Utrecht University

Master's Thesis

Directionality of problem shifting between international environmental regimes and its impacts on fragmentation

Student: Minttu Hänninen

Student number: 6882048

Email: m.m.m.hanninen@students.uu.nl

Supervisor: Dr. Rakhyun E. Kim

Second reader: Prof. Dr. Frank Biermann

Study programme: MSc Sustainable Development – Earth System Governance

Date: 28/07/2021

Abstract

Problem shifting has been identified as a common occurrence in international environmental governance, as addressing an environmental problem in one issue area may create problems for another. Instances of problem shifting have often been thought of as symmetrical between a pair of regimes, but this may not be the case due to political salience of different environmental issues, member state interests, or the biophysical interlinkages between issue areas. This thesis looks into whether the direction of problem shifting between the climate and ozone regimes may impact the level of fragmentation between these regimes, operationalized as the role of institutions in addressing interlinked issue areas, and coordination between regimes. This thesis hypothesized that shifting a problem from the climate regime to the ozone regime will lead to more fragmentation, while a problem shifted into the climate regime will decrease regime fragmentation as it is addressed more efficiently. This argument was made based on the central role of the climate regime, as rapidly addressing climate change has gained high priority on the agenda in international environmental governance. The hypotheses were tested through a secondary literature review based on studies focusing on the relation between the two regimes of climate and ozone. Findings show that addressing problem shifting in either direction has led to increased fragmentation, therefore falsifying the hypotheses for this regime pair. However, the research functions as a first step to identify directionality of problem shifting between regimes, and further research could look into whether this impacts other aspects of the interactions between international environmental regimes. Understanding the nature of problem shifting can contribute to addressing the governance objectives of international environmental regimes on the whole, rather than focusing on individual regimes.

Key words

Problem shifting, directionality, fragmentation, international environmental regimes

Acknowledgements

I would like to express my appreciation for my supervisor Dr. Rakhyun Kim, who provided helpful feedback throughout the process of writing this thesis, and was always encouraging and engaged in the topic. I would also like to thank the second reader Prof. Dr. Frank Biermann for additional comments. Finally, I would like to extend sincere thanks to my friends and family, who supported me and offered advice when needed. This strange year would have been very different without them.

Table of Contents

List of abbreviations

CDM	Clean Development Mechanism
CFC	Chloroflurocarbon
COP	Conference of the Parties
GHG	Greenhouse Gas
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
IPCC	Intergovernmental Panel on Climate Change
KP	Kyoto Protocol
MOP	Meeting of the Parties
MP	Montreal Protocol
NDC	Nationally Determined Contribution
ODS	Ozone Depleting Substance
PA	Paris Agreement
TEAP	Technology and Economic Assessment Panel
UNFCCC	United Nations Framework Convention on Climate Change

1. Introduction

There is a multitude of environmental problems which warrant attention on the international scale, which has led to the proliferation of environmental treaties. These international governance mechanisms have often been developed in isolation, with an eye to only a specific environmental problem (Kim & van Asselt, 2016). However, international regimes do not operate in isolation, rather creating positive or negative spillovers onto each others' issue areas (Faude & Groβe-Kreul, 2020). Negative spillovers can be conceptualized as problem shifting, which refers to situations where a solution to one problem generates new problems for other spatial or temporal contexts, or transfers the problem into something else (Kim & van Asselt, 2016). Policies addressing a certain environmental issue under one regime often impact other regimes due to biophysical, economic, and social interactions (Lade et al., 2020; Sterner et al., 2019). This can have important implications for the effectiveness of international environmental governance as a whole, as the aims of some regimes are achieved while others are degraded (Faude & Groβe-Kreul, 2020). It has been argued that the complex interconnections between environmental issues need to be addressed so that solutions aimed at enhancing sustainability in one issue area do not lead to negative effects on another (Liu et al., 2015; Steffen, Richardson, et al., 2015).

At the international level, it can be seen that some instances of problem shifting have been addressed to a greater extent than others. This can be done by consciously coordinating policies on both issue areas across the regimes, therefore leading to a greater integration of the regimes (Johnson & Urpelainen, 2012). Meanwhile, problem shifting which is not addressed can lead to, or maintain, a situation of fragmentation, where cooperation is conducted without coordination across issue areas and regimes (Johnson & Urpelainen, 2012). Fragmentation and integration are the opposite ends of a spectrum describing the interaction between different regimes, with the most fragmented state being regimes overlapping because of unintended consequences on each other, without linkages and reference to each other (Johnson & Urpelainen, 2012; Pattberg et al., 2014).

One setting where problem shifting has been identified is between the ozone and climate regimes, due to the fact that several gases have relevance as both ozone depleting substances (ODSs) and greenhouse gases (GHGs). Most ODSs under the Montreal Protocol (MP) of the ozone regime were almost entirely phased out by 2010, creating a co-benefit for the climate regime as they also functioned as GHGs (Michaelowa et al., 2019). However, the MP has promoted the use of alternatives to ODSs that are also GHGs, such as hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs). Especially HFCs have little impact on the ozone layer, but they are potent GHGs with a high global warming potential (GWP) (Birmpili, 2018; Michaelowa et al., 2019). Therefore, the ozone regime has shifted problems to the climate regime by promoting these substances. On the other hand, the climate regime also has the potential for problem shifting into the ozone regime, as the production of ODSs has been incentivized under some climate projects (Oberthür et al., 2011). Furthermore, geoengineering to counter climate change in the future may lead to harmful impacts on the ozone layer (Johnson & Urpelainen, 2012). Various policies have been implemented to reduce the instances of problem shifting between the two regimes, but it is worth considering whether the problem shifting from ozone to the climate regime, and the problem shifting from climate to the ozone regime, would be addressed as effectively. This raises the question whether the directionality of problem shifting matters for the level of fragmentation between two regimes.

