of mitigation measures (Vogt-Schilb et al., 2018).
- Have limited impact on long-term mitigation investments (Fuss et al., 2018) and adoption of mitigation measures in situations where decisions are relatively insensitive to prices[10] such as recycling, household energy efficiency investments (Bertoldi et al., 2005), transportation choices, and urban planning (Creutzig et al., 2011, 2016).

[4]Several ETSs include price stability mechanisms such as a price floor and/or ceiling. Information on ETS designs is available from ICAP (2021) while World Bank (2022) provides comparative information on all taxes and ETSs.

[5]Two ETS designs are common (Haites et al., 2018). One imposes a cap on specified emissions (sources and gases), distributes (free or by auction) tradable allowances (usually for 1 tCO2e) roughly equal to the cap and requires the designated sources to remit allowances equal to their verified emissions. The second uses an emissions intensity (baseline or performance standard) and activity level (current or historic) to create an emissions budget for each participant. If its actual emissions are less than its budget a participant receives credits for the difference while a participant with excess emissions must purchase credits for compliance. The EU ETS and Korea use the first design while China and Canada use the second.

[6]A fuel tax increase or fossil fuel subsidy removal raises the prices of fossil fuels and so reduces GHG emissions. But the price changes are rarely proportional to the carbon content which leads to inefficient, even perverse, adjustments. A few subsidies, such as those for CO_2 sequestration, are based on the reductions achieved but most, such as those for energy efficiency or renewable energy, are not proportional to the reductions achieved.

[7]Consumer responses to taxes on gasoline and diesel, like a carbon tax on these fuels, are to consume less by travelling less, shifting modes and switching to more efficient vehicles. Fuel taxes are not included in most lists of carbon taxes (World Bank, 2022) because they are not proportional to the carbon content, but they are a component of the effective carbon price faced by consumers (OECD, 2021). Carbon taxes are more effective than energy taxes at reducing emissions.

[8]Norway taxes CO_2 emissions in petroleum activities on the continental shelf at a higher rate than emissions from fossil fuels consumed onshore. Ireland imposes a lower tax on solid (coal) than liquid and gaseous fuels.

[9]The EU ETS – 30 countries – and RGGI – 11 US states – cover multiple jurisdictions. Carbon taxes cover 5.2% of global emissions while ETSs cover 16.5%.

[10]Decisions with a low price elasticity. The longer term price sensitivity (price elasticity) may be higher. Decisions also may be affected by principal-agent problems such as landlords' reluctance to make efficiency investments when tenants pay the energy bills.

Progressive emission reductions require tax rate increases or ETS cap reductions over time, taking into account technological and socio-economic changes as well as other policies that reduce emissions or mitigation costs. This creates an implicit strategy of implementing progressively higher cost mitigation measures over time. Relying solely on a carbon pricing policy to achieve a mid-century net zero target is not advisable because it would defer implementation of the high cost mitigation measures until lower cost measures have been exhausted and thus reduce the time available to reduce the emissions of sectors with high cost mitigation measures.

Climate impacts are the same regardless of where the GHG emissions occur while mitigation costs differ across both regions and countries. This creates the potential for significant economic benefits through international coordination of carbon pricing (Hoel, 1992), including options such as (1) a minimum price with each country keeping the proceeds (Parry et al., 2021; Weitzman, 2014); (2) a common price for all countries with financial transfers (Budolfson et al., 2021)[11]; and (3) a common price for a group of countries with tariffs on imports from other countries (Nordhaus, 2015).

Nominal tax rates and allowance prices, in practice, vary widely across jurisdictions; in 2021, large increases in allowance prices occurred in several jurisdictions (World Bank, 2022).[12] There is no evidence of any efforts by policymakers to harmonize carbon taxes across country boundaries, which would in any case be politically and technically difficult (Pollitt, 2016). Historically ETSs across countries have been linked, which reduces allowance price differences (Mehling & Haites, 2009), mainly through limited acceptance of Kyoto Protocol credits, but that has become much less common since 2014 (Haites, 2016).

3. Evidence of the effectiveness of carbon pricing on GHG emission reductions

Assessing the effectiveness of a specific tax or ETS is challenging because emissions usually are subject to multiple mitigation policies, and the direct and indirect impacts of other policies and exogenous factors such as economic conditions and fossil fuel prices (Koch et al., 2014). In addition, the tax rate or allowance price changes over time.

