Carbon Markets under the Paris Agreement: How Can Environmental Integrity Be Ensured?

Lambert Schneider

Propositions

1. Ensuring the environmental integrity of international carbon market mechanisms is difficult because environmental integrity can be undermined in many different ways and a single loophole can have a large impact.
   (this thesis)

2. Linking of emissions trading systems poses much less risks for environmental integrity than engaging in crediting mechanisms.
   (this thesis)

3. Regulatory oversight is critical for whether environmental markets foster innovation and lower costs or whether they give rise to abuse, fraud and corruption.

4. The principle that one policy instrument should be used to achieve one goal is not well suited to address environmental challenges in complex settings.

5. Cost-effectiveness is overvalued in climate policy: policy-makers should rather focus on long-term environmental effectiveness.

6. Multilateral agreements are essential to solve global challenges, even in a fragmented and polarized world where only the lowest common denominator can be agreed.

7. Perfectionism is a perfect way to unhappiness.

Propositions belonging to the thesis of Lambert Schneider

'Carbon Markets under the Paris Agreement: How Can Environmental Integrity Be Ensured?'

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Contents

Summary

The 2015 Paris Agreement allows countries to use international carbon market mechanisms to achieve their nationally determined contributions (NDCs). Carbon markets provide flexibility where and when emissions are reduced and could thereby lower the cost of mitigating climate change. This can help countries to enhance the ambition of their NDCs. If not designed and implemented robustly, however, carbon markets could lead to higher emissions and increase the cost of mitigating climate change. Ensuring environmental integrity of carbon market mechanisms is thus an important prerequisite for achieving their objectives.

This thesis assesses how the environmental integrity of international carbon market mechanisms can be ensured in the new context of the Paris Agreement in which all countries have NDCs. The thesis assesses how environmental integrity could be defined – here it is assumed to be ensured if the engagement in international transfers of carbon market units leads to the same or lower aggregated global emissions –, what the risks for undermining environmental integrity are, what approaches could be used to address these risks, and what this means for the future role of international carbon market mechanisms (see Figure S-1).

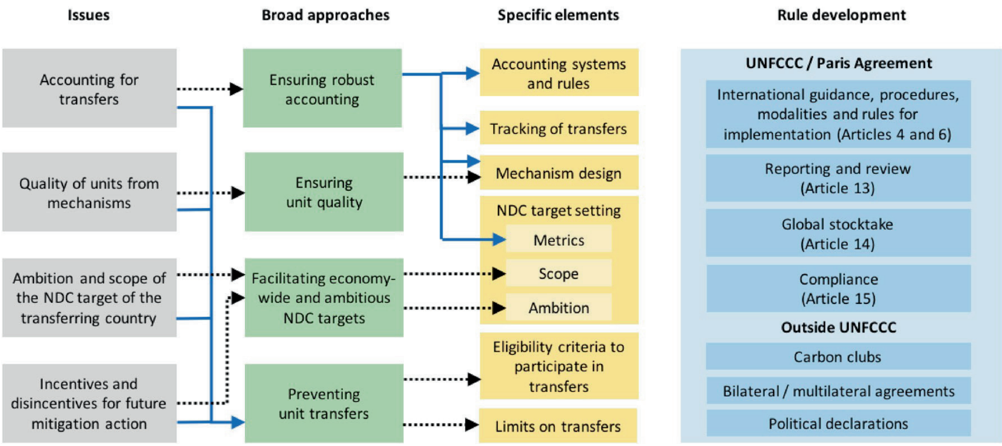

Figure S-1 Overview of approaches for addressing environmental integrity

The thesis identifies four factors that influence environmental integrity (Chapter 2):

- The accounting for international transfers of carbon market units;
- The quality of units generated (i.e. whether the market mechanism ensures that the issuance or transfer of units leads to emission reductions in the transferring country);
- The ambition and scope of the mitigation target of the transferring country; and
- Incentives or disincentives for future mitigation action, such as possible disincentives for transferring countries to define future mitigation targets less ambitiously or more narrowly in order to sell more units.

Robust accounting is a key prerequisite for ensuring environmental integrity. The diverse scope, metrics, types and timeframe of NDC targets is an important challenge, in particular for avoiding double counting and for ensuring that the accounting for carbon markets units is representative for the mitigation efforts by countries over time. The thesis identifies three ways in which double counting can occur: through double issuance (e.g. by issuing units from the same project under two crediting programs), through double claiming of the same emission reductions by the country where the emission reductions occur and the entity using the carbon market units, and through double use of carbon market units. A key finding is that double counting can also occur in rather indirect ways which can be challenging to identify. Effectively avoiding double counting mainly requires rules for accounting of unit transfers, appropriate design of carbon market mechanisms, and consistent tracking and reporting of units (Chapter 3).

Unit quality can, in theory, be ensured through appropriate design of carbon market mechanisms; in practice, existing mechanisms face considerable challenges in ensuring unit quality. The thesis assesses an interesting real-world example of how carbon markets can create perverse incentives and thereby undermine unit quality. It shows that projects abating HFC-23 and SF_6 waste gas emissions under the Kyoto Protocol's Joint Implementation mechanism increased waste gas generation to unprecedented levels as a means to increase credit revenues. Due to these perverse incentives, about two third of the issued credits do not represent actual emission reductions. This case study provides important lessons for carbon markets under the Paris Agreement because Joint Implementation was implemented in countries that had mitigation targets, and thus in a similar context as for countries with NDC targets (Chapter 4).

Unit quality is also an important matter for the new Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) adopted by the International Civil Aviation Organization. The scheme requires airline operators to purchase carbon market units to offset the increase in emissions above 2020 levels. It could constitute the single largest demand for carbon market units after 2020. The thesis shows that environmental integrity would be undermined if the scheme allows the unlimited use of credits from already implemented projects. While additionality and the quantification of emission reductions are, in principle, key considerations for unit quality for crediting mechanisms, the greenhouse gas (GHG) emissions impact from using credits from already implemented projects is more complex. If the supply of credits considerably exceeds demand, a key consideration for the global GHG emissions impact is whether already implemented projects would continue to reduce GHG emissions even without credit revenues, or whether they are 'vulnerable' to discontinuing GHG abatement. A detailed assessment of the status and operating conditions of projects under the Clean Development Mechanism, and their marginal costs of supplying credits, shows that most projects would continue GHG abatement even if they cannot sell credits. If CORSIA allows airline operators the unlimited use of offset credits from these projects, this will not only undermine its environmental objectives but also lead to continued low carbon prices, and thus neither offer incentives for new investments nor lead to any significant revenues for already implemented projects. The thesis recommends limiting eligibility under CORSIA to new or 'vulnerable' projects (Chapter 5).

Unit quality is also a key consideration when linking emissions trading systems (ETSs). As linking of ETSs faces several practical and political challenges and risks, including with regard to whether allowances have 'quality' and whether linking provides incentives or disincentives to enhance the ambition of caps, policy-makers are considering also restricted forms of linking ETSs. The thesis uses a simple economic model and three criteria – abatement outcome, economic implications, and feasibility – to assess three different options for implementing restricted linking of ETSs: quotas, exchange rates, or discount rates. The analysis shows that quotas can enhance cost-effectiveness relative to no linking and allow policy-makers to retain control on the extent of unit flows. Exchange rates could enhance abatement and economic benefits or have unintended adverse implications for cost-effectiveness and total abatement, depending on how rates are set. Due to information asymmetries between the regulated entities and policy-makers setting the exchange rate, and uncertainties about future developments, setting exchange rates in a manner that avoids such unintended consequences could prove difficult. Discount rates, in contrast, can ensure that both cost-effectiveness and total abatement are enhanced. The thesis recommends the consideration of quotas or discount rates, but to refrain from using exchange rates, due to the environmental integrity risks (Chapter 6).

The varying scope and ambition of current NDC targets, and possible disincentives to broaden their scope and enhance their ambition, could be addressed by facilitating the adoption of ambitious and economy-wide mitigation targets and by preventing the transfer of carbon market units in situations of high environmental integrity risks. This latter approach could be implemented through eligibility criteria or limits on the generation, transfer or use of carbon market units. Limits could in particular address the risk that some countries have mitigation targets that correspond to higher levels of emissions than independent projections of their likely emissions. If such ‘hot air’ can be transferred to other countries, it could increase aggregated emissions and create a perverse incentive for countries not to enhance the ambition of future mitigation targets. The thesis proposes a typology for such limits, explores key design options, and tests different types of limits in the context of fifteen countries. The analysis indicates that limits to international transfers could, if designed appropriately, prevent most of the hot air contained in current mitigation targets from being transferred, but also involve trade-offs between different policy objectives (Chapter 7).

The thesis concludes by discussing how four strategies to mitigate environmental integrity risks – robust accounting, ensuring unit quality, facilitating economy-wide and ambitious mitigation targets, and restricting international transfers – could be implemented under the Paris Agreement and CORSIA (see Figure S-1). Crediting mechanisms pose higher risks for environmental integrity than linking of ETSs and should therefore have a limited role in the future. International oversight can reduce the risks to environmental integrity to some extent. Acquiring countries could also reduce risks by only acquiring units from countries that also have ambitious NDC targets. Overall, policy-makers should not regard carbon market approaches as the one and only ‘silver-bullet’ to mitigating climate change but carefully assess what policy instrument or mix of instruments is best suited achieve and balance different policy objectives, in particular in light of the rapid transition that is necessary to achieve the goals of the Paris Agreement (Chapter 8).

Chapter 1
Introduction

Climate change is a serious threat to humanity. Its impacts are already being felt and could become much worse in the future. Climate-change impacts are diverse – including rising sea levels, more frequent extreme weather events, changing precipitation, expanding deserts, loss of biodiversity and ocean acidification – and could have serious consequences for humans, including significant loss and damage, threats to food security, abandonment of land, and increased migration (IPCC, 2014a). How much the earth will warm is critical for the scale of these effects. Limiting global mean temperature increase to 1.5°C above pre-industrial levels would have much less severe impacts than a 2°C increase but this would require a rapid peaking and steep decline of anthropogenic greenhouse gas (GHG) emissions thereafter (IPCC, 2018). Limiting climate change is also crucial because self-reinforcing feedbacks are a serious risk. They could push the earth beyond a threshold that causes continued warming in a 'hothouse-earth' pathway that likely causes series disruptions to ecosystems, society and economies, even if emissions are reduced (Steffen et al., 2018).

In 2015, after many years of negotiations, countries adopted the Paris Agreement to strengthen the global response to the threat of climate change (UNFCCC, 2015). This landmark treaty aims to hold the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit it to 1.5°C. To reach these goals, all countries must, every five years, formulate and communicate mitigation measures in the form of nationally determined contributions (NDCs). Countries can determine themselves what mitigation measures they pledge. NDCs should, however, reflect the country's "highest possible ambition" and each successive NDC should represent a "progression" beyond the current NDC. A 'global stocktake' is conducted every five years to assess whether the current mitigation pledges are adequate to meet the global goals of the Paris Agreement. This should then inform the formulation of countries' subsequent NDCs. This 'ambition cycle' aims to strengthen the mitigation actions by countries over time.

The agreement also includes several frameworks that support its implementation. Central elements are: an 'enhanced transparency framework' to track and review countries' progress in reducing GHG emissions and achieving their NDCs; a framework to engage in international carbon market mechanisms; a framework for providing financial resources to assist developing countries; and a "mechanism to facilitate implementation of and promote compliance". In 2018, countries adopted the Katowice Climate Package – a first package of a rules to implement the provisions of the Paris Agreement.

The Paris Agreement provides the international community with an ambitious framework for addressing climate change. This framework, however, needs to be filled and implemented by countries. In the run-up to the adoption of the Paris Agreement, many countries communicated intended nationally determined contributions which then became their first NDCs. With these NDCs, we are, however, off-track to reach the goals of the Paris Agreement. Current NDCs are estimated to lead to a temperature increase of about 2.6-3.1°C above pre-industrial levels (Rogelj et al., 2016). Global emissions are still rising while they should be declining very soon. Achieving the goals of the Paris Agreement will therefore require a transition at a scale and pace that has no precedent in history.

Carbon markets are seen as one of the possible means to raise the ambition of global mitigation action (Blandford, Davis, & Cozzi, 2017; Kreibich, 2018; Warnecke, Höhne, Tewari, Day, & Kachi, 2018). They provide flexibility where and when emissions are reduced and could thereby lower the cost of mitigating climate change. This can help countries to adopt more ambitious mitigation targets. Carbon markets could thus contribute to enhancing the ambition of NDCs and achieving the long-term goals of the Paris Agreement.

If not designed and implemented robustly, however, carbon markets could lead to higher emissions and increase the cost of mitigating climate change (see e.g. Kollmuss, Schneider and Zhezherin, 2015; Cames *et al.*, 2017). Ensuring environmental integrity of carbon market mechanisms is thus an important prerequisite for achieving the objectives of the Paris Agreement.

International carbon market mechanisms have been implemented under the 1997 Kyoto Protocol and in bilateral agreements. The Kyoto Protocol established three carbon market mechanisms: the Clean Development Mechanism (CDM), which enables industrialized countries with mitigation targets to use emission reduction credits from projects implemented in developing countries; Joint Implementation (JI), which does the same with projects implemented in industrialized countries; and international emissions trading (IET), which allows industrialized countries to trade carbon market units with one another.

The extent to which these mechanisms have achieved their stated goals has been questioned, particularly with regard to environmental integrity (Robert Bailis, Drigo, Ghilardi, & Masera, 2015; Calvin et al., 2015; Cames et al., 2017; Erickson, Lazarus, &

Spalding-Fecher, 2014; Haya & Parekh, 2011; He & Morse, 2013; Kollmuss et al., 2015; Michaelowa & Purohit, 2007; Purdon & Lokina, 2014; Schneider, 2009b, 2011; Spalding-Fecher et al., 2012; Tuerk, Fazekas, Schreiber, Frieden, & Wolf, 2013). Drawing on the lessons from those experiences is therefore vital to ensure that market mechanisms work as intended under the Paris Agreement.

The Paris Agreement establishes a new framework for using international carbon market mechanisms, which includes two main elements:

- *Cooperative approaches*: Article 6.2 allows countries to engage in 'cooperative approaches' and to use 'internationally transferred mitigation outcomes' (ITMOs) towards their NDCs. Article 6.2 is commonly understood to provide a framework that allows countries to engage in international carbon market mechanisms – be it through international linking of emission trading schemes (ETSs), international crediting mechanisms, or direct bilateral government-to-government transfers – and to use internationally transferred carbon market units to achieve their NDCs.
- *Crediting mechanism*: Article 6.4 establishes a new crediting mechanism under international oversight. The provisions of this mechanism resemble strongly those of the CDM: the mechanism has a dual objective of supporting mitigation action and sustainable development, is supervised by an international body, involves public and private entities, and requires mitigation action to be additional and to be verified by auditors.

The Paris Agreement requires that environmental integrity be ensured for both the cooperative approaches under Article 6.2 and the new crediting mechanism under Article 6.4. Articles 6.1 and 6.2 specifically refer to "promoting" and "ensuring" environmental integrity, and the provisions of the new crediting mechanism under Article 6.4 include several elements that aim to safeguard environmental integrity, such as that mitigation benefits be "real, measurable and long term" and that "additionality" be ensured (UNFCCC, 2015).

This thesis assesses key issues for ensuring the environmental integrity of international carbon market mechanisms. The main overarching research question of the thesis is:

> *How can the environmental integrity of international carbon market mechanisms be ensured in the new context of the Paris Agreement?*

To assess this, further research questions are:

1. How should environmental integrity be defined in the context of international carbon market mechanisms?

2. What influences environmental integrity and what are the risks for undermining environmental integrity?
3. What approaches could be used to mitigate environmental integrity risks and how could these approaches be implemented?
4. What should be the role of international carbon market mechanisms in the future, given the risks for environmental integrity and the available means to address them?

The thesis focuses on *international* carbon market mechanisms, noting that several aspects of the analysis and findings are also relevant for the *domestic* use of carbon market mechanisms. Moreover, the thesis focuses on the context of the *Paris Agreement* but also considers carbon market approaches that are implemented in other contexts. This holds in particular for the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) that was adopted by the International Civil Aviation Organization (ICAO) in 2016. This new global scheme requires airline operators to purchase carbon market units to offset increases in carbon dioxide emissions from international flights above 2020 levels (ICAO, 2016a, 2018). With a mitigation gap of 1.6 to 3.7 $GtCO_2$ over its operational period from 2021 to 2035, CORSIA could constitute the single largest demand for carbon market units after 2020 (Healy, 2017; ICAO, 2016b).

Chapter 2 of the thesis first provides a comprehensive overview of key issues and options for ensuring environmental integrity. This includes how environmental integrity could be defined – here it is assumed to be ensured if the engagement in international transfers of carbon market units leads to the same or lower aggregated global emissions – and a systematic identification and categorization of what influences environmental integrity and what approaches could mitigate environmental integrity risks.

The remainder of the thesis assesses specific aspects of achieving environmental integrity which were deemed to be of particular relevance for policy-makers and that had not yet been thoroughly investigated (Chapters 3 to 7). These aspects can be clustered in three broad themes:

1. *Accounting for the international transfer of carbon market units*: Article 6.2 of the Paris Agreement requires countries to "apply robust accounting to ensure, inter alia, the avoidance of double counting". A lack of robust accounting could undermine environmental integrity in several ways (Chapter 2). If emission reductions are double counted, for example, actual global GHG emissions are higher than the sum of what individual countries report (see Chapter 3). Establishing and implementing robust accounting rules is thus an important prerequisite for achieving environmental integrity (see Chapters 2 and 3). An important question is therefore how robust accounting can be implemented in the new context of the Paris Agreement, taken into account the diverse scopes, metrics, types and timeframes of current NDC targets.

2. *Quality of carbon market units*: International carbon market mechanisms typically issue units which can be transferred through registries. If units do not have quality (i.e., if they do not lead to at least 1 tCO_2e of emission reductions in the transferring country) aggregated emissions could increase (Chapter 2). An important question is therefore how future mechanisms should be designed so that they ensure unit quality, taking into account the new context of the Paris Agreement and the experiences and lessons from the existing mechanisms.
3. *Incentives and disincentives for enhancing mitigation action*: Article 4.3 of the Paris Agreement calls for a "progression" of NDCs reflecting the "highest possible ambition", and Article 4.4 encourages developing countries to move over time towards economy-wide targets. Moreover, Article 6.1 of the Paris Agreement explicitly envisages that the engagement of countries in international carbon market mechanisms allows for "higher ambition" in their mitigation actions. In practice, however, the possibility to engage in international carbon market mechanisms could provide both incentives or disincentives for enhancing mitigation action, and, vice versa, the ambition and scope of NDCs can affect the global GHG emissions impact of international carbon market mechanisms in various ways (Chapter 2). An important question is therefore how the engagement in carbon market mechanisms can provide incentives, rather than disincentives, for enhancing the ambition and broadening the scope of NDC targets over time and avoid perverse incentives and lock-in into higher emissions pathways.

Table 1-1 illustrates how the specific aspects investigated in this thesis relate to these three themes. Each chapter corresponds to a paper that has been published in a peer-reviewed journal. The papers have been editorially revised when including them in this thesis.

Chapter 3 examines in detail how *double counting of emission reductions* can be avoided. Robust accounting and in particular avoiding double counting is a focus of international negotiations on the rules governing Article 6 of the Paris Agreement, and international negotiations in Katowice in December 2018 failed on the question how double counting should be avoided for the crediting mechanism established under Article 6.4. This chapter assesses how double counting can occur, when it is relevant and how it could be addressed through international rules and the design of carbon market mechanisms.

Chapter 4 turns to the second theme and assesses an interesting real-world example of how carbon markets can create *perverse incentives* and thereby undermine unit quality. As part of a larger study on the performance of the Joint Implementation (JI) mechanism under the Kyoto Protocol (Kollmuss et al., 2015), this chapter assesses how projects abating hydrofluorocarbon-23 (HFC-23) and sulphur hexafluoride (SF_6) waste gas emissions in Russia increased the generation of waste gases to unprecedented levels as a means to increase credit revenues from the mechanism. This case presents an important lesson for carbon markets under the Paris Agreement because JI was implemented in countries that had mitigation targets, and thus in a similar context as for countries with NDC targets.

Table 1-1 Thematic focus of the chapters of the thesis

	Accounting for the international transfer of carbon market units	Quality of carbon market units	Incentives or disincentives for future mitigation action
Chapter 2: Environmental integrity of international carbon market mechanisms under the Paris Agreement			
Chapter 3: Addressing the risk of double counting emission reductions under the UNFCCC			
Chapter 4: Perverse effects of carbon markets on HFC-23 and SF6 abatement projects in Russia			
Chapter 5: Robust eligibility criteria essential for new global scheme to offset aviation emissions			
Chapter 6: Restricted linking of emissions trading systems: options, benefits, and challenges			
Chapter 7: When less is more: Limits to international transfers under Article 6 of the Paris Agreement			
Chapter 8: Discussion, conclusions and recommendations			

Note: Dark green indicates that this aspect is the main focus of the chapter. Bright green indicates that this aspect is also considered. Grey indicates that this aspect is not considered.

Chapter 5 takes up a matter that is controversially debated under both ICAO and the Paris Agreement: whether carbon market units from the Kyoto mechanisms should be eligible for use after 2020. The chapter assesses the environmental and economic implications of using offset credits from the largest mechanism to date – the CDM – under CORSIA, and analyses what type of *eligibility criteria* are necessary to perverse environmental integrity. Towards this end, a model is established that estimates the supply potential and the costs of generating certified emission reductions (CERs) for each of the 8,000 registered CDM projects and assesses under which conditions creating new demand for CERs from already existing projects triggers actual emission reductions, taking into account differences between project types.

Chapter 6 turns the focus from crediting mechanisms to another form of international carbon market mechanisms: the linking of ETSs. Several jurisdictions are considering, or have already established, links between their ETSs (ICAP, 2018), and some plan to account for the net flow of allowances between the linked ETSs under Article 6.2 of the Paris Agreement (European Union, 2017; Schneider, Cludius, & La Hoz Theuer, 2018). As linking of ETSs faces several practical and political challenges and risks, including with regard to whether allowances have 'quality' and whether linking provides incentives or disincentives to enhance the ambition of caps (Carbone, Helm, & Rutherford, 2009; Green, 2016; Helm, 2003; Holtsmark & Sommervoll, 2012), policy-makers are considering also *restricted forms of linking ETSs* in order to mitigate these risks. This chapter uses a simple economic model and three criteria – abatement outcome, economic implications, and feasibility – to assess three different options for implementing restricted linking of ETSs: quotas, exchange rates, or discount rates options.

Chapter 7 analyses a different approach to preserving environmental integrity, namely through *limits* to international transfers under Article 6 of the Paris Agreement. Limits, or eligibility criteria, are mainly considered to address the risk that countries could transfer 'hot air' – a term used in context of mitigation targets that countries over-achieve without pursuing further mitigation actions (Boehringer, 2000; den Elzen & de Moor, 2002; Kollmuss et al., 2015). They could, however, also be used to address other environmental integrity risks, such as the lack of robust accounting system, concerns related unit quality, or possible disincentives to enhance mitigation action in the future. This chapter proposes a typology for limits, explores key design options, and quantitatively tests different types of limits in the context of fifteen countries.

Lastly, *Chapter 8* discusses the overall findings of the thesis, provides conclusions and makes recommendations. These can inform the ongoing negotiations on Article 6 of the Paris Agreement, and the implementation of carbon market mechanisms by countries, jurisdictions and international organizations, such as ICAO.

Chapter 2
Environmental integrity of international carbon market mechanisms under the Paris Agreement

Abstract

The Paris Agreement establishes provisions for using international carbon market mechanisms to achieve climate mitigation contributions. Environmental integrity is a key principle for using such mechanisms under the Agreement. This paper systematically identifies and categorizes issues and options to achieve environmental integrity, including how it could be defined, what influences it, and what approaches could mitigate environmental integrity risks. Here, environmental integrity is assumed to be ensured if the engagement in international transfers of carbon market units leads to the same or lower aggregated global emissions. Four factors are identified that influence environmental integrity: the accounting for international transfers; the quality of units generated (i.e. whether the mechanism ensures that the issuance or transfer of units leads to emission reductions in the transferring country); the ambition and scope of the mitigation target of the transferring country; and incentives or disincentives for future mitigation action, such as possible disincentives for transferring countries to define future mitigation targets less ambitiously or more narrowly in order to sell more units. It is recommended that policy-makers combine several approaches to address the significant risks to environmental integrity.

Key policy insights:

- Robust accounting is a key prerequisite for ensuring environmental integrity. The diversity of nationally determined contributions is an important challenge, in particular for avoiding double counting and for ensuring that the accounting for international transfers is representative for the mitigation efforts by Parties over time.
- Unit quality can, in theory, be ensured through appropriate design of carbon market mechanisms; in practice, existing mechanisms face considerable challenges in ensuring unit quality. Unit quality could be promoted through guidance under Paris Agreement Article 6, and reporting and review under Article 13.
- The ambition and scope of mitigation targets is key for the incentive for transferring countries to ensure unit quality because countries with ambitious and economy- wide

targets would have to compensate for any transfer of units that lack quality. Encouraging countries to adopt ambitious and economy-wide NDC targets would therefore facilitate achieving environmental integrity.

- Restricting transfers in instances of high environmental integrity risk – through eligibility criteria or limits – could complement these approaches.

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2.1 Introduction

International carbon market mechanisms provide flexibility as to where and when greenhouse gas (GHG) emissions are reduced, and could thereby reduce the costs of mitigating climate change. This can help countries to adopt more ambitious mitigation targets. If not designed and implemented appropriately, however, international carbon market mechanisms could lead to higher global GHG emissions and could thereby also increase the costs of mitigating climate change.

International carbon market mechanisms have been implemented under the 1997 Kyoto Protocol and in bilateral agreements, including the international linking of emissions trading systems and bilateral crediting mechanisms such as the Joint Crediting Mechanism initiated by Japan.

The Paris Agreement establishes a new framework for voluntary cooperation that can involve international carbon market mechanisms to achieve climate mitigation contributions (UNFCCC, 2015). Article 6.2 allows countries to use 'internationally transferred mitigation outcomes' (ITMOs) to achieve their nationally determined contributions (NDCs), while Article 6.4 establishes a new crediting mechanism under international oversight. Environmental integrity is a key principle of Article 6 and the Paris Agreement.

This paper identifies and categorizes key issues and options for achieving environmental integrity, both for international carbon market mechanisms in general and for the specific context of the Paris Agreement. The paper first explores possible options for defining environmental integrity. Drawing upon available research on specific aspects of environmental integrity, the paper then systematically identifies and categorizes what factors influence environmental integrity and how environmental integrity could be undermined. This is followed by a systematic identification and categorization of possible approaches to mitigate environmental integrity risks in the context of the Paris Agreement. Based on this analysis, conclusions and recommendations are provided.

The environmental integrity of international carbon market mechanisms has, so far, mainly been investigated in the context of the 1997 Kyoto Protocol. Research on the Clean Development Mechanism (CDM) under Article 12 of the Protocol focused on the additionality of projects (Cames et al., 2017; Erickson et al., 2014; Gillenwater, 2012; Greiner & Michaelowa, 2003; Haya & Parekh, 2011; He & Morse, 2013; Michaelowa & Purohit, 2007; Schneider, 2009b; Spalding-Fecher et al., 2012; Stua, 2013; Trexler, Broekhoff, & Kosloff, 2006); the establishment of emission baselines (Robert Bailis et al., 2015; Fischer, 2005; Hermwille, Arens, & Burian, 2013; Kartha, Lazarus, & Bosi, 2004; Kartha, Lazarus, & LeFranc, 2005; Lazarus, Kartha, Ruth, Bernow, & Dunmire, 1999; Spalding-Fecher & Michaelowa, 2013) and how national policies should be considered in demonstrating additionality and establishing baselines (Liu, 2015; Spalding-Fecher, 2013). Other research areas include leakage effects (Calvin et al., 2015; Geres & Michaelowa, 2002; Kallbekken, 2007; Schneider, Lazarus, & Kollmuss, 2010; Sonter, Barrett, Moran, & Soares-Filho, 2015; Vöhringer, Kuosmanen, & Dellink, 2006), monitoring of emission reductions (Shishlov & Bellassen, 2016; Warnecke, 2014), and how the CDM could provide global net emissions reductions (Chung, 2007; Erickson et al., 2014; Kollmuss & Lazarus, 2011; Schneider, 2009a; Vrolijk & Phillips, 2013; Warnecke, Wartmann, Höhne, & Blok, 2014). Less literature is available on the environmental integrity of Joint Implementation under Article 6 of the Protocol (Kollmuss et al., 2015; Michaelowa, 1998; Schneider & Kollmuss, 2015) and International Emissions Trading under Article 17 of the Protocol (Aldrich & Koerner, 2012; Tuerk et al., 2013).

Relevant research was also conducted in the context of the negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) prior to the adoption of the Paris Agreement. This included mainly research on accounting for international transfers (Hood, Briner, & Rocha, 2014; Lazarus, Kollmuss, & Schneider, 2014; Prag, Aasrud, & Hood, 2011; Prag, Hood, Aasrud, & Briner, 2011; Prag, Hood, & Barata, 2013; Rich, Bhatia, Finnegan, Levin, & Mitra, 2014; Schneider, Kollmuss, & Lazarus, 2015); additionality and baseline setting for new, up-scaled carbon market mechanisms (de Sépibus & Tuerk, 2011; Füssler, Herren, Kollmuss, Lazarus, & Schneider, 2014); and governance arrangements (de Sépibus, Sterk, & Tuerk, 2013).

The environmental integrity of international carbon market mechanisms has also been studied outside the context of the UNFCCC and its Kyoto Protocol, with a focus on international linking of emissions trading schemes (Beuermann, Bingler, Santikarn, Tänzler, & Thema, 2017; Bodansky, Hoedl, Metcalf, & Stavins, 2016; Ranson & Stavins, 2016; Schneider, Lazarus, Lee, & van Asselt, 2017); the incentives for countries to enhance or lower the ambition of mitigation targets if they can engage in international carbon market mechanisms (Carbone et al., 2009; Helm, 2003; Holtsmark & Sommervoll, 2012); and non-governmental crediting programs (Erickson & Lazarus, 2013; Lee, Lazarus, Smith, Todd, & Weitz, 2013).

The Paris Agreement provides a new context for ensuring environmental integrity of international carbon market mechanisms. The diversity of NDC targets and less international oversight than under Kyoto Protocol could pose challenges for ensuring environmental integrity. Moreover, countries might implement new types of carbon market mechanisms, such as broad carbon pricing approaches or measures at the sectoral level, which may require new methods for quantifying emission reductions and ensuring environmental integrity.

A practical challenge is that the provisions of the Paris Agreement relating to environmental integrity are relatively general – which could be seen as 'constructive ambiguity' in order to achieve consensus – and are interpreted by Parties in different ways. For example, there is no agreement whether and how the international guidance under Article 6.2 should address environmental integrity.

The available research on environmental integrity in the context of the Paris Agreement focuses mainly on specific aspects, in particular accounting for international transfers, the design of crediting mechanisms, governance issues, incentives and disincentives for raising ambition, and the possible transition of the Kyoto mechanisms to the framework of the Paris Agreement (Bodansky et al., 2016; Broekhoff, Füssler, Klein, Schneider, & Spalding-Fecher, 2017; Cames et al., 2016; Greiner, Howard, Chagas, & Hunzai, 2017; Hermwille & Obergassel, 2018; Howard, 2017, 2018; Howard, Chagas, Hoogzaad, & Hoch, 2017; Kreibich, 2018; Kreibich & Hermwille, 2016; Kreibich & Obergassel, 2016; La Hoz Theuer, Schneider, Broekhoff, & Kollmuss, 2017; Marcu, 2017; Michaelowa et al., 2016; Michaelowa & Butzengeiger, 2017; Mizuno, 2017; Schneider, Füssler, Kohli, et al., 2017; Schneider & La Hoz Theuer, 2017; Spalding-Fecher, 2017; Spalding-Fecher, Sammut, Broekhoff, & Füssler, 2017; Stavins & Stowe, 2017; Warnecke et al., 2018).

These specific aspects have not yet been assessed and categorized in a systematic manner. This paper analyses the relevant provisions of the Paris Agreement, reviews the relevant literature, and evaluates submissions by Parties to the UNFCCC secretariat[1], with a view to defining environmental integrity (Section 2.2), identifying and categorizing risks to environmental integrity (Section 2.3), and identifying and categorizing approaches to address them (Section2.4). Based on this analysis, conclusions and recommendations are provided (Section 2.5).

The paper employs specific terminology and makes several assumptions. Mitigation targets communicated in NDCs are referred to as 'NDC targets'. For simplicity, the term 'international transfers' is used to refer to transfers of both mitigation outcomes generated under Article 6.2 and emission reductions resulting from the Article 6.4 mechanism. It is assumed that international mechanisms under Article 6 issue 'units' which are expressed as metric tons of CO_2 equivalent (tCO_2e), although the findings of this paper also hold if no formal units were issued. It is further assumed that countries achieve their NDC targets and that units are internationally transferred and used towards achieving NDC targets, and not for other purposes such as voluntary cancellation.

[1] http://www4.unfccc.int/sites/SubmissionPortal/Pages/Home.aspx

2.2 How could environmental integrity be defined?

The term 'environmental integrity' is used in various UNFCCC decisions and the Paris Agreement but not defined. Articles 6.1 and 6.2 of the Paris Agreement refer to "promoting" and "ensuring" environmental integrity. The provisions of the Article 6.4 mechanism do not refer to environmental integrity specifically, but include several elements that aim to safeguard it, such as that mitigation benefits be "real, measurable and long term"; that "additionality" be ensured; and that emission reductions be "verified and certified by designated operational entities". Environmental integrity is also referred to in other parts of the Paris Agreement and its decision on adoption (Article 4.13 and paragraphs 92 and 107 of decision 1/CP.21).

Based on a review of submissions and the literature (IPCC, 2014b; Woerdman, 2005), three possible definitions for environmental integrity are identified for the context of Article 6:

1. *Aggregate achievement of mitigation targets*: Environmental integrity would be ensured if the engagement in international transfers does not lead to a situation where aggregate actual emissions would exceed the aggregated target level;
2. *No increase in global aggregate emissions*: Environmental integrity would be ensured if the engagement in international transfers leads to aggregated global GHG emissions that are no higher as compared to a situation where the transfers did not take place; or
3. *Decrease of global emissions:* Environmental integrity would be ensured if the engagement in international transfers leads to a decrease in global GHG emissions as compared to a situation where the transfers did not take place.

The first approach would imply that global GHG emissions could increase as a result of engaging in international transfers. It would enable countries to engage in transfers that are not associated with any "mitigation outcomes", as referred to in Article 6.2. This approach also seems inconsistent with the principle in Article 6.1 that cooperation should "allow for higher ambition". The third approach would build on the objective in Article 6.1 to "allow for higher ambition" and that in Article 6.4 to "deliver an overall mitigation in global GHG emissions". However, enhancing ambition and ensuring environmental integrity are two separate concepts in the Paris Agreement. Combining these concepts may be more complex to operationalize and could dilute each of them. In the following, the second definition is therefore employed.

2.3 What influences environmental integrity?

Various factors influence the global GHG emissions outcome from using international carbon market mechanisms. Drawing on the review of submissions and the literature, four main factors are identified:

1. Accounting for international transfers;
2. Quality of units;
3. Ambition and scope of the mitigation target of the transferring country; and
4. Incentives or disincentives for future mitigation action.

2.3.1 Accounting for international transfers

Robust accounting of international transfers is a key prerequisite to ensure environmental integrity: if international transfers are not accounted for robustly, global GHG emissions could increase as a result of the transfers. A lack of robust accounting could undermine environmental integrity in several ways.

First, if emission reductions are double counted, actual global GHG emissions are higher than the sum of what individual countries report. Double counting occurs when a single GHG emission reduction is counted more than once towards achieving mitigation targets. This can occur in three ways (Hood et al., 2014; Prag, Hood, et al., 2011; Prag et al., 2013; Schneider et al., 2015; UNFCCC, 2012c):

1. *Double issuance* occurs if more than one unit is issued for the same emissions or emission reductions;
2. *Double claiming* occurs if the same emission reductions are counted twice towards fulfilling targets: by the country where the reductions occur, through reporting of its reduced GHG emissions, and by the country or entity using the units issued for these reductions. It could also occur between national mitigation targets and international mechanisms to address emissions from international aviation or international shipping, such as the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) adopted by the International Civil Aviation Organization (ICAO, 2016a); and
3. *Double use* occurs if the same issued unit is used twice to achieve a mitigation target.

Second, the time frame of mitigation targets is a critical issue when accounting for international transfers. If the time period in which transferred mitigation outcomes occur – also referred to as the 'vintage' of mitigation outcomes – differs from the year or period in which they are used to achieve a mitigation target, cumulative global GHG emissions could increase (Hood et al., 2014; Kreibich & Obergassel, 2016; Lazarus et al., 2014; Prag et al., 2013; Rich et al., 2014; Schneider, Füssler, Kohli, et al., 2017). This could, for example, occur if a country uses international transfers from a cumulative mitigation effort over a period to achieve a single-year target.