The question of directionality of problem shifting between regimes has not received much attention in previous literature, and remains undertheorized, despite the important implications it may have on addressing problem shifting and its consequences in international environmental governance. Faude and Groβe-Kreul (2020) suggest that problem shifting may challenge the legitimacy of problem shifting

regimes, as it negatively impacts achieving the governance goals of another regime. Meanwhile, Johnson and Urpelainen (2012) argue that the existence of significant negative spillovers leads to regime integration, as the negative governance results on the receiving issue area create incentives for states to cooperate. However, they make the assumption that negative spillovers from one regime to the other are reciprocated equally. This means that spillovers not only take place in both directions between regimes, but also that the relative importance of both spillovers is equally important in influencing the fragmentation of the regimes. While it can be seen that problem shifting has taken place in both directions in the example of the climate and ozone regimes above, it is not obvious that these instances of problem shifting can be equated to each other. Their timing may vary, and the damage caused to the other regime's issue area may not be equal in extent. Furthermore, this is mediated by political processes in the development of international regimes. This may lead to one direction of problem shifting having a larger effect on the regimes and their issue areas than the other.

While existing studies suggest that the consequence of addressing problem shifting is the integration of regimes, this conclusion may change when the directionality of problem shifting is accounted for. It is worth considering whether different directions of problem shifting lead to different impacts on the level of fragmentation between the regimes, rather than assuming that both directions will lead to an equal decrease, or increase, in fragmentation. This is found to be a promising new direction for research, which has not been explored in detail in previous literature. Therefore, this thesis questions the assumption that problem shifting between regimes is symmetrical in nature to give an explanation as to why problem shifting has not always led to similar results on the level of fragmentation between the relevant regimes. This thesis explores this proposition by taking up the problem shifting between the climate and ozone regimes introduced above, and analysing the direction of problem shifting and the impacts this may have on the fragmentation between regimes. Empirical observation of the interaction between these regimes shows that the directionality of problem shifting has not been clear-cut and constant over time.

Climate change in particular has been considered a core earth system process due to its importance in determining energy flows and regulating processes under other Earth subsystems. This places it at the centre of earth system interactions, with connections to most other environmental issue areas (Lade et al., 2020; Steffen, Richardson, et al., 2015). Due to this, there are many interlinkages between international climate treaties and treaties from other regimes. This indicates that despite the importance of climate change mitigation, it cannot be addressed without reference to other earth system processes (Steffen, Richardson, et al., 2015). Therefore, the increasing emphasis on climate change at the international level, even at the expense of other environmental regimes, may cause difficulties to holistically address environmental problems at the global scale. If the objectives of the climate regime are prioritized in international negotiations, it is possible that problem shifting from other environmental regimes to the climate regime receive more attention and get addressed more effectively, leading towards more integration between regimes. Meanwhile, the problem shifting from climate change to other regimes may be tolerated, and fragmentation exacerbated at the expense of the objectives of other environmental regimes. This proposition is explored through hypotheses which focus on the impact of different directions of problem shifting on fragmentation between the climate and ozone regimes.

1.1 Research aim and question

Based on the discussion above, this research aims to build on the theoretical connection of problem shifting and fragmentation, questioning the previous assumption that problem shifting between two

regimes is symmetric in terms of direction. This is done through an analysis of the instances of problem shifting that have taken place over time between the climate and ozone regimes, and how addressing instances of problem shifting has impacted the level of fragmentation between regimes. Furthermore, hypotheses on the direction of problem shifting in relation to the climate regime are tested through the case study. Ultimately, this research hopes to contribute to the conceptualization of problem shifting between regimes, and the broader discussion on the causes of regime fragmentation and integration in international environmental governance.

Therefore, the research question of this study is: *Does the direction of problem shifting impact the level of fragmentation between international environmental regimes?*

To answer this research question, first it is necessary to map out the development of regime interaction between the climate and ozone regimes. This will make it possible to establish the direction of problem shifting between the regimes, and identify how this has evolved over time. In selecting the case study, it has been ascertained that problem shifting has taken place in both directions between the regimes, but it can be argued that these interactions have not remained constant throughout the history of the regimes. Analysing the developments in regime interaction makes it possible to consider whether the direction of problem shifting has had an impact on the level of fragmentation between the regimes. As problem shifting may lead to different political responses or institutional arrangements by the regimes, the way each regime has addressed problem shifting influences whether the regimes become more fragmented or integrated. This thesis makes use of a secondary literature review to acquire data on the historical interactions between the regimes, which is needed to answer the research question. Insight on the role of problem shifting in contributing to fragmentation between regimes has implications for both theory and policy.