Overlapping policies affect taxes and ETSs differently. The tax rate does not change but the emissions subject to the tax are affected by the other policies. With an ETS, emission reductions due to other policies contribute to compliance with the cap and so reduce the allowance price. ETSs have introduced mechanisms, such as a minimum price and market stability reserve, to limit the effect of other policies on the allowance price (Bocklet et al., 2019).

Recent analyses of multiple carbon pricing instruments find that despite their variability they have a statistically significant effect on emissions (Köppl & Schratzenstaller, 2022). Assessments of the performance of individual taxes and ETSs are summarized by Hoppe et al. (2021). The most extensive literature relates to the EU ETS – the oldest and until 2021 the largest ETS – and British Columbia's tax which has a broader scope and covers more emissions than earlier European taxes.[13]

3.1. Impacts of the EU ETS

An extensive *ex post* literature concludes that the EU ETS reduced emissions with no statistically significant adverse impacts on competitiveness or leakage (Haites et al., 2018). Analyses of specific EITE sectors – aluminium, cement, and steel – likely to be particularly vulnerable to foreign competition, find no adverse

[11]Bataille et al. (2018) notes that the conclusion that optimal climate policy implies a unique carbon price around the globe is valid only if unlimited transfers among countries are possible to compensate for differences in abatement costs and welfare effects. Further key references see Supplementary Material 1.

[12]Finland, France and some Canadian provinces lowered fuel taxes when their carbon taxes were introduced so their real carbon tax rates are lower than the nominal rates. Emission reductions depend upon the real, rather than the nominal, tax rate. Various policies affect the relationship between the nominal and real tax rates over time.

[13]Runst and Thonipara (2020) estimates the impact of the Swedish carbon tax on residential CO_2 emissions between 2001 and 2016 and Andersson (2019) estimates its impact on transport emissions between 1990 and 2005. Governments rarely publish data on taxed emissions so evaluations rely on other sources, or proxies such as gasoline sales, for emissions data. Typically they cover only a share of the taxed emissions. Abatement costs and hence emission reductions due to a tax likely differ by sector so a reduction estimated for one sector is evidence that the tax has had an impact but may not be a good estimate of its overall effect.

impacts (Boutabba & Lardic, 2017). Dechezleprêtre et al. (2022) detects no carbon leakage by installations of multinational corporations subject to the EU ETS. Data on the embodied carbon of trade flows – whether the embodied emissions of imports increase or those of exports fall – for goods subject to the EU ETS also reveal no leakage (Naegele & Zaklan, 2019).

Most of the emissions reductions are due to relatively low-cost measures that can be implemented quickly, such as fuel switching (Edenhofer et al., 2011) and/or energy efficiency improvements (Löschel et al., 2019). Power and heating sources reduced emissions more than industrial sources – at approximately 4%/year vs 0.2%/year – faced with more costly options.[14] Studies that attempt to attribute a share of the reductions achieved to the ETS compared to business-as-usual estimate its contribution at 3–9% with one estimate of 28% (Borghesi & Verde, 2019).

3.2. Impacts of the BC carbon tax

British Columbia's carbon tax covers approximately 70% of the province's GHG emissions and took effect on 1 July 2008 at CAD 10/tCO_2.[15] The tax increased at a rate of CAD 5/tCO_2 per year for the next five years, then remained at CAD 30/tCO_2 until April 2019 before increasing by CAD 5/tCO_2 annually to CAD 50/tCO_2 on 1 April 2022. Studies find that the tax reduced per capita/household gasoline use (Haites et al., 2018 for review), as well as residential natural gas use (Xiang & Lawley, 2019) and diesel consumption (Bernard & Kichian, 2019). Urban households reduced gasoline consumption more than rural households because they have more transportation options (Lawley & Thivierge, 2018).

All of these studies are based exclusively or primarily on the initial five years of rising tax rates and each covers only some of the emissions subject to the tax. Erutku and Hildebrand (2018) find that the impact began to diminish after the tax rate was frozen. A recent analysis for 2008–2016 finds the tax reduced transport emissions but did not lead to a statistically significant reduction in aggregate CO_2 emissions (Pretis, 2022).