Third, if countries use different metrics for mitigation targets, such as different values for global warming potentials (GWPs), the international transfer of carbon market units can – if not converted appropriately – increase global GHG emissions.

Lastly, international transfers can involve activities that may result in emission reductions or removals that are only temporary, such as in the land-use, land-use change and forestry sector or in the case of geological storage of CO_2. If reversals of emission reductions or removals are not appropriately accounted for, cumulative global GHG emissions could increase.

Under the Paris Agreement, the diversity of NDCs is a key challenge for ensuring robust accounting for international transfers. Mitigation commitments under the Kyoto Protocol were economy-wide and expressed in absolute amounts of GHG emissions. They were also based on common multi-year periods, GHGs and GWP values. Under the Paris Agreement, however, countries communicated a variety of mitigation targets in their NDCs. Some targets are not economy-wide but cover only some sectors, gases, activities or geographical areas. The absolute level of GHG emission targets is not always clear, in particular when targets represent a deviation from a business as usual emissions pathway that could be updated in the future. Many countries communicated also targets in metrics other than GHG emissions, such as targets for renewable energy deployment. Most countries communicated only targets for a specific year and not a period, and countries use different GWP values (Graichen, Cames, & Schneider, 2016). If countries with different target metrics, target years or GWP values engage in international transfers, this could lead to higher global GHG emissions.

A further challenge specific to the Paris Agreement is that many NDCs include targets that are 'conditional' on support from other countries, sometimes in combination with less ambitious 'unconditional' targets. Some countries have stated in their NDC that such support could include the use of international market mechanisms. If, however, the same emission reductions are used to achieve both the conditional NDC of the transferring country and the NDC of the supporting country, this constitutes double claiming and leads to a weakening of overall ambition, compared to a situation where support is provided through forms of climate finance, in which the supporting country does not use the emission reductions to achieve its own NDC.

2.3.2 Quality of units

International carbon market mechanisms typically issue units which can be transferred through registries. Here, units are defined as having quality if the underlying mechanism ensures that the issuance or transfer of one unit, expressed as 1 tCO_2e, *directly* leads to an emission reduction of at least 1 tCO_2e in the transferring country, compared to the situation in the absence of the mechanism. Hence, here the *direct* emissions outcome from the underlying mechanism is considered, independently of other more indirect factors, such as the ambition and scope of the mitigation target of the transferring country.

The factors that influence the unit quality vary according to the type of mechanism.

Under *crediting mechanisms*, the quality of credits is, in principle, ensured if the mitigation action is additional – that is, it would not occur in the absence of the incentives from the crediting mechanism – and if the emission reductions are not overestimated. Ensuring that emission reductions are not overestimated involves several aspects, including that the emission reductions be real, measurable and attributable to the credited activity and that indirect emission effects be appropriately considered.

In a market situation where the supply of credits considerably exceeds demand, however, the GHG emissions impact from creating further demand for credits is more complex. If in such a market situation projects have already been implemented – and hence investment costs are sunk – a key consideration for the global GHG emissions impact is whether the projects would continue to reduce GHG emissions even without credit revenues, or whether they are at risk of discontinuing GHG abatement (Schneider & La Hoz Theuer, 2017; Warnecke et al., 2017).

Under *emission trading systems (ETSs)*, the quality of allowances mainly depends on whether the ETS cap is set below the emissions level that would occur in the absence of the trading system, and whether emissions are monitored appropriately. Other design features, such as price collars, allowance reserves, import of credits, and provisions for banking of allowances, also affect unit quality – mainly by altering the cap. If an ETS with an ambitious cap is linked to one that is over-allocated, linking could reduce aggregated abatement from both systems (Green, Sterner, & Wagner, 2014).

The Paris Agreement could also enable *direct bilateral government-to-government transfers*, without using a crediting mechanism or linking ETSs, akin to transfers of assigned amount units (AAUs) under Article 17 of the Kyoto Protocol. In some instances, these transfers could be underpinned by mechanisms: under the Kyoto Protocol, for example, countries established Green Investment Schemes (GISs) under which revenues from international transfers of AAUs were invested in activities designed to assist climate change mitigation (Tuerk et al., 2013). Where mitigation outcomes from specific mitigation actions are transferred, the quality of the transferred units hinges on similar criteria as for crediting mechanisms. Where direct bilateral transfers occur without implementing any mitigation action, the transferred units would not have quality.

2.3.3 Ambition and scope of the mitigation target of the transferring country

The mitigation target of a transferring country can affect the global GHG emissions impact of international transfers *indirectly*, because the target's scope and ambition may determine whether the transfer of units that lack quality impacts the country's efforts in achieving its target. Assume a country that issues units lacking quality. The units are issued for emission reductions that fall within the scope of the country's target and are transferred to another country which uses them to achieve its target. If the transferring country has an *ambitious* target – which requires the country to pursue further mitigation action to achieve its target – it may have to compensate for the transfer in order to still achieve its target, either by further reducing emissions or by purchasing units. The country thus has an incentive to ensure that units generated by mechanisms have quality. The same may not be true, however, for a country with a target that is less stringent than its business-as-usual (BAU) emissions (i.e. which does not require the country to take mitigation action to achieve its target) or for units issued for emissions or emission reductions that fall outside the scope of the target. In these instances, the country might accrue more financial revenues from over-estimating emissions reductions and selling the resulting units, without infringing its ability to achieve its target.

The more ambitious a mitigation target is, the more likely it is that a country would compensate for the transfer of units that lack quality and therefore only authorize the transfer of quality units. This is supported by evidence from Joint Implementation under the Kyoto Protocol where units from countries with ambitious Kyoto Protocol targets were assessed to have a significantly higher quality than those from countries with targets less stringent than the likely BAU emissions (Kollmuss et al., 2015). Whether a country compensates for a lack of unit quality and has incentives to ensure unit quality may also depend on *when* transfers are made. Before the target year or period, the country may not have certainty whether it will achieve its target and may thus be cautious in authorizing projects. However, once over-achievement of the target becomes certain, the country may have less incentive to ensure unit quality because it may no longer have to compensate for the transfer of units that lack quality.

Under the Paris Agreement, a key challenge is that countries self-determine the ambition and scope of their mitigation targets. Independent evaluations indicate that the ambition of current NDC targets varies strongly, despite the uncertainties and limitations in assessing such ambition. A number of countries are projected to significantly over-achieve their NDC targets with current policies in place. Moreover, the scope of many NDC targets is limited to some gases or sectors (Aldy & Pizer, 2016; Höhne, Fekete, den Elzen, Hof, & Takeshi, 2017; La Hoz Theuer, 2016; Meinshausen & Alexander, 2016; Rogelj et al., 2016).

Two important conclusions can be drawn from these considerations. First, a lack of unit quality is critical in two situations: if the emission sources are not included within the scope of a mitigation target, or if the transferring country has a target that does not require further mitigation action. Second, the ambition and scope of targets is key for the incentive to ensure unit quality. Encouraging countries to adopt ambitious and economy-wide NDC targets may therefore also facilitate achieving environmental integrity under Article 6.

2.3.4 Incentives or disincentives for future mitigation action

International carbon markets could lower the cost of mitigation, and thereby enable countries to adopt more ambitious mitigation targets. Article 6.1 of the Paris Agreement explicitly envisages that the engagement of countries in international transfers allows for "higher ambition" in their mitigation actions. In practice, however, the possibility to engage in international carbon market mechanisms could provide both incentives and disincentives for future mitigation action – and thereby indirectly affect GHG emissions both positively and negatively.

For acquiring countries, using international carbon markets could lower the costs of achieving their targets, and thereby enable these countries to adopt more ambitious targets. Yet for transferring countries, the possibility to use international carbon markets could create incentives to set mitigation targets at unambitious levels, or to define their scope narrowly, in order to accrue more benefits from transferring units internationally (Carbone et al., 2009; Green, 2016; Helm, 2003; Holtsmark & Sommervoll, 2012; Howard, 2018; Spalding-Fecher, 2017; Warnecke et al., 2018).

International carbon market mechanisms could also affect mitigation efforts in more indirect ways:

- Implementing market mechanisms could help to build capacity and increase awareness of climate issues, which might lead to enhanced mitigation efforts in the future (Spalding-Fecher et al., 2012);
- Under crediting mechanisms, transferring countries could have perverse incentives not to adopt mitigation policies, because such policies might lower the potential for generating and exporting credits (Liu, 2015; Spalding-Fecher, 2013; Strand, 2011). This poses a dilemma: if crediting mechanisms require project developers to consider mitigation policies and regulations in the demonstration of additionality, they may discourage policy-makers from adopting such policies. If they allow project developers to ignore mitigation policies and regulations, they may credit activities that are not additional, because they would be implemented anyway due to the policies and regulations;
- Crediting mechanisms could also create perverse incentives for project developers to pursue a more GHG-intensive course of action, so that the baseline from which emission reductions are credited is higher (Schneider, 2011; Schneider & Kollmuss, 2015); and
- Depending on how carbon market mechanisms are implemented, market participants could favour mitigation actions that are cost-effective in the short and medium term, and neglect mitigation actions that are costlier but foster transformational change and avoid lock-in of more carbon-intensive technologies. For example, crediting landfill gas capture could provide incentives to continue pursuing landfilling, while other

waste management practices, such as composting or recycling, would lead to lower GHG emissions.

2.4 Addressing environmental integrity under the Paris Agreement

Environmental integrity could be addressed in different ways, which are clustered here into four broad approaches: robust accounting; ensuring unit quality; facilitating economy-wide and ambitious mitigation targets; and restricting international transfers. Here we discuss how these four approaches could be implemented in the context of the Paris Agreement. For each approach, specific elements to implement it are identified and briefly discussed (Figure 2-1). The effectiveness and the political and practical feasibility of the approaches may strongly hinge on how they would be implemented and is subject to further research.

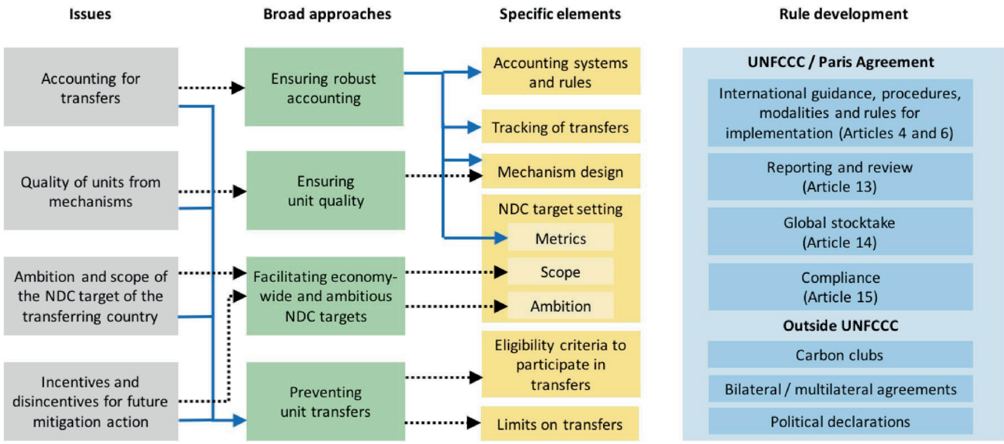

Figure 2-1 Overview of approaches for addressing environmental integrity

2.4.1 Robust accounting

The Paris Agreement and decision 1/CP.21 include several provisions to achieve robust accounting: Article 4.13 requires countries to "account for their NDCs". Article 6.2 requires countries engaging in international transfers to "apply robust accounting to ensure, inter alia, the avoidance of double counting". Article 6.5 requires that emission reductions resulting from the Article 6.4 mechanism be used by only one Party to achieve its NDC. This is complemented by the transparency framework in Article 13, which requires countries to track progress towards achieving NDCs, and the global goals of the Paris Agreement.

Accounting for NDCs is an important prerequisite for accounting for international transfers. This requires that NDC targets are clearly defined (e.g. with regard to their geographical coverage, the emissions sources and GHGs included and the time frame covered); that they are expressed in quantifiable terms (e.g. GHG emissions or megawatts of renewable power capacity); that the target level be clearly specified (e.g. in relation to historical data or a BAU emissions path); and that progress towards NDC targets be tracked.

Accounting for *international transfers* requires several additional elements to be implemented. Establishing an *accounting system* and *accounting rules* for international transfers is a central element, in particular to avoid double claiming and to ensure that the accounting for international transfers is representative of the mitigation efforts by Parties over time.

Paragraph 36 of decision 1/CP.21 envisages that double claiming be avoided on the basis of 'corresponding adjustments' for emissions or removals. Corresponding adjustments could be applied to reported emission totals or to an emissions budget that reflects the emissions level of the NDC target, similar to the 'assigned amounts' established under the Kyoto Protocol. Both approaches avoid double claiming and imply that the transferring country would, for each unit transfer, need to reduce its emissions below its NDC target. Corresponding adjustments could be applied to transferring countries in two ways: either they are only applied if the emission reductions fall within the scope of the NDC target, or they are applied in an all cases, regardless of the scope of the transferring country. And they could apply to international transfers in the context of both Article 6.2 and Article 6.4, or different approaches could be employed for international transfers of emission reductions generated under the Article 6.4 mechanism (Howard et al., 2017; Kreibich & Obergassel, 2016; Schneider, Füssler, Kohli, et al., 2017; Spalding-Fecher, 2017).

Several practical challenges arise from the diversity of current NDCs. Targets in *non-GHG metrics* could be accounted for by applying adjustments in the respective metric of that target. For example, if a country has a target of installing 100 Megawatt of renewable power capacity and authorizes the international transfer of emission reductions from a 5 Megawatt wind power project, it could apply an adjustment of 5 Megawatt to its reported progress in achieving its renewable power target (Schneider, Füssler, Kohli, et al., 2017).

Countries that communicated a target *range* would need to clarify which target is used as basis for accounting for international transfers. If double claiming should be avoided also with regard to *conditional* targets, international market mechanisms could still be used, but only if the acquiring country does not use emission reductions that are also counted towards achievement of the transferring country's NDC.

A critical element is appropriate accounting for the time frame of mitigation targets and when the mitigation outcomes occurred. In contrast to the Kyoto Protocol, many NDCs only include single-year targets. Carbon market mechanisms, however, typically issue units for multi-year periods. Several options could be pursued to address this challenge: (a) using continuous multi-year target trajectories or budgets, such as under the Kyoto Protocol, (b) accounting for transfers only in common single-year targets, or (c) approaches to make the transfers of mitigation outcomes representative over time, such as averaging transfers over defined time periods (Howard et al., 2017; Lazarus et al., 2014; Prag et al., 2013; Schneider, Füssler, Kohli, et al., 2017).

Other necessary elements for accounting for international transfers include systems to track international transfers, such as electronic registries or international transaction logs, as they were for example implemented under the Kyoto Protocol; appropriate design of market mechanisms in order to avoid double issuance of units; and the use of common metrics (e.g. GWPs), as envisaged in paragraph 31a of decision 1/CP.21.

2.4.2 Ensuring unit quality

Under the Paris Agreement, unit quality could be addressed through the rules, modalities and procedures of Article 6.4 and through international guidance on Article 6.2, though Parties have different views on whether the latter should address environmental integrity issues other than robust accounting (Obergassel & Asche, 2017). Including provisions on unit quality in the guidance under Article 6.2 may help to prevent a situation where countries evade requirements under Article 6.4 by transferring units with less quality under Article 6.2 instead (Michaelowa et al., 2016). Countries could also be required to report on how they ensure unit quality, and the reported information could be reviewed under Article 13.

Ensuring unit quality requires appropriate design of carbon market mechanisms. In practice, ensuring unit quality could be challenging, in particular if international guidance is general and vague. Crediting mechanisms face challenges in assessing additionality and emissions baselines, mainly due to the information asymmetry between project developers and regulators, and uncertainty of assumptions on future developments, such as international fuel prices (Cames et al., 2017; Fischer, 2005; Gillenwater, 2012; Kollmuss et al., 2015; Schneider, 2009b; Spalding-Fecher et al., 2012). Another challenge inherent to the concept of crediting is that offsets subsidize the deployment of low-emitting technologies rather than penalizing the deployment of high-emitting technologies. As a consequence, offsets lower the costs of energy (or other commodities or services), which can lead to greater use of energy (or other commodities or services). Such effects, also referred to as ‘market leakage’, are commonly not accounted for under existing crediting mechanisms, and may thus lead to an over-estimation of emission reductions (Calvin et al., 2015; Kallbekken, 2007; Vöhringer et al., 2006). The ambition of ETSs also varies, and several existing ETSs face challenges with surplus allowances (Erik Haites et al., 2018; Narassimhan, Gallagher, Koester, & Alejo, 2018). Ensuring unit quality for new types of mechanisms, such as broad carbon pricing policies or measures at the sectoral level, may require new approaches such as modelling or extensive data collection. Exchange rates, discount rates, and GISs have been used or proposed as means to mitigate concerns over varying unit quality, but these approaches also face challenges (Macinante, 2015; Marcu, 2015; Schneider, Lazarus, et al., 2017; Tuerk et al., 2013).

2.4.3 Facilitating economy-wide and ambitious mitigation targets

Article 4.3 of the Paris Agreement calls for a "progression" of NDCs reflecting the "highest possible ambition", and Article 4.4 encourages developing countries to move over time towards economy-wide targets. While these provisions guide Parties, NDCs are ultimately self-determined by them. Parties could, however, decide to establish participation requirements for engagement in international transfers under Article 6 that provide incentives for countries to expand the scope of their NDCs, such as by limiting international transfers to emission reductions generated from sectors or gases covered by the NDC of the transferring country or, alternatively, by requiring that countries commit to expand the scope of their NDCs to economy-wide targets in the future in order to participate in Article 6. Enhancing the ambition and scope of NDC targets could also be facilitated indirectly, such as through guidance on transparency and understanding of NDCs under Article 4.8, reporting and review under the transparency framework under Article 13, the global stocktake under Article 14, or the mechanism to facilitate implementation and promote compliance under Article 15.

2.4.4 Restricting international transfers

Approaches that restrict international transfers are not included in the Paris Agreement but were proposed by some Parties and are being considered in the negotiations of the rulebook for the Paris Agreement. International transfers could be restricted in situations where risks to environmental integrity are considered higher, for example, if a system to account for international transfers is not in place, if the units were issued under a mechanism without international oversight, or if the emission reductions were generated outside the scope an NDC target. The latter approach could partially also address concerns that countries could have perverse incentives to set future NDC targets unambitiously or to define their scope narrowly, in order to sell more units; if transfers were effectively prevented in such situations, these countries would have less benefits from setting targets unambitiously or narrowly.

International transfers could be restricted in two ways:

- *Eligibility criteria* could require countries to meet certain requirements before they can participate in international transfers under Article 6. Countries could, for example, be required to have an accounting system in place or to have demonstrated that their mechanisms comply with internationally agreed principles on unit quality; and

- *Limits on international transfers* could reduce or, in some instances, prevent international transfers. Limits could be established with the aim of (a) generally reducing the amount of international transfers and thereby limit detrimental effects on unit quality, or (b) addressing specific environmental integrity risks, such as preventing transfers from countries with targets levels below BAU emissions while allowing countries with ambitious NDC targets to engage in transfers without limitations (La Hoz Theuer, Schneider, & Broekhoff, 2019).

Both limits and eligibility criteria were established under the Kyoto Protocol but were mainly used to ensure robust accounting and did not specifically address the quality of units or ambition of mitigation targets. The 'commitment period reserve' limited the extent to which countries could transfer units and mainly addressed the risk of over-selling. Eligibility requirements to participate in international carbon markets focused on reporting of GHG inventories and the establishment of registry infrastructure (Yamin & Depledge, 2004).

2.4.5 International rules versus responsibility by countries

A key question in the negotiations on the rulebook for the Paris Agreement is to what extent environmental integrity will be addressed through international rules and how much responsibility will lie with the Parties engaging in international transfers. All the approaches identified above could be implemented through international rules or under the responsibility of countries. Some authors also caution against establishing onerous international requirements that could dampen incentives for ambitious international cooperation (Mehling, Metcalf, & Stavins, 2018).

In either case, international reporting and review under Article 13 of the Agreement could help enhance transparency, and thereby provide incentives for countries to ensure environmental integrity and address any shortcomings in response to review findings.

If international rules are not deemed sufficient, countries could address environmental integrity issues by forming 'carbon clubs' or committing to political declarations (Keohane, Petsonk, & Hanafi, 2017). Yet these approaches can only address environmental integrity by the participating countries, which may limit their effectiveness.

2.5 Conclusions and recommendations

This paper has identified and categorized environmental integrity risks of international carbon market mechanisms and ways to overcome them under the Paris Agreement.

The risks for environmental integrity are notable. The diverse scope, metrics, types and timeframes of NDC targets pose challenges for robust accounting. The experience with existing carbon market mechanisms suggests that ensuring unit quality can be challenging. The diverse ambition and the limited scope of some NDCs reduces the incentives that countries have for ensuring unit quality. The literature also suggests that there is a material risk of countries choosing targets less ambitiously or more narrowly in order to sell more carbon market units.

Addressing these risks is challenging but important. If environmental integrity is not ensured, international carbon market mechanisms do not achieve their objectives – they would neither reduce emissions nor cut the costs of mitigating climate change. This paper identified four broad approaches to address environmental integrity risks.

Robust accounting is a key prerequisite for ensuring environmental integrity. It would be greatly facilitated if countries move towards economy-wide GHG emissions targets based on continuous multi-year periods and common GWPs. Relevant decisions under the Paris Agreement could encourage or require countries to adopt such types of targets in future NDCs if they wish to engage in international transfers. With regard to current NDCs, it is recommended that international guidance specifically address how and when corresponding adjustments should be applied, how international transfers should be accounted for in the case of single-year targets and targets in metrics other than GHG emissions, and how international transfers should be transparently tracked and reported upon. Given that significant demand for carbon market units could arise from CORSIA, it is also important that double counting is effectively avoided between NDCs under the Paris Agreement and offsetting obligations by airline operators under CORSIA.

The adoption of *ambitious and economy-wide targets* significantly reduces environmental integrity risks. Although NDCs are ultimately self-determined by Parties, the adoption of such targets could be facilitated through a range of measures, including through international guidance on clarity, transparency and understanding of NDCs, or the global stocktake referred to in Article 14 of the Paris Agreement.

The available experience suggests that *ensuring unit quality* can be challenging in practice. The environmental integrity risks may, however, differ between mechanisms and activities. Countries could prioritize carbon market mechanisms or activities that pose lower risks to environmental integrity, such as internationally linking emissions trading systems with similar ambition levels.

Restricting transfers in instances of higher environmental integrity threats could serve as a safeguard and mitigate other environmental integrity risks, but may also face practical challenges and constraints.

The feasibility and practical implementation of these four broad approaches is subject to further research. Which of these approaches – or combinations – are effective may depend on how they are implemented. For example, vague international guidance on unit quality and weak governance arrangements to ensure adherence may not affect the type and scale of transfers countries engage in. Whether an approach is effective may thus largely depend on the political feasibility of designing it in a meaningful manner.

Given that environmental integrity risks are significant, that each of the approaches faces challenges and limitations, and that the identified approaches can be complementary rather than mutually exclusive, it is recommended that policy-makers pursue all four broad approaches to promote environmental integrity.

Chapter 3
Addressing the risk of double counting emission reductions under the UNFCCC

Abstract

Avoiding double counting of emission reductions is a key policy concern to Parties to the United Nations Framework Convention on Climate Change (UNFCCC). Double counting of emission reductions can occur when a single greenhouse gas emission reduction or removal, achieved through a mechanism issuing units, is accounted more than once towards attaining mitigation pledges. We systematically assess how double counting can occur and how it could be addressed. We identify that double issuance – the issuance of two units for the same reductions – and double claiming – the accounting of the same reductions both in a greenhouse gas inventory and in units towards attaining a mitigation pledge – are the most important forms of double counting. They can occur not only directly, but in rather indirect ways which can be challenging to identify. Addressing double counting effectively requires international coordination in three areas: accounting of units, design of mechanisms that issue units, and consistent tracking and reporting on units. While international agreement on principles for accounting and mechanism design is crucial to preventing double counting, the governance arrangements for implementation and international oversight could vary. This article discusses options and makes recommendations for rules to address double counting in two distinct periods: through 2020 and post-2020 under a potential new international climate regime.

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3.1 Introduction

Avoiding double counting of emission reductions is a key policy concern to Parties to the United Nations Framework Convention on Climate Change (UNFCCC), for both the mitigation pledges made under the Cancun Agreements and a post-2020 climate regime (UNFCCC, 2012c). If emission reductions are double counted, actual global greenhouse gas (GHG) emissions could be higher than the sum of what individual countries report. As a result, countries could appear to meet established mitigation pledges, while total emissions exceed these levels. Double counting of emission reductions would also make mitigation efforts less comparable and could discourage the use of market-based approaches to mitigate climate change, and thus increase global GHG abatement costs.

This paper systematically assesses how double counting can occur and how it could be addressed. We consider double counting in the context of mechanisms, in which units, representing emissions or emission reductions, are issued and transferred between countries or other entities. We focus on mitigation pledges made under the UNFCCC which are expressed – ex-ante or ex-post – as absolute, multi-year GHG emission budgets. Although also important, we do not discuss potential double counting from mitigation pledges made outside the UNFCCC, mitigation pledges expressed in other metrics, such as renewable energy or energy efficiency targets, or mitigation pledges expressed for a single year. Under these circumstances, accounting for unit transfers is more complex (Hood et al., 2014; Lazarus et al., 2014; Prag et al., 2013). We also do not discuss issues arising from accounting for financial or technology pledges and the emission reductions resulting from such pledges (UNFCCC, 2012c), and the particular challenges arising from accounting for the land-use sector, such as distinguishing human-induced from natural changes, accounting for non-permanence of emission reductions or removals, quantifying emissions or removals from specific land-use activities, and accounting for harvested wood products (Canaveira, 2013; Hood et al., 2014; Prag et al., 2013).

The term *double counting* is used in different ways by Parties and stakeholders (UNFCCC, 2012c). We define the term broadly: double counting occurs when a single GHG emission reduction or removal, achieved through a *mechanism* issuing *units*, is counted more than once towards attaining mitigation pledges. In this context, we define *mitigation pledges* as internationally communicated mitigation commitments, targets or goals under the UNFCCC, including commitments inscribed in Annex B to the Kyoto Protocol, Cancun pledges, and intended nationally determined contributions under a future climate regime. Units can be *allowances* and *credits*. Allowances are issued under cap-and-trade mechanisms where the emissions of a country or a group of entities are capped and allowances are allocated to the country or entities in line with the cap, such as under emissions trading schemes (ETS). Credits are units that are issued under a crediting scheme for emission reductions achieved against a crediting baseline, such as under the

Clean Development Mechanism (CDM). For the purpose of this paper, we make the simplifying assumption that one credit represents one metric ton of CO_2 equivalent of additional emission reductions, meaning that the mitigation action would not occur in the absence of the incentives from the crediting mechanism, that the baseline reflects the emissions level that would occur in the absence of the incentives from crediting mechanism, and that actual emissions and any indirect emission impacts are accurately quantified.

3.2 How can double counting occur?

Based on a review of the existing literature and UNFCCC submissions (Hood et al., 2014; Prag, Hood, et al., 2011; Prag et al., 2013; UNFCCC, 2012c; World Resources Institute, 2013a, 2013b), we identify three ways of how double counting can occur:

1. *Double issuance,* which occurs if more than one unit is issued for the same emission or emission reduction. This leads to double counting of emission reductions if two or more units, representing the same emissions or emission reductions, are used to attain mitigation pledges;
2. *Double claiming,* which occurs if the same emission reduction is counted twice towards attaining mitigation pledges: once through a GHG inventory by the country where the reduction occurs and once again by the country using a corresponding emission reduction unit. More specifically, double claiming will occur if:

    a. an emission reduction falls within the scope of a country’s mitigation pledge;
    b. the emission reduction is reflected in the country’s GHG inventory;
    c. the same emission reduction is also reflected in a unit that is transferred to another country;
    d. the transferred emission reduction unit is not accounted for by the transferring country (i.e. either by adding the unit transferred to its reported emissions or subtracting it from its emissions budget); and
    e. the country acquiring the unit uses it to attain its own mitigation pledge; and

3. *Double use,* which refers to the situation where the same issued unit is used twice to attain a mitigation pledge, either twice by the same country or once each by two different countries. Double use may occur, for example, if a unit is duplicated in registries, or if one country uses the same unit in two different years to attain mitigation pledges.

Below we further explore how double issuance and double claiming can arise.

3.2.1 Double issuance

Issuing two units for the same emission or emission reduction under a single mechanism is the simplest and most obvious form of double issuance, and hence also easiest to address. In a fragmented carbon market, with multiple mechanisms under international, bilateral, national or non-governmental governance, there is a risk that two different mechanisms could issue a unit for the same emission or emission reduction (Table 3-1).

Table 3-1 Overview of ways in which double issuance can occur

Mechanism(s) involved	Entities involved	Description	Example(s)
One	One	Two units are issued under the same mechanism to the same entity for the same emissions or emission reductions.	Double registration of a project under the same mechanism, double issuance due to two monitoring reports that overlap in time.
Two	One	Two units are issued under two mechanisms to the same entity for the same emissions or emission reductions.	A project developer registers a project under two mechanisms.
One	Two	Two different entities are each issued a unit under the same mechanism for the same emissions or emission reductions.	The producer and the consumer of a biofuel claim the same emission reduction under two projects registered under the same mechanism.
Two	Two	Two units are issued under the two mechanisms to two different entities for the same emissions or emission reductions.	The producer of a biofuel claims an emission reduction under mechanism A, and the consumer claims it under mechanism B.

Double issuance can involve one or two mechanisms and one or two entities. Indirect forms of double issuance can arise if mechanisms issue units for indirect emissions that occur upstream or downstream of the entities receiving the units. Crediting mechanisms often award credit to those entities that undertake the mitigation actions, while the actual emission reductions occur elsewhere. This makes crediting mechanisms more vulnerable to double issuance than cap-and-trade mechanisms, for which the emission sources falling under the cap are clearly defined from the outset and any overlap with another cap-and-trade mechanisms could be easily identified and avoided.

For example, the CDM issues credits to renewable power plant operators, while emissions are reduced in fossil fuel fired power plants, or to composting facilities for avoiding the dumping of waste on a landfill, while the emission reductions occur at the landfill sites. In some cases, the ownership of the emission reductions is not obvious, and different entities could potentially claim units for the same emission reductions. For example, in a project to promote efficient lighting in households, the households could claim the emission reductions, but so could an energy service company distributing efficient lamps, as could the producers of those lamps.

Double issuance due to the accounting of indirect emissions can become particularly challenging where crediting mechanisms account for life-cycle emissions that may occur far upstream or downstream of where the mitigation activity is implemented. Imagine, for example, a project producing biofuels and another abating N_2O from nitric acid production, both under the CDM. The biofuels project uses nitrogen fertilizer in growing its feedstock crops. Due to the biofuels projects, more fertilizer is consumed and hence more nitric acid is produced. The project abating N_2O from nitric acid production can claim more credits due to the increased biofuel production. Double issuance would occur if the biofuels project used the actual N_2O emission factor observed at the nitric acid plant to calculate upstream project emissions from nitric acid production. In this case, both projects would indirectly claim for the same reductions. Double issuance would be avoided if the biofuel project would use the unabated N_2O emission factor to calculate project emissions.

This example illustrates the challenges of identifying and addressing rather indirect forms of double issuance. An important hurdle is that information on where the emission reductions occur (e.g. at which nitric acid plant or landfill site) is sometimes not readily available. In some instances, double issuance may be difficult to identify at all.

3.2.2 Double claiming

Double claiming is controversially discussed in the context of transfer of units from developing to developed countries in the context of the Cancun pledges for 2020 (UNFCCC, 2012c). Under the UNFCCC, developed countries can reflect in their biannual reporting the number of units that they intend to use (UNFCCC, 2012a). However, there are no reporting provisions for developing countries with regard to units issued, transferred, or used to attain mitigation pledges. Double claiming would occur if a seller country does not account for units issued for emissions or emissions reductions within its jurisdiction and internationally transferred (e.g. by adding them to its emissions inventory, or subtracting them from its emissions budget), and if the buyer country uses the units for attaining its mitigation pledge. This form of double counting could range from 0.4 to more than 1 Gt CO_2e in 2020 (Erickson & Lazarus, 2013; UNEP, 2013).

As with double issuance, double claiming can occur in more indirect ways when mechanisms account for indirect emissions. Imagine, for example, a country that pledges to reduce emissions from deforestation, and also hosts an efficient cook-stove project under the CDM reducing the use of non-renewable biomass. The resulting emission reductions might be used for pledge attainment by both the host country and the country buying the credits from the cook-stove project. Another indirect form of double claiming can occur due to international trade of electricity, fuels, feedstocks and technologies, if the mitigation actions are taken in one country while the emission reductions occur in another.

3.3 Relevance of double counting for UNFCCC

Double counting of emission reductions is clearly relevant for mitigation pledges by Parties under the UNFCCC and its instruments. In addition, to achieve the ultimate objective of the Convention, avoiding double counting may also be important with regard to GHGs addressed under other treaties, such as GHG emissions from international aviation and maritime transport, which may be addressed under the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO), or GHG emissions addressed under the Vienna Convention to Protect the Ozone Layer and its Montreal Protocol on Substances that Deplete the Ozone Layer. For example, the same emission reduction should not be used by both an airline to fulfil its requirements under a potential market-based measure under ICAO and by a Party towards attaining pledges.

In the context of UNFCCC pledges, double counting could potentially occur where:

1. Units (whether issued under domestic or international governance) are transferred internationally between national jurisdictions and used by the buyer country towards meeting its UNFCCC pledges; or
2. Units are issued for domestic emissions or emission reductions for sectors or gases that do not fall within the scope (geographical coverage, emission sources, GHGs, and time period) of a mitigation pledge and are used by the same country towards meeting a UNFCCC pledge.

In contrast, double counting is not relevant for the UNFCCC, if a country issues units under a domestic mechanism, such as an ETS, but does not use these units to attain its pledge under UNFCCC. In this case, the emission reductions from the domestic mechanism are reflected in the countries reported GHG emissions. Moreover, only the *net* transfer of units between domestic mechanisms is relevant in the context of UNFCCC pledges. For example, large volumes of allowances may be transferred between two linked ETS but only the net transfer would need to be accounted towards attaining UNFCCC pledges. In this regard, also the timing of accounting for unit transfers may be different: while changes in holdings of ETS units may be accounted and reflected in national registries immediately, the accounting for UNFCCC purposes could occur once ex-post (e.g. together with reporting of GHG emissions). However, Parties could consider (voluntarily) extending UNFCCC rules for addressing double counting to other (domestic) mechanisms or encourage such mechanisms to apply the same rules, for several reasons. First, double counting of emission reductions at the domestic level could make it more difficult for countries to achieve their UNFCCC pledges; it is in the interest of countries to avoid double counting of emission reductions at domestic level. Second, double counting between UNFCCC pledges and voluntary actions, such as voluntary offsetting of emissions by individual, companies and institutions, could undermine the credibility of the market for voluntary offsetting. And third, internationally agreed rules to avoid double counting with units outside the scope of UNFCCC pledges could help ensure that carbon markets are seen as a credible and effective tool to mitigate climate change.

3.4 Addressing the risk of double counting

At COP18 in Doha, Parties agreed to consider the issue of double counting in the two work programs established under the Subsidiary Body for Scientific and Technological Advice (SBSTA) on a framework for various approaches (FVA) and a new market-based mechanism (NMM). However, whether and how double counting of emission reductions needs to be addressed under the UNFCCC is a controversial issue (UNFCCC, 2012c).

An important question is whether double counting needs to be prevented *ex-ante* through internationally agreed rules or whether it is sufficient to determine *ex-post*, through tracking and reporting, how much double counting is occurring. We argue that preventing double counting ex-ante is important, for several reasons: First, not preventing double counting would make mitigation pledges less comparable. Second, allowing double counting of emission reductions could set disincentives to use international carbon market instruments, if countries that acquire units are not assured that they have sole claim to the reductions. Third, double counting of emission reductions could reduce the cost effectiveness of GHG abatement using carbon markets, since one unit would not necessarily represent one metric ton of emissions or emission reductions. Fourth, we showed above that double counting can occur in indirect forms; this could make it difficult to identify or quantify it ex-post. But even if the amount of double counting would be known ex-post, the aggregated mitigation outcome would be lower than the sum of what countries pledged, and the extent of double counting might be different than what was anticipated when agreeing on mitigation pledges. If the difference is significant, existing or future pledges might need to be adjusted or strengthened, in order to meet agreed climate protection goals. The need to strengthen future pledges as the result of double counting by some countries could introduce yet another source of potential conflict and divisiveness or divergence in international efforts to address climate change.