This thesis will address existing gaps in literature in the following ways. Considering the potential differences of problem shifting from one regime to the other can inform the conceptualization of problem shifting, and lead to identifying important nuances that may influence the consequences of problem shifting in international environmental governance. Furthermore, this study aims to see whether the directionality of problem shifting is a variable which impacts the level of fragmentation between regimes. This contributes to the ongoing broader discussion on the causes of fragmentation in international governance, which have so far been studied less than its consequences (Biermann et al., 2020). Fragmentation is often considered a contextual feature of the regime complex, but its variation over time, and the variables impacting change, have received little attention so far (Biermann et al., 2020). Finally, there has been little literature which considers fragmentation at the interface of different issue areas (Biermann et al., 2020). This research addresses this knowledge gap by selecting a case study of a regime pair with interlinked issue areas.

The thesis is structured as follows. The next section explains the theoretical underpinnings of the research, including a broader exploration of the concept of problem shifting and the context it takes place, as well as the argumentation behind the hypotheses. This is followed by an explanation of the applied methods, including case selection, data collection and the operationalization of variables. In the fourth section the results from the case study are presented and analysed, divided thematically based on identified instances of problem shifting between the two regimes. The falsification of hypotheses is also discussed. The fifth section provides discussion on unexpected findings, the implications findings have on theory and policy, and the limitations of the research, also providing suggestions for future research. The final section summarizes the findings and concludes.

2. Theoretical background

The following section introduces the concept of problem shifting in more detail, followed by a theoretical argument as to why the directionality of problem shifting would be relevant for the level of fragmentation between regimes. Based on this discussion, hypotheses are suggested for analysing the impacts of directionality on fragmentation.

2.1 What is problem shifting?

Problem shifting refers to situations where a solution to one problem generates new problems for other spatial or temporal contexts, or transfers the problem into something else (Kim & van Asselt, 2016). It occurs when the performance of one system or issue area is improved by degrading another, or the pursuit of objectives under one issue area is hindered by solutions proposed for another issue area (Faude & Groβe-Kreul, 2020; Johnson & Urpelainen, 2012; Kim & van Asselt, 2016; Nilsson & Persson, 2012). It has been argued that problem shifting is a sizable problem in international environmental governance (Kim & van Asselt, 2016). Indeed, the existence of problem shifting has been well documented, although often referred to with different terms in the literature, including negative spillovers, cascade effects, adverse side effects, and unintended consequences (Johnson & Urpelainen, 2012; Kim & van Asselt, 2016; Ürge-Vorsatz et al., 2014; van den Bergh et al., 2015; Von Stechow et al., 2015; Yang et al., 2012). For example, negative spillovers are defined as the consequences of sector specific actions on other jurisdictions or sectors, displaying overlap with the definition of problem shifting (Ürge-Vorsatz et al., 2014). While these terms refer to similar phenomena, they may vary in the level of intentionality of the shifted problem, based on whether the intended sector or regime was purposefully shifting the problem or whether it happened by accident (Ürge-Vorsatz et al., 2014). The definition of problem shifting here does not mandate whether the problem is shifted intentionally or not, allowing for analysis of both purposeful and accidental instances of problem shifting as they have the same impact on the receiving regime.

Regimes function as the context where problem shifting takes place, and on the other hand are the entities which may display different levels of fragmentation. Global governance is not built up with just sector-specific institutions, but is also impacted by their interactions with each other within regime complexes (Faude & Groβe-Kreul, 2020; Galaz et al., 2012). A regime has been described as the “principles, norms, rules, and decision-making procedures around which actor expectations converge in a given issue-area" (Krasner, 1982, as cited in van Asselt, 2011). Collections of individual regimes form regime complexes, defined as “an array of partially overlapping and non-hierarchical institutions governing a particular issue area” (Raustiala & Victor, 2004, as cited in Pattberg et al., 2014). Regime complexes include several distinct, but loosely linked institutions. These can consist of legal agreements, such as international treaties like the UNFCCC or the Montreal Protocol (Gómez-Mera et al., 2020; Johnson & Urpelainen, 2012). As international regimes interact with each other within regime complexes, problem shifting may arise as obligations under treaties of one regime influence the action taken under another (Johnson & Urpelainen, 2012). As regimes address problem shifting, they can change the institutional architecture of the regime complex by altering governance arrangements. Therefore, the structure of regime complexes can vary over time (Gómez-Mera et al., 2020).

2.2 Hypotheses

Problem shifting can be linked to fragmentation between regimes, as arising problems may be addressed by policy under either regime, or by both. When issue areas overlap, problem shifting may induce the regimes to coordinate policy, leading to reduced fragmentation, or on the other hand

increase fragmentation as several regimes attempt to address the same problem. Indeed, interaction of different issue areas may sometimes lead to legal conflict between regimes, which has been described as fragmentation in the literature (van Asselt et al., 2008). In a situation of high fragmentation, several international institutions with differing character, constituency, spatial scope, and subject matter exist simultaneously (Biermann et al., 2009). Fragmented legal responses may be poorly coordinated in relation to each other, rather focusing on the objectives of individual treaty regimes (Kim & Bosselmann, 2013).