With respect to the impact on industry, the carbon tax induced shifts in employment from more to less carbon-intensive industries with a small statistically significant increase between 2007 and 2013 (Carbone et al., 2020) and wage reductions in adversely impacted sectors (Yip, 2018, 2020). Although cement exports were reduced (Thivierge, 2020) there was no negative impact on GDP (Bernard & Kichian, 2021) due in part to the redistribution of tax revenue to firms and households.

4. Impact of carbon pricing on innovation

Documenting the innovation stimulated by a mitigation policy is challenging, particularly with multiple jurisdictions implementing policies. Innovation may occur any time after a policy is proposed by any jurisdiction and may happen anywhere. Innovations may originate with regulated entities, their suppliers, or independent academic, government or industry researchers. Innovation in response to a mitigation policy varies by policy type (Jaffe et al., 2002) and stringency (Aghion et al., 2016). Industrial sources that engage in R&D shifted their research activities towards a technological change (innovation and deployment of new technology) when covered by the EU ETS (Calel & Dechezleprêtre, 2016). Pricing policies encourage adoption of lower cost mitigation measures which requires marginal technology changes, rather than more radical, higher cost or potentially transformational innovation (Calel, 2020).[16] While there is evidence that carbon pricing stimulates innovation, there is no consensus on the impact of pricing policies on emissions.

5. Carbon pricing and a mid-century net zero target

As of November 2021, 135 countries have adopted a net zero target, with a mid-century or earlier date for more than 90% of the countries (Rogelj et al., 2021). A mid-century net zero target poses a challenge for mitigation of

[14]Calculated from EU ETS compliance data by sector for the period 2013 through 2019.
[15]Agriculture emissions are not covered. Electricity generation is virtually GHG emissions free so the tax does not affect the price of electricity.
[16]van den Bergh and Savin (2021) and Lilliestam et al. (2022) debate the evidence supporting the findings presented in Lilliestam et al. (2021).

emissions by EITE sources. Given a national net zero target this discussion assumes that EITE sectors have access to zero emissions electricity.[17]

Studies of options to reduce emissions by EITE sectors vary in terms of their geographic coverage, from global (van Sluisveld et al., 2021) to Europe (Marcu et al., 2021), Sweden (Nurdiawati & Urban, 2021) orthe US (Hasanbeigi et al., 2021). Although the sectoral coverage varies as well, all of the studies agree that decarbonization is possible by mid-century if more ambitious policies are implemented soon (Bashmakov et al., 2022).

The literature on policies to reduce the emissions of EITE sources shows support for a mix of policies, notably to include RD&D and commercialization of new technologies, carbon pricing, contracts for differences,[18] other subsidies, product/consumption charges, product standards, tradable performance standards (TPS),[19] and a carbon border adjustment mechanism (CBAM) (Bataille et al., 2018; Grubb et al., 2022; Nilsson et al., 2021).

Since the products of these EITE sources are traded, policy choice is constrained by international trade law.[20] Trade law requires that a country's treatment of 'like' imports may not discriminate on the basis of their country of origin or process or production methods. Providing rebates of mitigation costs on exported goods creates a risk that one or more importing countries will subject them to countervailing duties. Thus policies will differ for import-competing and export sectors.[21,22]

A package of policies that includes carbon pricing performs better than a carbon pricing policy on its own due to the existence of multiple market failures (Dubash et al., 2022). Carbon pricing can reduce the size of the rebound effect associated with most mitigation policies (Freire-González, 2020) with an ETS being more effective than a carbon tax (van den Bergh, 2011). An ETS with free allowances is part of most packages because of its demonstrated capacity to minimize leakage.

Figure 1 outlines possible policy packages for EITE sectors that a country could implement with minimal risk of adverse economic impacts.

Possible policy packages for EITE sectors that a country could implement with minimal risk of adverse economic impacts are illustrated in Figure 1. All options consider carbon pricing as part of the policy package. If a country is a net importer of an EITE good (I), a product charge based on emissions intensity can be levied on sales by domestic producers (a product specific carbon tax) with an equivalent carbon border adjustment (CBAM) for imports (1)[23,24] or a tradable performance standard can be instituted for domestic sales of a good (domestically produced or imported) with domestic producers covered by ETS with free allowance allocation (2).[25] If a country is net exporter of a good (II), financial assistance to domestic firms not tied to the level of export sales for R&D support, assistance for new/modernized plants, and worker training (3), or procuring goods with prices above market price from domestic firms e.g. using contracts for differences (4) can be considered to support low carbon development. Domestic producers of export goods in policy packages 3 and 4 are subject to an ETS and receive free allowances. Producers of EITE exports could be