It is often argued that a system for consistent tracking and reporting of international units is crucial to addressing double counting (UNFCCC, 2012c). While such as system is important to facilitate the transfer and accounting of units, it is not sufficient to prevent double counting. Addressing double counting requires a coherent set of rules which address all stages of the life-cycle of units (Prag et al., 2013), including the issuance, transfer and use of units:

- *Accounting rules* are key for addressing double claiming and to avoid the double use of one unit;
- Rules for the *design of mechanisms* are mainly needed to address double issuance but are also needed to avoid indirect forms of double claiming; and
- A system of *consistent tracking of units* is needed to facilitate the identification and avoidance of double counting through appropriate oversight on the issuance, transfer and use of units.

3.4.1 Accounting of units

We discuss two options for accounting of units, which both fully prevent double claiming and double use, as long as all countries involved in international transfers apply the same approach[2]:

- Approach A: Accounting for net flows of units; and
- Approach B: Restricting the use of units.

Under approach A, units issued for domestic emissions or emission reductions that fall *within* the scope of a country's mitigation pledge and transferred to other countries are subtracted from the emission budget of the originating country (or added to its verified emissions) and added to the emission budget of the country using the units to attain its mitigation pledge (or subtracted from its reported emissions). Units issued for domestic emissions or emission reductions that fall *outside* the scope of a country's mitigation pledge, however, do not need to be subtracted from the country's emission budget. They can either be used by the same country to attain its pledge – in this case the units are added to the country's emission budget – or they can be transferred to other countries – in this case the units are added to the emission budget of the country using the units to attain its mitigation pledge. This approach builds on the accounting approach under the Kyoto Protocol. A country would meet its pledge if the following accounting balance gives a surplus equal to or larger than zero for the target period:

[2] For simplicity, we do not reflect other reduction obligations, such as mandatory cancellations to address non-permanence or to compensate for excess issuance of units.

Surplus = Emission budget corresponding to the mitigation pledge
+ Units acquired from other countries (or an international registry) and used for pledge attainment
+ Units issued for domestic emissions or emission reductions that fall *outside* the scope of the mitigation pledge and used for pledge attainment
– Verified emissions
– Units issued for domestic emissions or emission reductions *within* the scope of the mitigation pledge and transferred to other countries

Under approach B, only units issued for emissions or emission reductions that fall *outside* the scope of a mitigation pledge can be used to attain a mitigation pledge. Units issued for emissions or emission reductions that fall *within* the scope of a mitigation pledge could still be issued and transferred, but could not be used for attaining mitigation pledges. A country would meet its pledge if the following accounting balance gives a surplus equal to or larger than zero for the target period:

Surplus = Emission budget corresponding to the mitigation pledge
+ Units acquired from other countries (or an international registry), issued for emissions or emission reductions that fall outside the scope of a mitigation pledge, and used for pledge attainment
+ Units issued for domestic emissions or emission reductions outside the scope of the mitigation pledge and used for pledge attainment
– Verified emissions

Both approaches require differentiating between reductions *within* and *outside* the scope of a mitigation pledge, where the scope includes the following dimensions: the time frame, the geographic area, the greenhouse gases, and the sectors or emission sources covered by the pledge. Hence, describing and expressing mitigation pledges unambiguously with regard to their scope is another important prerequisite to address double counting. Furthermore, the two approaches only effectively prevent double claiming if both the buyer and the seller country apply the same accounting approach. Hence, international agreement on a consistent approach for accounting of units is another prerequisite to avoid double claiming.

Approach A ensures full fungibility of units (i.e. their exchangeability), since units issued for emissions or emission reductions *within* and *outside* the scope of a mitigation pledge can both be used by the buyer for attaining mitigation pledges. It also enables international linking of ETS: the net amount of allowances transferred between two ETS can be reflected in the UNFCCC pledges through additions to or subtractions from the emission budget.

Approach B provides flexibility in how units are issued, transferred and used by countries. It allows units for domestic reductions *within* and *outside* the scope of a pledge to be issued and transferred, without requiring the originating country to account for the transferred units. However, this option creates two types of internationally recognized units. Most importantly, this option requires the countries using the units for attaining their mitigation pledges to distinguish between these two types of units, and thus limits the fungibility of units. In practice, this option would likely imply that unit types that are not eligible for attaining mitigation pledges are excluded from ETS. Nevertheless, such units could be purchased and used through other channels, such as government programs for results-based financing.

Approach A appears to be the most simple and 'logical' way of accounting for units. We recommend this approach for a post-2020 climate agreement. Up to 2020, accounting of units is politically difficult to address. Units issued for emissions or emission reductions in countries with mitigation pledges made under the Cancun Agreements may be double counted as both the originating country and the country using the units would claim the same emission reductions. However, context is important with regard to these pledges. Some developing countries argue that their pledges were made assuming international support from developed countries, including through the use of mechanisms with unit transfer. It is also important to note that many developing countries have made a pledge under the Convention for the first time. In this regard, one could argue that deducting transferred units from their emissions budget (or adding them to their reported emissions) would constitute a burden for developing countries. For the period up to 2020, approach B could be an alternative way forward for the accounting of *credits*, while approach A could be applied to the accounting of *allowances*.

Under both approaches, developed and developing countries could bilaterally agree to a shared approach for accounting of units under the Cancun pledges up to 2020. For example, developed countries could only use half of the units acquired from developing countries for compliance. Developing countries would then only need to deduct half of the issued and transferred units from their emissions budget. This option would avoid double counting, partially support developing countries in achieving their 2020 pledges, and may still reduce the costs for developed countries in meeting their pledges. In the absence of any international agreement to address double claiming, caution may be needed in considering the use of units for attaining pledges. In the absence of international agreement, Parties could seek to agree on accounting of units through bilateral agreements, however, doing so could be inefficient, not address all forms of double counting, deter international unit transfers, and limit the scale of associated international financial flows.

3.4.2 Design of mechanisms

Appropriate design of mechanisms is another important prerequisite to avoid double issuance and double claiming, in particular with regard to crediting mechanisms. To effectively avoid double counting, we recommend agreeing internationally on principles or rules for the design of mechanisms.

Transparent information on mechanisms is important to identify any double counting or to verify that double counting is not occurring. We recommend establishing a centralized information platform under the UNFCCC which includes information on each mechanism. Both cap-and-trade and crediting mechanisms should clearly specify their scope, including the jurisdictions, emission sources, greenhouse gases, time period covered. Furthermore, each crediting mechanism should maintain a publicly accessible database on credited activities which allows clearly identifying each credited activity, including the location, the emission sources and gases, and the vintage of the emission reductions.

Double counting due to double issuance of units can be addressed in two ways: by allowing double issuance but ensuring that only one of the double-issued units is used to attain mitigation pledges or by avoiding double issuance (CAR, 2011; GSF, 2013; VCS, 2013). The following approaches could be employed to avoid that one or more entities seek credits for the same emission reductions under the same or different crediting mechanisms (see Table 3-1):

- *Attestation by the entities seeking credits:* Crediting mechanisms could require that any entity seeking credits sign an attestation declaring that it has not and will not seek credits for the same emission reductions under another or the same crediting mechanism. Such attestations are, for example, required by the Climate Action Reserve (CAR), the Gold Standard (GS) and the Voluntary Carbon Standard (VCS) (CAR, 2011; GSF, 2013; VCS, 2013). Attestations could be formulated as legally enforceable declarations which would allow the regulatory body or others to seek legal remedies in the case of non-compliance. Attestations could be required once when a credited activity is approved or for each issuance request.
- *Written attestation from other entities:* The regulator of a crediting mechanism could require the entities seeking credits under the mechanism to acquire an attestation from potential other entities, which could claim credits for the same emission reductions, that they have not and will not seek credits for the same emission reductions. This approach is, for example, followed in some CDM and GS methodologies.
- *Host country oversight:* Countries hosting mechanisms could have the responsibility to ensure that no double issuance occurs within their jurisdiction. Parties could agree that host countries have to issue letters of approval for any emission reductions that are claimed within their jurisdiction. Letters of approval have to be issued under the CDM.

- *Transparent procedures for transfer of credited activities between crediting mechanisms:* Crediting mechanisms could establish transparent procedures to terminate crediting or transfer a credited activity to another mechanisms. The CAR and the VCS have procedures to both transfer projects from and to other schemes (CAR, 2011; VCS, 2013).
- *Verification of no double counting through third-party verifiers or regulators:* Third-party verifiers or the regulators of a crediting mechanism could be required to check for each issuance request whether the same reductions have already been issued as credits in the same or another crediting mechanism. The scope of the check could depend on the material risk of double counting, implementing a risk-based approach.
- *Only one type of entity can seek credits:* The regulator of a crediting mechanism or Parties could decide that only one type of entity (e.g. the producer, the operator, or the consumer) can seek credits under the mechanism. Under the CDM, the available baseline and monitoring methodologies often allow only one entity to claim CERs for a proposed project activity.
- *Limitation to activities with clear ownership of credits:* The scope of crediting could be limited to activities with clear ownership of credits (e.g. those where the mitigation activity occurs in the same place as most of the emission reductions). The VCS and CAR intend to limit eligibility to projects types for which the ownership of the credits is unambiguous (CAR, 2011; VCS, 2012).

Some of these approaches could pose challenges. Requiring entities to make declarations on what other entities will or will not do could pose legal risks for those entities, especially if they have no contractual arrangements with the other entities or if they do not know who they are. Even if the other entities never planned to seek any credits, they may be hesitant to make a written commitment, as they have no incentives to give away such rights and may not be aware of the consequences. Allowing only one type of entity to seek credits under one mechanisms may not necessarily prevent double issuance between different mechanisms; and seeking international agreement for all mechanisms which entities can seek credits may turn out to be difficult. The limitation of mechanisms to activities with clear ownership of credits could reduce the scope of mechanisms considerably. For these reasons, we recommend combining attestations by the entities seeking credits, host country oversight, transparent procedures for transfer of credited activities between mechanisms, and verification of no double counting through third-party verifiers or regulators.

The risk of double issuance or double claiming due to the accounting of indirect emissions could be addressed through appropriate principles for the design of mechanisms, such as the following:

- In the case that indirect emissions overlap between a crediting mechanisms and a mitigation pledge or cap-and trade mechanism, double counting could be addressed either if the jurisdiction implementing the mitigation pledge or the cap-and-trade mechanism establishes an allowance reserve to compensate for any credits that fall within its scope, or if the crediting mechanism avoids the crediting of any emission reductions that fall within the scope of the mitigation pledge or cap-and-trade mechanism. The following two principles could avoid both double counting and over-crediting:

a. Indirect *baseline emissions* that fall within the scope of a mitigation pledge or cap-and-trade mechanisms could either not be included in the calculation of emission reductions or a different unit type could be issued for those reductions;
b. Indirect *project (or leakage) emissions* that fall within the scope of a mitigation pledge, should be included in the calculation of emission reductions or other units corresponding to that amount should be cancelled, in order to avoid over-crediting of emission reductions.

- In the case that indirect emissions overlap between two crediting mechanisms (or two credited activities within one mechanism), double counting could be addressed by ensuring that only one mechanism issues units for reductions in indirect emissions. The following two principles could avoid both double counting and over-crediting:

a. In the case of indirect *baseline emissions*, the emission factor should reflect the actual emissions occurring with any credited activity implemented upstream or downstream (and not the emissions that would occur in the absence of the credited activity implemented upstream or downstream), in order to ensure that only the credited activity upstream or downstream claims the emission reductions.
b. In the case of indirect *project (or leakage) emissions*, the emission factor should reflect the emissions that would occur in the absence of the credited activity implemented upstream or downstream (and not the actual emissions occurring with the credited activity implemented upstream or downstream), in order to ensure that only the credited activity upstream or downstream claims the emission reductions (see biofuels example in section 3.2.1).

In many cases, pragmatic approaches are needed to implement these principles for accounting of indirect emissions. In some cases it is not known where the indirect emissions occur, and hence whether they fall within the scope of mitigation pledges or other credited activities. Default emission factors, derived in a representative manner reflecting these principles, can avoid double counting and over-crediting in a reasonable manner.

3.4.3 Consistent tracking of units

Consistent tracking of unit flows is often regarded as a key means to address double counting. In our assessment, international oversight on the *issuance* and *accounting* of units is key to effectively prevent double counting; it allows *ex-post* detecting any double use of units or any inconsistencies in unit information between the originating country and the country using the units for attaining its mitigation pledge. Hence, international oversight on unit flows adds transparency but is not necessarily needed to prevent double counting.

However, an important prerequisite for avoiding double counting is that sufficient information is attached to the units. Above we showed that it is important to identify whether a unit was issued for emissions or emission reductions *within* or *outside* the scope of a mitigation pledge. With this in mind, units should not only be tagged with regard to where the mitigation action occurs, such as the host country identifier under the CDM, but also in which country the reductions occur, when they occurred, and whether they fall within or outside the scope of a mitigation pledge. Understanding when the reductions from a unit occur is more difficult for allowances than for credits. Allowances may be issued for a particular calendar year or compliance period, but they can often be banked between compliance periods. This raises issues for accounting of UNFCCC pledges if allowances are banked from a period prior to a mitigation pledge into the period covered by the mitigation pledge (Prag et al., 2013).

We recommend that international agreement is sought on information that should be attached to any units that are eligible for attaining mitigation pledges. Each unit should have a globally unique serial number which should include comprehensive information through relevant identifiers, including:

- a unique identifier for each *mechanism* under which units are generated;
- a *country* identifier which should, in the case of crediting mechanisms, include the country where the mitigation action takes place, and, if different, the country where the emission reduction occurred;
- information on the *vintage* of the units, including the compliance period for which units were issued for trading mechanisms and the time period in which the emission reductions occurred for crediting mechanisms;
- information whether or not the unit is issued for emissions or emission reductions that fall within or outside the *scope of a mitigation pledge*;
- for crediting mechanisms, the relevant activity (e.g. the project number);
- information whether the units are subject to provisions to address potential non-permanence.

The governance arrangements and the level of international oversight on mechanisms and unit accounting is one of the politically controversial issues in UNFCCC negotiations

(Prag, Hood, et al., 2011; Prag et al., 2013; UNFCCC, 2012c). Parties could agree to establish governance arrangements under UNFCCC, or to make use of national, bilateral or non-governmental governance structures. Table 3-2 highlights examples of government arrangements for the three stages of the life-cycle of units: mechanisms issuing units, registries transferring units, and the accounting of units.

Table 3-2 Examples of governance arrangements for issuance, transfer and accounting of units

	UNFCCC/multilateral	National/bilateral	Non-governmental
Mechanisms issuing units	CDM NMM Joint Implementation (JI)	Joint Crediting Mechanism (JCM) JI track 1	VCS GS CAR
Registries transferring units	CDM registry International transaction log (ITL)	National registries under the Kyoto Protocol	VCS registry GS registry CAR registry
Balances accounting units	Compilation and accounting database under the Kyoto Protocol	Common reporting tables submitted for 2020 UNFCCC pledges	

Above we showed that international agreement on common rules and principles for unit accounting and mechanisms is key to prevent double counting of emission reductions. However, which entities issue, transfer and account for units is less important, as long as procedures for reporting, review, and resolution of any non-compliance ensure that internationally agreed rules are followed. For any mechanisms that are not operated under the UNFCCC, we recommend conducting an initial international review which establishes the eligibility for issuing units that can be used to attain pledges under UNFCCC. The continued compliance could then be assessed through regular subsequent reviews. With regard to the transfer of units, we see less need for rigorous international oversight – as long as Parties agree on common rules for attaching relevant information to units – since any double counting could be detected when units are accounted.

3.5 Conclusions

In light of an increasingly fragmented carbon market and the current diversity of international mitigation pledges, double counting of emission reductions could significantly undermine international efforts to tackle climate change. Our analysis shows that double counting can occur in various forms and indirect ways. It may be difficult to address ex-post and should rather be prevented ex-ante. Addressing double counting requires international coordination in three areas: accounting of units, design of mechanisms that issue units, and consistent tracking and reporting on units. A new international post 2020 climate regime should include principles and rules in all three areas. In the absence of international agreement, Parties could seek to avoid double counting through bilateral agreements, however, doing so could be inefficient, not address all forms of double counting, deter international unit transfers, and limit the scale of associated international financial flows.

Chapter 4
Perverse effects of carbon markets on HFC-23 and SF_6 abatement projects in Russia

Abstract

Carbon markets are considered a key policy tool to achieve cost-effective climate mitigation (IPCC, 2014b; World Bank, 2014). Project-based carbon market mechanisms allow private sector entities to earn tradable emissions reduction credits from mitigation projects. The environmental integrity of project-based mechanisms has been subject to controversial debate and extensive research (CDM Policy Dialogue, 2012; Gillenwater & Seres, 2012; Hayashi & Michaelowa, 2013; IPCC, 2014b; Ruthner et al., 2011; Schiermeier, 2011; Schneider, 2009b; Spalding-Fecher et al., 2012), in particular for projects abating industrial waste gases with a high global warming potential (GWP). For such projects, revenues from credits can significantly exceed abatement costs, creating perverse incentives to increase production or generation of waste gases as a means to increase credit revenues from waste gas abatement (Schneider, 2011; UNEP, 2007; UNFCCC, 2005, 2011; Wartmann, Hofman, & Jager, 2006). Here we show that all projects abating HFC-23 and SF_6 under the Kyoto Protocol's Joint Implementation mechanism in Russia increased waste gas generation to unprecedented levels once they could generate credits from producing more waste gas. Our results suggest that perverse incentives can substantially undermine the environmental integrity of project-based mechanisms and that adequate regulatory oversight is crucial. Our findings are critical for mechanisms in both national jurisdictions and under international agreements.

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The Kyoto Protocol's project-based mechanisms, the Clean Development Mechanism (CDM) for emission reductions projects in developing countries and Joint Implementation (JI) for projects in industrialized countries, provided industrialized countries flexibility in meeting their greenhouse gas (GHG) reduction commitments. Numerous sub-national and national jurisdictions are implementing similar mechanisms around the world, often in combination with emissions trading schemes (World Bank, 2014).

Projects abating waste gases with a high global warming potential (GWP) can generate large volumes of emission reductions at low abatement costs (IPCC, 2014b; Rahman & Kirkman, 2015). Under the CDM, the two largest waste gas project types—incineration of hydrofluorocarbon-23 (HFC-23) from hydrochlorofluorocarbon-22 (HCFC-22) production and destruction of nitrous oxide (N_2O) from adipic acid production— account for only 0.3% of the registered projects but generated about half of the 1.5 billion emission reduction credits issued so far (UNEP DTU Partnership, 2015). For such projects, revenues from credits can significantly exceed GHG abatement costs and, in some instances, the costs of producing the main product (UNFCCC, 2005; Wartmann et al., 2006). This can create perverse incentives for plant operators to increase production or waste generation beyond levels that would occur in the absence of crediting (Schneider, 2011; Schneider et al., 2010; UNEP, 2007; UNFCCC, 2011). If more waste gas is generated owing to the incentives from crediting, emission reductions are overestimated; the emissions baseline is inflated compared to the emissions that would actually occur without crediting, and, in consequence, excess credits are issued.

Such perverse incentives can be avoided through appropriate safeguards in methodological standards for the calculation of emission reductions, mainly by capping the amount of production and waste generation to historically observed levels or conservative benchmarks for the purpose of calculating emission reductions. Under the CDM, safeguards to prevent perverse incentives were gradually introduced and strengthened over time, following observations that the initial safeguards may not have been adequate (Schneider, 2011; UNFCCC, 2011, 2012b). Whereas the CDM requires using internationally agreed standards and international approval for registering projects and issuing credits, JI allows using a project-specific approach for calculating emission reductions, and either the host countries or the international Joint Implementation Supervisory Committee (JISC) execute regulatory oversight. Under host country oversight, countries can largely establish their own rules for approving projects and issuing credits without international oversight. The host country can determine whether it deems emission reductions as additional. Under international oversight, the JISC oversees project approval and issuance of credits.

This Letter assesses perverse incentives in the context of JI. We evaluate JI projects that incinerate high GWP waste gases, as these project types were particularly vulnerable to perverse incentives under the CDM. Four such projects were registered under JI, all of them under host country oversight. They account for 54 out of the 863 million credits issued to the 604 JI projects registered as of 1 April 2015 (ref. UNEP DTU Partnership, 2015). The four projects involve five plants: two hydrochlorofluorocarbon-22 (HCFC-22) and two sulphur hexafluoride (SF_6) production plants in Russia, and one trifluoroacetic acid (TFA) production plant in France. The production of HCFC-22 generates hydrofluorocarbon-23 (HFC-23) as an unwanted waste gas; in the production of SF_6 a waste stream of SF_6 is generated at rectification; and the production of TFA generates various unwanted fluorinated waste gases. The amount of waste gas generated depends on the production level of the main product – HCFC-22, SF_6 and TFA – and the waste generation rate, which is defined as the quantity (mass) of waste gas generated per quantity (mass) of product produced (UNFCCC, 2011). The waste generation rate depends on factors, such as plant design, product purity requirements, and degree of process optimization (McCulloch & Lindley, 2007). In the absence of regulations, incentives, or voluntary commitments by the industry, the waste gases are usually vented to the atmosphere. The five registered JI plants capture and incinerate these waste gases (see Supplementary Documentation).

The plant in France aimed to address perverse incentives by capping the emission reductions to the historical emissions of the installation. However, data on historical and monitored production and waste gas generation are not available to assess whether the cap adequately prevented perverse incentives.

Three plants in Russia initially applied caps on the production and waste generation rate to avoid perverse incentives, drawing upon CDM standards. In the second quarter of 2011, the plant operators decided to retroactively change the way emission reductions are calculated as of 1 January 2010, removing the caps and crediting all waste gas destroyed. Moreover, data and information provided in the original project documentation was considered incorrect, or not applicable, and replaced (see Supplementary Information). Figure 4-1 shows that waste gas generation increased in all three facilities to unprecedented levels compared to both historical and originally projected levels, after abandoning methodological safeguards in 2011.

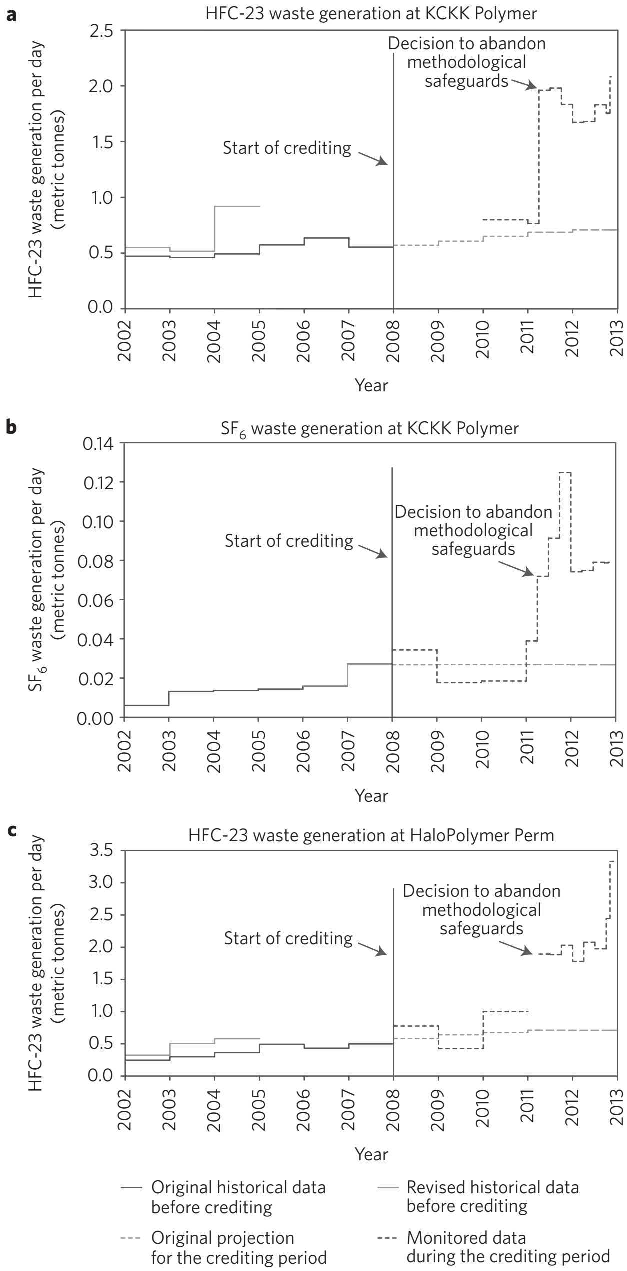

Figure 4-1 HFC-23 and SF6 waste generation at three plants in Russia. a, HFC-23 waste generation at the KCKK Polymer plant. b, SF6 waste generation at the KCKK Polymer plant. c, HFC-23 waste generation at the HaloPolymer Perm plant. Waste generation increased in all three plants beyond previously reported levels when plant operators decided in 2011 to abandon methodological safeguards to prevent perverse incentives.

The project at the fourth plant in Russia was developed and approved in 2011/2012 and claimed credits retroactively as of 1 January 2008. The project did not apply any methodological safeguards to avoid perverse incentives; all waste gas destroyed was credited. For the period 2008 to 2010, for which data on both SF_6 production and SF_6 waste generation are available, the average waste generation rate was 16.9%, which considerably exceeds the default value of 0.2% suggested by the Intergovernmental Panel on Climate Change (IPCC; ref. IPCC, 2006) or the average historical waste generation rate of 2.0% observed at the KCKK Polymer plant. A comparison with GHG inventory data reported by Russia to the United Nations Framework Convention on Climate Change (UNFCCC; ref. Russian Federation, 2014) shows that waste generation significantly increased with the implementation of the JI project (Figure 4-2). Before project implementation, the GHG inventory emissions from SF_6 manufacturing – which cover both SF_6 plants and which may not only include waste gas emissions from SF_6 production but also emissions from handling of SF_6 at the production site, and thus represent the upper end of the possible range – varied between 4 and 53 tons of SF_6 over the period 1990 to 2007, whereas after project implementation the plant reported an average annual waste gas generation of 117 tons of SF_6.

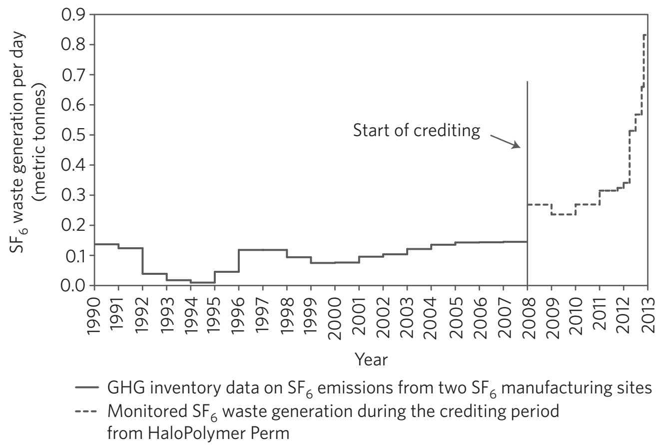

Figure 4-2 SF_6 waste generation at the HaloPolymer Perm plant. The GHG inventory data includes emissions from both SF6 production plants in Russia (KCKK Polymer and HaloPolymer Perm). After the start of crediting, the waste generation from HaloPolymer Perm increased beyond historical emission levels reported in the Russian GHG inventory from both plants.

The abrupt increase occurred in all four plants exactly at the point in time when plant operators could generate (more) credits by producing more waste gas, and higher levels of waste generation were sustained thereafter. The increase in waste generation is mostly attributable to an increase in the waste generation rate, and not in production levels (see

Supplementary Information). There was also no reporting of any changes in plant capacity, design, or product specifications which might have affected the waste generation rate. Without credit revenues, plant operators would have economic incentives to reduce rather than increase waste generation (Schneider, 2011; UNFCCC, 2011).

Absent methodological safeguards to prevent perverse incentives, increasing waste gas generation beyond levels that would occur in the absence of crediting leads to excess issuance of credits. The extent of such over-crediting is uncertain; it depends on how much waste gas the plants would otherwise have generated. We assess the magnitude of over-crediting using three scenarios to estimate the plausible range of waste gas generation that would have occurred in the absence of crediting (see Methods). We conclude that, in the periods where methodological safeguards were not applied, about 28 to 33 million credits were issued in excess, corresponding to 66 to 79% of the credits issued for these periods.

Several lessons can be learned from this analysis. First, although previous research indicated that perverse incentives affected plant operations, the extent and implications were more confined (Schneider, 2011; Schneider et al., 2010; UNFCCC, 2012b). Our results suggest that perverse incentives arising from project-based mechanisms can have rather substantial adverse impacts on environmental integrity, with about two-thirds of the credits being issued in excess in periods when no safeguards were applied. Second, regulatory oversight by the host country alone may not be sufficient to ensure environmental integrity. Under the Kyoto Protocol, Russia had no incentives to ensure environmental integrity of JI projects; it had an emissions target well above its actual emissions and could issue credits from its emissions budget without repercussions for meeting its target. For the three plants in Figure 4-1 the methodological safeguards were removed at a point in time when perverse incentives from HFC-23 CDM projects received wide media and policymaker attention, leading ultimately to a ban of HFC-23 credits under the EU's emissions trading scheme and a revision of the applicable methodological standard under the CDM (ref. European Commission, 2011; UNFCCC, 2011). Third, the Accredited Independent Entity (AIE) performing the relevant auditing functions – Bureau Veritas Certification – did not address the perverse incentives. Although AIEs were accredited by the JISC, the projects were implemented under oversight by the host country, in which case the JISC did not assess the performance of auditors or apply any sanctions in cases of non-performance. Finally, we note a lack of transparency, with project information being only partially publicly available.

These lessons are critical for both ongoing international discussions on the review of JI and market-based mechanisms under the new climate agreement, as well as the growing use of domestic carbon markets around the world. Our findings confirm earlier research that project-based mechanisms are exposed to significant risks of over-crediting, for example, due to the information asymmetry between project operators and auditors or regulators (Gillenwater & Seres, 2012; Ruthner et al., 2011; Schneider, 2009b; Spalding-Fecher et al., 2012). If crediting mechanisms are further pursued, it is essential that adequate international oversight be executed for any mechanisms involving international transfer of credits, that methodological standards be internationally accepted and include appropriate safeguards to prevent perverse incentives, that mechanisms monitor the performance of auditors and apply effective sanctions in the case of non-performance, and that information on credited activities is transparent and publicly accessible.

Methods

Data on production and waste gas generation was gathered from project design documents (PDDs) and monitoring reports, published by the UNFCCC[3] and the Russian Registry of Carbon Units[4], and audited by AIEs. The monitoring and verification reports publicly available are incomplete for four out of the five plants: for HFC-23 and SF_6 abatement at KCKK Polymer, the first and second monitoring report covering the years 2008 and 2009 are lacking. For HFC-23 abatement at HaloPolymer Perm, the first, second and fourth monitoring report, covering the years 2008 and 2009 and the period 1 January to 31 March 2011, are lacking, as well as the fourth verification report for the period 1 January to 31 March 2011. Moreover, as of 1 January 2012, HaloPolymer Perm reports only HFC-23 incineration but no longer HFC-23 generation. We conservatively assume that all HFC-23 generated was incinerated. If HFC-23 was partially vented or sold, the actual HFC-23 generation in 2012 would be even higher than presented in Figure 4-1. Finally, monitoring reports are not publicly available for the plant in France.

Project-based mechanisms generally calculate emission reductions by comparing an emissions baseline with monitored project emissions and adjusting for any indirect upstream or downstream leakage emissions occurring as a result of the project:

$$ER = BE - PE - LE \qquad \text{(Equation 4-1)}$$

where ER are the emission reductions, BE are the baseline emissions, PE are the project emissions and LE are the leakage emissions (all expressed as metric tons of CO_2 equivalent). Whereas project emissions can in most cases be directly measured, baseline emissions are estimated based on a counterfactual, hypothetical scenario. Baselines often aim to reflect the emissions level that would most likely occur if the project was not implemented, but could also be set at a lower, more conservative level – for example, to address uncertainties or to prevent perverse incentives. Over-crediting, or excess issuance of credits, occurs if the estimated baseline is higher than the emissions level that would

[3] http://ji.unfccc.int

[4] http://www.carbonunitsregistry.ru

occur if the project was not implemented (or if project or leakage emissions are underestimated).

Absent methodological safeguards, the four projects determine baseline emissions as the observed waste gas generation, that is, assuming that the same amount of waste gas would be generated and emitted in the absence of crediting. We estimate the extent of excess issuance of credits as the difference between the claimed baseline emissions ($BE_{claimed}$) and different assumptions on plausible baseline emission levels ($BE_{plausible}$):

$$E = BE_{claimed} - BE_{plausible} \qquad \text{(Equation 4-2)}$$

where *E* are the credits issued in excess, $BE_{claimed}$ are the baseline emissions specified in the monitoring reports of the plants and $BE_{plausible}$ is our estimate of the plausible range of baseline emissions (both expressed in metric tons of CO_2 equivalent).

We use three scenarios to reflect the range of plausible baseline emissions ($BE_{plausible}$). For the three plants in Figure 4-1, historical data on waste generation is available. We estimate the magnitude of over-crediting over the period 1 April 2011 to 31 December 2012, when methodological safeguards were not applied, assuming that the three facilities would have produced the same amount of waste gas per day as before the start of crediting, as during the crediting period before their decision to abandon the methodological safeguards, or as originally projected when the project was approved. The credits issued in excess would amount to 19.7, 17.3, or 17.6 million, respectively, corresponding to 69%, 61%, or 62% of the 28.3 million credits issued to the three facilities over that period.

For SF_6 abatement at HaloPolymer Perm in Figure 4-2 the magnitude of over-crediting is more uncertain because historical data is not available. We determine plausible baseline emission levels based on the SF_6 production and a range of plausible assumptions on the waste generation rate:

$$BE_{plausible} = P_{SF6} \times w_{SF6} \times GWP_{SF6} \qquad \text{(Equation 4-3)}$$

where P_{SF6} is the SF_6 production at the plant (in metric tons of SF_6), w_{SF6} is the waste generation rate expressed as metric tons of SF_6 waste gas generated per metric tons of SF_6 produced, and GWP_{SF6} is the global warming potential of SF_6 valid for the first commitment period under the Kyoto Protocol (metric tons of CO_2 equivalent per metric tons of SF_6). We estimate the magnitude of over-crediting for the period 2008 to 2012 when methodological safeguards were not applied. For the period 2008 to 2010 we use the SF_6 production data reported by the plant. For 2011 and 2012, SF_6 production data is not reported; we conservatively assume that the plant would operate at its maximum production capacity. We use three scenarios to estimate the plausible range of the waste generation rate, assuming that the plant would have operated at a waste generation rate of 0.2%, as suggested by the IPCC, 2.0%, as observed before crediting at the KCKK Polymer SF_6 production plant, or 3.8%, as approximated based on SF_6 emissions data reported in the Russian GHG inventory (see Supplementary Information). The credits issued in excess would amount to 13.5, 11.9, or 10.2 million, respectively, corresponding to 99%, 87%, or 75% of the credits issued over that period.

Supplementary documentation

Additional project information

The four registered JI projects include five production plants that produce HCFC-22, SF_6 and TFA. HCFC-22 is a GHG and an ozone-depleting substance regulated under the Montreal Protocol on Substances that Deplete the Ozone Layer. It is mainly used in refrigeration and air-conditioning appliances and as a feedstock in the production of polymers. HFC-23 is an unwanted by-product from HCFC-22 production; it has a GWP of 12,400 over a 100 year time horizon (IPCC, 2013). SF_6 is mainly used as insulator gas in the electrical industry. In the rectification of SF_6, a small fraction of SF_6 is lost through the off-gas. Larger quantities may be lost in the process of filling cylinders but these emissions are not subject to the JI projects (IPCC, 2006). SF_6 has a GWP of 23,500 over a 100 year time horizon (IPCC, 2013). TFA is the precursor to several products in the chemical industry. A range of fluorinated gases are unwanted by-products from TFA production.

Project RU1000201 (unique number assigned by the international transaction log operated by the United Nations Framework Convention on Climate Change) covers two plants at the industrial facility KCKK Polymer which produce HCFC-22 and SF_6. The project includes abatement of the HFC-23 waste gas stream from HCFC-22 production and the SF_6 waste gas stream from SF_6 rectification. Another industrial facility in Russia, HaloPolymer Perm, produces also both HCFC-22 and SF_6. HFC-23 and SF_6 emissions are addressed separately in two projects (RU1000202 and RU1000309). The projects RU1000201 and RU1000309 install a new HFC-23 and SF_6 destruction unit, while project RU1000202 consists of a modernization and capacity enhancement of three existing destruction units. All three projects aim at destroying all HFC-23 and SF_6. Another smaller HCFC-22 production plant in Russia, operated by JSC Khimprom Volgograd, was proposed as JI project but never registered. These three registered and the proposed project cover all production facilities in Russia: three HCFC-22 production facilities with a total capacity of about 44,000 tons per year and two SF_6 production facilities with a total capacity of about 1,800 tons per year (UNIDO & GEF, 2012). Project FR1000029 at Rhodia Salindres in France abates a waste stream from the production of TFA consisting of HFCs, PFCs, and GHGs regulated under the Montreal Protocol on Substances that Deplete the Ozone Layer.