Fragmentation has often been discussed between policies or regimes within the same issue area, such as climate change (Biermann et al., 2009). However, it can also be used in the context of interacting regimes in different issue areas, as it relates to the type of interaction between them. Therefore, fragmentation can be considered to be a state in which cooperation between regimes in different issue areas is carried out without coordination in other, interlinked issue areas (Johnson & Urpelainen, 2012). Under these circumstances, it is possible for the prioritization of certain issue areas to arise (van Asselt et al., 2008). In contrast, in the case of low fragmentation, states coordinate policy under different issue areas without prioritizing only one of them (Johnson & Urpelainen, 2012).

Scholars argue that fragmentation is a quality of the regime, and can vary in the level of fragmentation from low to high rather than being a single value (Biermann et al., 2020; Pattberg et al., 2014). This forms a continuum which ranges from fully integrated institutions with encompassing and hierarchical rules to highly fragmented collections of institutions with no common core or interlinkages between the regimes (Johnson & Urpelainen, 2012; Keohane & Victor, 2011; Pattberg et al., 2014). A fully integrated regime complex would be built around a single legal instrument which covers the entire issue area, although this is politically unrealistic, and therefore does not take place in the context of international environmental governance (Biermann et al., 2020; Keohane & Victor, 2011).

Pattberg et al. (2014) find that the most fragmented state is when regimes overlap due to impacts on each other's domains but have not established solid links or references to each other. This would be a likely situation for problem shifting to occur, as not considering the interactions of different issue areas comes with a risk of problem shifting (Kim & Bosselmann, 2013). However, fragmentation is not necessarily static through time, and arising problem shifting may lead to changes to the level of fragmentation between two regimes. This side of the relationship between problem shifting and fragmentation has received little attention so far.

The research by Johnson & Urpelainen (2012) is a notable exception. They argue that negative spillovers, in this paper referred to as problem shifting, are important to determining whether the regime complex becomes fragmented or integrated. According to their argument, if a negative spillover between regimes arises, it is useful to seek integration to avoid the negative consequences through coordination of supportive policies. However, this assumes symmetricity of relations between two equal regimes. By extension, it is assumed that the problem shifting between two regimes is equal in both directions, as both regimes would have the same interactions with each other (Faude & Groβe-Kreul, 2020; Johnson & Urpelainen, 2012). However, considering the interaction between regimes empirically, this may not be the case and this argument should not be taken at face value.

The natural interactions between issue areas may already cast doubt to this assumption. Problem shifting from one regime to another implies a biophysical link between the issue areas in question. Environmental issue areas are built around substantive problems, which may be linked to each other through interrelations between natural processes (Johnson & Urpelainen, 2012; Pattberg et al., 2014). For example, between the climate and ozone regimes, ODSs such as the chloroflurocarbons (CFCs) were both harmful to the ozone layer, and strong GHGs (Roberts, 2017). This means that reducing

CFCs would create a positive effect to the climate regime, but replacing them with substances such as HFCs with higher GWP instead led to an instance of problem shifting to the climate regime (Michaelowa et al., 2019; Roberts, 2017). Meanwhile, changes in temperature and the chemical composition of the stratosphere caused by GHG emissions impact the concentrations of ozone (Norman et al., 2008). However, ODSs and GHGs impact the atmosphere in different ways and on different time scales, which suggests that assuming the interactions are the same in both directions may lead to missing important details about the nature of problem shifting between the regimes.

However, these natural processes by themselves do not warrant a case of problem shifting (Kim & van Asselt, 2016). To constitute as problem shifting, the regimes addressing these environmental issue areas hinder the pursuit of each other's objectives through their solutions for combatting the problem within their own issue area. Therefore, more importantly from a governance perspective, it is also possible that the direction of problem shifting is impacted by the socioeconomic mechanisms of decision-making that are at play when regimes address the relevant issue areas (van den Bergh et al., 2015). These can include the political salience of different issue areas, and actions pursued by involved actors, such as regime member states. Political salience refers to the relative importance that actors assign to different issues on the political agenda (Beyers et al., 2018; Oppermann & de Vries, 2011). Indeed, problem shifting may be a conscious decision made after contemplating the pros and cons of different solutions (Kim & van Asselt, 2016). Therefore, the relative importance placed on addressing different environmental problems can play a role in whether problem shifting gets addressed through regime integration, or is accepted or even intentionally promoted. This may create trade-offs as some issues receive more attention than others in international politics (Oppermann & de Vries, 2011). Meanwhile, individual parties to regimes may pursue their own agenda, as states choose to invest in international institutions only when they benefit their interests (Keohane & Victor, 2016).

Looking at the example of the climate and ozone regimes, in the 1980s the problem of ozone depletion was a highly relevant issue, but since then climate change has increased its political salience (Oberthür et al., 2011). Therefore, problem shifting from the ozone regime to the climate regime has come under fire, and has also been addressed to some degree with the Kigali Amendment after extensive negotiations (Michaelowa et al., 2019). Meanwhile, the potential of the climate change regime to cause problem shifting to the ozone regime has been discussed in relation to geoengineering, and the production of ODSs incentivized by the climate regime (Johnson & Urpelainen, 2012; Oberthür et al., 2011). In particular, any action in relation to geoengineering that damages the ozone layer would be taken as a conscious decision because the risk of unabated climate change would be considered more dangerous than slowing down the recovery of the ozone layer. This suggests that the direction of problem shifting may change due to political decisions, as previous problems are addressed, or new solutions to current or arising problems are brought to the table. Furthermore, one issue area can gain more political salience over time vis-à-vis the other, creating incentives to address problem shifting in one direction while allowing it to take place in the other.