[17]Decarbonization of the electricity supply may occur prior to or concurrent with decarbonization of the EITE sectors.
[18]Financial compensation for the marginal costs of low-carbon production compared to business as usual production.
[19]TPS do not explicitly put a price on carbon nor limit amount of emission allowances.
[20]Mitigation policies apply to sources while trade law applies to goods. Links between EITE sources and the internationally traded goods they produce must be established. This has already been done in the case of the EU ETS where the free allowance allocation to an installation is based on its production of specified emissions-intensive goods. So the links between 'goods' and 'sources' are clear.
[21]Sectors can be classified as part of the policy development process. For example an import competing good could be defined as one whose consumption exceeds domestic production and whose exports are less than X% of production while an export good is one whose production exceeds domestic consumption and whose imports are less than Y% of consumption.
[22]In practice it is unlikely that a country will be able to classify every traded good produced by EITE sectors as an import-competing or export good. Countries are likely to classify goods differently just as their definitions of sectors eligible for free allowances differ. And classifications are likely to change over time.
[23]See Böhringer et al. (2022) for a summary of the challenges involved in implementing a CBAM.
[24]Proposals in the EU's Fit for 55 Package indicate an incremental shift toward package 1 for producers of aluminum, cement, electricity, fertilizers and iron and steel (European Commission, 2021). Free allowances to producers of these goods under the ETS would be phased out between 2026 and 2035 and imports would be subject to an equivalent border adjustment. Requiring EU producers to purchase allowances has the effect imposing an emissions intensity charge on the goods they produce.
[25]A similar package could be implemented with a maximum emissions standard, but the tradable performance standard creates stronger incentives to reduce the good's emissions intensity and it raises fewer potential trade law problems.

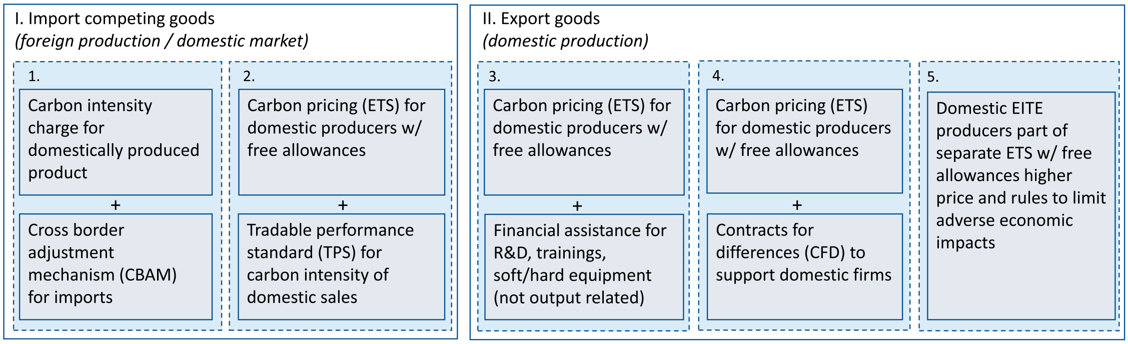

Figure 1. Five possible policy packages for countries depending on production and sales of EITE goods.

moved into a separate ETS with rules designed to ensure a higher allowance price while protecting international competitiveness (5).[26]

Effective mitigation policies have economic impacts. They increase the prices of emissions-intensive goods to induce changes in consumption, production and trade volumes with impacts on employment and economic activity domestically and in other countries.[27] Revenue generated by the carbon pricing in each policy package can fund domestic adjustments to cushion adverse impacts, for example through policies such as worker retraining and support for lower production levels.