The projects RU1000201 and RU1000202 were developed at the same time by Camco International. They initially applied the CDM baseline and monitoring methodology AM0001 for HFC-23 destruction (version 5.2), with some adjustments. The methodology aims to avoid perverse incentives through two provisions:

1. The amount of HCFC-22 eligible for crediting is capped to the maximum annual HCFC-22 production observed in the period 2002 to 2004. This provision aims to avoid perverse incentives to increase HCFC-22 production beyond levels that would be produced in the absence of the CDM; and
2. The maximum HFC-23 that can be used for crediting is capped to the minimum of the annual waste generation rates observed in the period 2002 to 2004. This provision aims to avoid perverse incentives to artificially increase the HFC-23 waste generation rate beyond levels that would occur in the absence of the CDM.

The original PDDs of the projects RU1000201 and RU1000202 both limited the amount of HCFC-22 that is eligible for crediting and established a cap on the maximum HFC-23 waste generation eligible for crediting, in line with the methodology. No CDM methodology was developed for abatement of SF_6 emissions from SF_6 rectification, but project RU1000201 nevertheless capped the amount of saleable SF_6 production and the rate of SF_6 losses in relation to the saleable production of SF_6, similar to the provisions in the CDM methodology for HFC-23 abatement.

In 2011, both projects adopted a revision to the monitoring plan, using a JI specific approach instead of applying a CDM methodology. The new approach was applied retroactively as of 1 January 2010 to both projects. The revision removes both the cap on the amount of HCFC-22 production that is eligible for crediting and the cap on the waste generation rate; all waste gas generated becomes eligible for crediting. The revised monitoring plans also declare key data and information provided in the original PDDs as inaccurate, including regulations applicable in Russia and historical data on HCFC-22 production, HFC-23 generation, and HFC-23 abatement.

Both original PDDs state that HFC-23 was already abated in part prior to the implementation of the JI projects in existing incinerators, together with other waste gases originating from the same industrial facility. Historical abatement levels are partially quantified. The original PDDs indicated that the level of abatement depended on the capacity of the existing destruction units and the extent to which these had to destroy toxic waste gases. According to the original PDDs, the objective of both projects is to enhance HFC-23 abatement beyond historical levels. In contrast, the documentation of the revised monitoring plans of both projects declares that HFC-23 was not abated prior to the start of the JI project. With regard to SF_6 abatement in project RU1000201, both the original PDD and the revised monitoring plan consistently state that it was not captured and abated prior to the implementation of the JI project. Both original PDDs also considered applicable regulations with regard to a "specified level of maximum permissible emissions" in calculating the level of baseline emissions. The documentation on the revised monitoring plan of both PDDs concludes that no regulations are applicable and removes the relevant provisions from the calculation of baseline emissions. The information on the level of waste gas formation in the original PDDs is indicated as black continuous line in Figure 4-1, the information according to the revised monitoring plan as grey continuous line. Both the information in the original PDDs and the information in the revised monitoring plan was confirmed as correct by two different AIEs, Det Norske Veritas (DNV) at PDD determination and Bureau Veritas Certification (BVT) at verification. The project RU1000309 does not provide information whether SF_6 was abated prior to the implementation of the project and states that its destruction is not required by regulations.

In some countries, small quantities of HFC-23 are sold. According to information in the original PDD of project RU1000201, a small fraction of the HFC-23 was sold in the period 2002 to 2007. In the calculation of emission reductions, the actual sales of HFC-23 are monitored and subtracted from the baseline emissions. However, the economic value of one ton of HFC-23 incinerated and credited under JI could be higher than the market price for HFC-23, depending on the price of ERUs and HFC-23. This could create perverse incentives for the project participants to incinerate rather than sell HFC-23. In the project RU1000201, the available monitoring reports, covering the period from 1 January 2010 to 10 November 2012, document that no sales of HFC-23 occurred. The project RU1000202 did not report any historical sales of HFC-23.

Implications of the increase of waste gas generation

An increase of the waste gas generation can have different implications with regard to the amount of potential over-crediting:

- *Increased waste generation rates*: If the increase of waste gas generation occurs due to an increase in the waste generation *rate*, then the amount of over-crediting correlates with the increase in waste gas generation;
- *Production shifts*: If the increase of waste gas generation occurs due to an increase in production of the main product — HCFC-22, SF_6 or TFA — and if the product is used (and not vented to the atmosphere), then the emissions impact depends on where and how the product would otherwise be produced (i.e. at which waste generation rates the other plants would operate), whether the waste gas is abated, and whether any abatement occurs under JI or the CDM. Production shifts due to incentives from JI could lead to over-crediting and potential economic distortion of competition; and
- *Increase in production and venting of the product*: In the worst case, the main product could be produced without demand, for the purpose of generating and incinerating

the waste gas under a crediting mechanism, and be vented to the atmosphere. In this case, the GHG emissions increase would be larger than the amount of credits issued, due to the GWP of the main products HCFC-22 and SF_6. In addition, efforts to protect the ozone layer would be undermined in the case of HCFC-22.

Monitoring data that would allow determining the way in which the waste gas generation was increased is not available. In the case of the three plants illustrated in Figure 4-1, the new approach towards calculating emission reductions, introduced in 2011 and retroactively applied as of 1 January 2010, does not monitor anymore HCFC-22 and SF_6 production. To assess whether the production or the waste generation rate increased in these plants, we estimate the plausible range of the waste generation rate using three scenarios: first, we assume that the plants would operate at their maximum HCFC-22 and SF_6 production capacity. Information on the production capacities is provided in monitoring reports; the capacity did not change in the period 2010 to 2012 in any of the three plants. This approach provides the lower end of the possible range of the waste generation rate. Second, we use the annual HCFC-22 and SF_6 production level projected in the original PDDs. And third, we correlate data from the projects with data from GHG inventory reports submitted by the Russian government to the UNFCCC (Russian Federation, 2014). In Russia, three HCFC-22 plants with a total capacity of about 44,000 tons are reported to be operational (UNIDO & GEF, 2012). The two registered JI plants together have a capacity of 40,200 tons and thus make up for most of the production capacity in Russia. For the period 2002 to 2007, for which HCFC-22 production data is available from both the Russian GHG inventory and the two registered JI projects, the HCFC-22 production in the GHG inventory is reasonably consistent with the amount of HCFC-22 production reported by both plants in their revised monitoring plans under JI (see Figure 4-3).

Figure 4-3 shows that the total HCFC-22 production in Russia did not substantially increase in 2011 and 2012 compared to previous years and was significantly lower than the total production capacity of 44,000 tons. Under this third approach, we assume that the two registered JI plants would continue to produce about 97% of the Russian production, as in the period 2002 to 2007. We allocate the total production to the two plants proportionally to their plant capacity, which is largely consistent with their historical production shares.

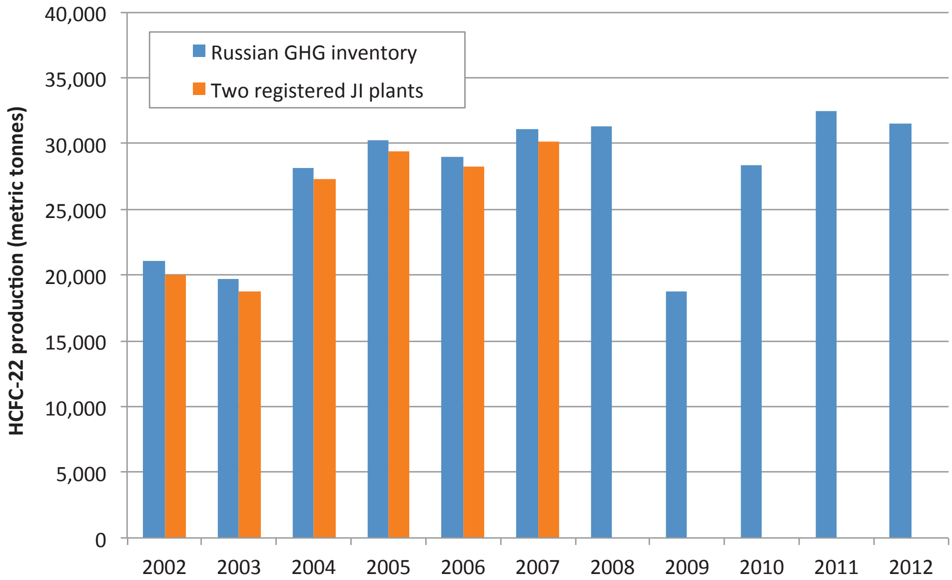

Figure 4-3 HCFC-22 production in Russia. The Russian GHG inventory includes data from three HCFC-22 production plants whereas the two registered JI projects include two HCFC-22 production plants.

Figure 4-4 shows how the HFC-23 and SF_6 waste generation *rate* developed over time, based on the three approaches to estimate HCFC-22 and SF_6 production. The relative increase in the waste generation *rate* in Figure 4-4 is similar to the increase in absolute waste gas generation in Figure 4-1. Moreover, total HCFC-22 production in Russia did not increase substantially in 2011 and 2012 compared to previous years, except for the decline in 2009 which may be attributable to the economic recession in that year. This confirms that the increase in waste generation can largely be attributed to an increase in the waste generation *rate*. In 2012, the HFC-23 waste generation rate at HaloPolymer Perm not only exceeds the IPCC range of 1.5% to 4.0% but also any known values from other operating plants, including historical and monitored data from the 19 CDM plants located in developing countries (Schneider, 2011; UNFCCC, 2011).

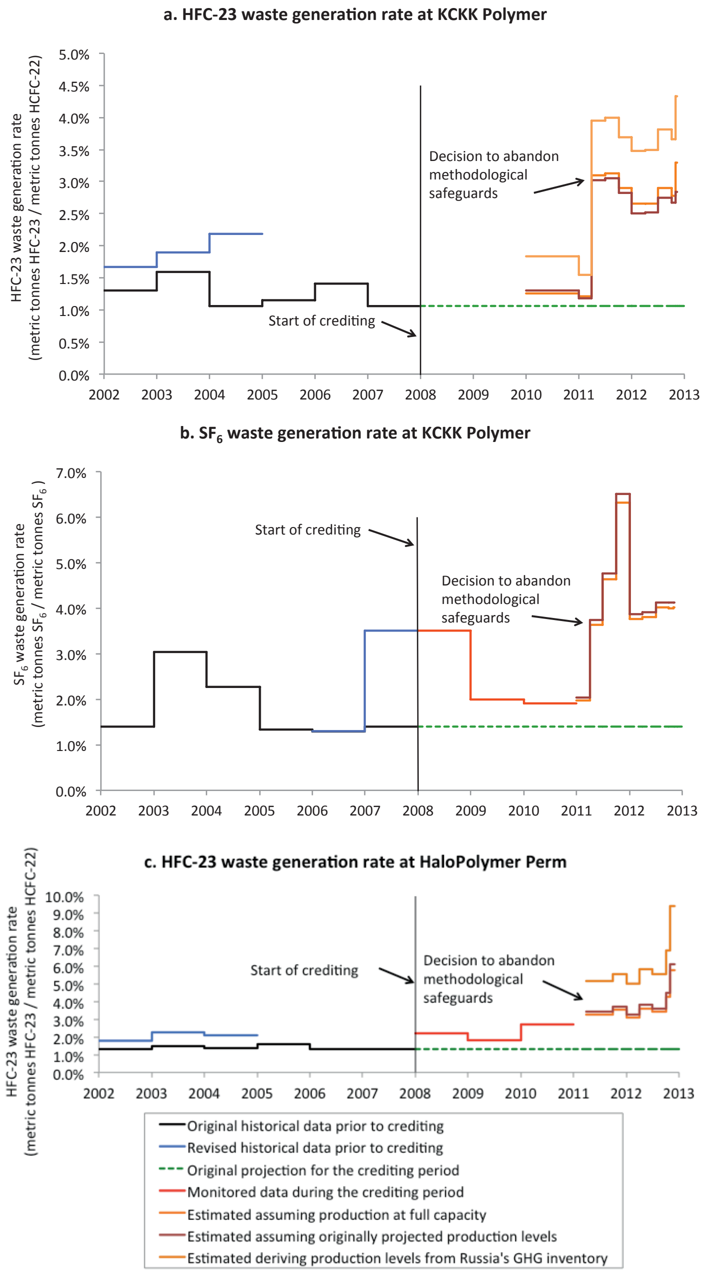

Figure 4-4 HFC-23 and SF_6 waste generation rates at the KCKK Polymer plant (panels a and b) and HFC-23 waste generation rate at the HaloPolymer Perm plant (panel c). For three different scenarios for HCFC-22 and SF_6 production, the waste generation rate increases beyond historically observed levels, after the plant operators decided to abandon methodological safeguards to prevent perverse incentives.

In the case of SF_6 abatement at HaloPolymer Perm, as illustrated in Figure 4-2, data on SF_6 production is not available for the period prior to 2008; therefore, the waste generation rate cannot be determined for that period. We approximate the waste generation rate roughly, by combining GHG inventory data for the period 1990 to 2007 with production data for the period 2008 to 2010. If the GHG inventory emissions were caused by the two plants proportionally to their production capacity, if the emissions were only caused from waste gas generation during production and not from handling SF_6 at the production site, and if the plant in Figure 4-2 would have produced over the period 1990 to 2007 the same amount of SF_6 as in the period 2008 to 2010, the waste generation rate would vary from 0.4% to 5.8% over the period 1990 to 2007, with an average of 3.8%. This range is significantly lower than the rate of 16.9% reported by the plant in the period 2008 to 2010, which indicates that the increase in waste gas generation may be mostly attributable to an increase in the waste generation rate.

Finally, we observe peaks in waste generation during some periods: HFC-23 and SF_6 waste generation was significantly ramped up in October and November 2012 at HaloPolymer Perm and SF_6 waste generation at KCKK Polymer peaked in the fourth quarter of 2011. A possible explanation could be that the further increase could enable the delivery of more credits as per the 1st of December delivery date commonly used for futures and other contracts in the carbon market.

Chapter 5
Robust eligibility criteria essential for new global scheme to offset aviation emissions

Abstract

Aviation may have contributed as much as 4.9% to global radiative forcing in 2005 and its carbon dioxide emissions could grow by up to 360% between 2000 and 2050 (Owen, Lee, & Lim, 2010). In 2016, the International Civil Aviation Organization adopted a global scheme requiring airline operators to offset increases in carbon dioxide emissions from international flights above 2020 levels (ICAO, 2016a, 2017). Here we show that the scheme will only compensate for the emissions increase if robust criteria for the eligibility of offset credits are adopted. Offset supply from already implemented greenhouse gas abatement projects registered under the Clean Development Mechanism alone could exceed demand from International Civil Aviation Organization's scheme. Most of these projects continue abatement even if they cannot sell offset credits. If the scheme allows airline operators the unlimited use of offset credits from already implemented projects, it will result in no notable emissions reductions beyond those that would occur anyway and neither offer incentives for new investments nor reward previous investments in offset projects. We recommend limiting the eligibility to new projects or projects that are at risk of discontinuing greenhouse gas abatement without further support. The findings are critical for negotiations under both International the Civil Aviation Organization and the Paris Agreement.

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[5] Note that figures and tables originally included in supplementary information were integrated in the main text and methods section.

Emissions from international civil aviation and maritime transportation are not included in countries' climate change mitigation targets under the United Nations Framework Convention on Climate Change (UNFCCC), its Kyoto Protocol and the Paris Agreement. Instead, the Kyoto Protocol has mandated countries to work through the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO) to address these emissions. In 2010, ICAO adopted an aspirational goal of carbon-neutral growth, meaning that global net carbon dioxide (CO_2) emissions from international aviation should be frozen at their 2020 levels (ICAO, 2010). To pursue this goal, ICAO adopted the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which will complement measures to reduce emissions through technological and operational improvements and sustainable fuels with a mechanism for the purchase of offset credits to compensate for emissions (ICAO, 2016a, 2017). With an estimated mitigation gap of 1.6–3.7 Gton CO_2 over its operational period from 2021 to 2035, CORSIA could constitute the single largest demand for offset credits after 2020 (ref. Healy, 2017). The CDM is the largest offsetting program available at present. It was established under the Kyoto Protocol to provide flexibility to industrialized countries in reaching their emission reduction targets. With the last commitment period of the Kyoto Protocol ending in 2020, the future of the CDM is uncertain. In past years, the market for certified emission reductions (CERs) has been characterized by supply greatly exceeding demand, which has led to CER prices dropping well below €1 and a notable decline in project registration and CER issuance (Intercontinental Exchange, 2018; UNFCCC, 2017d). In this letter, we assess the environmental implications of using CERs issued for emission reductions up to 2020 under CORSIA.

Several factors influence the global greenhouse gas (GHG) emissions outcome from using offset credits (Chapter 2). One important factor is that, at the time of project implementation, the investment in emission reductions should not have occurred in the absence of the incentives created by the offsetting program. This ex-ante determination of additionality is fundamental for achieving a climate neutral effect from offsetting. In a market situation where the supply of credits considerably exceeds demand, however, additionality at project inception, although unchanged, is not relevant for the climate effect of new support provided to projects that have made their investments already. Instead, a key consideration for the global GHG emissions effect of new demand (such as from CORSIA) is whether the projects would continue to reduce GHG emissions even without CER revenues, or whether they are at risk of discontinuing GHG abatement without these revenues. For this reason, we do not assess whether projects were additional at their inception but rather analyse their current vulnerability to discontinuing GHG abatement, a new concept that we developed as part of this research. We focus here on this aspect as it has major implications for CORSIA's climate impact, noting that other aspects, in particular avoiding double counting of emission reductions, are also important.

Projects are typically vulnerable if they have ongoing operational costs but insufficient financial benefits beyond CER revenues to maintain the GHG abatement or if they face important non-financial barriers. For example, the use of biomass for energy generation requires the sourcing of biomass fuels for which supply is often more expensive and less reliable than for fossil fuels. Some biomass projects are at high risk of discontinuing GHG abatement because the sourcing of biomass is only economically viable with ongoing financial support. Some projects may also face non-financial barriers that could make the project vulnerable to discontinuation without continued CDM support; for example, if technical support provided through CDM intermediaries is no longer provided. In contrast, projects are typically non-vulnerable if ongoing alternative revenues or cost savings exceed ongoing operational expenditures once initial costs for project implementation have been sunk, or the dismantling of the project may incur larger costs than its continued operation. Once implemented, these projects have economic incentives to continue GHG abatement, with or without CER revenues. Projects also might continue GHG abatement because new policies promote or require continuation or because discontinuation is technically not viable.

In a market situation where supply greatly exceeds demand, creating new demand for offset credits (such as through CORSIA) would not lead to further emission reductions if it is served by non-vulnerable projects. Here we show that this risk is material if all types of CER were eligible for use under CORSIA because (1) the CER supply potential exceeds the demand from CORSIA, (2) most CDM projects are not vulnerable to discontinuing GHG abatement without CER revenues and (3) these projects can supply offset credits at lower costs than vulnerable projects.

To estimate the CER supply potential, we develop a new methodology that – in contrast to previous estimates (Rob Bailis, Broekhoff, & Lee, 2016; Cames et al., 2017; IGES, 2017; Warnecke, Day, & Tewari, 2015; World Bank, Ecofys, & Vivd Economics, 2016) – evaluates the actual status and operational conditions of CDM projects, in particular through an extensive survey of more than 1,300 projects, and CDM regulatory requirements that could limit the ability of projects to issue CERs (Methods). The survey results show that 97% of the registered CDM projects were implemented, of which 90% (87% of the total registered) continue the operation of their GHG abatement activities, despite limited or no financial support from CER revenues (Table 5-1). Drawing upon this data, as well as other information (Schneider & Cames, 2014; UNFCCC, 2017d), the supply potential from the over 8,000 registered projects and 'programmes of activities' is estimated to be about 4.65×10^9 CERs for the period 2013–2020 (Table 5-2). In contrast, the current demand for CERs—including recognition of CERs under emissions trading systems and carbon taxes, national and multilateral purchase programs, and voluntary offsetting—is estimated to amount to up to 600×10^6 over the same period (European Commission, 2018b; Hamrick & Gallant, 2017; ICAP, 2018; UNFCCC, 2016, 2017c). The remaining supply potential (about 4×10^9) thus exceeds the demand from CORSIA of $1.6–3.7 \times 10^9$ offset credits (Healy, Van Velzen, Graichen, & Graichen, 2017), even if no other offsetting programs were eligible to supply credits and if no CERs were issued for emission reductions occurring after 2020.

Table 5-1 Status of projects by project type

Project type	Share of projects that were implemented[(a)]	Share of implemented projects that continue abatement[(b)]	Share of implemented and abating projects that have a CDM monitoring system in place[(c)]
Biomass energy: Agriculture and forestry residues	95%	82%	83%
Biomass energy: Bagasse power	97%	68%	29%
Biomass energy: Palm oil solid waste	100%	83%	50%
Cement: Clinker	100%	81%	100%
Coal mine methane	100%	91%	67%
Energy efficiency: Household stoves	83%	100%	83%
Energy efficiency: Household lighting	68%	83%	96%
Energy efficiency: Industry	94%	87%	66%
Energy efficiency: Coke oven gas / iron & steel heat	99%	88%	81%
Energy efficiency: Cement heat	100%	100%	100%
Fossil fuel switch: Oil to natural gas	100%	87%	80%
Fossil fuel switch: New natural gas plant	100%	81%	87%
Micro hydropower (<2 MW)	97%	71%	77%
Hydropower (2-20 MW)	98%	99%	95%
Landfill gas: Flaring	85%	62%	82%
Landfill gas: Power generation	93%	79%	83%
Methane avoidance: Flaring	98%	36%	73%
Methane avoidance: Power generation	96%	79%	75%
Methane avoidance: Composting	70%	69%	81%
Methane avoidance: Domestic manure	94%	94%	100%
N_2O abatement from adipic acid production	100%	100%	50%
N_2O abatement from nitric acid production	100%	49%	93%
HFC-23 abatement from HCFC-22 production	100%	69%	77%
Solar photovoltaic	97%	99%	76%
Solar water heating	100%	59%	100%
Wind power	99%	98%	95%
Global average	97%	90%	89%

Data derived from a survey with a sample size of 1,310 CDM projects. The table summarizes the survey results by project type for the questions 3, 5 and 9 on the project status (see methods section). (a) The share has been determined based on the following answers to question 3: "Fully implemented", "Implementation / construction started", "Investment decision made", "Dismantling of project activity". (b) The share has been determined based on the following answers to question 5: "in regular operation" and "No CDM-conformant operation, alternative GHG mitigation equipment operating". (c) The share has been determined based on the following answers to question 9: "implemented and operational". The answer "I don't know" was excluded from all totals.

Table 5-2 Factors contributing to a lower CER supply potential than the emission reductions anticipated in project design documents

	Billion CERs	%
Ex-ante estimates in project design documents	**7.67**	
Contribution of different limitations	**-3.01**	100%
Lower actual issuance	-1.90	63%
Non-implementation of projects	-0.10	3%
Non-continuation of GHG abatement	-0.42	14%
Availability of data to monitor emission reductions	-0.33	11%
No administrative steps taken in time to renew the crediting period	-0.27	9%
CER supply potential	**4.65**	

To assess the extent to which CDM projects are vulnerable to discontinuing GHG abatement, we first systematically classify projects according to their likelihood of (dis)continuing GHG abatement without further support. This is done on the basis of an evaluation of applicable policies and laws, as well as economic and other conditions of projects in different countries (Methods). In a second step, we apply this vulnerability classification to the CER supply potential. Figure 5-1 shows the results in relation to the CER supply potential. About 3.8×10^9 CERs, or 82% of the total CER supply potential, stem from project types that typically have a low vulnerability to discontinuing GHG abatement. While many of these projects currently do not issue CERs, most could resume CER issuance if they had enough incentives to do so. For another 13%, the vulnerability is variable, depending on the specific circumstances of the project. Only about 170×10^6 CERs, or 4% of the CER supply potential, are from project types that typically have a high vulnerability to discontinuing GHG abatement and that still report to be operational or could resume operations. The estimated CER supply potential from vulnerable project types is not only small because of the market share of vulnerable project types but also since many vulnerable projects already discontinued GHG abatement due to their vulnerability. We estimate that their share would otherwise be about twice as high. Additionally, some projects are not vulnerable anymore because domestic policies provide incentives or require their continued abatement.

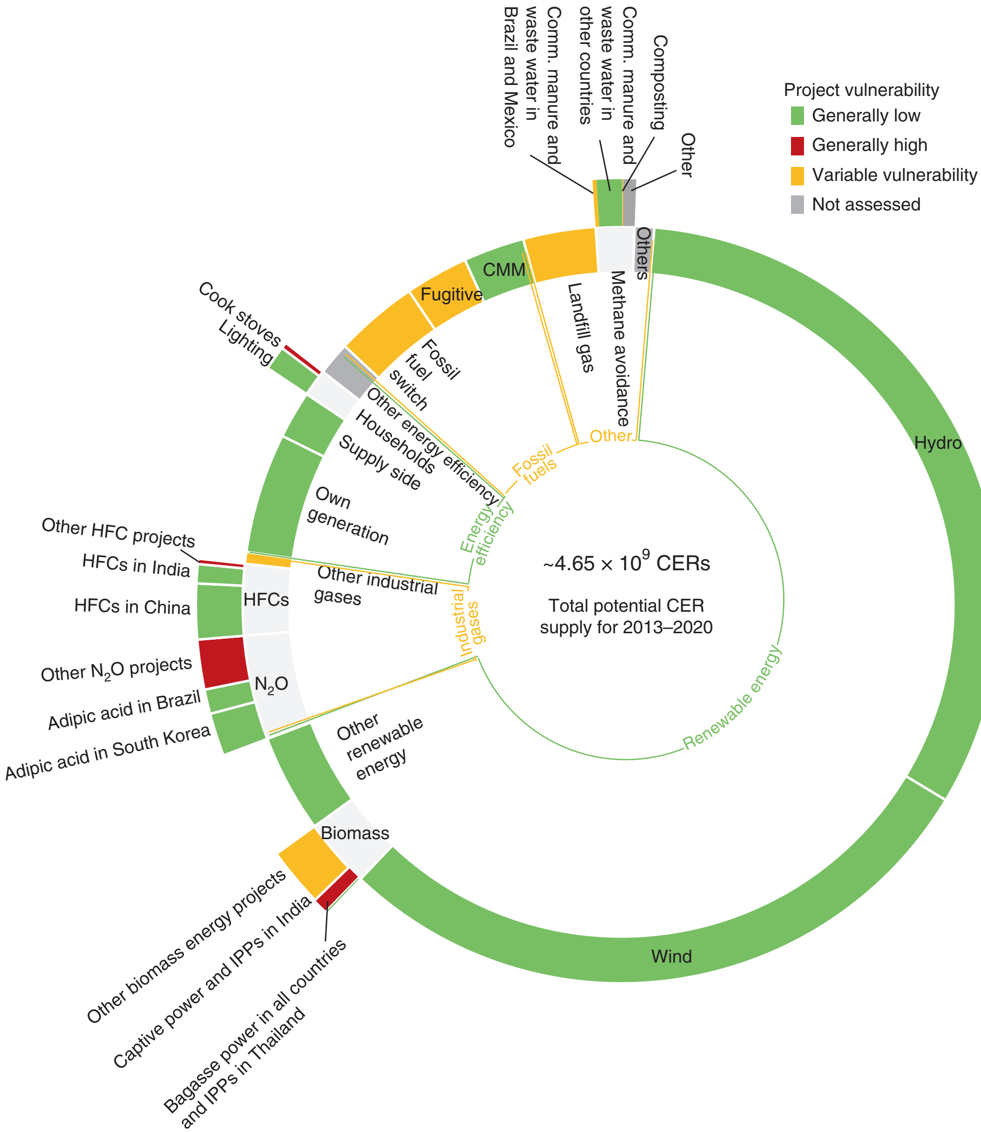

Figure 5-1 CER supply potential for the period 2013–2020 by major project types and vulnerability to discontinuing GHG abatement. The main circle clusters the vulnerability of projects by major project types (see also **Table 5-3**). Some project types are further subdivided (outer circle) to show results for specific countries and project sub-types, where available. For methods and calculations, refer to Methods (CMM, coal mine methane; IPP, independent power producer; HFCs, hydrofluorocarbons).

Table 5-3 Overview of vulnerability to discontinuing GHG abatement for assessed project types

Project type and sub-type	Project vulnerability
Biomass energy: Use of biomass-based fuels, such as agricultural and forestry residues, biogas and biodiesel, for energy generation	**Variable** according to subtype and local conditions
Bagasse power	**Low:** Usually a low risk activity due to the highly positive economic conditions from the utilisation or sale of electricity to the grid (e.g. detailed analysis confirms this case for projects in India and Brazil).
Biomass independent power producers (IPPs) and captive biomass energy	**Variable**: Highly variable depending upon local market conditions for biomass and grid connectivity regulation. High vulnerability in some areas of India due to competition for biomass and the unreliable biomass supply; low vulnerability in Thailand.
Coal mine / bed methane: Treatment and/or utilisation of methane from coal mines, including ventilation air methane	**Low**: Financial benefits for power generation from methane utilisation often exceed operating expenditures.
EE households: Lighting, stoves and appliances	**Variable** according to subtype and local conditions
Lighting	**Low:** Despite disengagement of project owners, regulations often require continued use of lightbulbs (e.g. Mexico), whilst decreasing costs and increasing awareness of benefits makes their continued use likely even in the absence of regulation (e.g. Pakistan and India).
Cooking stoves	**High:** Disengagement of third party project owners. Barriers related to the affordability of new stoves, knowledge of benefits and cultural preferences may prevent continued use despite potentially being economically beneficial for owners.
EE industry: Efficiency improvement in industrial plant processes	**Low**: Significant cost savings with no or low additional OPEX
EE own generation: Use of process wastes for heat or energy generation	**Low**: Significant cost savings with no or low additional OPEX
EE supply side: Efficiency improvements of existing energy generation facilities incl. fossil fuel plants, cogeneration and combined cycle projects	**Low**: Significant cost savings with no or low additional OPEX
Forests Afforestation, reforestation, mangroves and agroforestry	**Variable** according to capacity of owner and local legislation
Fossil fuel switch: New natural gas plants and switch from oil to natural gas	**Variable** according to project subtype and global fuel markets
Fugitive: Treatment of fugitive gases from oil and gas production	**Variable** according to project subtype
Geothermal	**Low**: Significant revenues and very low OPEX

Project type and sub-type	Project vulnerability
HFCs: Treatment of HFC23 waste gases	
HFC23 in China and India	**Low** due to domestic policies to incentivize abatement
HFC23 in other countries	**High**: OPEX incurred yet no significant financial benefits. Uncertain when emissions will be addressed under the Kigali Amendment to the Montreal Protocol.
Hydro	**Low**: Significant revenues and very low OPEX
Landfill gas: Treatment of landfill gas and municipal solid waste including flaring and power generation activities	**Variable** according to subtype and local conditions
Methane avoidance: Avoidance, treatment and utilisation of methane from manure, wastewater, palm oil waste and composting	**Variable** according to subtype and utilisation of wastes and methane
Commercial livestock manure management	**Variable:** Continuation is economically rational in the absence of barriers. Low vulnerability in Thailand. High vulnerability in Mexico and Brazil, where farmers do not have capacities to continue in the absence of third party project owners.
Waste water	**Low:** Revenues and cost savings from energy generation greater than operating expenditures. Common practice in India, Malaysia and Thailand, even outside of CDM.
Palm oil solid waste composting	**Variable** across local regions, depending on the maturity of the market for alternative uses of palm oil processing residues
N_2O: Decomposition of N_2O from nitric and adipic acid production	
N_2O in South Korea and Brazil	**Low**: Specific situation for projects in these countries understood
N_2O in other countries	**High**: Incurs OPEX but no or very low financial benefits
PFCs+SF_6: Avoidance, treatment or recycling PFC and SF_6 gases	**Low (AM78) - High (AM35/65):** No revenues but additional OPEX for projects using methodologies AM35/AM65
Solar: Solar PV, solar thermal and solar water heating	**Low:** Non-CER revenues usually greater than OPEX
Wind	**Low**: Significant revenues and very low operating expenditures
Other project types	**Unknown vulnerability**

To assess the costs of supplying CERs, we derive a supply curve for the identified CER supply potential. For each CDM project we estimate the marginal cost of supplying CERs from today's perspective, using various data sources and taking into account the project type, the country it is located in and our vulnerability classification. We assume that projects with low vulnerability have to cover only ongoing CDM transaction costs, whereas projects with high vulnerability must also cover their marginal GHG abatement costs (Methods).

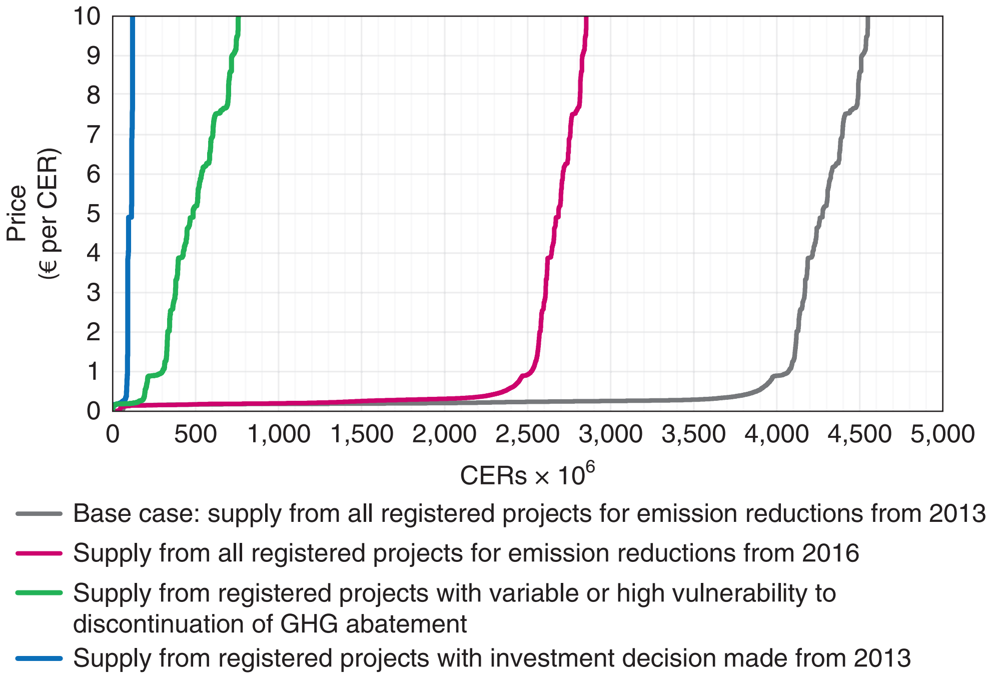

Figure 5-2 Marginal costs of supplying CERs for the period 2013–2020. The left part of the 'base case' curve is relatively flat because it mainly includes projects with low vulnerability. These projects only have to cover ongoing CDM transaction costs – but no marginal abatement costs – to issue CERs. The right part of the curve is steeper because it includes mostly projects with high or variable vulnerability. These projects also have to cover GHG abatement costs. The figure also illustrates scenarios for vintage restrictions under consideration for CORSIA. Please note that this figure includes only the supply from registered projects.

Figure 5-2 shows that all existing registered projects could supply over 4×10^9 CERs at a cost below €1 (black line). Almost 3.8×10^9 (92%) of these CERs are from low vulnerability projects. Projects classified as having high or variable vulnerability have higher costs of generating CERs (green line). If all CERs were eligible, the new demand from CORSIA would mostly be served by projects with low vulnerability. In consequence, the scheme may not achieve notable emission reductions beyond those that would occur without it. A further implication of this analysis is that CER prices would probably remain low. The sale of CERs would not generate substantial financial returns for project owners and host countries, beyond the transaction costs for verifying emission reduction and issuing CERs; as such, CORSIA would neither provide support for vulnerable projects, nor offer incentives to develop new projects.

To address these risks, we recommend that ICAO restricts the types of offset credits that are eligible under the scheme to:

- Projects that are newly developed in response to CORSIA; and
- Implemented projects that are vulnerable to discontinuing GHG abatement.

New projects could be promoted through 'vintage' restrictions, as envisaged under CORSIA (ICAO, 2016a) and proposed by some Parties (European Commission, 2018a); for example, by limiting eligibility to projects where the investment decision was made after the adoption of CORSIA or after the approval of the offsetting program by ICAO. Vulnerable projects could be promoted by limiting eligibility to a list of project types that typically have a high vulnerability to discontinuing GHG abatement (see Table 5-3 for our assessment).