Johnson and Urpelainen (2012) expect that asymmetry of problem shifting would reduce its influence on regime fragmentation, as distributional conflict would hinder collective decision-making, and emphasize the role of powerful states. However, even if the importance of power relations between states is considered in the creation of problem shifting, it does not necessarily remove the role problem shifting can play on the development of fragmentation between regimes. This is because power relations between states play important roles for the salience and funding of environmental regimes, and therefore can contribute to whether problem shifting takes place. A powerful, politically salient, or well-funded regime may be able to shift a problem to another regime without repercussions, while a problem shifted in the opposite direction would be addressed more effectively.

Considering the centrality of climate change as an environmental problem at the international level, this thesis takes it as a starting point for analysis and studies its connections to other environmental issue areas, with the ozone regime as the case study. Climate change is interlinked to several, if not all, other issue areas of environmental regimes, therefore creating overlaps between legal instruments and regime mandates, creating potential for problem shifting (van Asselt, 2014; van Asselt et al., 2008). Despite its perceived importance, the climate issue needs to be addressed simultaneously with other environmental problems (Steffen, Broadgate, et al., 2015). However, the political salience of the climate issue vis-à-vis other environmental problems raises the possibility that the direction of the problem shifting between this and other regimes leads to different responses to problem shifting.

The hypotheses explore the argument that the climate regime is prioritized higher in international negotiations than other environmental issue areas. If actors notice that problem shifting which hinders achieving the objectives of the climate regime is taking place, they are likely to attempt to address it purposively due to the high political salience of the climate change issue. This will lead to the integration of policies under the two regimes, and therefore lower fragmentation. Meanwhile, if the climate regime is shifting problems into other regimes, there is less likely to be action to address this issue due to the high importance placed on fast climate mitigation. This would lead to high fragmentation between the regimes. In this situation, the other regimes may be left to their own devices to deal with the shifted problem and its impacts on the relevant issue area. In this thesis the ozone regime represents another environmental regime, whose interactions with the climate regime are considered.

Based on the above theoretical discussion, the following hypotheses are tested in this thesis:

H1. If problem shifting is from the ozone regime to the climate regime, it will lead to reduced regime fragmentation.

H2. If problem shifting is from the climate regime to the ozone regime, it will lead to increased regime fragmentation.

3. Methods

This research was conducted as a secondary literature review on the interactions of two international environmental regimes. The following section explains the methods of this research, including the case selection, data collection, and operationalization of variables.

3.1 Case selection

To answer the research question, a case study focused on a single regime pair, that of climate and ozone, was selected. Focusing on a single case allowed for in-depth considerations of the interactions between the regimes, as they have developed and adapted new policy over time. The interactions between the climate and ozone regimes have been well-documented and discussed broadly in the literature, providing a useful case study for secondary literature review. In addition, there is clear indications that problem shifting has taken place between these regimes. A case where problem shifting has been identified in both directions was selected, so that the independent variable is present. However, the direction of problem shifting requires more consideration. Climate change and ozone depletion have parallel human drivers, as some gases used in refrigeration and other industries are both ODSs as well as GHGs (Lade et al., 2020). The way these interactions have been addressed under each of the regimes provides for an interesting discussion on the directionality of problem shifting, and its impacts on regime fragmentation.

Climate is considered to be one of the most important environmental problems today, and is therefore receiving a lot of attention in international environmental governance. Many view it as the most critical challenge facing humanity today (Larson, 2016). Climate, along with biosphere integrity, has been identified as a key planetary boundary, which mediates other environmental processes (Lade et al., 2020; Steffen, Richardson, et al., 2015; Sterner et al., 2019). The climate system has several global tipping points, which emphasizes the importance of timely and effective action (Donges et al., 2017). These considerations highlight the relevance of climate as the central case study regime. Its interactions with the ozone regime are studied with an eye to the hypotheses that problem shifting leads to different impacts on the level of fragmentation depending on its direction.

The regime complex which has been formed around climate change involves diverse institutions and actors, rather than a single comprehensive system (Keohane & Victor, 2011). Among institutions related to climate change, the UNFCCC has been central in international negotiations and has been identified as the core of international climate change governance (Biermann et al., 2009; Keohane & Victor, 2016; van Asselt et al., 2008). This is why this study takes the UNFCCC, and the related Kyoto Protocol (KP) and Paris Agreement (PA) as the focus of the case study. These institutions are focused on the stabilization of GHG concentrations in the atmosphere so that dangerous human interference with the climate system can be avoided (Biermann et al., 2009; Michaelowa et al., 2019; van Asselt, 2014).

While the UNFCCC and its institutions are considered particularly important for climate negotiations, they are not the only forum for addressing climate change in international governance (Keohane & Victor, 2011; van Asselt, 2014). There is a variety of other governance arrangements at different levels, including public-private partnerships and regional initiatives, whose approaches to addressing climate change range from top down to bottom up (Biermann et al., 2009; Hare et al., 2010). However, the UNFCCC has been ratified by almost all countries, displaying its importance as an international arena for climate talks (Biermann et al., 2009; Keohane & Victor, 2011; van Asselt, 2014).