6. Distributional effects of carbon pricing policies

The revenue raised by carbon pricing policies affects socio-economic groups differently and how that revenue is spent influences those distributional effects (Steenkamp, 2021). In practice, the use of carbon pricing revenue varies widely by jurisdiction. Some treat it as general revenue while others distribute it to firms and low income households and fund environmental projects and low carbon technologies to build public support for the policy (Raymond, 2019; World Bank, 2022).[28]

The most widely studied effect is the direct impact of a carbon tax on household income. Typically it is regressive in developed countries and progressive in developing countries (Koh et al., 2021; Köppl & Schratzenstaller, 2022). Governments can redistribute tax revenue to low income households or implement other changes to taxation and transfer systems to achieve desired distributional outcomes and avoid adverse impacts (e.g. Bertoldi, 2022; Budolfson et al., 2021).[29]

Even if a carbon tax is progressive, it increases prices for fuels, electricity, transport, food and other goods and services, an impact that adversely affects the most vulnerable. Thus, carbon taxes may not be suitable for developing countries with a limited capacity to effectively collect taxes and distribute the revenue to low income households (Steinebach & Limberg, 2022).

Distributional impacts typically have not been a significant issue for ETSs, in part due to relatively low allowance prices. Equity across participants, especially EITE sources, generally is addressed through free allowance allocations. Impacts of ETSs on household incomes, with the exception of electricity prices, have been too

[26]In addition to free allowances based on current output and a market stability reserve, the ETS for these installations could include a minimum and maximum price (Flachsland et al., 2020) and periodic reviews to ensure compliance costs do not exceed a specified share, such as 5%, of production costs.

[27]Adversely affected exporters may challenge the policies under international trade law and/or implement retaliatory trade measures. A number of countries that export the specified goods to the EU have expressed concerns with respect to its CBAM proposal (Acar et al., 2022; Eicke et al., 2021; Lim et al., 2021).

[28]Revenue raised through carbon taxes and ETSs is used differently (Carl & Fedor, 2016; Marten & van Dender, 2019; World Bank, 2022). About 40% of carbon tax revenue is treated as general revenue and most of the balance is used to offset the burden of the tax while about 80% of ETS auction revenue is earmarked for environmental objectives. EU member states are required to use ETS auction revenues to support energy efficiency, renewable energy supply and energy poor households.

[29]Equal per capita distribution – carbon dividends – is sometimes proposed.

small to be a concern. Some ETSs are designed to limit electricity price increases (Petek, 2020) or use some revenue for bill assistance to low-income households (RGGI, 2019).

Carbon pricing can reduce employment and/or wages in large emissions-intensive sources so economic impacts differ across communities depending upon their mix of emissions-intensive industries (Yip, 2018, 2020). This may also be the case between urban and rural areas (Creutzig et al., 2020).

7. Conclusions

A mid-century net zero target creates a challenge for reducing the emissions of EITE sectors that have high marginal mitigation costs, notably in aluminium, cement, chemicals, iron and steel, lime, pulp and paper and petroleum refining industries. Available studies agree that decarbonization is possible by mid-century if more ambitious policies are implemented soon.

More ambitious mitigation policies for EITE sectors are likely to vary by country, be implemented at different times and differ in ambition. Thus a country wishing to accelerate the decarbonization of these EITE sectors should design its mitigation policies to minimize the risk of leakage due to production shifts to different jurisdictions with less costly policies. To comply with international trade law policy packages for import-competing and export sectors will need to differ.

A country can implement policy packages on its own to reduce emissions by its EITE sectors. Since a country imports or exports the products of several EITE sectors a variety of policy packages for different sectors is likely. Carbon pricing is a critical component of each package due its ability to minimize the risk of adverse economic impacts, to support innovation and to generate revenue.

Policy packages for import-competing goods include:

- A product charge based on emissions intensity levied on sales of domestic goods and an equivalent carbon border adjustment mechanism (CBAM) for imports; and
- A tradable performance standard for domestic sales of a good (domestic or imported) together with an ETS with free allowance allocations for domestic producers.

Policy packages for export goods, that minimize the risk of countervailing duties imposed by importers, include an ETS with free allowances for domestic producers plus financial assistance not tied to the level of export sales. Examples of such financial assistance are R&D support, or support for new/modernized plants, for worker training or government purchases of low carbon products whose costs exceed the market price using contracts for differences. Alternately EITE producers of export goods could be moved into a separate ETS with provisions designed to ensure a higher allowance price while protecting international competitiveness.

Effective mitigation policies shift consumption and production patterns to reduce emissions. The impacts of those shifts, such as a plant closure, can be large or abrupt for specific income groups or regions. Carbon pricing revenue can be used to assist groups or regions adversely impacted by the domestic impacts of mitigation policies and to build public support for the policies.

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