Figure 5-2 shows the implications of these and other possible restrictions on the potential and costs of supplying CERs. Restricting eligibility to projects classified as having a high or variable vulnerability to discontinuing GHG abatement would reduce the potential supply to about 770×10^6 CERs. With regard to vintage restrictions, alongside limiting eligibility to new projects, policy makers are also considering restrictions on the basis of recently implemented projects or the timing of the emission reductions. The figure shows that limiting eligibility to projects with an investment decision date on or after 1 January 2013 (blue line) would lower the supply potential considerably, to about 120×10^6 CERs. Restricting the supply potential to CERs from emission reductions that occurred on or after 1 January 2016 (purple line) would not be effective to ensure that CORSIA would trigger further emission reductions, as this would still provide for a large supply potential from projects with low vulnerability. Policy makers are also considering restrictions on the basis of the date of registration. Such restrictions would also not be effective, since there is a large portfolio of projects that were developed before 2013 and that took administrative steps which secured their right to register under the CDM any time in the future (UNFCCC, 2017d).

To conclude, our analysis shows that establishing robust eligibility criteria is essential for CORSIA to achieve its objective of carbon-neutral growth. While these findings are critical for the ongoing negotiations of the rules for CORSIA, they are also relevant for other regimes, including domestic carbon pricing schemes that allow the use of offset credits, a possible future mechanism under IMO to offset emissions from international maritime transportation, and the Paris Agreement. Some countries proposed that CERs (and other Kyoto units) be eligible to achieve nationally determined contributions after 2020 (ref. UNFCCC, 2018). This could likewise undermine mitigation efforts under the Paris Agreement. We therefore recommend that policy makers, when establishing new sources of demand for offset credits, restrict the eligibility to new projects that are developed in direct response to the new demand and/or to existing projects that are vulnerable to discontinuing GHG abatement.

Methods

CER supply potential. The methodology applied to estimate the CER supply potential from each of the over 8,000 registered CDM projects and programmes of activities combines information from individual projects with information on project types and host country level, where available. Official information on CDM projects and their expected emission reductions is drawn from a UNFCCC database (UNFCCC, 2017d). The CER supply potential is estimated for emission reductions occurring from 1 January 2013 to 31 December 2020, noting that CERs from emission reductions up to 2012 are unlikely to be eligible under CORSIA. For periods for which CERs have already been issued, UNFCCC data on the actual issuance is used (UNFCCC, 2017d). For programmes of activities, we determine the CER supply potential by aggregating information from all individual component project activities (CPAs) that have been included in the programmes of activities. We use the data available as of 12 April 2017.

Under current CDM rules, project owners can issue CERs from past emission reductions at any time in the future, subject to four constraints that can affect the amount of and the period for which CERs can be issued:

1. *Technical implementation and operation status*: Initial implementation and subsequent operation of projects is a key prerequisite for issuing CERs. Through our survey on the status and prospects of CDM projects we generate a unique database with project information not available at UNFCCC level. The survey gathers information on the implementation and operational status of GHG abatement activities and the operational status of CDM monitoring systems (Table 5-1). For industrial gas projects, we use data from a study that provides project-specific estimates of the emission reduction volume (Schneider & Cames, 2014). These estimates consider the plant-specific performance and the effect of changes to methodologies at the renewal of a crediting period;
2. *Crediting periods*: CDM project participants can choose between a fixed or a renewable crediting period. In principle, projects with renewable crediting periods can generate CERs for 3 times 7 instead of 10 years but administrative steps for renewal of crediting periods have to be taken 180 days before the previous crediting period ends. If these steps are not taken in time, CERs cannot be issued for a certain period (UNFCCC, 2017b, 2017a). Our analysis of UNFCCC data (UNFCCC, 2017d) shows that more than 1,000 projects have not taken these steps in time, most probably due to the current market situation. The renewal of crediting periods might require an update of the methodological approaches and data used to calculate emission reductions, which in

some instances can notably alter the amount of CERs in subsequent crediting periods. We identify for each project the duration of crediting periods and how CDM requirements for crediting period renewal affect the project's ability to issue CERs;

3. *Availability of data to monitor emission reductions*: Monitoring emission reductions is a further prerequisite for issuing CERs (UNFCCC, 2017b, 2017a). In the current market situation, many projects continue monitoring emission reductions but do not issue CERs, whereas others have stopped collecting data for CDM monitoring purposes. We assess which projects typically continue collecting relevant monitoring data and how CDM monitoring requirements affect their ability to issue CERs. UNFCCC data is used if projects have recently issued CERs, confirming an operational monitoring system. For projects without issuance activities, we use our own survey data about the operational status of CDM monitoring systems (Table 5-1); and
4. *Project performance*: For many projects, the actual issuance of CERs differs from the amount expected when registering the project. This can have various reasons, including technical operation problems, management problems, or unanticipated availability of resources, such as a lower water availability for a hydropower plant or a lower methane generation from a landfill. The performance varies considerably between different types of projects. We therefore use UNFCCC data to evaluate the actual project performance of different project types and adjust the estimates of the CER supply accordingly (UNFCCC, 2017d).

Figure 5-3 presents the methodology used to assess whether and for which time period projects can issue CERs. The flow chart identifies nine circumstances (questions 1 to 9) that can affect the ability to issue CERs over time and seven possible outcomes (A to G) for the period for which CERs can be issued. Key aspects that determine the ability to issue CERs include the continuation of GHG abatement or the possibility to resume abatement, the availability of monitoring data and CDM requirements governing the renewable of the crediting period. Important technical aspects are whether non-implemented projects could still be implemented with appropriate incentives (question 9) and whether projects that discontinued GHG abatement could be resumed (question 6). In the last case, several CDM requirements come into play, which partially differ between projects and programmes of activities, such as with regards to the requirements to continuously monitor emission reductions (question 4) and whether administrative steps to renew the crediting period have been undertaken (question 5) (UNFCCC, 2017b, 2017a). In several instances, issuance is temporarily not possible but could be resumed at a future point in time. We assume that these projects could re-start issuing CERs for emission reductions generated as of 1 January 2019.

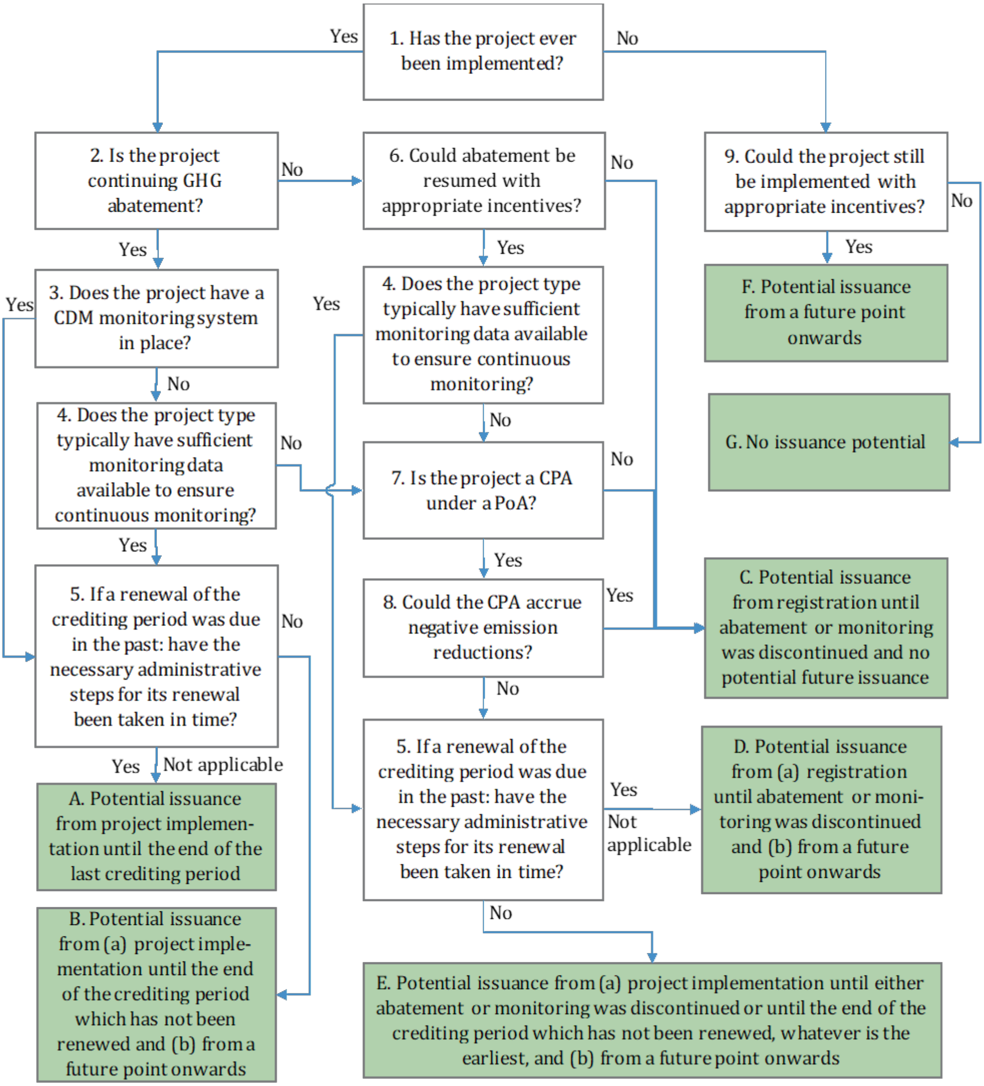

Figure 5-3 Methodological approach to assess the time period for which projects can issue CERs

In some instances, we have sufficient information to clearly answer a question in Figure 5-3 at the level of an individual project. In other instances, we have information and data at aggregated levels, such as information from our survey. In these cases, we use the survey results to assign probabilities to certain answers. For example, if the survey data indicate that 80% of biomass projects have ever been implemented (question 1), 80% of the CER potential from a biomass project would be carried forward to question 2 and 20% to question 9. The outcome for individual projects is thus a probability distribution across the eight possible outcomes that is used to calculate the CER supply potential of each individual project over time. Table 5-2 summarizes how the different conditions of projects lower the potential of the CER supply, as compared to the emission reductions expected in project design documents.

Vulnerability of projects to discontinuing GHG abatement. In this letter, we differentiate CDM projects on the basis of their vulnerability to discontinue GHG abatement without ongoing support. The underlying methodology to assess the likelihood of project continuation evaluates the projects' conditions in a systematic step-wise process (Figure 5-4). The following aspects are considered:

- *Applicable laws and regulations*: Laws and regulations in host countries might directly affect whether a project continues GHG abatement. They could explicitly require the continuation of the project or outlaw other practices which might cause the continuation of GHG abatement to be the only feasible option;
- *Economic benefits and costs*: In the absence of CER revenues, the continuation of GHG abatement is heavily influenced by the net financial flows that occur as a result of the project's continued operation, compared to discontinuing operation. Such flows include operational expenditures and financial benefits such as revenues or cost savings generated through the project's outputs. Only costs incurred in the future are relevant; past costs such as upfront capital expenditure are not considered as they are not relevant for the decision whether or not to continue project operation. It is assumed that, in the case of bankruptcy due to the loss of CER revenues, a liquidator would continue operation if this generates positive cash flows as compared to discontinuing operation; and
- *Barriers and other conditions*: Non-financial barriers or other conditions might also affect the continuation of GHG abatement. The continuation (or an alternative scenario to the continuation) might not be feasible, even if it results in positive net cash flows. This could, for example, be due to situations where the financial benefits are accrued by different entities than the operators of the project or where cultural preferences or information deficits prevent an economically attractive course of action from continuing without the support from CER revenues.

In a first step, the methodology is applied to 18 different project types, considering their typical conditions, rather than to individual projects (main circle in Figure 5-1; Table 5-3). In a second step, a more detailed assessment is conducted for some project types and some individual projects, considering the situation of specific project sub-types and specific host countries for which information is available. This includes biomass, N_2O, HFCs, households and methane avoidance (outer circle in Figure 5-1; Table 5-3).

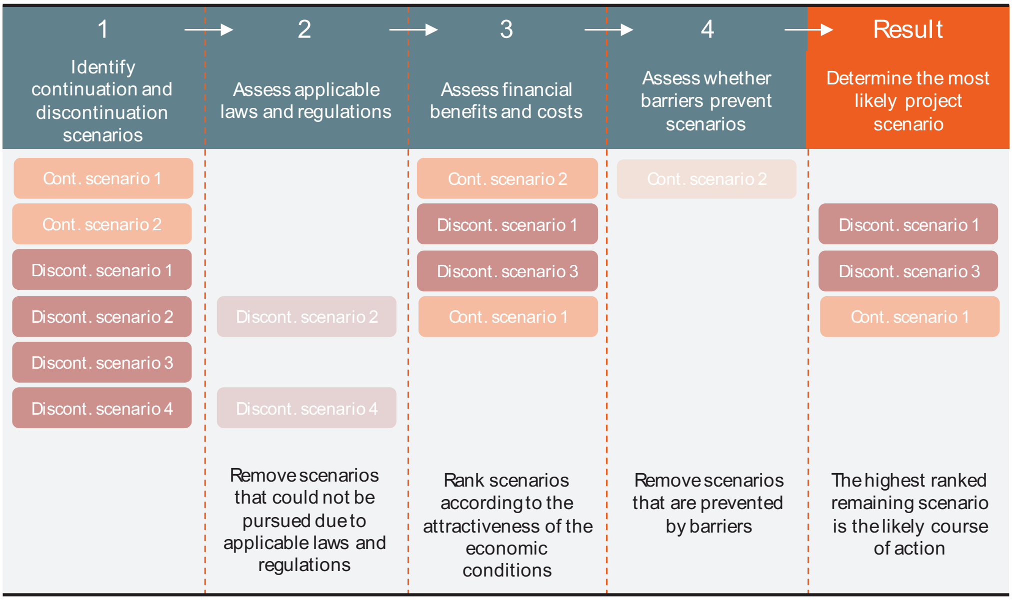

Figure 5-4 Decision chart used for the assessment of the risk that different CDM project types discontinue GHG abatement

On the basis of this assessment, we classify different project types as follows (Table 5-3):

- *High vulnerability*: The majority of projects within the project type discontinue GHG abatement without CER revenues or alternative support;
- *Low vulnerability*: The majority of projects within the project type continue GHG abatement even without CER revenues or alternative support;
- *Variable vulnerability*: The conditions for continuing GHG abatement are variable across projects due to a high dependence on local conditions or specific circumstances of individual projects, such that a generalized classification of project vulnerability is not possible; and
- *Unknown vulnerability*: The discontinuation risk of the project type has not been assessed.

Survey on the status and prospects of CDM projects. Information from a comprehensive survey on the status and prospects of registered CDM projects is used for several components of our research, including aspects of the project vulnerability evaluation and the evaluation of the ability and the marginal costs of specific projects to issue CERs, as described in other methodology sub-sections. The survey was conducted in 2014.

Of the 32 questions assessed in the survey, the results for the following fixed multiple-choice questions were used in various parts of this research:

- Question 3. What is the current technical implementation status of the CDM GHG mitigation activity?
- Question 5. What is the current operational status of the CDM component of the GHG mitigation activity?
- Question 9. What is the implementation status of the CDM monitoring system (measurements required for the CDM only)?
- Question 22. What CER price level is required by the project to continue verification and issuance activities?
- Question 23. What is your best estimate on the total costs per verification and issuance cycle until successful CER issuance is achieved (for example costs for verifier, internal labour costs)?

The results of questions 3, 5 and 9 are summarized in Table 5-1.

The scope for the survey is defined as all 7,338 registered CDM projects with a registration date by 31 December 2012. The sampled population within this scope is defined by focusing on specific countries and project types to allow for a good representation of the largest participants in addition to some smaller countries and a good representation of all regions. To facilitate the inclusion of under-represented regions, some selected countries have been grouped together and were sampled and analysed at the regional level. A similar approach for project types selection is applied, leading to a representation of largest and smaller scale project types. Programmes of activities were considered as normal CDM projects for the analysis. This leads to specific combinations of countries and project types included in the analysis, representing over 77% of the total CDM project population as per the above-defined scope (Table 5-4).

A stratified sampling exercise was conducted to sample sufficient projects from each host country and project type combination to return a maximum error margin of 20% at this sub-strata level, with the results then weighted appropriately for analysis at the primary strata and population levels. Disproportional stratified sampling is applied to gain an accurate representation of all sub-strata that cover a broad range of different numbers of projects while at the same time resource constraints predetermine the overall sample size. This resulted in a total sample size of 1,310 projects. This sample size returned a considerably improved error margin of around 10% at the primary strata level (specific host countries or project types), and 6% at the population level. For questions 3 and 5, an 82.1% response rate from the sample was achieved, allowing for an estimated error margin of 7%. For question 9, the response rate was 66.3% with a 9% error margin. For questions 22 and 23, the response rate was 44.7% and 40.2% respectively, with an error margin of 11%.

Table 5-4 Total number of registered CDM projects per selected project type and country combinations

	01.1 Agric. / Forest Residue	01.2 Bagasse power	01.3 Palm oil waste	02.1 Clinker replacement	03.1 CMM	04.1 Household Stoves	04.2 Household Lighting	05.1 EE Industry	06.1 Coke oven gas / Iron Steel heat	06.2 Cement heat	07.1 Oil to NG fuel switch	07.2 New NG plant	08.1 Micro Hydro	08.2 Hydro 2<20MW	09.1 Landfill gas flaring	09.2 Landfill gas power	10.1 Methane Flaring	10.2 Methane power	10.3 Composting	10.4 Domestic manure	11.1 Adipic acid	11.2 Nitric acid	12.1 HFC23	13. 1 Solar PV	13. 2 Solar water heating	14. 1 Wind	Total
Brazil	16	27							2		6			41	23	15	60	3	1		1	4		1		51	251
Chile	8												2	21	11	4	6	1				3		7		18	81
China	131	2		5	60	4	15	4	78	106	1	20	3	745	1	62	19	40		30	2	44	11	138	1	1487	3009
Colombia	2	1									1			9	13	3	1	3	1			2				1	37
India	182	49	3	13		30	33	58	46	5	6	13	9	93		3	5	12	1	9		8	5	81	7	573	1244
Indonesia	7		7	1				5		1		4	2	12	6	3	18	44	9			2					121
Israel	1							1			1				2	5	1	2				4		7		2	26
Malaysia	9		29					3				1	1	3	3	6	20	36	27								138
Mexico	6					1	1	4	1					4	9	15	66	33				1	1			28	170
Peru	1	1									1		3	27	3	1	1	1						5		1	45
S. Africa	3					1	3	2	4					3	1	6		3				5		7	5	12	55
S. Korea											4		4	11		5		1			1	4	1	32	1	13	77
Thailand	16	3	3							3				2		6	4	65						26		3	131
Vietnam	7	1					1	1		1			2	129	1	2	4	16		1					1	5	172
C. America	4	2	2			1							5	28	1	2		11	1							11	68
SS Africa	1	2				5	6							7	1					3				1		5	31
TOTAL	394	88	44	19	60	42	59	78	131	116	20	38	31	1135	75	138	205	271	40	43	4	77	18	305	15	2210	5656

The sampled projects were evaluated through a combination of online surveys, emails, telephone calls and in-person interviews. Project owners were the source of information for 47% of projects assessed, CDM project developers for 24% and CER buyers for 12%; information for the remaining 17% of projects was obtained from CDM consultants, Designated Operational Entities (DOEs) and Designated National Authorities (DNAs).

We evaluated whether respondents might have misrepresented their projects. A comparison of the responses for the operational status of projects from different respondent groups shows similar results and thus does not indicate such incentives for a specific respondent group.

CER supply curve. The CER supply curve in Figure 5-2 represents the marginal cost of supplying CERs from today's perspective and reflects the number of CERs that could come to market at a given price level. We derive the supply curve by combining the supply potential of each registered project, as described above, with estimates of its marginal GHG abatement costs and ongoing CDM transaction costs. To calculate this, we use information on the project type, the country the project is located in and our classification of the project's vulnerability to discontinuing abatement.

The ongoing CDM transaction costs include costs associated with administrative processes to receive CERs, such as monitoring and verification of emission reductions, issuance fees, and costs related to the renewal of the crediting period, where applicable. The main source of data for ongoing CDM transaction costs is the survey described above, to which we add estimates of monitoring costs for each project type (Warnecke, Klein, Perroy, & Tippmann, 2013). Less than 10% of the supply potential is from project types that are not covered by the survey; for these we use cost estimates from another source (Vivid Economics, 2013). For the few project types not covered by either source, we apply the average costs from the survey data.

To reflect that project owners may not be ready to proceed to the issuance of CERs if they do not make a profit, we add a margin of €20,000 to the ongoing CDM transaction costs. We apply this margin only to projects that were not issued with CERs over the two-year period before April 2017 (the date on which we extracted the issuance data), assuming that projects that recently issued CERs may continue to do so without any extra margin. Whether such a margin is required, and which size of margin, is uncertain. A sensitivity analysis confirms that the overall shape of the CER supply curve does not change if the margin is removed or if it increased it to €50,000. We also compared the survey results on administrative verification and issuance costs with alternative sources and tested the sensitivity of using cost estimates from three alternative sources. The choice of source does not materially affect the results.

For projects with a high vulnerability, we also include an estimate of their marginal GHG abatement costs. These include any ongoing operational costs incurred for continuing abatement activities, minus any revenues or cost savings earned from the project's activities (for example, the sale or own use of electricity generated) excluding revenues from the sale of CERs. Our estimates of marginal GHG abatement costs are derived from responses to questions 22 and 23 of the survey described above, except for industrial gas projects. For industrial gas projects (HFC-23 and N_2O abatement) we use detailed data for each individual plant derived from a comprehensive review (Schneider & Cames, 2014). To test the robustness of our results, we also performed a sensitivity analysis in which we halved the marginal GHG abatement costs derived from the survey responses. This changes the slope of the CER supply curves slightly, but the overall findings remain robust.

The marginal GHG abatement costs for projects with a low vulnerability to discontinuing GHG abatement are assumed to be zero because these projects typically continue operations, whether or not they are issued with CERs. In the case of project types that have variable vulnerability, we randomly divide the projects into three equal groups. We assume that one-third of the projects have a low vulnerability and one-third have a high vulnerability and treat these as per all other projects falling within these respective categories. For the third group, we assign a randomly determined share of the project's full marginal GHG abatement cost, such that, on average, projects within this third group face half of the marginal abatement costs that they would if they were highly vulnerable.

We derive the supply curve by sorting projects in ascending order in terms of their marginal cost and calculating the cumulative potential supply of CERs (eligible to the particular scenario) at each price level from projects whose marginal cost is equal to or lower than that price.

Data availability

Parts of the datasets generated during or analysed for this letter are available upon request. The data can only be made available in aggregated form and some parts of the data cannot be provided due to the confidential nature of the survey responses and plant-specific data used in this letter.

Chapter 6
Restricted linking of emissions trading systems: options, benefits, and challenges

Abstract

With over 17 emissions trading systems (ETSs) now in place across four continents, interest in linking ETSs is growing. Linking ETSs offers economic, political, and administrative benefits. It also faces major challenges. Linking can affect overall ambition, financial flows, and the location and nature of investments, reduces regulatory autonomy, and requires harmonization of ETS design elements. This article examines three options that could help overcome challenges by restricting the flow of units among jurisdictions through quotas, exchange rates, or discount rates. We use a simple model and three criteria –abatement outcome, economic implications, and feasibility –to assess these 'restricted linking' options. Quotas can enhance cost-effectiveness relative to no linking and allow policy-makers to retain control on the extent of unit flows. Exchange rates can create abatement and economic benefits or unintended adverse implications for cost-effectiveness and total abatement, depending on how rates are set. Due to information asymmetries between the regulated entities and policy-makers setting the exchange rate, as well as uncertainties about future developments, setting exchange rates in a manner that avoids such unintended consequences could prove difficult. Discount rates, in contrast, can ensure that both cost-effectiveness and total abatement are enhanced. Overall, restricted linking options do not achieve the benefits of full linking, but also avoid some major pitfalls, as well as offering levers that can be adjusted, should linking concerns prove to be more significant than anticipated.

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6.1 Introduction

Emissions trading systems (ETSs) are a widely used policy tool to reduce greenhouse gas (GHG) emissions. As of February 2016, 17 distinct ETSs operated across four continents, with another 15 in preparation or under consideration (ICAP, 2016). The emergence of these new systems, the adoption of the Paris Agreement with provisions enabling international transfers of units, and recognition of the challenges of building a global carbon market have led to renewed interest in options for linking ETSs.

Linking ETSs can yield multiple benefits, such as leading to lower overall abatement costs, but can also face considerable challenges, in particular if the ambition and design of ETSs differ (Bodansky et al., 2016; Burtraw, Palmer, Munnings, Weber, & Woerman, 2013; Flachsland, Marschinski, & Edenhofer, 2009b; Ranson & Stavins, 2016). These challenges have raised interest in restricted forms of linking, which involves the partial, conditional, or restricted recognition of units from another ETS (Burtraw et al., 2013; Füssler, Wunderlich, & Taschini, 2016; Marcu, 2015; Mehling & Görlach, 2016).

This article explores benefits of, and challenges for, options for restricted linking of ETSs. We assess three restricted linking options: *quotas*, which restrict the amount or type of units from other jurisdictions that can be used for compliance; *exchange rates*, which adjust the value of units transferred between jurisdictions by a conversion factor; and *discount rates*, which also involve a conversion factor, but placing a greater value on units of the own jurisdiction. We use a simple representation of two ETSs in two jurisdictions with linear marginal abatement cost curves to compare these options with regard to three broad criteria: GHG abatement outcome; economic implications, including cost-effectiveness, abatement costs, distributional impacts, and unit liquidity and fungibility; and feasibility, including implementation challenges arising from setting the quota, exchange rate, or discount rate, and how the restricted linking options affect the regulatory autonomy of a jurisdiction's decision-maker. Our comparison of these options against criteria, while not a fully comprehensive analysis, provides important insights into the potential consequences of restricted linking that are particularly timely given increased interest in alternatives to full linking of ETSs.

We begin by introducing the context for linking ETSs and the rationale for considering restricted forms of linking, along with describing the three restricted linking options (Section 6.2). We then introduce the methods and criteria used to assess these options (Section 6.3). We assess the options by comparing them to the situation of full linking and no linking (Section 6.4), discuss our findings (Section 6.5), and provide conclusions (Section 6.6).

6.2 Context and overview of restricted linking of ETSs

Linking of ETSs generally means that one ETS accepts a unit that is also used by another ETS as a compliance instrument. The linking of ETSs can take different forms, with three main dimensions (Mehling & Görlach, 2016):

- *Bilateral/multilateral*: *Bilateral linking* involves two ETS, whereas *multilateral linking* involves multiple ETSs;
- *Direct/indirect: Direct linking* implies that one ETS accepts a unit issued by another ETS, whereas *indirect linking* refers to the situation in which two ETSs both recognize a unit from a third system. For example, both the EU ETS and the New Zealand ETS initially allowed the use of Certified Emission Reductions (CERs) from the Clean Development Mechanism (CDM) and Emission Reduction Units (ERUs) from Joint Implementation (JI); and
- *Full/restricted*: *Full linking* involves the unconditional mutual recognition of units without any quantitative or qualitative restrictions, whereas restricted linking involves the partial, conditional, or restricted recognition of units from another ETS (see below).

Full linking of ETSs can yield multiple benefits, including lower overall abatement costs, enhanced market liquidity, reduced price volatility, a potential reduction in carbon leakage risks, and reduced transaction costs. By lowering overall costs, linking can generate domestic support and encourage jurisdictions to adopt more ambitious targets (Bodansky et al., 2016; Burtraw et al., 2013; Flachsland et al., 2009b; Kachi et al., 2015; Ranson & Stavins, 2016).

Full linking of ETSs also faces considerable challenges, some of which policy-makers may address by exploring restricted linking of ETSs. Full linking may pose challenges if key ETS design elements – such as the allocation of allowances; measurement, reporting, and verification (MRV) standards; cost containment measures (price floors or ceilings); offsets rules and limits – differ between ETSs based on the political and economic context. Further challenges to full linking include: assessing and comparing the ambition of the ETS caps set by the jurisdictions; the potential for a sense of reduced ambition if linking to an ETS that is viewed as less stringent; real or perceived loss of regulatory autonomy; unequal capacities among jurisdictions; and potentially competing domestic policy objectives (Bodansky et al., 2016; Burtraw et al., 2013; Green et al., 2014; Eric Haites, 2014; Kachi et al., 2015; Ranson & Stavins, 2016; Sterk, Braun, Haug, Korytarova, & Scholten, 2006; Sterk & Schüle, 2009; Tuerk et al., 2009).

To the extent that designs and ambition differ among jurisdictions, linking will alter carbon prices and the location and extent to which long-term investment in low-carbon technologies and any associated co-benefits occur (Bodansky et al., 2016; Flachsland, Marschinski, & Edenhofer, 2009a). While in principle these shifts – from higher- to lower-cost emission reduction opportunities – will improve overall economic efficiency, it may be difficult for policy-makers to justify these shifts to constituencies that may see reduced investment and co-benefits or face higher allowance prices. Furthermore, linking creates financial transfers across jurisdictions, which can be particularly challenging if the direction of flow is from smaller or less affluent jurisdictions towards larger or more affluent ones. Jurisdictions that see a decline (increase) in allowance prices from linking will also see a reduction (increase) in investment in abatement activities, a decrease (increase) in allowance auction revenues, and a net flow of resources to (from) other jurisdictions. Doda & Taschini (2016) suggest that the difference in (emissions) size and the existence of unilateral tax distortions (e.g. a tax on allowance transactions) may affect otherwise mutually advantageous linking arrangements. To the extent that allowances are auctioned, full linking could reduce overall auction revenues across the jurisdictions. Where auction proceeds are already earmarked for specific uses (e.g. tax rebates or investments), the decline, if significant, could create a political barrier to linking. In addition, linking may create political uncertainty, as another jurisdiction's future withdrawal could undermine the system. Some even argue that linking can create a potential disincentive to maintaining or increasing ambition in an individual jurisdiction (Helm, 2003). Given the mix of benefits, obstacles, and risks, successful linking requires carefully matching jurisdictions with compatible ETS designs and domestic policy objectives (Comendant & Taschini, 2014), and "navigating tradeoffs between efficiency and political feasibility" (Green et al., 2014, p. 1066).

The challenges to full linking have increased interest in options for restricted linking that jurisdictions could pursue to capture some of the political, economic, and environmental benefits associated with linking. Restricted linking enables the flow of units among jurisdictions, but with specific constraints to help address concerns that linkage of not fully harmonized ETSs might create. While these options have been discussed in many venues, they have yet to be examined thoroughly in the literature. This article aims to help fill that gap by exploring the potential advantages and drawbacks of different restricted linking options. We examine three restricted linking options:

1. *Quotas*, also referred to as *quantity limits*, restrict the amount of (specific types of) units from other jurisdictions that can be used for compliance. Quotas can be formulated and implemented in different ways. They would be typically designed to limit overall net imports rather than exports and could be expressed as a fraction of total compliance obligations that an entity can surrender;[6]

[6] One-way linking, which refers to the situation in which units from one jurisdiction are recognized in another jurisdiction but not vice versa, could be seen as a special case of quotas where one jurisdiction introduces a quota of zero, whereas the other jurisdiction does not apply a quota.

2. *Exchange rates*, also referred to as *trading ratios*, imply that units from one jurisdiction can be used for compliance in another, but their value is adjusted by a conversion factor. Exchange rates operate in a symmetrical fashion. If an exchange rate is set such that two units from jurisdiction A could be used in place of one unit in jurisdiction B, then in jurisdiction A, one jurisdiction B unit would be worth two-jurisdiction A units. This symmetry creates fungibility and enables units to flow readily back and forth among the jurisdictions; and
3. *Discount rates* could be regarded as a variation on exchange rates. They also involve a conversion factor, but such that more than one unit from another jurisdiction is required to meet a compliance obligation in the own jurisdiction, thereby placing a greater value on units of the own jurisdiction. While exchange rates inherently require a symmetrical relationship in the value of jurisdictions' allowances, discount rates do not. Jurisdictions could apply one discount rate in one direction of allowance flow (e.g. 3:1 from system A to system B) and parity (1:1) or a rate of different magnitude in the other direction (e.g. 2:1 from system B to system A).

These options are not mutually exclusive, but could be combined, for example, by applying both quotas and discount rates to units from another ETS. Some of these options have already been implemented in ETSs, and others are still being explored by policy-makers and researchers. Quotas have been applied by most ETSs with regard to offsets, usually with the intent of ensuring that a certain fraction of the emission reductions be achieved domestically by the entities regulated by the ETS.

Perhaps most examined through the World Bank's Globally Networked Carbon Markets initiative,[7] the concept of exchange rates has received limited attention in the carbon market literature (Füssler et al., 2016; Marcu, 2015). Burtraw et al. (2013) examine the implications of linking the Regional Greenhouse Gas Initiative (RGGI) and California ETS with an exchange rate where three RGGI units are equivalent to one California unit. Other research on trading ratios mainly focused on non-uniformly mixed pollutants, such as sulphur or nitrogen oxides, where the ultimate damage is strongly affected by the location of emission (Mendelsohn, 1986). There, the case for trading ratios is clearer; in an ETS for local or regional air pollutants, a trading ratio can make a ton of emission reduction in a more populated air shed more valuable than one in a remote area, increasing both health benefits and economic efficiency. For carbon dioxide (CO_2) and most GHGs; however, damage is largely unaffected by the location of emission. The nature and rationale for exchange rates for GHG emissions have more to do with expanding markets, improving liquidity, and enabling links that might not otherwise be feasible.

[7] See http://www.worldbank.org/en/topic/climatechange/brief/globally-networked-carbon-markets

Discount rates were proposed in the American Clean Energy and Security Act of 2009, commonly referred to as the Waxman-Markey bill, which stated that an entity would need to turn in 1.25 tons of offsets for a compliance obligation of one ton, implementing effectively a 20% discount rate. Similarly, France introduced a general 10% discount on domestic JI projects, implying that only 90% of the emission reductions be issued as ERUs. Existing research has focused on discount rates in the context of offset mechanisms (Bakker, Haug, Van Asselt, Gupta, & Saïdi, 2011; Chung, 2007; Erickson et al., 2014; Schneider, 2009a; Warnecke et al., 2014).

There are also situations where jurisdictions merge or join existing ETSs, and operate with the same, common rules and units. Examples include Norway joining the EU ETS, or Northeastern US States collaborating together to form the RGGI. We consider these situations to be distinct from linking, where the individual systems remain distinct in rules, units, and administration, and thus do not examine them further here. Policy-makers can also pursue an *incremental alignment* of ETSs, program elements, such as coverage, allocation rules, or monitoring, reporting and verification (MRV) standards, but stopping short of mutual unit recognition. This has also been referred to as "linking by degrees" (Burtraw et al., 2013).

6.3 Methods

We assess the three restricted linking options by comparing them with the situations of no linking and full linking. We use three broad criteria to evaluate the merits and drawbacks of each option:

1. *GHG abatement outcome:* We assess the GHG abatement across and within individual jurisdictions, given existing emissions caps. We do not consider impacts on environmental co-benefits, since these are highly specific to the jurisdictions' context. We also do not consider how an option could encourage or discourage deeper reduction targets in future periods, an implication that is more difficult to assess without significant speculation;
2. *Economic implications:* We assess the cost implications, including cost-effectiveness, total abatement costs across and within individual jurisdictions and distributional impacts, and implications for unit liquidity and fungibility. For a given abatement outcome, we define *cost-effectiveness* as the total abatement costs in both jurisdictions with no linking divided by the total abatement costs in both jurisdictions with restricted (or full) linking. In cases where a restricted linking option changes the overall abatement outcome, we use this changed abatement level in comparing the costs with no linking; to this end, we assume that the abatement under no linking would change in each jurisdiction proportionally to their emission reduction targets. Market *liquidity* refers to the ability to purchase or sell units without causing drastic changes in their

price. We assume that liquidity increases with the number of actors in the market for the commodity. We consider two units as *fungible* if they can be mutually substituted in place of one another when surrendering them for compliance. We do not assess potential macroeconomic impacts, such as effects on employment, economic growth, or changes in environmental co-benefits, since they strongly depend on the specific context of the jurisdictions and the nature of abatement options pursued or not pursued as the result of linkage. We also do not assess the impacts on price volatility and the risk of carbon leakage (i.e. the risk of production shifts between jurisdictions as a result of carbon markets affecting competitiveness) which depend on several context-specific factors, including how allowances are allocated to entities, whether allowance prices are reflected in the cost of products, and the extent to which barriers may limit the trade of products among jurisdictions; and

3. *Feasibility*: The feasibility of restricted linking options depends on many aspects. We explore two aspects that appear particularly important and can be assessed without the specific context of the jurisdictions: implementation challenges arising from setting the quota, the exchange rate or the discount rate, and how the restricted linking options affect the regulatory autonomy of a jurisdiction's decision-makers. We do not assess other aspects, such as how economic and environmental outcomes are perceived by influential actors, or the impact of linking on a jurisdiction's emissions goals, investment in low-carbon technologies, abatement costs for covered entities, or consumer costs, and how such impacts are assessed and communicated. These aspects often depend on the specific political and economic context of the jurisdictions.