Meanwhile, the ozone regime is built around the Vienna Convention for the Protection of the Ozone Layer, and particularly the Montreal Protocol on Substances that Deplete the Ozone Layer (MP) adopted in 1987, with no other significant institutions addressing this issue area (Biermann et al., 2009). The MP and its amendments create the governance structure for phasing out the use of ODSs, such as CFCs and HCFCs (Sterner et al., 2019). Specifically, they control the production and consumption of ODSs in industries such as refrigeration and air conditioning where they are used as chillers, with the aim of protecting human health and the environment (Birmpili, 2018; Michaelowa et al., 2019). By 2010, 99% percent of baseline levels of ODSs had been phased out, and the ozone layer is expected to recover to pre-1980 levels by 2050 (Birmpili, 2018; Roberts, 2017). The MP has achieved universal ratification, which is very rare in international governance (Birmpili, 2018).

While a single case study may be said to lead to limited generalizability, it is considered a sufficient starting point to consider whether the hypotheses are supported by empirical evidence, considering the limited time available for this research. The climate and ozone regime pair is particularly suitable as a case study, as there are clear instances of problem shifting, as well as many policies that have addressed it. Further studies considering more regime pairs is welcomed to establish the implications of the direction of problem shifting more broadly in international environmental governance.

3.2 Data collection

The main data collection method for this research was a secondary literature review. The literature review took into account peer-reviewed journal articles and book chapters published on the interactions of the relevant case regimes. The collection of data was conducted through an online search using strategic key words. These included various combinations of climate change, ozone depletion, Montreal Protocol, UNFCCC, Kyoto Protocol, Paris Agreement, and Kigali Amendment. Following the online search for articles, further literature was sought by going through the reference lists of these articles. After reading the abstracts and full articles of literature identified through the online search, 28 articles were found to be relevant for answering the research question, and were included in the analysis. Others were excluded due to their brief reference to the interactions of the case study regimes, lack of availability, or narrow geographical focus, as this research is studying the regime interactions at the global level.

The included articles are from years 1997-2019. The starting year is based on the establishment of the Kyoto Protocol, which created a discernible division of labour between the two regimes. Meanwhile, articles until present were eligible, but the newest relevant article was found from 2019. This literature ranging over the period of more than 20 years gives a comprehensive picture of the developments in regime interactions over time. During this time, the regimes have evolved to include new policies, and to some extent changed the scope of their mandates. This was considered important as the direction of problem shifting can change when new policy is introduced, either reducing an instance of problem shifting or creating a new one. Furthermore, when selecting articles, a division was made based on an initial estimate of which direction of problem shifting the article was focused on, so that it could be ascertained that literature discussing both directions would be included. This was necessary so that the impacts the direction of problem shifting has on fragmentation could be analysed. More literature was identified with a focus on problem shifting from the ozone to the climate regime than vice versa, so a completely balanced distribution of articles between directions could not be attained. However, this is at least partially explained by the finding that more instances of problem shifting have taken place in this direction than in the opposite direction. The selected articles can be seen in Table 1.

These methods were found to be the most suitable for this research considering the focus of the research question. The data attained by literature review gives insight into the ways that problem shifting has been addressed in the legal framework of the relevant regimes. The collected data is qualitative in nature so that an in-depth consideration of the relationship between problem shifting and fragmentation can be carried out. Furthermore, developments of regime interaction over time can be easily seen through the inclusion of literature from a range of more than 20 years. No ethical issues were expected to arise due to the open availability of the used data online and the general nature of the research focus (Cardno, 2019).

Table 1. Literature identified for analysis, with an initial estimate of which direction of problem shifting is the main focus.

Selected articles		
Estimate of problem shifting direction	Problem shifting direction ozone → climate	Problem shifting direction climate → ozone
Author(s) and year of publication	Benedick, 1998 Oberthür, 2001 Thoms, 2003 Velders et al., 2007 Depledge, 2007 Norman et al., 2008 Depledge, 2009 Velders et al., 2009 Molina et al., 2009 Roberts & Grabiel, 2009 Velders et al., 2012 Andersen et al., 2013 Montzka et al., 2014 Canan et al., 2015 Hurwitz et al., 2016 Roberts, 2017 Bergeson, 2017 Heath, 2017 Michealowa et al. 2019	McCulloch, 2005 Schneider, 2007 Wara, 2008 Heckendorn et al., 2009 Oberthür et al., 2011 Schneider, 2011 Keith et al., 2016 Larson, 2016 Talberg et al., 2018

3.3 Operationalization of variables

In this research, the independent variable is the direction of problem shifting, while the dependent variable is the level of fragmentation between regimes. The direction of problem shifting was operationalized as a directional link between the regimes. Problem shifting may either take place from the climate regime to the ozone regime, or vice versa. Furthermore, problem shifting may take place as a result of separate policies, leading to instances of problem shifting that may take place between the regimes simultaneously or at different points in time. This enabled there to be several instances of problem shifting at the same time, without conflating all problem shifting happening between the two regimes as the same instance. This allowed for the identification of which regime is causing each instance of problem shifting.

In addition, it was considered which regime addressed the problem shifting. This is relevant for the impacts on fragmentation, as the direction of problem shifting is determined by which is the sending regime of a problem, while the way it changes the level of fragmentation between regimes is determined by which regime, and how, addresses it. This is because new institutional arrangements, such as amendments or shifts in mandate, may be created to address an instance of problem shifting. It is possible that an instance of problem shifting is triggered by policy under one regime, but this regime may or may not actively seek solutions to reduce the negative impacts on issue areas beyond its individual scope. Meanwhile, the actions under the receiving regime may reduce the negative impacts caused by the problem shifting from the other regime. Problem shifting may also be solved by policy which was not aimed directly at addressing it.

For the dependent variable of fragmentation, the operationalization was based on the framework presented by Pattberg et al. (2014). Pattberg et al. suggest that institutional fragmentation can be measured on a scale ranging from low to high based on the involvement of institutions in setting the agenda, objectives, and standards for implementation, monitoring and compliance. This framework was adapted in this research so that it can be used in relation to the fragmentation between regimes, rather than within a single issue area as done in the original framework. It was considered whether a certain regime has taken the role of agenda, objective, or standard setting in relation to a certain issue with relevance to both of the regimes. In addition to the criteria identified by Pattberg et al., an indication of the coordination between involved institutions was added. This has been used as an indication of the level of fragmentation between regimes in other research, as discussed in the theory section (Johnson & Urpelainen, 2012). The presence of coordination is important as it indicates whether the existing policies under the other regime are considered when creating policy to address problem shifting. The chosen criteria for the level of fragmentation can be seen in Table 2. Addressing instances of problem shifting may shift the regimes toward a lower or higher level of fragmentation. To measure this, the impacts of policy addressing each instance of problem shifting between the regimes were analysed in light of this criteria. This enabled discussion on whether one direction of problem shifting has had different impacts on fragmentation than the other.

Table 2. Operationalization of fragmentation (adapted from Pattberg et al., 2014).

Level of fragmentation	Criteria
Low	Core institution sets the agenda, objectives, and standards for implementation, monitoring and compliance on an issue. Other institutions are subordinate to the core institution.
Medium-low	One core institution and several nested institutions share the tasks of setting the agenda, objectives, and standards for implementation, monitoring and compliance on an issue. Institutions may coordinate with each other.
Medium-high	Several distinct institutions are active in setting the agenda, objectives, and standards for implementation, monitoring and compliance on an issue. Institutions may coordinate on an ad hoc basis, but usually work unilaterally.
High	Several distinct institutions are active in setting the agenda, objectives, and standards for implementation, monitoring and compliance on an issue, leading to overlaps or gaps between the regimes. There is hardly any coordination.

4. Results

This section presents the findings of the analysis. First, the history of regime interaction is presented, divided thematically into six sections. The first two sections provide background on the interactions between the regimes, while the following sections are based on certain interactions which are classified as instances of problem shifting between the two regimes. The original impact of the ozone regime is found to be positive for the climate regime, but various policies that have been adopted since in both regimes have given rise to problem shifting. Figure 1 summarizes the findings of the analysis on the direction of problem shifting, including six identified instances of problem shifting and the main policies implemented that addressed them. After identifying these instances in the literature, their influence on regime fragmentation is analysed by considering how the situation after implementing policy to address problem shifting compares to the criteria for regime fragmentation. Finally, the implications of the analysis for falsifying the hypotheses are discussed.