We use a simple representation of two ETSs in two jurisdictions to assess the abatement outcome and economic implications of the restricted trading options. In our model, we define each jurisdiction by: (1) the total abatement under no linking, reflected by the difference between its emission cap and business-as-usual (BAU) emissions and (2) a simplified, linear marginal abatement cost (MAC) curve that represents how its cost of reducing emissions increases with the level of abatement. We apply this model, first for reference, to the cases of no linking and full linking and then to quotas, exchange rates, and discount rates. We assume that the two ETSs have a long-term target path below BAU emissions (i.e. with no over-allocation of allowances) and allow for banking of allowances, providing entities with a certain long-term emissions budget, and that the two ETSs do not have any price containment mechanisms, such as offsets, reserves, floors, caps, and/or triggers. It is important to note the limitations of these assumptions, the criteria, and the simplified model, which are further discussed in Section 6.5. For the purpose of illustrating the results in charts, we set the parameters of the model such that, in the absence of any linking, one jurisdiction has an allowance price (per ton of CO_2) three times higher than the other, similar to the parameterization used by Burtraw et al. (2013). We refer alternately here to the 'lower-price' jurisdiction (or jurisdiction A) and the 'higher-price' jurisdiction (or jurisdiction B). The simplified model and its application are further described in the supplementary information to this article.

6.4 Assessment of restricted linking options

6.4.1 The reference cases: no linking and full linking

The cases of no linking and full linking of ETSs create helpful reference scenarios for examining restricted linking options. In the absence of linking, differing emission caps and marginal abatement lead to different allowance prices among systems. If systems are fully linked, their allowance prices converge, and abatement activity would shift from the higher-price jurisdiction (B) towards the lower-price jurisdiction (A).

Figure 6-1 depicts this dynamic. It shows the contribution of each jurisdiction to total emission reductions or abatement (the width of the x-axis). Assuming no linking, abatement activity in the lower-price jurisdiction (A) moves from left to right along an abatement cost curve (red line) until its targeted emission reductions are achieved (width of the red dotted line). Similarly, abatement activity in the higher-price jurisdiction (B) moves along its abatement cost curve (blue line), but flipped, starting from the right side of the chart until its targeted emission reductions are achieved (width of the blue dotted line). The width of the x-axis corresponds to the total emission reductions in both jurisdictions, with the dotted red and blue lines indicating the reductions in each jurisdiction under no linking. The resulting allowances prices in the two systems ($p_{A,0}$ and $p_{B,0}$) differ, as shown.

If these systems are fully linked, the allowance prices in the two systems converge at a common price (p_E). Entities in the lower-price jurisdiction (A) abate more emissions, while entities in the higher-price jurisdiction (B) abate less. A respective amount of units is transferred from the lower-price jurisdiction (A) to the higher-price jurisdiction (B) (green dotted line), with a net financial transfer from the higher-price to the lower-price jurisdiction (the amount of units transferred, shown by the green dotted arrow, times the linked-system allowance price).

Full linking leads to several economic benefits. The primary beneficiaries of the economic surplus from linking are the entities covered by the ETSs. Total costs to achieve the overall abatement outcome are reduced, and these benefits from increased cost-effectiveness are shared among the two jurisdictions. While there is greater abatement in the lower-price jurisdiction (A), the financial transfer (by entities) from the higher-price jurisdiction (B) in acquiring allowances exceeds the cost of the added abatement, providing an economic surplus, as shown by the red shaded area in Figure 6-1. For the higher-price jurisdiction (B), overall costs decrease because the reduction in abatement costs exceeds the transfer payment made to the lower-price jurisdiction (A), creating the economic surplus shown by the blue shaded area. Furthermore, full linking enhances market liquidity by increasing the number of allowances and actors across the linked market, creating an added economic benefit. The units from the two jurisdictions are fully fungible. However, full linking requires considerable effort to harmonize and therefore also reduces the regulatory autonomy of the decision-makers (see Section 6.2).

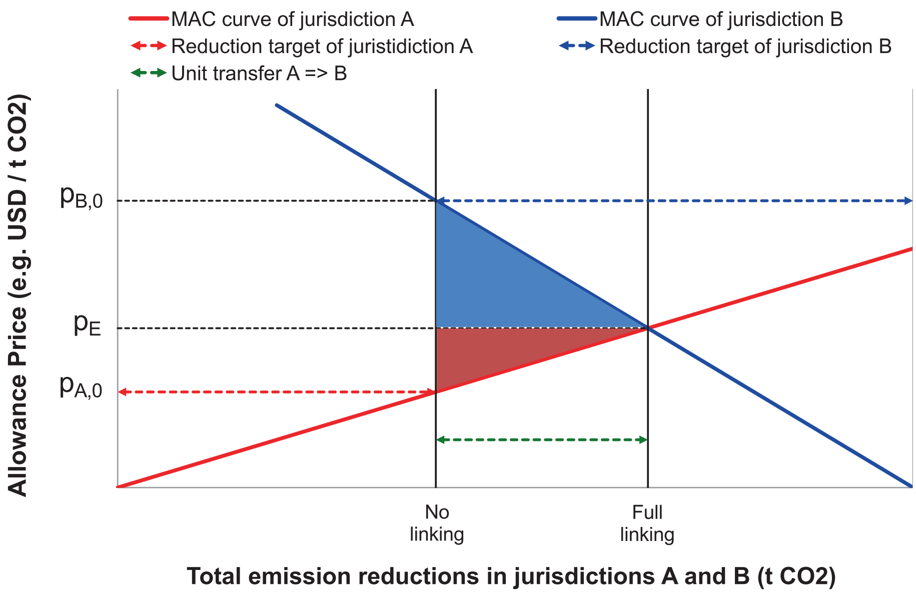

Figure 6-1 Implications of no linking and full linking (simplified model)

6.4.2 Quotas

Quotas will only have implications if they effectively limit the transfer of allowances. This holds if the quota is set lower than the net allowance flow under full linking. Figure 6-2 illustrates the implications of a quota that enables 50% of the unit transfer that would occur with full linking (orange lines). The quota does not affect the overall level of abatement across jurisdictions, but affects the level of abatement in each jurisdiction. As under full linking, abatement increases in the lower-price jurisdiction (A) and decreases in the higher-price jurisdiction (B), but to a lesser extent than under full linking. The amount of allowances transferred (green line) corresponds to the quota limit.

The economic implications of a quota will tend to lie between those of no linking and full linking. As Figure 6-2 shows, economic gains (shaded area) per net unit transferred among jurisdictions decrease as one moves from no linking (where the price disparities are highest) towards full linking (where price disparities disappear). For example, with linear MAC curves, as shown in Figure 6-2, a 50% quota yields 75% of the cost-effectiveness gains from full linking. Quotas imply that different prices persist in the two jurisdictions, though with a smaller difference ($p_{A,Q}$, $p_{B,Q}$).

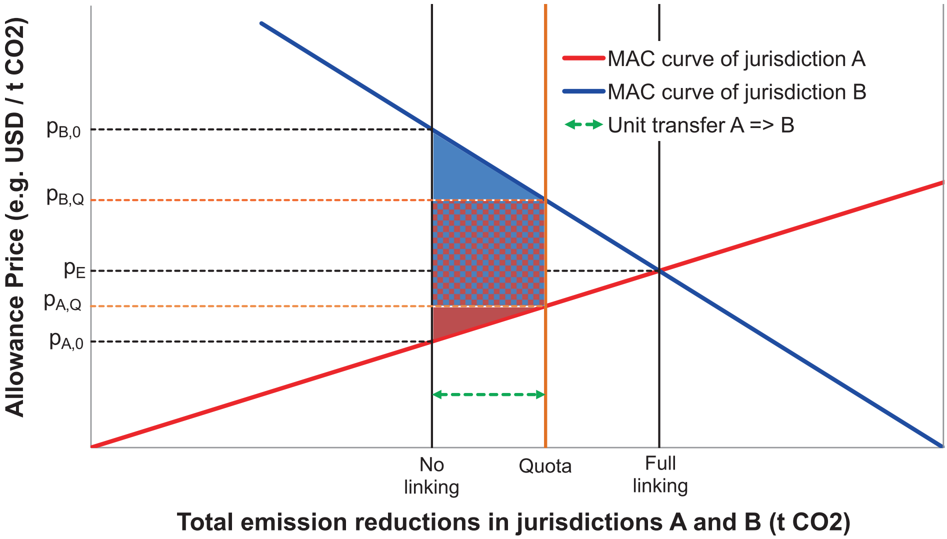

Figure 6-2 Implications of a quota set at 50% of the net allowance transfers under full linking (simplified model)

Another interesting implication is how the relative economic gains for the two jurisdictions could differ from those under full linking. With quotas, the economic benefit shown by the hatched rectangle in Figure 6-2 could in principle accrue to either jurisdiction A or B, depending on how the quota is implemented. If the quota is expressed as a percentage of the compliance obligations by entities in the higher-price jurisdiction (B), it would limit the *demand* for allowance transfers from the lower-price jurisdiction (A). As the entities in the lower-price jurisdiction (A) would compete to sell allowances to the higher-price jurisdiction (B), the price for such transfers would likely settle at the allowance price in the lower-price jurisdiction ($p_{A,Q}$), and the economic benefit shown by the hatched area in Figure 6-2 would confer to the entities in the higher-price jurisdiction (B).

However, a quota could also be set on the *supply* side, as an export quota. To implement an export quota, the lower-price jurisdiction (A) could limit the number of allowances that can be used by other jurisdictions (e.g. B), for example, through auction licenses or permits that entities from other jurisdictions would need to hold and surrender when using its allowances outside the jurisdiction. Entities in the higher-price jurisdiction (B) would then compete for the rights to use a limited amount of allowances from the lower-price jurisdiction (A), and the price for using transferred allowances would likely settle at the allowance price in the higher-price jurisdiction ($p_{B,Q}$). In other words, the lower-price jurisdiction (A) would capture the scarcity rent (hatched area in Figure 6-2). In conclusion, quotas that limit *supply* will create greater economic benefits for the exporting, lower-price jurisdiction (A), while quotas that limit *demand (or use)* will create greater economic benefits for the importing, higher-price jurisdiction (B).

Relative to no linking, quotas will increase market liquidity as they will increase the number of potential buyers and holders of units. Without full linking, however, jurisdiction A and jurisdiction B allowances would not be fully fungible and would therefore continue to be traded as different commodities at commodity exchanges.

Deciding how and where to set the quota level presents a significant implementation challenge. Economic modelling could help policy-makers understand the implications of different quota levels, based on estimated marginal abatement potentials and costs, relative to a projection of BAU emissions. But history has shown that abatement potentials, abatement costs, and emissions trajectories can often diverge significantly from prior expectations. To respond to such unexpected developments, policy-makers could adjust the quota level over time. However, unless adjustments are predictable, they could undermine investment certainty. Furthermore, if one jurisdiction wishes to adjust a quota, it may require negotiation and agreement with policy-makers in other linked jurisdictions. Such a requirement may be laid down in a linking agreement, but it could also be made subject to a simplified amendment procedure (cf. Mehling & Haites, 2009). One option to avoid potentially difficult negotiations on quota adjustments could be agreeing ex ante on an automatic adjustment, triggered, for example, by observed allowance prices. If allowance prices were to exceed a threshold over a defined time period, an import quota could be increased, and conversely, it could be adjusted downwards if prices were to fall below a floor.

An important feature of quotas is that, compared to full linking, they enable policy-makers to retain a certain level of control on the extent of unit flows and related impacts.

6.4.3 Exchange rates

The implications of exchange rates are more complex than those of quotas. First, in contrast to full linking or quotas, exchange rates can affect the total abatement across the two jurisdictions. Second, the abatement outcome and economic implications are highly sensitive to the value at which the exchange rate is set.

Figure 6-3 illustrates the implications of different exchange rate values for two key parameters – total abatement and cost-effectiveness – using the model and parameters described in Section 6.2. For ease of comparison, the figure also illustrates the outcome for full linking, no linking, and quotas. The black line reflects different exchange rate levels

(R) that increase clockwise on the curve. For the purpose of this analysis, we define the exchange rate as the number of units from the jurisdiction with the *expected* lower-price absent linking (A) that are needed for compliance in the jurisdiction with the *expected* higher-price absent linking (B).

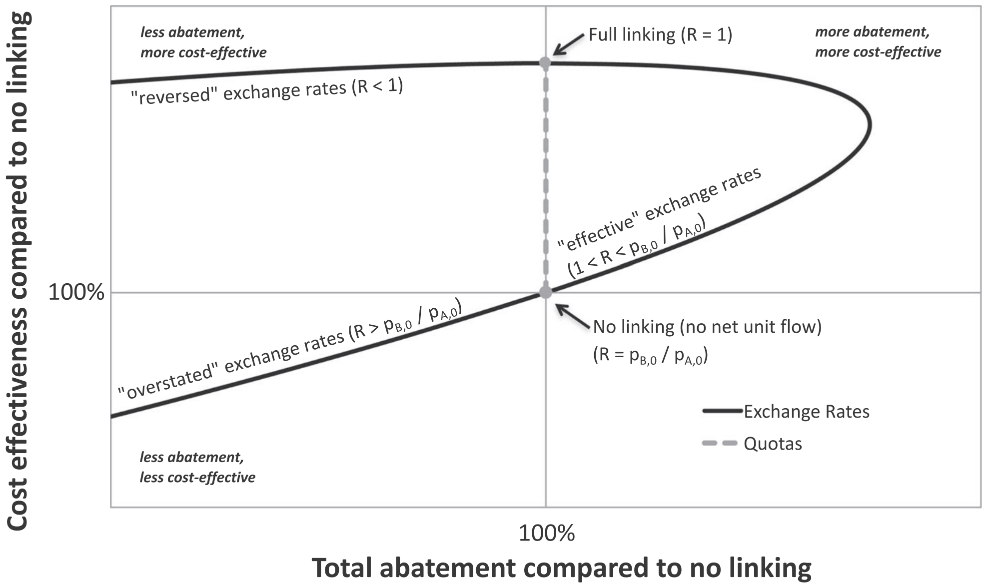

Figure 6-3 Implications of varying exchange rates on total abatement and cost-effectiveness (simplified model)

The implications differ for three ranges of possible values:

- *'Effective' exchange rates:* We define effective exchange rates, found in the upper right quadrant in Figure 6-3, as rates at which both total abatement and cost-effectiveness are higher than with no linking. Exchange rates are effective if set above 1 (which corresponds to full linking, the upper grey dot in Figure 6-3), but lower than the ratio of allowance prices under no linking ($1 < R < p_{B,0} / p_{A,0}$). The net flow of allowances is from the lower-price jurisdiction (A) to the higher-price jurisdiction (B), and as a result fewer emissions are allowed in the higher-price jurisdiction (B) for every allowance from the lower-price jurisdiction (A). As exchange rates move from the no linking value to the full linking value (parity), the flow of allowances from A to B increases, while the net emissions benefit per unit transferred decreases, leading to the behaviour shown in Figure 6-3, where the overall abatement outcome reaches a maximum at a middle-range rate;
- *'Reversed' exchange rates:* We define reversed exchange rates, found in the upper left quadrant in Figure 6-3, as below 1 ($R < 1$). We refer to them as reversed exchange rates

because they reverse in which jurisdiction allowances are valued higher: while units still flow from the lower-price jurisdiction (A) to the higher-price jurisdiction (B), their value is effectively 'inflated': less than one allowance from the lower-price jurisdiction (A) is required to emit one more ton in the higher-price jurisdiction (B). Abatement decreases in each jurisdiction relative to full linking, and as a result total abatement declines relative to both full linking and no linking. Cost-effectiveness decreases relative to full linking as well, though it remains above the no linking level until exchange rates reach low levels (not shown in Figure 6-3); and

- *'Overstated' exchange rates:* We define overstated exchange rates, found in the lower left quadrant in Figure 6-3, as rates set above the ratio of allowance prices under no linking ($R > p_{B,0} / p_{A,0}$). We refer to them as overstated because they exaggerate the expected price difference between both jurisdictions with no linking. Remarkably, they reduce both total abatement and cost-effectiveness relative to no linking. In other words, overstated exchange rates lead to worse outcomes than no linking. Under overstated exchange rates, the direction of allowance flows and transfer payment reverses, with entities in the lower-price jurisdiction (A) buying allowances from the higher-price jurisdiction (B). As a consequence, less abatement occurs in the jurisdiction with the lower-cost abatement opportunities (A), while more abatement occurs in the jurisdiction with higher-cost abatement opportunities (B), decreasing the cost-effectiveness. While not calling them overstated exchange rates, Burtraw et al. (2013) discuss such rates in the context of linking California-Québec and RGGI.[8]

In all three cases, assuming no constraints on allowance flow or use, the exchange rate will determine the ratio of allowance prices: the price in jurisdiction B is always *R* times higher than the one in jurisdiction A. In comparison with quotas, exchanges rates allow the two jurisdictions' allowances to be fully fungible and offer the same liquidity as full linking.

Exchange rates could be set at different values depending on which policy objectives are pursued. If the primary policy objective is enhancing market liquidity while avoiding any other impacts, one could argue that an exchange rate set at the ratio of the allowance prices under no linking ($R = p_{B,0} / p_{A,0}$) would best fit that purpose. If a key policy objective is enhancing cost-effectiveness, values closer to 1 may provide more benefits. If policy-makers intend to ensure that total abatement is increased rather than decreased, moderate exchange rates, set between 1 and the ratio of allowance prices under no linking, would best ensure that this policy objective is met (aside, of course, from tightening the cap). Hence, approaching the 'best' exchange rates may require balancing different policy objectives. That said, for a broad range of policy objectives, policy-makers will likely want

[8] Burtraw et al. (2013) evaluated an exchange rate of 3 between California-Québec and RGGI. The findings are similar to our simplified model, though our model does not account for the presence of floor prices.

to set the exchange rate within the spectrum of *effective* exchange rates, rather than *overstated* or *reversed* exchange rates, which lead to several adverse impacts.

In practice, setting exchange rates poses several challenges. Ensuring that the exchange rate is set and remains within the *effective* range is difficult. Doing so requires that those who set exchange rates have good information and foresight, for each jurisdiction, on BAU emissions and on the abatement potential and costs. Yet, BAU emissions and abatement potential and costs may face major uncertainties. Furthermore, there may be information asymmetries between regulators and the regulated entities with respect to abatement opportunities and costs. Because of these uncertainties and information asymmetries, a regulator might set an exchange rate *ex ante* that, based on best available information at the time, appears to be in the *effective* range, but turns out to be a *reversed* or *overstated* exchange rate.

Regulators could aim to adjust exchange rates to mitigate these risks. However, in practice, this too could be challenging. Once systems are linked through an exchange rate, only a single allowance price will remain. It then becomes impossible to observe, and difficult to impute from modelling or other data, what the relative allowances prices in different jurisdictions would have been were the systems not linked, the ratio of which is essential for understanding whether an exchange rate is *effective*, *overstated*, or *reversed*. And lastly, negotiating exchange rate values, including the basis for any adjustments over time, with other jurisdictions – or entrusting this process to a third party – could also be very challenging. Exchange rates could be viewed as valuing a jurisdiction's climate mitigation actions; this perception could make negotiations on exchange rates politically sensitive. The World Bank's Globally Networked Carbon Markets Initiative suggested that financial markets themselves could set exchange rates, and they could indeed 'float', as they do for currencies and other financial products. However, it remains unclear how this would work in practice. Unlike other products and services and the currencies used for their exchange, emissions allowances have no value outside the markets created by the regulators themselves.

Exchange rates also do not provide advantages with regard to the regulatory autonomy of decision-makers. Once exchange rates have been set, decision-makers cannot influence allowance, investment, and financial flows.

6.4.4 Discount rates

Discount rates can be regarded as a variation on exchange rates, with a view to addressing some of the challenges inherent to exchange rates. In contrast to exchange rates, they do not need to be set in a symmetrical fashion, which allows establishing discount rates in ways that ensure that rates are always *effective*, and neither *reversed* nor *overstated*. If policy-makers want to ensure that a discount rate always 'lands' in the *effective* range – even under information asymmetry and uncertainty with regard to BAU emissions, abatement potential, and abatement costs – they could implement it in either of the following ways:

1. *One-way discount rates:* One jurisdiction allows imports of allowances from another jurisdiction, converted at a discount rate above 1 (i.e. more than one allowance from the other jurisdiction is required to emit one more ton in the importing jurisdiction). No allowance exports would be allowed to the other jurisdiction; and
2. *Two-way discount rates*: Both jurisdictions allow importing units, each using a discount rate that is above 1. In both directions of allowance flows, more than one imported allowance would be required to emit one more ton in the importing jurisdiction.

The abatement outcome and economic implications are similar to those of effective exchange rates. The two approaches would guarantee that both total abatement and cost-effectiveness could only increase as a result of allowance trade among jurisdictions. However, with discount rates, allowances are only transferred between jurisdictions if the difference in allowance prices without linking exceeds the discount rate. For example, if both jurisdictions applied a 20% discount to allowances imported from the other jurisdiction (1.25 imported allowances required per ton emitted), trade would only start if the price difference between the jurisdictions (with no linking) is larger than this differential. If the price difference is smaller, the outcome would be the same as for no linking. In other words, the price difference between the two jurisdictions is capped to a maximum of 20%.

In this regard, discount rates can work in a similar manner as price containment mechanisms, unless prices rise simultaneously in both systems. Moreover, unlike exchange rates, discount rates do not provide for fungibility of allowances, and hence, like quotas or one-way linking, they also fail to provide for significantly enhanced market liquidity.

Setting the level of discount rates, and possibly updating them, is an important challenge, similar to quotas as discussed above, but less so than for exchange rates, since they can be set up in ways that avoid unintended consequences. Applying discount rates reciprocally (both jurisdictions discount unit imports at the same rate) might address perceptions about valuing reductions differently across jurisdictions. Compared to exchange rates, discount rates could be more easily adjusted over time and would allow regulators to retain more decision-making autonomy compared to full linking.

6.5 Discussion

Our assessment of restricted linking options shows that the abatement outcome, the economic implications, and the feasibility differ considerably between the three options. Table 6-1 compares the three restricted linking options against the main criteria.

Table 6-1 Summary comparison of options against key criteria (relative to no linking)

		Economic implications		Feasibility	
	Total abatement	Cost-effectiveness	Unit liquidity and fungibility	Challenges to set quotas, exchange rates or discount rates	Implications for regulatory autonomy
Full linking	• No change	• Maximized cost-effectiveness	• Increased liquidity • Full fungibility		• Reduced regulatory autonomy
Quotas	• No change	• Enhanced cost-effectiveness	• Increased liquidity but much less so than full linking • No fungibility	• Quota level difficult to set due to uncertainty and information asymmetry	• Jurisdictions maintain stronger regulatory autonomy compared with full linking and can adjust quota levels
Exchange rates	• Increased total abatement with effective rates • Decreased total abatement with reversed rates	• Enhanced cost-effectiveness with effective or moderately reversed rates • Decreased cost-effectiveness with overstated or strongly reversed rates	• Increased liquidity (similar to full linking) • Full fungibility	• Outcome could be contrary to the policy objectives pursued due to uncertainties and information asymmetries in setting the exchange rate • Mutually agreeing exchange rate values and modalities for future adjustments could be politically challenging	• Reduced regulatory autonomy
Discount rates	• Increased total abatement	• Enhanced cost-effectiveness	• Increased liquidity but much less so than full linking • No Fungibility	• Rate level difficult to set due to uncertainty and information asymmetry	• Jurisdictions maintain stronger regulatory autonomy compared with full linking and can adjust discount rates

The most appropriate option for restricted linking depends on the specific policy objectives pursued. If the ultimate goal of policy-makers is indeed full linking, and restricted linkage is viewed as a step towards that end, then quotas may be an attractive option. In contrast to exchange rates, they cannot undermine cost-effectiveness and overall abatement and do not create different perceptions of the relative value and implied ambition of each ETS that could ultimately hamper efforts to reach agreement on full linking.

If the main policy goal is increasing liquidity, exchange rates could be considered. However, information asymmetries and uncertainties in setting the rate could seriously undermine the intended policy objectives. In this regard, one could question whether exchange rates would not mainly add another layer of complexity when negotiating a linking agreement, while not necessarily addressing the concerns with full linking. Our findings on exchange rates are similar to those of Burtraw et al. (2013), who evaluated an exchange rate of 3 between California-Québec and RGGI. Under current allowance prices, this exchange rate would fall in the *overstated* range.

By contrast, discount rates can avoid some of the challenges of exchange rates. Discount rates could be set up in ways that ensure that both cost-effectiveness and total emissions abatement are enhanced. They implicitly link flexibility and mitigation ambition – the more the regulated entities use the flexibility to import units from another jurisdiction, the more emissions are reduced. Applying discount rates reciprocally (both jurisdictions discount unit imports at the same rate) might address perceptions about valuing reductions differently across jurisdictions.

Our analysis builds on a simplified model and several assumptions. The direction of the implications can be generalized to other two-jurisdiction relationships, where marginal abatement costs increase in a roughly linear fashion, entities can bank allowances and have certainty on a long-term target trajectory below BAU levels, and price containment mechanisms are not in place. Different parametrizations of the linear MAC curves lead to similar outcomes.

In practice, many ETSs have features and circumstances which are not considered in this article, including price containment mechanisms, offset use, targets above BAU, political uncertainty on the ambition of future targets, more complex abatement cost functions, and transaction costs. Moreover, linking the ETSs of more than two jurisdictions would add further complexity (Mehling & Görlach, 2016). Price containment measures create well-recognized challenges to linking (Harrison, Klevnas, Radov, & Foss, 2006). If two ETSs have a price floor, full linking will generally, but not always, impose the higher-price floor on both schemes. If only one of the two ETSs has a price floor, it will become applicable in both schemes and could increase the total abatement outcome from both ETSs (Burtraw et al., 2013). Linking can also change the amount and type of offsets used and thus the total abatement, depending on the extent of over- or under-crediting by different offset types (Erickson et al., 2014). If one system is over-allocated and the other not, then (restricted) linking them could reduce overall emissions abatement. Under uncertainty on the future target trajectory, entities may prioritize short-term over long-term abatement options, and (restricted) linking could lead to less cost-effective outcomes in a long-term perspective. Linking, whether full or restricted, could also have impacts on the ambition of the future target periods. If restrictions allow less harmonized systems to link, they could also reduce incentives to harmonize and move towards full linking. Finally, (restricted) linking two ETSs involves transaction costs which could outweigh the benefits for one or both of the linking partners (Flachsland et al., 2009a).

Assessing these features and circumstances in the context of restricted linking requires considering the context of specific ETSs and is beyond the scope of this article and subject to further research. Fully understanding the implications of restricted linking will require assessing other environmental, economic and political implications, such as on environmental co-benefits, price volatility, and risks of carbon leakage. Generally, the implications and feasibility of linking – whether full or restricted – will depend heavily on the design of the ETSs (e.g. allocation rules, price containment measures), the ambition of the caps (e.g. over-allocation or accumulated surpluses, political certainty), the size of the ETSs (e.g. if one ETS is much smaller than the other), the marginal abatement cost curves, and the use of price containment mechanisms. The present analysis provides only a partial picture of the various aspects that play a role when considering (restricted) linking of ETSs. It is therefore important for researchers and policy-makers to carefully consider and assess the implications of (restricted) linking in their specific context.

6.6 Conclusions

While restricted linking options do not, in principle, achieve the potential benefits of full linking, they can lessen some of the potential pitfalls. They can increase cost-effectiveness while maintaining more regulatory autonomy for decision-makers. They also offer easier off-ramps to terminate linking arrangements[9] and levers to adjust (e.g. quota levels or discount rates), should linking concerns prove to be more significant than anticipated. Restricted linking options may thus represent a cautious approach that can be more easily implemented and explored where full linking is either infeasible in the near term or incompatible with the objectives of the jurisdictions involved. Borrowing the 'match-making' analogy that Comendant and Taschini (2014) invoke for the process of finding the right 'linking partner', restricted linking is akin to moving in together, either before (or with no intention of) getting married.

Our analysis shows that restricted linking could have unintended adverse outcomes. Careful consideration of the specific ETS design and context of the prospective linking partners is key to avoid such consequences. The most suitable option for restricted linking also depends on the policy objectives pursued. Quotas and discount rates, or their combination, could provide benefits compared to no linking, whereas exchange rates could lead to unintended adverse environmental and economic consequences. Discount rates are a promising option if the main policy objective is increasing cost-efficiency, flexibility and total abatement outcome, while maintaining regulatory autonomy.

[9] Where linking is formalized in a linking agreement, this may require a termination procedure (Mehling & Haites, 2009). The way the termination of a linking agreement is organized may affect abatement costs and subsequent price divergence (Pizer & Yates, 2015).

Supplementary information

This supplementary information describes in more detail the simplified model used to assess options for restricted linking of emissions trading systems (ETSs). We use the model to compute the abatement level, allowance prices, and abatement costs. We apply the model, first for reference, to the cases of no linking and full linking, and then to quotas, exchange rates and discount rates.

Model description

In our model, we use a simple representation of two ETSs in jurisdictions A and B with linear marginal abatement cost curves. We assume that the two ETSs have a long-term target path below business-as-usual emissions (i.e. with no over-allocation of allowances) and allow for banking of allowances, providing entities with a certain long-term emissions budget, and that the two ETSs do not have any price containment mechanisms, such as offsets, reserves, floors, caps and/or triggers. The limitations of these assumptions are discussed in Section 6.5 of the article.

We define each jurisdiction by: (1) the total abatement under no linking, reflected by the difference between its emission cap and business-as-usual emissions, and (2) a simplified, linear marginal abatement cost curve that represents how its cost of reducing emissions increases with the level of abatement:

$$MAC_A(AB_A) = A \cdot AB_A \qquad \text{(Equation 6-1)}$$

$$MAC_B(AB_B) = B \cdot AB_B \qquad \text{(Equation 6-2)}$$

where MAC_A and MAC_B are the marginal abatement costs in jurisdictions A and B for a given abatement level AB_A or AB_B. For a given abatement level AB_A and AB_B in jurisdictions A and B, the corresponding allowance prices and abatement costs in each jurisdiction are computed as:

$$p_A = A \cdot AB_A \qquad \text{(Equation 6-3)}$$

$$p_B = B \cdot AB_B \qquad \text{(Equation 6-4)}$$

$$COST_A = 0.5 \cdot A \cdot AB_A^2 \qquad \text{(Equation 6-5)}$$

$$COST_B = 0.5 \cdot B \cdot AB_B^2 \qquad \text{(Equation 6-6)}$$

where p_A and p_B are the allowance prices in jurisdictions A and B, and $COST_A$ and $COST_B$ are the abatement costs in jurisdictions A and B.

We define the cost effectiveness as the total abatement costs in both jurisdictions with no linking divided by the total abatement costs in both jurisdictions with restricted (or full) linking. The cost effectiveness (CE) is thus computed as:

$$CE = \frac{COST_{A,0}+COST_{B,0}}{COST_A+COST_B} \qquad \text{(Equation 6-7)}$$

where $COST_{A,0}$ and $COST_{B,0}$ are the abatement costs under no linking.

Where a restricted linking option changes the overall abatement outcome, we use this changed abatement level to calculate $COST_{A,0}$ $COST_A$, $COST_{B,0}$ and $COST_B$. To this end, we assume that the abatement under no linking would change in each jurisdiction proportionally to their emission reduction targets.

For the purpose of illustrating the results in charts in the article, we set the parameters of the model such that, in the absence of any linking, jurisdiction B has an allowance price three times higher than jurisdiction A, similar to the parameterization used by Burtraw *et al*. (2013):

$A = 0.3$, $B = 0.6$, $AB_{A,0} = 20$, and $AB_{B,0} = 30$

where $AB_{A,0}$ and $AB_{B,0}$ are the abatement levels in each jurisdiction under no linking.

No linking

The allowances prices in jurisdictions A and B ($p_{A,0}$ and $p_{B,0}$) and the abatement costs in jurisdictions A and B ($COST_{A,0}$ and $COST_{B,0}$) are computed using Equations 6-3 to 6-6, based on the abatement levels without linking ($AB_{A,0}$ and $AB_{B,0}$).

Full linking

Under full linking, both ETSs have equal marginal abatement costs and the overall abatement level is unchanged. The market equilibrium is thus given by two conditions:

$$A \cdot AB_{A,F} = B \cdot AB_{B,F} \quad \text{and} \qquad \text{(Equation 6-8)}$$

$$AB_{A,F} + AB_{B,F} = AB_{A,0} + AB_{B,0} \qquad \text{(Equation 6-9)}$$

where $AB_{A,F}$ and $AB_{B,F}$ are the abatement levels in jurisdictions A and B under full linking. This gives:

$$AB_{A,F} = \frac{B \cdot (AB_{A,0}+AB_{B,0})}{A+B} \quad \text{and} \qquad \text{(Equation 6-10)}$$

$$AB_{B,F} = \frac{A \cdot (AB_{A,0}+AB_{B,0})}{A+B} \qquad \text{(Equation 6-11)}$$

The equilibrium allowance price $p_E = p_{A,F} = p_{B,F}$, the abatement costs in jurisdictions A and B ($COST_{A,F}$ and $COST_{B,F}$), and the cost effectiveness under full linking (CE_F) are computed with Equations 6-3 to 6-7 respectively, based on the abatement levels under full linking ($AB_{A,F}$ and $AB_{B,F}$).

Full linking involves a net transfer of allowances from jurisdiction A to jurisdiction B (T_F), which is computed as:

$$T_F = AB_{A,F} - AB_{A,0}. \qquad \text{(Equation 6-12)}$$

Quotas

Quotas restrict the amount of units from other jurisdictions that can be used for compliance. Quotas can be formulated and implemented in different ways. Here we define the quota level Q as the fraction of allowances that can be imported by jurisdiction A divided by the amount of allowances that are imported under full linking. The allowance transfer under the quota (T_Q) is thus given by

$$T_Q = Q \cdot T_F \qquad \text{(Equation 6-13)}$$

The abatement levels under the quota in each jurisdiction ($AB_{A,Q}$ and $AB_{B,Q}$) are then computed as:

$$AB_{A,Q} = AB_{A,0} + T_Q \quad \text{and} \qquad \text{(Equation 6-14)}$$

$$AB_{B,Q} = AB_{B,0} - T_Q. \qquad \text{(Equation 6-15)}$$

The allowance prices in jurisdictions A and B ($p_{A,Q}$ and $p_{B,Q}$), the abatement costs in jurisdictions A and B ($COST_{A,Q}$ and $COST_{B,Q}$), and the cost effectiveness under the quota (CE_Q) are computed with Equations 6-3 to 6-7 respectively, based on the abatement levels under the quota ($AB_{A,Q}$ and $AB_{B,Q}$).

Exchange and discount rates

Exchange rates imply that units from one jurisdiction can be used for compliance in another, but their value is adjusted by a conversion factor. Exchange rates operate in a symmetrical fashion. If an exchange rate is set such that two units from jurisdiction A could be used in place of one unit in jurisdiction B, then in jurisdiction A, one jurisdiction B unit would be worth two jurisdiction A units.

Discount rates could be regarded as a variation on exchange rates. They also involve a conversion factor, but such that more than one unit from another jurisdiction is required to meet a compliance obligation in the own jurisdiction, thereby placing a greater value on units of the own jurisdiction. While exchange rates inherently require a symmetrical relationship in the value of jurisdictions' allowances, discount rates do not. Jurisdictions could apply one discount rate in one direction of allowance flow (e.g., 3:1 from system A to system B) and parity (1:1) or a rate of different magnitude in the other direction (e.g., 2:1 from system B to system A).

We define the exchange or discount rate R as the number of allowances from jurisdiction A that are needed for compliance in jurisdiction B.

In contrast to full linking and quotas, exchange and discount rates can alter the overall abatement from both jurisdictions. The market equilibrium is given by three conditions: First, the marginal abatement costs in jurisdiction B are R times higher than in jurisdiction A (Equation 6-16). Second, the abatement in jurisdiction A under the exchange or discount rate ($AB_{A,R}$) corresponds to the abatement without linking, plus the allowances transferred to jurisdiction B (T_R) (Equation 6-17). Third, the abatement in jurisdiction B under the exchange or discount rate ($AB_{B,R}$) corresponds to the abatement without linking, minus the allowances imported, however, adjusted for the exchange or discount rate R (Equation 6-18):

$$R \cdot A \cdot AB_{A,R} = B \cdot AB_{B,R} \qquad \text{(Equation 6-16)}$$

$$AB_{A,R} = AB_{A,0} + T_R \qquad \text{(Equation 6-17)}$$

$$AB_{B,R} = AB_{B,0} - \frac{T_R}{R} \qquad \text{(Equation 6-18)}$$

These three conditions give the abatement levels under the exchange rate in each jurisdiction:

$$AB_{A,R} = \frac{AB_{A,0} + R \cdot AB_{B,0}}{1 + \frac{A \cdot R^2}{B}} \qquad \text{(Equation 6-19)}$$

$$AB_{B,R} = \frac{AB_{A,0} + R \cdot AB_{B,0}}{R + \frac{B}{A \cdot R}} \qquad \text{(Equation 6-20)}$$

The allowance prices ($p_{A,R}$ and $p_{B,R}$) and the abatement costs ($COST_{A,R}$ and $COST_{B,R}$) in each jurisdiction under the exchange or discount rate are computed with Equations 6-3 to 6-6 respectively.

The allowance prices in jurisdictions A and B ($p_{A,R}$ and $p_{B,R}$), the abatement costs in jurisdictions A and B ($COST_{A,R}$ and $COST_{B,R}$), and the cost effectiveness under the exchange or discount rate (CE_R) are computed with Equations 6-3 to 6-7 respectively, based on the abatement levels under the exchange or discount rate ($AB_{A,R}$ and $AB_{B,R}$).

Chapter 7

When less is more: Limits to international transfers under Article 6 of the Paris Agreement

Abstract

International carbon markets can be an important tool in achieving countries' mitigation targets under the Paris Agreement, but they are subject to a number of environmental integrity risks. An important risk is that some countries have mitigation targets that correspond to higher levels of emissions than independent projections of their likely emissions. If such 'hot air' can be transferred to other countries, it could increase aggregated emissions and create a perverse incentive for countries not to enhance the ambition of future mitigation targets. Limits to international transfers of mitigation outcomes have been proposed to address this risk. This article proposes a typology for such limits, explores key design options, and tests different types of limits in the context of 15 countries. Our analysis indicates that limits to international transfers could, if designed appropriately, prevent most of the hot air contained in current mitigation targets from being transferred, but also involve trade-offs between different policy objectives. Given the risks from international transfer of hot air and the uncertainty over whether other approaches will be effective in ensuring environmental integrity, we recommend that countries take a cautious approach and pursue a portfolio of approaches to ensure environmental integrity, in which case limits could provide for additional safeguards.

Key policy insights:

- Limits to international transfers involve trade-offs between different policy objectives, in particular reducing the risk that countries transfer hot air and enabling participation in carbon markets.
- Under 'relative' limits a country may transfer mitigation outcomes to the extent that its actual emissions are below the limit. Relative limits derived from historical emissions data have significant limitations, and none of the tested approaches was found to be effective for all countries. Relative limits based on emission projections could be a more valid approach, although they are also technically and politically challenging.

- Under 'absolute' limits a country could only issue, transfer or acquire a certain amount of mitigation outcomes. Absolute limits set at sufficiently low levels could prevent countries from transferring large amounts of hot air, but are bluntly applicable to all countries, whether or not they have hot air.

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7.1 Introduction

Article 6 of the Paris Agreement allows countries to use international carbon markets to achieve their mitigation targets communicated in nationally determined contributions (NDCs), hereinafter referred to as 'NDC targets'. Article 6.2 allows countries to use 'internationally transferred mitigation outcomes' (ITMOs) (i.e. climate change mitigation achieved in one country but claimed by another) to achieve their NDC targets. Article 6.4 establishes a new crediting mechanism under international supervision that could be used for similar purposes.

Carbon markets are considered a key tool to reduce greenhouse gas (GHG) emissions (IPCC, 2014b). They can reduce the cost of achieving mitigation targets by providing flexibility in how and where emissions are reduced and could thereby facilitate the adoption of more ambitious mitigation targets. Yet international carbon markets involve a number of environmental integrity risks (Schneider & La Hoz Theuer, 2019): if not designed and implemented appropriately, they could result in greater GHG emissions than if they were not employed. The Paris Agreement therefore requires Parties to ensure environmental integrity when engaging in international transfers of mitigation outcomes.

A key risk to environmental integrity concerns international transfers from countries with weak mitigation targets. Under the 1997 Kyoto Protocol, some countries had mitigation targets which did not require the country to take any mitigation action, creating surplus units that were often referred to as 'hot air' (Boehringer, 2000; Boehringer, Moslener, & Sturm, 2007; Brandt & Svendsen, 2002; den Elzen, Roelfsema, & Slingerland, 2009; IPCC, 2001, sec. 6.3.1; Paltsev, 2000; Victor, Nakicenovic, & Victor, 1998). Independent assessments of current NDC targets suggest that this situation may also arise under the Paris Agreement, since the mitigation targets of several countries could correspond to higher levels of emissions than the projection of their likely emissions level with the policies in place at the time of setting the target (CAT, 2018; den Elzen et al., 2016; Meinshausen & Alexander, 2016). These countries could thus *appear* to generate emission reductions (relative to their targets), without generating any *actual* emission reductions.

Hot air could pose several risks to environmental integrity under Article 6. If the rules under Article 6 were to allow countries to transfer hot air to other countries, then global GHG emissions could end up higher than they would have been if the countries' NDC targets were achieved without such transfers. This is because the transfer would allow the acquiring country to increase its emissions above its NDC target, while the transferring country would not need to engage in corresponding emission reductions to achieve its NDC target. Allowing countries to transfer hot air could also create a perverse incentive for transferring countries not to enhance the ambition of mitigation targets in future NDCs, in order to accrue higher benefits from international transfers. Countries with hot air, moreover, may have less incentives to ensure environmental integrity, as they would achieve their NDC target even if they engage in transfers that do not represent actual mitigation outcomes (Kollmuss et al., 2015; Schneider & La Hoz Theuer, 2019).

Parties to the Paris Agreement are currently negotiating the rules for the implementation of Article 6. An important and controversial issue is whether and how international rules should promote environmental integrity. Several Parties have proposed that international transfers under Article 6 be subject to quantitative limits. Such limits are proposed to address environmental integrity concerns but also to pursue other policy objectives, such as ensuring that a minimum portion of mitigation action takes place domestically (see, e.g. AOSIS, 2017; Arab Group, 2017; Brazil, 2014, 2016, 2017; LMDC, 2017; Venezuela, 2017).

While limits to international transfers are an important topic in the ongoing negotiations, research on this topic is sparse. This article explores how limits could be established and assesses the implications of different types of limits, with a focus on whether and how they mitigate the risk of international transfer of hot air. The article draws on relevant literature, submissions by countries, and the experience with limits under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. In addition, the implications of different types of limits are tested in the context of 15 countries, using data on historical emissions, information from NDCs, and independently-established emission projections.

The article employs specific terminology and makes several assumptions. Article 6.2 of the Paris Agreement does not specify what an ITMO is, nor how transfers should take place. ITMOs could be international units that are transferred between electronic registries or they could be amounts that are reported by countries for accounting purposes (Schneider, Füssler, Kohli, et al., 2017). It is assumed here that ITMOs are amounts reported by countries. For simplicity, the term 'ITMOs' is used to refer to transfers both of mitigation outcomes generated under Article 6.2 and of emission reductions resulting from the Article 6.4 mechanism. It is further assumed that ITMOs are expressed in tons of carbon dioxide equivalent (tCO_2e), noting that the findings would also hold if this was not the case.

No agreed definition of 'hot air' exists. This paper adopts the approach typically employed in the literature where hot air is defined in the context of mitigation targets that countries over-achieve without pursuing further mitigation actions (Boehringer, 2000; den Elzen & de Moor, 2002; Kollmuss et al., 2015; Schneider & La Hoz Theuer, 2019; UNFCCC, n.d.; Victor et al., 1998). Throughout this paper, hot air is understood as the difference between the NDC target level and the projection of the likely emissions level with the policies in place at the time of setting the target. We use the projection with policies in place at the time of setting the target because countries formulate their targets based on known circumstances at that point in time.

7.2 General design options for limits to international transfers

Limits could be pursued to achieve different policy objectives. They could be established with the aim to prevent the transfer of hot air, or to reduce disincentives for transferring countries to increase ambition in future NDCs. They could also be introduced in order to address the risk of 'over-selling' (i.e. that countries transfer so many mitigation outcomes that they can no longer achieve their NDC target). Finally, limits could also be pursued to ensure that a minimum portion of mitigation effort takes place domestically – which is often referred to as 'supplementarity'.

Limits could be applied not only to international transfers in the context of Article 6, but also in the context of 'banking' or 'carry-over' of units. Although this latter aspect is not further explored in this paper, similar considerations would apply.

Limits to international transfers were employed under the Kyoto Protocol, albeit without addressing the risk of transfer of hot air. A principle of 'supplementarity' was established – that participation in market mechanisms should be 'supplemental' to domestic action – but never operationalized in the form of a quantitative limit. To prevent over-selling, a 'commitment period reserve' was introduced, requiring that each Party maintain a minimum reserve of units that cannot be transferred internationally (Yamin & Depledge, 2004).

The Doha Amendment to the Kyoto Protocol includes a provision that aims specifically at addressing the risk of transfer of hot air: Article 3.7ter establishes that countries' assigned amounts (i.e. their budget of emissions under the Kyoto Protocol) in the period 2013–2020 cannot exceed each country's average annual emissions over the period 2008–2010. This provision thus implicitly ensures that countries' targets in the second commitment period correspond, at a minimum, to the average reported emissions for 2008–2010. In so doing, this provision reduces the amount of hot air that countries could transfer (Chen, Gütschow, Vieweg, Macey, & Schaeffer, 2013). The Doha Amendment, however, has not yet entered into force.

In the ongoing negotiations, Brazil proposes limits to international transfers which could address the risk of transfers of hot air. Other countries and groups of countries – such as the Alliance of Small Island Developing States, the Arab Group, Like Minded Developing Countries and Venezuela – propose limits akin to the supplementarity principle and to the commitment period reserve, among others. This section explores various design options for limits, taking into account the various policy objectives mentioned above. Section 7.3

then tests different options for limits, focusing specifically on the objective of preventing transfer of hot air.

7.2.1 Relative and absolute limits

Limits could be established in a number of ways. Here, two main types are distinguished. Under a *relative limit*, a country would be allowed to transfer ITMOs to the extent that its actual emissions in the target year or period are below a specified limit. This type of limit is referred to here as a *relative* because it would allow the country to transfer any amount of ITMOs – as long as it reduces emissions respectively below the limit. Relative limits can reduce the risk of transferring hot air and avoid perverse incentives for countries not to enhance the ambition of future NDCs.

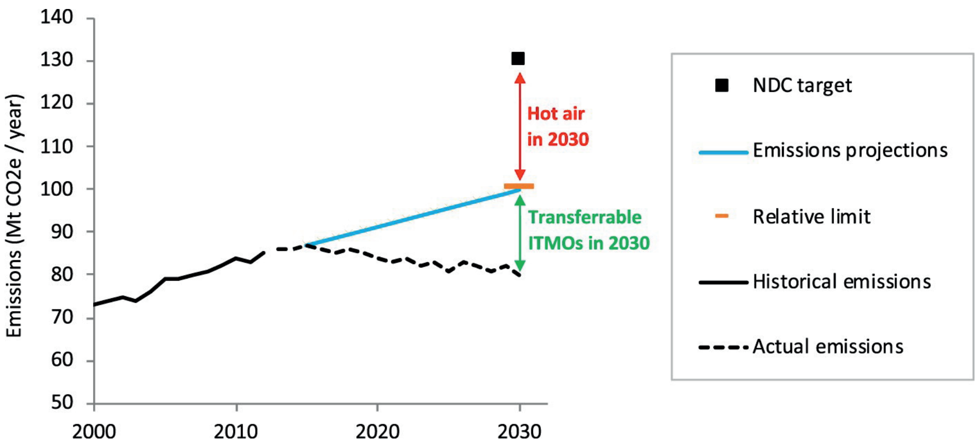

Figure 7-1 Relative limit based on emissions projections in 2030. The figure illustrates the application of a relative limit for a country with an NDC target for 2030 (black square) that is less stringent than the projected emissions (blue line). The country thus has hot air (red arrow). The country implements mitigation actions which bring its emissions (black dashed line) below the emissions projection. In this example, the relative limit (orange line) for 2030 is set exactly at the level of the projection of the likely emissions level with the policies in place at the time of setting the target. The amount of ITMOs the country is allowed to transfer in 2030 corresponds to the reduction of emissions below the limit (green arrow).

To prevent transfers of hot air, relative limits would ideally be set exactly at the projection of the likely emissions level with the policies in place at the time of setting the target, as shown in Figure 7-1. In this case, the limit would prevent transfers of hot air while still enabling transfers that do result from abatement action. In practice, however, establishing emission projections is both technically and politically challenging: they are based on assumptions about future developments and therefore involve considerable uncertainties.

No internationally agreed method exists to establish emission projections, and estimations often diverge considerably between authors, depending on the assumptions and methods used (Rogelj et al., 2017). Policy-makers could therefore also consider deriving relative limits from other parameters, such as average historical emissions, as proposed by Brazil (Brazil, 2014, 2017).

Under an *absolute limit*, a country could issue, transfer or acquire only a certain absolute (or fixed) number of ITMOs (e.g. a fixed percentage of reported emissions in a given year). Absolute limits would restrict international transfers from *all* countries, irrespective of environmental integrity risks. They would, therefore, help *contain* rather than address the risk of transferring hot air. Absolute limits could also be employed to reduce the risk of over-selling or to operationalize the principle of supplementarity.

7.2.2 Applicability to transferring or acquiring countries

Limits could be applied to transferring and/or acquiring countries, as well as to different groups of countries. Limits placed on *transferring countries* could help prevent hot air transfers, reduce perverse incentives not to enhance the ambition of future NDCs, and prevent over-selling. Limits placed *on acquiring countries* could help ensure supplementarity but may do little to address the hot air risk, because transferring countries could still in principle transfer all of the hot air contained in their NDCs.

Limits could also apply to all countries, or only to some countries. Limits could, for example, not apply to least developed countries or to small island developing states, as these country groups are differentiated under the Paris Agreement.

7.2.3 Applicability to types of transfers

Limits could apply to all international transfers under the Paris Agreement or only to some types of transfers. Limits could, for example, not apply to ITMO transfers that are backed by mechanisms that may involve lower environmental integrity risks. International linkages between emissions trading systems (ETSs), for example, could have limited environmental integrity risks because jurisdictions with ambitious ETS caps are unlikely to link to an ETS that is much less ambitious or over-allocated (Ranson & Stavins, 2016). Although crediting mechanisms could also ensure environmental integrity, the available analyses indicate that they face considerable challenges and uncertainty in this regard (Cames et al., 2017; Erickson et al., 2014; Gillenwater, 2012; Kollmuss et al., 2015; Schneider, 2009b). Yet distinguishing ITMO transfers backed by linkages of ETSs from other types of transfers could be technically and politically challenging. It would require international agreement on a definition of ETSs and a method to determine how many ITMOs were transferred through the linkage of two ETSs.

7.2.4 Methods for establishing the limit

The level of limits could be established in a number of ways. Limits could be based on different *parameters*, such as historical GHG emissions or the historical GHG emissions intensity per gross domestic product (GDP), a GHG emissions level corresponding to the NDC target, or actual GHG emissions in the target year or period. The parameters could be determined using different *reference periods*, with various lengths and starting points. Finally, several *methods* could be applied to calculate the level of the limit, such as simple percentages, average values or an extrapolation of trends.

7.2.5 Timing and point of application

Internationally agreed limits are only effective if they are adhered to when countries account for their NDCs. When and how limits could be applied would depend on the rules under the Paris Agreement. An *ongoing* application of limits (e.g. at the point of issuance in transferring countries and/or at the point of use by acquiring countries) could be implemented if ITMOs were international units that are tracked through registries. If ITMOs were amounts reported for the purpose of accounting for international transfers through 'corresponding adjustments', limits could be applied *ex-post*, when countries account for their NDCs. In this latter case, it would be the responsibility of countries to ensure that they engage in transfers in a manner consistent with the limit.

Other design features are also relevant, such as considerations on when to establish and assess limits. These are not further considered here.

7.3 Testing different options for establishing limits

7.3.1 Approach and methodology

To understand the suitability and implications of the various options for establishing limits, different methods for determining limits are tested in the context of 15 countries that represent a variety of circumstances. The different options for establishing limits are assessed against two criteria: whether and how they address the environmental integrity risk of international transfers of hot air, and whether and how they allow countries to transfer ITMOs that result from actual mitigation action.

To assess these implications, the GHG emissions levels corresponding to the NDC targets are compared with independently-established emissions projections in order to assess whether and how much hot air is contained in NDC targets. For each type of limit, it is then assessed whether and how the country could engage in international transfers and the extent to which this would involve hot air. The analysis assesses the implications for the year 2030, which is used as target year by all selected countries. It is important to note that this analysis is *not* an assessment of the ambition of individual NDC targets, which would have to take into account equity and development considerations as well as other country circumstances.

The data used for the analysis is derived from two main sources. Information on historical GHG emissions, on emissions projections, and on the quantification of countries' NDC targets is drawn from the Climate Action Tracker (CAT) project.[10] The data from CAT is used because it provides independent, coherently-applied emissions projections derived from country-specific information. We use the 2015 emissions projections, as they approximately reflect the policies that were in place when countries set their targets. Where the CAT data includes a range for the level of NDC targets and/or for emission projections, the average value is used. Data gaps were filled using 2017 data from CAT and WRI (2017), making adjustments to ensure time series consistency. Some approaches make use of historical and projected GDP values; these were drawn from USDA-ERS (2017).

7.3.2 Relative limits

Relative limits could be established with the objective to prevent the transfer of hot air while enabling the transfer of mitigation outcomes that are additional to those implemented at the time when the target is set. In this case, relative limits set exactly at the level of emissions projections with policies in place at the time of setting the target would – theoretically – best achieve both objectives (see section 7.2.1 above). As establishing emissions projections is both technically and politically challenging, several alternative approaches for establishing relative limits are tested, with the aim of understanding whether they could be good *approximations* of emissions projections with policies at the time of setting the target.

In total eight alternative approaches are tested to each of the 15 countries. These include relative limits based on *historical GHG emissions*, as proposed by Brazil, or based on *historical GHG emissions per gross domestic product* (GDP). In addition to using *average* historical data to establish the limit, the *extrapolation of historical trends* is also tested, using the least squares method. In all scenarios, a historical reference period is used to calculate the average values or extrapolate the trend, though with different lengths. For average historical data, three-year and five-year periods are tested; for the extrapolation of historical trends, five-year and ten-year periods are tested. Table 7-1 shows the results of the analysis. For each country and for each approach to establish relative limits, the table presents the deviation of the relative limit from the average emissions projections in 2030. The smaller the deviation, the better the approach approximates the emissions projections. A negative value denotes a situation where the relative limit lies below (i.e. is more

[10] https://doi.org/10.1007/s10584-015-1482-3

stringent than) the projections. Information on the range of the projections by CAT is also provided, highlighting the uncertainty surrounding the projections. Finally, Table 7-1 also presents the relative difference between the NDC target level and the emissions projections; positive values mean that the NDC target level is above the projection (i.e. contains hot air). Figure 7-2 illustrates the results of the different approaches for selected countries.

Table 7-1 and Figure 7-2 show that none of the analysed approaches is effective for all countries. The calculated relative limits often differ significantly from the emission projections, leading to high standard deviations for all approaches for relative limits. In many cases, the difference between the relative limit and the emissions projection is larger than the difference between the NDC target and the emissions projection. This implies that none of the tested approaches achieves the objective of preventing the transfers of hot air for all countries while enabling ITMO transfers that result from mitigation actions. It was also not possible to identify groups of countries, such as developed or developing countries, for which a particular approach would consistently achieve these objectives. The results, however, differ between the different approaches.

Table 7-1 Deviation of relative limits from average emission projections in 2030

			Deviation of relative limits from avg. emission projections in 2030							
			Historical GHG emissions				Historical GHG emissions per GDP			
		NDC compared	Average		Trend		Average		Trend	
Country	Range of emissions projection	to average projection	3 yrs	5 yrs	5 yrs	10 yrs	3 yrs	5 yrs	5 yrs	10 yrs
Argentina	+/−14%	−6%	−35%	−35%	−39%	−22%	+2%	+9%	−214%	−212%
Brazil	Single point	−5%	−23%	−25%	+10%	+8%	+6%	+8%	−21%	−31%
China	+/−4%	+10%	−24%	−28%	+54%	+49%	+123%	+130%	−23%	−72%
Ethiopia	Single point	−40%	−70%	−70%	−61%	−54%	−5%	+4%	−272%	−281%
EU	+/−7%	−13%	+16%	+18%	−30%	−24%	+54%	+57%	−11%	−37%
Gambia	Single point	−23%	−42%	−46%	+30%	+13%	+30%	+25%	+129%	+92%
India	+/−1%	+5%	−54%	−56%	−13%	−16%	+74%	+79%	−10%	−14%
Indonesia	Single point	+21%	−36%	−39%	+17%	−6%	+66%	+68%	+29%	−36%
Japan	+/−5%	−11%	+8%	+6%	+43%	−6%	+25%	+23%	+56%	−3%
New Zealand	Single point	−37%	−13%	−13%	−10%	−21%	+37%	+39%	+2%	−21%
Norway	Single point	−52%	+2%	+2%	−5%	−8%	+45%	+45%	+15%	−11%
Peru	Single point	−22%	−43%	−44%	−20%	−21%	+18%	+23%	−64%	−96%
Russia	+/−1%	+17%	−14%	−15%	+4%	−2%	+10%	+10%	−1%	−68%
South Africa	Single point	−44%	−39%	−39%	−29%	−22%	−11%	−10%	−29%	−43%
South Korea	+/−8%	−27%	−8%	−12%	+63%	+34%	+47%	+45%	+65%	+11%
Standard deviation			0.24	0.24	0.35	0.25	0.35	0.36	1.01	0.90

Source: Own calculations based on 2015 data by CAT and by USDA-ERS (2017). Figures in red indicate hot air.

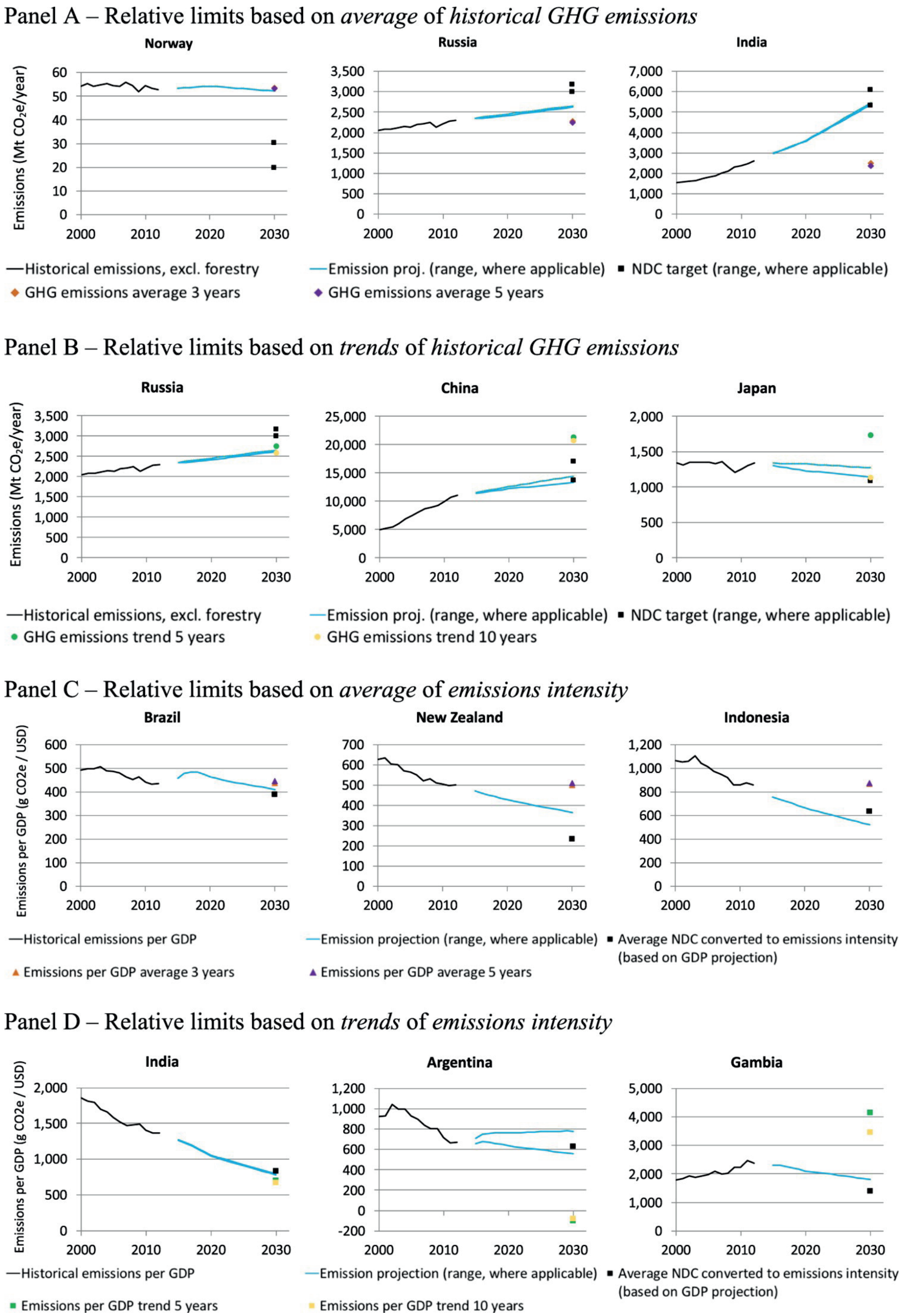

Figure 7-2 Results for relative limits for selected countries

Relative limits based on the *average* of *historical GHG emissions* would imply that countries can only transfer ITMOs if they are on a decreasing emissions pathway. That would prevent the transfer of all hot air contained in the NDC targets of the tested countries. Yet most countries have increasing emission trends. This type of limit could make it difficult for these countries to engage in international transfers, especially if they would have to reduce emissions far below their NDC target before being able to transfer ITMOs (see example of India in Panel A of Figure 7-2). Nonetheless, the standard deviations in Table 7-1 indicate that relative limits based on the average of historical GHG emissions performed best in approximating emission projections among the countries and options tested. No significant differences in the results were found between 3-year and 5-year reference periods. Panel A in Figure 7-2 illustrates this limit for a country with stable emissions (Norway) and for countries with increasing emissions (Russia and India).

Relative limits based on *trends* of *historical GHG emissions* are good approximations for emissions projections for the few countries where the rate of increase or decrease in emissions is expected to stay stable over time, such as in the case of Russia (see panel B in Figure 7-2). Yet this approach quickly loses accuracy when countries' rates change over time – which is the case for most other countries analysed here, such as China. The time period used to calculate the trend was found to have a very significant impact for some countries, such as for Japan. Somewhat surprisingly, for the tested countries, the standard deviation indicates that relative limits based on *trends* of GHG emissions fared overall worse in approximating emissions projections than relative limits based on *averages* of GHG emissions.

Relative limits based on the *average* of *historical emissions intensity* (i.e. GHG emissions per GDP), as shown in panel C, are close to the emission projections for a few countries, such as Brazil, but lie far above the projections for most countries – as the emissions intensity is expected to decrease for most of the countries. This is of little consequence for countries such as New Zealand, whose targets are more stringent than the emission projection. It would, however, allow for most or all of the hot air to be transferred for other countries, such as in the case of Indonesia.

Relative limits based on *trends* of *historical emissions intensity*, as shown in panel D, could potentially reflect that the emissions intensity is decreasing for most countries. Yet the suitability of this approach depends on how countries' rate of emissions intensity changes over time. In India, for example, the rate of decrease is expected to stay relatively constant until 2030. In Argentina, the rate of decrease is expected to become less prominent over time, causing this type of limit to fall below the emissions projection. In Gambia, a change in the trend causes this type of limit to lie far above the projections. The standard deviation indicates that limits based on trends of historical emissions intensity are the worst performing approach among all relative limits tested in terms of their suitability as an approximation of emissions projections.

7.3.3 Absolute limits

Six approaches for establishing absolute limits are tested. These include absolute limits based on *GHG emissions* and absolute limits based on *NDC target levels*. For limits based on the NDC target level, the reference period is the NDC target year (i.e. 2030). For limits based on GHG emissions, two options are tested: GHG emissions in the three years preceding the communication of the NDC target, with a time gap to account for data availability (2010–2012); and projected GHG emissions in the three years preceding the target year with a time gap to account for data availability (i.e. 2025–2027). For illustrative purposes, the implications are assessed for fixed percentages of 1% and 5%, noting that any other values could be used.

Table 7-2 Transferrable volumes of ITMOs under different absolute limits in 2030 ($MtCO_2e$)

		Limits based on average 2010–2012 emissions		Limits based on pre-target year emissions		Limits based on NDC target level	
	Amount of hot air	1%	5%	1%	5%	1%	5%
Argentina	−33	3	17	5	23	5	24
Brazil	−71	10	50	12	59	12	61
China	1393	106	530	144	722	153	763
Ethiopia	−125	1	5	2	8	2	9
EU	−514	46	232	39	195	35	174
Gambia	−1	0	0	0	0	0	0
India	285	25	124	49	245	57	285
Indonesia	230	7	35	11	57	13	66
Japan	−129	13	65	12	60	11	54
New Zealand	−31	1	4	1	3	1	3
Norway	−27	1	3	0	1	0	1
Peru	−30	1	4	1	5	1	5
Russia	435	23	113	29	143	31	154
South Africa	−419	6	29	5	26	5	26
South Korea	−196	7	34	5	27	5	27
Aggregated amount of hot air (100%)	2344						
Amount of hot air that can be transferred		160	802	233	1167	253	1267
Percentage of hot air that can be transferred		7%	34%	10%	50%	11%	54%
Percentage of hot air that is prevented from transfer		93%	66%	90%	50%	89%	46%

Source: Own calculations based on 2015 data by CAT. Note: negative values for the amount of hot air denote situations where the country's NDC target is more stringent than the projection of the likely emissions with the policies in place at the time of setting the target. Figures in red indicate hot air. In the bottom section of the table, the volume of hot air and the "amount of hot air that could be transferred" correspond to the sum from the four countries with hot air. Cells marked with a '0' are rounded-down figures.

Table 7-2 outlines the results for each country and each approach for establishing absolute limits. The upper section of the table presents how much hot air is estimated to be contained in each NDC target and contrasts this amount with the volume (in $MtCO_2e$) that each country would be able to transfer internationally under different absolute limits. The bottom section of Table 7-2 summarizes the results for each of the approaches.

The results in Table 7-2 illustrate that absolute limits would contain the transfer of hot air from countries such as Russia and China, but also restrict transfers from countries with NDC targets more stringent than BAU, such as South Africa. The table also indicates that, in containing hot air transfers, the threshold used (i.e. 1% or 5%) plays a more important role than the parameter employed to derive the limit. A 1% limit on any of the parameters, for example, would prevent about 90% of the hot air from being transferred – whereas a 5% limit would allow up to 54% of the hot air to be transferred.

7.4 Discussion and conclusions

In considering limits to address the risks from international transfers of hot air, policy-makers may have to balance various policy objectives. Those include reducing the risk that countries engage in the transfer of hot air, facilitating participation in international transfers (in particular for countries that effectively engage in mitigation action), and avoiding disincentives for countries to increase the ambition of future NDCs targets. Practical considerations – such as methodological challenges and the political feasibility of different options – are also relevant, among others. Ultimately, the setting of limits is a policy choice that must balance these policy objectives.

The analysis in this article showed that approaches for establishing *relative limits* based on historical emissions data have significant limitations. Among all approaches tested here, none was found to be effective for all countries: in some instances, the limits were far below the projection of the likely emissions with the policies in place at the time of setting the target, in others they were far above. Among the countries and options tested, relative limits based on historical GHG emissions were most effective in preventing the transfer of hot air. This is because this type of limit prevents transfers of hot air from all countries with increasing GHG emission trends. While the analysis in this article is limited to 15 countries, data by Meinshausen and Alexander (2016) on current NDC targets and emissions projections for 196 countries indicates that most countries with hot air have *increasing* emission trends – which means that this type of limit would prevent nearly all hot air in current NDC targets from being transferred. This type of limit would, however, only allow countries with decreasing emissions pathways to transfer ITMOs. While this could be seen to be consistent with the long-term goals of the Paris Agreement, it could prevent many developing countries from engaging in international carbon market mechanisms – even if their targets do not contain hot air. This, in turn, could make it difficult to agree on such an approach under the consensus-based decision-making process under the UNFCCC.

Given the challenges with approaches based on historical emissions data, relative limits based on emission projections may provide a more valid approach if relative limits are to be considered, although they also face technical and political challenges. Any limits based on emission projections would ideally be based on an internationally agreed methodology which would include provisions to ensure consistency and comparability between countries and means to address the uncertainty of key variables such as economic growth.

Absolute limits set at sufficiently low levels could prevent an individual country from transferring large amounts of hot air. The analysis showed that the threshold used (e.g. 1% or 5%) is the main factor in the effectiveness of absolute limits in preventing transfers of hot air, with the lower of the two tested thresholds being significantly more effective in containing (albeit not fully preventing) transfers of hot air. Further advantages of absolute limits include that they are simple and provide ex-ante certainty on the volume of permissible transfers. A key disadvantage is that they are bluntly applicable to all countries – whether or not there is a risk of transfer of hot air – and could thus affect countries' ability to engage in international transfers. This, in turn, could potentially increase the costs of mitigating climate change if, without such limits, countries were to engage in larger amounts of transfers that are backed by actual emission reductions. The ability to transfer is impacted mainly by the threshold applied. For example, if countries representing half of global GHG emissions were transferring countries, a 1% limit would imply a total global potential for ITMO transfers of about 250 million tCO_2e in 2030. Other possible impacts of absolute limits may also be important to consider. Absolute limits on the basis of NDC target levels, for example, could generate perverse incentives for countries not to enhance the ambition of future NDC targets. Similarly, limits based on pre-target year emissions could provide disincentives for countries to over-achieve their NDC targets, as this would affect the limit applicable to the subsequent period.

For both relative and absolute limits, a key political challenge is that countries may be reluctant to agree to international rules that might restrict their ability to engage in international transfers. This holds for all approaches but may be particularly relevant for the context of international linking of ETSs where the amount of transfers is driven by the regulated entities. As ITMO transfers that are backed by linking of ETSs may also pose lower environmental integrity risks (see section 7.2.3), policy makers could consider exempting such transfers from any limits. While this increases complexity, it could help balance the policy objectives of promoting environmental integrity and enabling participation in international carbon markets. It may also be important to set limits in a way that minimizes the possibility of manipulation that could result in inflated limit levels. The methodology should therefore be internationally agreed and be applied consistently across countries.

The analysis has a few limitations. An important limitation is that there are significant uncertainties in emissions projections and challenges in interpreting NDC targets. For these reasons, the results for individual countries are also uncertain. Another limitation is that the analysis was conducted only for 15 countries and only four of them are estimated to have hot air. Other data and assessments of NDC targets, however, confirm that the ambition of NDC targets varies strongly and that hot air could be included in a large number of NDCs (den Elzen et al., 2016; Meinshausen & Alexander, 2016). Whether and how much hot air a country has varies also considerably between the different assessments. This confirms that establishing emission projections and interpreting NDC targets is not straightforward and that limits derived from emission projections may be both technically and politically difficult to implement.

Whether or not limits are ultimately needed also depends on whether other policy approaches can effectively address environmental integrity risks under Article 6. Several approaches could be pursued (Schneider & La Hoz Theuer, 2019): First, environmental integrity risks could also be addressed by ensuring that ITMOs represent actual abatement action, such as through international guidance and oversight on the implementation of carbon market mechanisms. The experience from existing carbon market mechanisms suggests, however, that ensuring quality can be both technically and politically challenging (Cames et al., 2017; Kollmuss et al., 2015; Schneider, 2009b). Second, environmental integrity risks might also be reduced by facilitating progression in the ambition of NDC targets. Yet this could prove to be difficult, as NDCs are self-determined by Parties. Third, countries could pursue approaches outside the context of the UNFCCC and the Paris Agreement, such as forming 'carbon clubs' (i.e. groups of countries that apply uniform environmental integrity principles or provisions). These clubs, however, can only address environmental integrity within members of the club, and rely on the willingness of club members to ensure environmental integrity, even when circumstances change (Schneider, Füssler, La Hoz Theuer, et al., 2017). Finally, a key question is whether buyer countries will acquire ITMOs from countries that have hot air and whether and how they can identify the situations where acquiring ITMOs involves environmental integrity risks. In the early years of the Kyoto Protocol, for example, several countries declared that they would not purchase hot air. In later years, however, several countries purchased units that originated from countries with hot air and that were unlikely to be backed by actual emission reductions (Kollmuss et al., 2015; Tuerk et al., 2013). Any declared intentions by countries to uphold environmental integrity would thus need to survive the test of time, which may be difficult in the context of changing political climates and rising carbon prices.

In promoting environmental integrity under the Paris Agreement, the balance between centralized international oversight on the one side and flexibility for countries and market participants on the other has always been a controversial point of discussion. This is particularly the case with the bottom-up nature of the Paris Agreement. In the light of past experiences with the Kyoto Protocol and the potentially significant volume of hot air contained in current NDCs (see Table 7-2), we recommend that policy-makers carefully consider how to address the risk of hot air under the Paris Agreement.

Given the uncertainty of whether other approaches to promote environmental integrity will be effective, we recommend that Parties take a cautious approach and consider establishing limits for those types of transfers that pose higher environmental integrity risks. Given the challenges identified with relative limits, absolute limits may be a simpler option to pursue.

Chapter 8
Discussion, conclusions and recommendations

This thesis assesses key issues for ensuring environmental integrity of international carbon market mechanisms under the Paris Agreement. This includes a systematic identification and categorization of what influences environmental integrity and what approaches could mitigate environmental integrity risks (Chapter 2) and a thorough analysis of specific aspects of ensuring environmental integrity (Chapters 3 to 7).

This chapter discusses key findings, draws overall conclusions and makes recommendations for ensuring environmental integrity of international carbon market mechanisms. The chapter address both how international rules can promote environmental integrity and how environmental integrity can be ensured when designing and implementing carbon market mechanisms on the ground. The conclusions and recommendations aim to inform policy-makers and stakeholders involved in the ongoing negotiations on Article 6 of the Paris Agreement and on the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) adopted by the International Civil Aviation Organization (ICAO), as well as policy-makers and stakeholders implementing domestic, bilateral or non-governmental carbon market approaches.

While the previous chapters were written before the adoption of the rulebook for the Paris Agreement by the Conference of the Parties serving as the Meeting of the Parties to the Paris Agreement (CMA) in Katowice in December 2018, this chapter specifically reflects the outcome from Katowice and makes recommendations for the development of international rules on Article 6 – on which agreement could not yet be reached in Katowice. The chapter also reflects recent developments on international rules for CORSIA and makes respective recommendations, where relevant.

The chapter synthesizes the findings in relation to the four research questions that were identified in the introduction (Chapter 1). Section 8.1 addresses the first question: how environmental integrity could be defined in the context of international carbon market mechanisms. The discussion, conclusions and recommendations with regard to the second and third research questions are structured around the four approaches that were identified in this thesis for addressing environmental integrity: robust accounting; ensuring unit quality; facilitating economy-wide and ambitious mitigation targets; and restricting international transfers. Sections 8.2 to 8.5 assess for each of these four approaches what influences environmental and what the risks for undermining environmental integrity are (second research question) and what approaches could be used to mitigate these risks and how these approaches could be implemented (third research question). This is followed by a broader perspective on the role that international carbon markets should play in the future, given the risks for environmental integrity and available means to address them (forth research question, section 8.6).

8.1 Defining environmental integrity

The term 'environmental integrity' is used in various decisions under the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement but has not yet been defined. In the context of international carbon market mechanisms, the term could, in principle, be defined in three ways (Chapter 2):

1. *Aggregate achievement of mitigation targets*: Environmental integrity would be ensured if the engagement in international transfers does not lead to a situation where aggregate actual emissions would exceed the aggregated target level;
2. *No increase in global aggregate emissions*: Environmental integrity would be ensured if the engagement in international transfers leads to aggregated global emissions that are no higher as compared to a situation where the transfers did not take place; or
3. *Decrease of global emissions:* Environmental integrity would be ensured if the engagement in international transfers leads to a decrease in global emissions as compared to a situation where the transfers did not take place.

The first approach would imply that global emissions could increase as a result of engaging in international transfers. The third approach would mix the definition of environmental integrity with the concepts of "allowing for higher ambition" (Article 6.1) and delivering an "overall mitigation in global emissions" (Article 6.4) which both address the objective that carbon markets should ultimately facilitate lowering global emissions. The second definition is therefore recommended to be employed.

8.2 Robust accounting

Robust accounting is a key prerequisite for achieving environmental integrity. Ensuring robust accounting is much more challenging under the Paris Agreement than it was under Kyoto Protocol. Under the Kyoto Protocol, mitigation targets were expressed as absolute, economy-wide greenhouse gas (GHG) emission budgets for common and continuous multi-year periods, based on a common basket of GHGs and using common Global Warming Potential (GWP) values to convert gases other than CO_2 into CO_2 equivalents. This makes accounting for the transfer of carbon market units relatively straight-forward.

Under the Paris Agreement, countries can determine themselves what type of mitigation targets or actions they communicate in their nationally determined contributions (NDCs). This led to considerable diversity in the scope, metrics, types and timeframes of NDC targets. Many NDC targets are not expressed as absolute levels of GHG emissions but relative to business-as-usual (BAU) emissions or relative to the gross domestic product (GDP). Many NDCs also include targets in metrics other than GHG emissions, such as targets for renewable electricity generation. Some NDCs do not cover all sectors of the economy or all GHGs, some are ‘conditional’ on the provision of support, some include target ranges, and some do not include any quantitative mitigation targets but only actions or strategies. Countries use also different GWP values to quantify and account for their NDCs. A further cross-cutting challenge is that many NDCs are not clearly described (Graichen et al., 2016).

This diversity could undermine robust accounting in different ways. If emission reductions are double counted, actual global GHG emissions are higher than the sum of what individual countries report (Chapter 3). Environmental integrity could also be undermined if the diverging time frames of current NDC targets are not appropriately accounted for, if countries use inconsistent metrics such as different GWP values, or if any reversals of emission reductions or removals, such as in the land-use, land-use change and forestry (LULUCF) sector, are not appropriately accounted for (Chapter 2). Establishing and implementing robust accounting rules is thus an important prerequisite for achieving environmental integrity.

Providing clarity on NDC targets is a first important perquisite for enabling robust accounting (Chapter 2). This could, in principle, be facilitated through the Katowice decision on mitigation (“Further guidance in relation to the mitigation section of decision 1/CP.21”), which includes detailed provisions for what information countries should provide with regard to their mitigation targets. This guidance is, however, only mandatory for second and subsequent NDCs. Robust accounting for the international transfer of carbon market units would be facilitated if future decisions under Article 6 would require countries to update their NDC, as necessary, and fully apply this guidance if they choose to voluntarily engage in Article 6 or authorize the use of offset credits under CORSIA.

Avoiding double counting of emission reductions is a key concern when engaging in international carbon market mechanisms. The negotiations on international rules for Article 6 in Katowice failed mainly due to disagreement on whether and how double counting should be avoided for the new crediting mechanism established under Article 6.4.

Chapter 3 showed that double counting can occur in three forms – double issuance, double claiming and double use – and that a range of measures are necessary to avoid all three forms of double counting. This includes accounting rules and systems to avoid double claiming; the appropriate design of carbon market mechanisms to avoid double issuance, such as provisions to avoid that the same activity can issue carbon market units under more than one carbon market program and that indirect overlap in the emission reduction claims is avoided; and systems to track unit transfers to avoid all forms of double counting. While all forms of double counting are recognized in provisionally approved rules for CORSIA (ICAO, 2017), the negotiations on Article 6 focused on avoiding double claiming and the draft negotiation texts do not include provisions for avoiding double issuance. I therefore recommend that all three forms of double counting be addressed under Article 6.

The Paris Agreement and the Katowice decisions foresee that double claiming be avoided through the application of 'corresponding adjustments' to reported GHG emissions. The timing of the application of such adjustments is a critical and challenging aspect that has yet to be resolved. Key questions include what should trigger the application of an adjustment, to which calendar year adjustments should be applied, and when the application of adjustments should be reported. An important challenge is the application of adjustments in the context of single-year targets. Carbon market mechanisms typically operate based on multi-year periods. If carbon market units from several years are internationally transferred between countries and used to achieve a single-year target, aggregated GHG emissions could increase under a range of scenarios (Schneider, Füssler, Kohli, et al., 2017). Among the various options considered to address this challenge (Chapter 2), using continuous multi-year targets, such as under the Kyoto Protocol, is the most robust option, in particular in the light of CORSIA which uses continuous multi-year periods and is likely to become the single largest source of demand for carbon market units in the next decade. Multi-year targets also provide the advantage that they pose fewer risks for countries to achieve their targets and provide more certainty and clarity on the impact of NDCs on cumulative emissions. I therefore recommend that countries engaging in international carbon market mechanisms move over time towards continuous multi-year NDC targets. This could be required or encouraged in two ways: through international guidance under Article 6, which could for example include respective participation requirements, and through international agreement on 'common time frames' for NDCs, as envisaged under Article 4.10 of the Paris Agreement.

Applying consistent GWP values is another element of robust accounting. Similar to the issue of the time frame of mitigation targets, robust accounting could also be exacerbated if countries used different GWP values to account for their NDCs (Chapter 2). While the Katowice decisions on mitigation and the transparency framework ("Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement") foresee the use of common GWP values for second and subsequent NDCs, countries still use a large diversity of GWP values in their current NDCs. To address this challenge, I recommend that international rules on Article 6 establish a participation requirement that countries engaging in the international transfer of carbon market units should use the same GWP values.

The accounting for emission reductions that are not covered by NDC targets is a further important topic in the negotiations. If the emission reductions from a carbon market unit do not fall within the scope of the NDC of the transferring country, double counting would not occur, and hence a corresponding adjustment would theoretically not be necessary on the side of the transferring country (Chapter 3). Some Parties, however, raised concerns that such an accounting approach could create disincentives for countries to move towards economy-wide mitigation targets, as envisaged under Article 4.4 of the Paris Agreement, and that transferring countries could have less incentives to ensure the quality of the transferred units (Chapter 2). A further practical challenge is that this approach requires distinguishing whether or not emission reductions occurred within or outside the scope of NDCs, which can prove to be difficult in some instances (Chapter 3). To address these concerns, such carbon market units could not be eligible for international transfers under the Paris Agreement or corresponding adjustments could be required regardless of whether the emission reductions occurred within or outside the scope of NDCs. The latter approach would also simplify accounting, as it would not require determining whether or not emission reductions are covered by NDCs.

In summary, robust accounting for international transfers of carbon market units under the Paris Agreement and the use of carbon market units under CORSIA would be greatly facilitated if countries (a) move towards a system of continuous multi-year time frames of mitigation targets; (b) express targets such that they could be converted – at least ex-post – into absolute levels of GHG emissions; (c) apply common GHG metrics; and (d) broaden the scope of NDC targets with the view to including all sectors and all GHGs reported in GHG inventories under the Paris Agreement (CO_2, CH_4, N_2O, PFCs, HFCs, SF_6 and NF_3). This should preferably be required or encouraged through relevant decisions under the Paris Agreement but could also be addressed in bilateral or multilateral agreements between jurisdictions engaging in carbon market approaches.

Recommendations for international rules under the Paris Agreement and ICAO

International rules for Article 6 of the Paris Agreement could facilitate robust accounting through the establishment of minimum requirements and participation requirements which countries need to satisfy if they choose to voluntarily engage in Article 6 or authorize the use of offset credits under CORSIA. This could include a requirement to apply international guidance on the Katowice decision on mitigation ("Further guidance in relation to the mitigation section of decision 1/CP.21") already to their first NDC; a requirement to use in second and subsequent NDCs multi-year targets or trajectories as the basis for accounting for carbon market units; and a requirement that two countries engaging in a voluntary cooperation under Article 6 use the same GWP values to account for their NDCs. Furthermore, provisions for Article 6 should reflect and address all forms of double counting, through respective definitions and by including specific provisions on how carbon market mechanism could be designed to address double issuance. To avoid disincentives for broadening the scope of NDC targets over time, adjustments could be required for all types of transfers, regardless of whether or not they are covered by NDC targets. An outstanding future decision on common timeframes for NDCs could foresee that countries communicate mitigation targets for common multi-year periods. These rules would also facilitate robust accounting for carbon market units used under CORSIA.

8.3 Ensuring unit quality

Ensuring unit quality requires appropriate design of carbon market mechanisms. What influences unit quality and how it can be ensured depends on the type of carbon market mechanism (Chapter 2). This thesis focuses on crediting mechanisms but also addresses the international linking of emissions trading systems (ETSs).

Under *crediting mechanisms*, the quality of credits is, in principle, ensured if the mitigation action is additional – that is, it would not occur in the absence of the incentives from the crediting mechanism – and if the emission reductions are not overestimated. A key challenge is assessing additionality and emissions baselines, mainly due to the information asymmetry between project developers and regulators, and uncertainty of assumptions on future developments, such as international fuel prices. Under the new context of the Paris Agreement, a further challenge is how NDC targets should be considered in quantifying emission reductions. Another challenge inherent to the concept of crediting is that offsets subsidize the deployment of low-emitting technologies rather than penalizing the deployment of high-emitting technologies. As a consequence, credits lower the costs of energy (or other commodities or services), which can lead to greater use of energy (or other commodities or services). Such effects, also referred to as 'market leakage', are commonly not accounted for under existing crediting mechanisms, and may thus lead to an over-estimation of emission reductions (Chapter 2).

The Kyoto mechanisms provide important insights in the challenges with ensuring the quality of credits. An important lesson is the risk with projects abating industrial waste gases with high GWPs. For such projects, revenues from credits can significantly exceed abatement costs, creating perverse incentives to increase production or generation of waste gases as a means to increase credit revenues from waste gas abatement (Schneider, 2011; UNEP, 2007; UNFCCC, 2005; Wartmann et al., 2006). The analysis of projects abating HFC-23 and SF_6 under Joint Implementation (JI) in Chapter 4 showed that these projects increased waste gas generation to unprecedented levels once they could generate credits from producing more waste gas, thereby substantially undermining the quality of the credits. Due to these perverse incentives, about two third of the issued credits do not represent actual emission reductions. This case study also revealed severe issues with the performance and oversight of auditing companies and a lack of transparency, as project information is only partially publicly available.

Similar concerns were also identified with other JI projects that were implemented in countries that had weak mitigation targets and that had therefore no incentives to ensure the quality of transferred units. Overall, the lack of unit quality under JI may have increased global GHG emissions by about 600 million tCO_2e – of which 400 million tCO_2e alone occurred due to the recognition of JI credits under the EU ETS (Kollmuss et al., 2015). For the Clean Development Mechanism (CDM), various assessments conclude that for a large share of projects the additionality is unlikely or questionable (Cames et al., 2017; Erickson et al., 2014; Schneider, 2009b). On the other hand, many projects are likely to continue operation without issuing credits and may thus contribute to lowering global GHG emissions (Erickson et al., 2014; Schneider & Cames, 2014; Spalding-Fecher et al., 2012; Warnecke et al., 2017, 2015).

Recently, an important controversy emerged whether credits from already implemented CDM and JI projects should be eligible for use after 2020. In the negotiations on the rules for Article 6 of the Paris Agreement, some Parties proposed that these credits be eligible for achieving NDCs, and the ICAO considers allowing airline operates to use these credits under CORSIA. The unlimited use of these credits could, however, seriously undermine environmental integrity. While additionality and the quantification of emission reductions are, in principle, key considerations for unit quality, the GHG emissions impact from using credits from already implemented projects is more complex. If the supply of credits considerably exceeds demand, a key consideration for the global GHG emissions impact is whether already implemented projects would continue to reduce GHG emissions even without credit revenues, or whether they are at risk of discontinuing GHG abatement. A detailed assessment of the status and operating conditions of existing CDM projects in various countries shows that most of these projects continue abatement even if they cannot sell offset credits. This is because they have ongoing revenues (e.g. from electricity sales) which exceed their ongoing operational costs. The results from modelling the offset credit supply potential and the marginal costs of generating offset credits show that using these credits after 2020 will result in no notable emissions reductions beyond those that would occur anyway and result in low offset credit prices that neither offer incentives for new investments nor reward previous investments in offset projects (Chapter 5).

These findings are important for the future use of crediting mechanisms under the Paris Agreement and CORSIA, and for crediting mechanisms under national or bilateral agreements or by non-governmental organizations. Overall, the available evidence suggests that project-based mechanisms are exposed to significant risks of over-crediting and that using credits from already implemented projects after 2020 could seriously undermine future mitigation efforts. To mitigate these risks, it is essential that:

- crediting mechanisms establish stringent project eligibility criteria which effectively exclude project types with uncertain additionality;
- crediting mechanisms require the use of internationally accepted or thoroughly reviewed methodological standards to quantify emission reductions and that such standards include appropriate safeguards to prevent perverse incentives;
- crediting mechanisms monitor the performance of auditors and apply effective sanctions in the case of non-performance;
- information on credited activities be transparent and publicly accessible;
- the use of offset credits from already implemented projects be limited to new projects (i.e. which were implemented *after* the decision to allow the use of offset credits was made) or projects that are at risk of discontinuing greenhouse gas abatement without further support.

Under *emission trading systems (ETSs)*, the quality of allowances mainly depends on whether the ETS cap is set below the emissions level that would occur in the absence of the trading system, and whether emissions are monitored appropriately. The ambition of current ETSs varies, and several existing ETSs face challenges with surplus allowances (Erik Haites, 2018; Narassimhan et al., 2018). Other design features, such as price collars, allowance reserves, import of credits, and provisions for banking of allowances, also affect unit quality – mainly by altering the cap. If an ETS with an ambitious cap is linked to one that is over-allocated, linking could reduce aggregated abatement from both systems (Chapter 2).

In practice, this seems unlikely to happen, for several reasons. First, while some ETSs are over-allocated in the short-term, most ETSs have a price that is well above zero (World Bank & Ecofys, 2018). This means that the market participants expect – at least in the long-term – that there is scarcity and no over-allocation of allowances. Second, most ETSs have established mechanisms that address or avoid continued over-allocation, such as price floors or stability mechanisms (ICAP, 2018). And third, whether policy-makers from a jurisdiction with an ambitious ETS cap would want to link with a jurisdiction with a weak ETS cap is questionable, as this would involve considerable financial flows to the other jurisdiction. Borrowing on the analogy of 'carbon dating' (Doda & Taschini, 2016), linking partners may want to find a match with similar ambitions. ETSs also have the advantage that they penalize the generation of emissions rather than subsidizing the reduction of emissions (which could lead to leakage effects, see Chapter 2) and that they directly expose all covered entities with a carbon price.

Overall this suggests that environmental integrity risks from international transfers of carbon market units are likely to be higher for crediting mechanisms than for international linking of ETSs.

Recommendations for international rules under the Paris Agreement and ICAO

Under the Paris Agreement, unit quality could be addressed through the rules, modalities and procedures of Article 6.4 and through international guidance on Article 6.2, though Parties have different views on whether the latter should address environmental integrity issues other than robust accounting (Obergassel & Asche, 2017). In the current negotiation texts, specific provisions to ensure unit quality are only included for the Article 6.4 mechanism. For international cooperation under Article 6.2, the text requires countries only to report on how they promote environmental integrity. In the light of the experiences with JI, it seems however questionable whether an approach that only provides transparency will provide sufficient incentives for countries to ensure unit quality. In contrast to the current status of the negotiations under the Paris Agreement, ICAO adopted a more stringent approach where crediting programs must demonstrate that they ensure unit quality and be approved by the ICAO Council. I therefore recommend strengthening the approach to ensuring unit quality under the Paris Agreement. This could include the elaboration of principles and concrete criteria for how Parties should ensure unit quality (see examples above), a thorough international review of how countries ensure environmental integrity, or the establishment of an international body that oversees the engagement of countries in international carbon market mechanisms.

8.4 Facilitating economy-wide and ambitious mitigation targets

The ambition and scope of mitigation targets can impact environmental integrity in *indirect* ways. If a country has an ambitious economy-wide mitigation target and transfers units that lack quality, it may have to compensate for the transfer in order to still achieve its target, either by further reducing emissions or by purchasing units. The same may not be true, however, if the mitigation target of a country is so weak that it does not require the country to take any mitigation action to achieve its target, or if the emission reductions fall outside the scope of the target. In these instances, the country might accrue more financial revenues from over-estimating emissions reductions and selling the resulting units, without infringing its ability to achieve its target.

Countries with weak mitigation targets have less incentives to ensure the quality of the units they authorize for use by other countries or by airline operators under CORSIA (Chapter 2). The experience with JI showed that this risk is material (Chapter 4). And, unfortunately, the ambition and scope of current NDCs varies strongly. The available evaluations suggest that many NDC targets indeed do not require the country to take any further mitigation action to action to achieve it (Aldy & Pizer, 2016; Höhne et al., 2017; Rogelj et al., 2016) (Chapter 7).

This has also implications for whether international carbon markets provide incentives for countries to enhance the ambition and broaden the scope of NDC targets over time, as envisaged in Articles 4.4 and 6.1 of the Paris Agreement. For acquiring countries, using international carbon markets could lower the costs of achieving their targets, and thereby enable these countries to adopt more ambitious targets. Yet for transferring countries, the possibility to use international carbon markets could create incentives to set mitigation targets at unambitious levels, or to define their scope narrowly, in order to accrue more benefits from transferring units internationally (Carbone et al., 2009; Green, 2016; Helm, 2003; Holtsmark & Sommervoll, 2012; Howard, 2018; Spalding-Fecher, 2017; Warnecke et al., 2018) (Chapter 2).

Facilitating the adoption of economy-wide and ambitious mitigation targets could thus be one of the possible means to indirectly mitigate environmental integrity risks from international carbon market mechanisms. Article 4.3 of the Paris Agreement calls for a "progression" of NDCs reflecting the "highest possible ambition", and Article 4.4 encourages developing countries to move over time towards economy-wide targets. While these provisions guide Parties, NDCs are ultimately self-determined by them. This narrows the possibilities to facilitate ambitious targets through international rules. Several approaches could, however, provide incentives for countries to enhance the ambition broaden the coverage of NDC targets, as pointed out below.

Recommendations for international rules under the Paris Agreement and ICAO

Parties could consider establishing participation requirements for the engagement in international transfers under Article 6 and the use of carbon markets under CORSIA with the view to providing incentives for countries to expand the scope of their NDCs. This could be implemented by limiting international transfers to carbon market units from emission reductions covered by the NDC or, alternatively, by requiring that countries commit to expand the scope of their NDCs to economy-wide targets in the future or that they apply adjustments regardless of whether the emission reductions are covered by the NDC in order to participate in Article 6 (see also Section 8.2). Enhancing the ambition and scope of NDC targets could also be facilitated indirectly, through transparent information on NDCs, reporting and review under the transparency framework under Article 13, the global stocktake under Article 14, or the mechanism to facilitate implementation and promote compliance under Article 15 (Chapter 2).

8.5 Restricting international transfers

Approaches that restrict the international transfer of carbon market units could complement other approaches to promote environmental integrity: they could be implemented with the view to ensuring that robust accounting systems are in place; that carbon market units have quality; or that the engagement in carbon market approaches provides incentives, or avoids disincentives, for enhancing the ambition and scope of mitigation targets over time (Chapter 7).

Restrictions could apply to the issuance, transfer or use of carbon market units and be implemented in several ways:

- *Eligibility criteria* which require that certain requirements must be met in order to issue, transfer or use carbon market units (Chapters 2, 3, 4 and 7);
- *Limits (or quotas)* which restrict the number or type of carbon market units that may be issued, transferred or used (Chapters 2, 6 and 7);
- *Exchange rates* which adjust the value of carbon market units transferred between jurisdictions by a conversion factor (Chapters 2 and 6); and
- *Discount rates* which also involve a conversion factor but place a greater value on carbon market units of the own jurisdiction (Chapters 2 and 6).

Both eligibility criteria and limits were established under the Kyoto Protocol. They were mainly used to ensure robust accounting and did not specifically address the quality of units or the ambition of mitigation targets (Chapter 7). Approaches that restrict international transfers are not included in the Paris Agreement but were proposed by some Parties and are being considered in the negotiations of the international rules for Article 6 of the Paris Agreement. The ICAO explicitly foresees eligibility criteria for offset credits that may be used under CORSIA (Chapter 5). These criteria cover accounting issues, such as avoiding double counting of emission reductions and addressing non-permanence, and issues related to unit quality, such as criteria for the assessment of additionality and the quantification of emission reductions. Most non-governmental crediting programs also have project eligibility criteria with the aim of ensuring unit quality. Limits are often applied for the use of credits in ETSs (ICAP, 2018) and could also be used for the linking of ETSs (Chapter 6). Exchange or discount rates are both explored as a means to mitigate risks with regard to the quality of units (Chapters 2 and 6).

The findings from this thesis suggest that eligibility criteria, limits and discount rates could mitigate environmental integrity risks whereas exchange rates may not be effective and could lead to unintended consequences:

- *Eligibility criteria* are a simple and effective tool to restrict the engagement in carbon market approaches to conditions that pose less threats to environmental integrity.

They are particularly suitable for crediting mechanisms where eligibility could be limited to activities with a high likelihood of additionality. While this approach is increasingly embraced by non-governmental offsetting programs (of which several are in the process of excluding project types with less certainty of additionality) it proved to be politically difficult to agree upon under multilateral mechanisms, such as the CDM and JI. Eligibility criteria could also be imposed by buyers of offset credits. Most governmental and multilateral programs and initiatives have established eligibility criteria that aim to address environmental integrity risks. With regard to the use of offset credits from already implemented projects, robust eligibility criteria are essential to ensure that, as a result of the incentives, new mitigation activities are implemented existing mitigation activities that are at risk of discontinuing GHG abatement are enabled to continue operation (Chapter 5).

- *Limits* could mitigate environmental integrity risks but are difficult to establish in effective ways and involve trade-offs with other policy objectives such as achieving cost-effectiveness. Limits could be established in two ways (Chapter 7): *Absolute* limits generally reduce the number of units that can be transferred and thereby indirectly limit environmental integrity risks from unit lacking quality. They could still enable to lower the costs of mitigation and are relatively simple to implement (Chapter 6 and 7). *Relative* limits aim to directly address environmental integrity risks by allowing unit transfers only to the extent that the actual emissions of a country are below the limit. Relative limits could thereby specifically aim to prevent the transfer of units from countries with weak mitigation targets. The testing of approaches for establishing limits in the context of fifteen countries provides mixed results. Relative limits based on historical emissions data are found to have considerable shortcomings. They could for example hinder some countries that have ambitious targets from engaging in international transfers. Relative limits based on emission projections may provide a more valid approach, although they also face technical and political challenges. Any limits based on emission projections would ideally be based on an internationally agreed methodology which would include provisions to ensure consistency and comparability between countries and means to address the uncertainty of key variables such as economic growth (Chapter 7).
- *Exchange rates* involve the risks of unintended implications for cost-effectiveness and environmental integrity. Depending on how exchange rates are set, aggregated emissions could increase or decrease. Due to information asymmetries between the regulated entities and policy-makers setting the exchange rate, and uncertainties about future developments, setting exchange rates in a manner that avoids such unintended consequences could prove difficult (Chapter 6). I therefore recommend not to pursue exchange rates.
- *Discount rates*, in contrast, can ensure that both cost-effectiveness and total abatement are enhanced (Chapter 6). This might partially mitigate risks with regard to unit

quality. One of the principles of the Article 6.4 mechanism is that it should contribute to an "overall mitigation in global emissions". Discount rates are one of the means to effectively implement this principle, but are disputed in the negotiations (Obergassel & Asche, 2017; Schneider, Warnecke, Day, & Kachi, 2018).

Recommendations for international rules under the Paris Agreement and ICAO

Eligibility criteria could be an effective tool to promote environmental integrity for both Article 6 and CORSIA. They could be applied with regard to satisfying requirements for robust accounting and ensuring unit quality. Similar to the approach taken by some non-governmental offsetting programs, the supervisory body of the Article 6.4 mechanism could ensure that eligibility is limited activities that pose lower risks for unit quality. Under both CORSIA and the Paris Agreement, eligibility criteria could ensure – through vintage restrictions – that only carbon market units from newly implemented activities are eligible (Chapter 5). Eligibility criteria could also ensure that countries that wish to engage in international carbon market mechanisms formulate their future NDCs in ways that facilitate robust accounting for international carbon market units.

Limits may be practically and politically challenging to pursue under the Paris Agreement. Technically, all approaches for setting limits tested in this thesis have some limitation and involve trade-offs between ensuring environmental integrity and enabling the participation in carbon market approaches. Politically, many countries oppose limits because they do not regard them to be consistent with the principles of Article 6 and fear that they might restrict their ability to engage in international transfers. This may be particularly relevant for the context of international linking of ETSs where the number of transfers is driven by the regulated entities. As international linking of ETSs may pose lower environmental integrity risks than the international transfer of credits (see Section 8.3), policy makers could consider exempting international linking of ETSs from any limits. While this increases complexity, it could help balance the policy objectives of promoting environmental integrity and enabling participation in international carbon markets (Chapter 7).

Discount rates could be a means to enhance the environmental impact of carbon market mechanisms. While they are less suited to specifically address environmental integrity concerns, they could help enhance ambition by lowering aggregate emissions further.

8.6 Future role of international carbon markets

International carbon markets provide benefits and opportunities but also entail risks for environmental integrity.

The most prominent benefit is that carbon markets can reduce the cost of mitigating climate change and thereby enable the adoption of more ambitious climate mitigation targets. But there are other important benefits. Putting a price on carbon provides incentives to search and discover new mitigation activities that might otherwise not be discovered. International carbon markets can enhance technology transfer and mobilize financial flows to less developed countries. Many mitigation activities triggered through international carbon markets also have considerable co-benefits for sustainable development. And perhaps the greatest successes of the CDM is that it increased knowledge and awareness and build capacity about climate mitigation in developing countries, which may have paved the way for the adoption of broader climate policies in some countries (Spalding-Fecher et al., 2012).

A key challenge of international carbon markets is ensuring environmental integrity. If environmental integrity is undermined, this increases not only global emissions but also the costs of mitigating climate change.

Overall, the findings from the thesis and the literature show that environmental integrity risks are notable. A serious threat is that environmental integrity could be undermined in multiple ways, and single loophole could have considerable impact and undermine overall integrity. The experience with the existing mechanisms and the international negotiations on Article 6 confirm that closing all loopholes could prove to be technically and politically difficult.

This raises the question what role carbon markets should play in the future, given the risks and the available means to address them. As one can imagine, the answer to this question is not a simple “yes, let’s use them” or “no, better not”, but a rather a consideration of how and under what conditions they should be used.

A first consideration for the future role of international carbon markets is which type of carbon market approaches are most effective in achieving their objectives. The available information suggests that environmental integrity risks differ considerably between the different types of mechanisms. Among the three possible ways of engaging in international carbon market mechanisms – international linking of ETSs, international crediting mechanisms, or direct bilateral government-to-government transfers – linking of ETSs may pose the lowest risks for environmental integrity. While linking can reduce aggregated abatement if an ETS with an ambitious cap is linked to one that is over-allocated, this seems unlikely to happen in practice (Section 8.3). By contrast, effectively addressing the risks associated with crediting mechanisms – in particular ensuring additionality and robust baselines, avoiding perverse incentives for host countries not to adopt climate policies in order to sell more credits, and ‘market leakage’ – is both technically and politically difficult. And lastly, the experience with direct government-to-government transfers shows that ensuring environmental integrity was not even an objective in some transfers (Tuerk et al., 2013).

Altogether, this suggests that among the three type of mechanisms, well-designed ETSs may be most effective in achieving environmental integrity and cost-effective GHG abatement. More advanced economies that have the necessary capacity should thus consider introducing and linking ETSs, rather than relying on crediting approaches. In this regard, ICAO could also consider using allowances from ETSs, rather than credits from crediting mechanisms, to offset emissions from international aviation in the future. Politically, however, it could be difficult to ensure that only ETSs with ambitious caps are eligible. Moreover, using only allowances from ETSs would exclude countries without an ETS from supplying offsets to the scheme. Lastly, careful consideration should be given to how any ETS price stability mechanisms interact with the use of allowances under CORSIA, in order to avoid that the use of allowances under CORSIA triggers more allowance being brought to the market.

Where crediting mechanisms are pursued, they could focus on addressing emissions in countries which lack capacity for implementing broad climate policies and for which building capacity and mobilizing financial flows is key to overcoming barriers for a low carbon development. In these situations, crediting mechanisms could play a role in identifying untapped mitigation opportunities. To avoid environmental integrity risks, crediting mechanisms could also primarily be used a vehicle to disburse climate finance, rather than for offsetting mitigation targets (Schneider & Spalding-Fecher, 2015). Examples include the World Bank's Pilot Auctioning Facility for Methane and Climate Change Mitigation and its Carbon Initiative for Development. Crediting mechanisms could also still play a role for voluntary offsetting of GHG emissions.

The role and scope of crediting mechanisms might not only be limited due to concerns over environmental integrity but also because more and more countries implement broad climate policies. In countries with ambitious NDCs and climate policies, the potential for crediting may be small. Under JI, only few projects were implemented in countries with ambitious climate policies. The EU, for example, had to limit the eligible project types considerably to avoid double counting and overlap with the EU ETS and other regulations (Kollmuss et al., 2015).

A second consideration for the future role of carbon markets is what governments arrangements and conditions best ensure environmental integrity. An important finding of the thesis is that the ambition and scope of NDCs is key for the *incentives* to ensure environmental integrity. Environmental integrity risks are strongly reduced if carbon market units are purchased from countries with ambitious and economy-wide mitigation targets. Given the principle of self-determination of NDCs under the Paris Agreement, it could however prove difficult to limit the use of carbon market approaches to countries with ambitious mitigation targets.

Outside the UNFCCC context, countries could decide to only engage in market approaches with other countries if these also have ambitious NDC targets. This could apply to all three forms of possible cooperation: linking of ETSs, purchase of credits, or direct bilateral government-to-government transfers. This approach could be formalized through political declarations or the formation of ‘carbon clubs’ (Keohane et al., 2017). Such declarations or clubs, however, can only address environmental integrity within members of the club, and rely on the willingness of club members to ensure environmental integrity, even when circumstances change. In the early years of the Kyoto Protocol, for example, several countries declared that they would not purchase hot air. In later years, however, some countries purchased units that originated from countries with hot air and that were unlikely to be backed by actual emission reductions. Any declared intentions by countries to uphold environmental integrity would thus need to survive the test of time, which may be difficult in the context of changing political climates and rising carbon prices (Chapter 7).

Ensuring environmental integrity through voluntary actions by countries – or a buyer-beware approach – also requires that countries are able to identify environmental integrity risks in a timely manner. The EU, for example, limited the eligibility of credits from some industrial gas project types in its ETS but did not effectively protect its scheme from the large number of poor quality JI credits from Ukraine and Russia (Kollmuss et al., 2015).

An interesting related question is what governance arrangements for carbon market approaches best ensure environmental integrity. Carbon market mechanisms can be operated by domestic, bilateral, multilateral or non-governmental organizations and different degrees of international oversight could be provided under the Paris Agreement. The findings of the thesis suggest that international oversight could help mitigate environmental integrity risks to some extent. The increase of waste generation rates from industrial gas projects to unprecedented levels, as described in Chapter 4, would not have been possible if internationally approved CDM methodologies had been used. The same holds for many other JI projects that would not have been eligible under current CDM rules (Kollmuss et al., 2015). On the other hand, international rules often rely on the lowest common denominator and only establish minimum requirements. Under the CDM, for example, limiting the eligibility of project types with the view to addressing additionality concerns was politically not possible, whereas many non-governmental carbon offsetting programs restricted eligibility in the first place and adapt eligibility to new circumstances.

A third and last consideration is when carbon market approaches and when other types of climate policies are better suited to effectively reduce emissions. This is a complex and controversially debated question which goes beyond the scope of this thesis and which may depend on the specific circumstances. Broadly speaking, carbon markets have proven to be effective if the entities exposed to the carbon price consider the incentives in their economic decision-making, which generally applies to large emitters in the energy and other industry sectors but often not to households, except if intermediaries such as energy service companies are involved (Schneider & Spalding-Fecher, 2015; Warnecke et al., 2017). Carbon markets have also proven to be effective in discovering new low-cost mitigation opportunities which were not addressed through regulations. Under JI and the EU ETS, for example, N_2O emissions in the chemical industry were reduced far below levels required by regulations (Kollmuss et al., 2015). In the long-standing debate whether carbon taxes or ETSs are better suited, an important advantage of ETSs is that they provide flexibility to auction or freely allocate allowances. In sectors that are exposed to the risk of carbon leakage (i.e. shifts in production due to carbon costs), free allocation allows to mitigate this risk while still exposing the regulated entities to the full price of carbon and thereby providing the full incentives to reduce emissions.

Carbon markets can also have important shortcomings compared to other mitigation policies. They require significant capacity to regulate and implement them and can involve notable transaction costs, in particular for disperse mitigation activities. In many instances, simple regulations, such as bans or efficiency standards, could be much simpler to implement. A further shortcoming is that, without a clear price signal from an ambitious long-term target trajectory, entities may prioritize short-term over long-term abatement options, which could lead to less cost-effectives outcomes in a long-term perspective or, in the worst case, impede the transition to a low carbon economy and lead to a lock-in into higher emissions pathways. Another critique to carbon market approaches is that they provide only incentives to achieve a single policy-objective – mitigating climate change – and do not provide incentives for entities to balance this with other objectives, in particular for achieving other sustainable development goals and avoiding adverse social and environmental impacts.

It is thus important that policy-makers do not regard carbon market approaches as the one and only 'silver-bullet' to mitigating climate change but carefully assess what policy instrument or mix of instruments is best suited to achieve and balance different policy objectives, in particular in light of the rapid transition that is necessary to achieve the goals of the Paris Agreement.

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