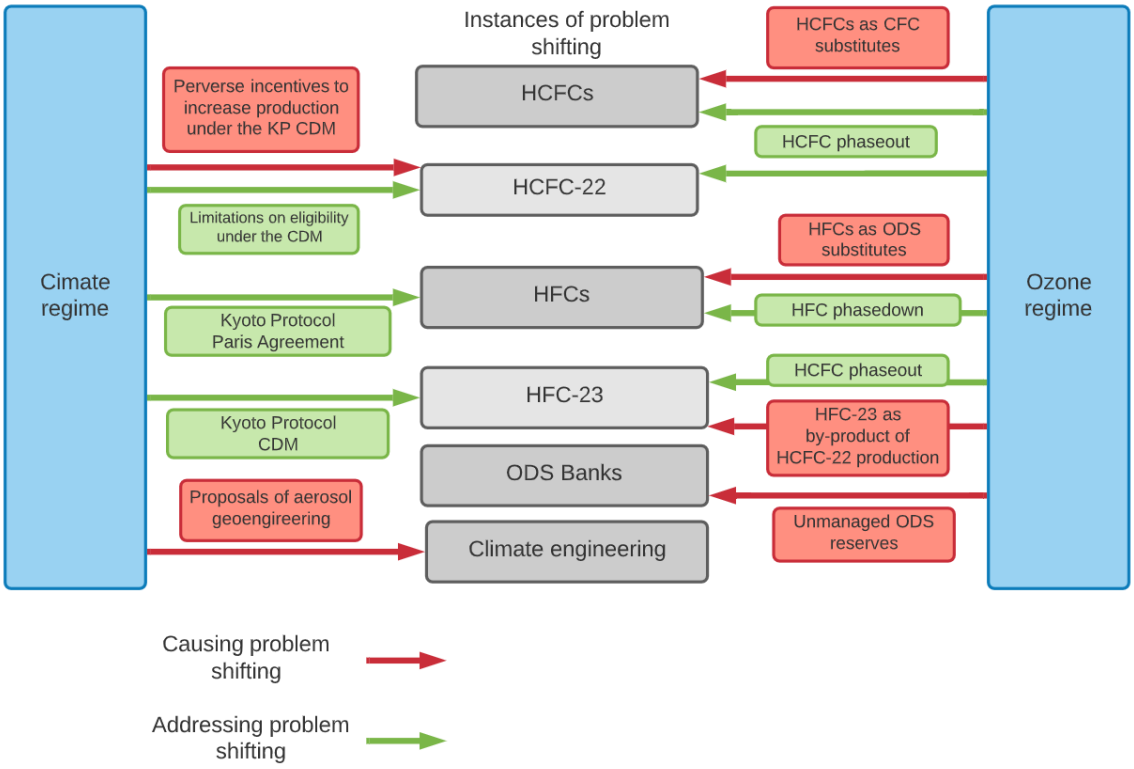

Figure 1. The direction of instances of problem shifting between the two regimes (red arrows) and the policies taken by each regime to address them (green arrows).

4.1 Direction of problem shifting

4.1.1 Unintended positive spillover from CFC phaseout

Considering the literature on the early interaction between the two regimes, the key message that arises is that the MP was initially leading to benefits to both the ozone layer as well as to the climate. This is because CFCs, the gases that the MP initially aimed at reducing, are also powerful GHGs (Oberthür et al., 2011). Therefore, while problem shifting can be identified between the regimes, it is important to note that this is not the only interaction which has taken place.

CFCs are ODSs, which were scheduled for phase out under the MP in the 1980s, slowing down the destruction of the ozone layer (Heath, 2017; Roberts, 2017). The global warming effect of CFCs was confirmed in the 1970s, indicating that the link between the ozone and climate regimes has been known for a long time (Andersen et al., 2013). Andersen et al. (2013) find that the link to climate change added to the scientific reasoning for phasing out CFCs. However, while the interactions of ozone and climate protection were realized quite early, there was little concrete action taken in the first decade after the creation of the MP to reduce potential conflicts (Oberthür et al., 2011). Canan et al. (2015) argue that at this time the reasoning for phasing out the production and consumption of ODSs was focused on protecting the ozone layer, rather than the climate benefits. This is because the MP does not contain any official commitments on addressing climate impacts, nor those for the broader environment (Oberthür, 2001). Therefore, the initial climate benefits of the MP took place mostly as an unintended, although positive, spillover between the two regimes.

However unintended, these benefits were not minor in terms of greenhouse effects (Norman et al., 2008). It was highlighted by several articles that the climate benefits from the MP were calculated to be 5 times higher by 2010 than the benefits of the first commitment period of the KP (2008-2012) (Andersen et al., 2013; Birmpili, 2018; Depledge, 2007; Velders et al., 2007). Some articles note that the MP was not only a success in terms of its impacts on the ozone layer, but also in terms of climate mitigation due to the phaseout of CFCs (Birmpili, 2018; Depledge, 2007; Molina et al., 2009).

However, CFCs are not the only chemicals which are relevant for both the ozone layer and climate change. The MP originally focused on just the CFCs, but as scientific knowledge accrued, other substances were added in the scope of MP through amendments (Birmpili, 2018; Norman et al., 2008; Roberts, 2017). By 2010, the production and consumption of almost a 100 ODSs had been nearly eliminated (Andersen et al., 2013; Roberts, 2017). These were also often GHGs with high GWP, highlighting the interconnectedness of the regimes (Michaelowa et al., 2019; Oberthür et al., 2011). This has led to benefits to both the ozone layer, as well as to the climate regime, indicating that the underlying impact of the ozone regime to attaining the objectives the climate regime has been positive. However, as seen in the next sections, instances of problem shifting have arisen as the regimes have developed over the years, and these have been found to pose a threat to the climate benefits created by the initial phaseout of ODSs.

4.1.2 Early days of the Kyoto Protocol – delimiting the mandate of the two regimes

When the KP was created under the UNFCCC in 1997, it made a clear division of labour in relation to the ozone regime: only substances not included under the MP would be included under the KP (Oberthür, 2001; Oberthür et al., 2011). This meant that the KP could not take action on ODSs like CFCs or HCFCs, despite their high GWP (Oberthür, 2001). On the other hand, HFCs came to be included under the KP as one of six GHGs, as they were not yet controlled under the MP (Michaelowa et al., 2019; Oberthür et al., 2011). HFCs have high GWP, but they do not deplete the ozone layer (Michaelowa et al., 2019; Roberts, 2017). Therefore, they have often been used as substitutes to ODSs. Hence, the creation of the KP led to a situation where ODSs and other GHGs were controlled under different treaties, despite their biophysical links to both the ozone and climate issue areas. Velders et al. (2007) note that if the MP had not been created when it was, the ODSs that were controlled under it would most likely have been included under the KP due to their high GWP. This highlights the encompassing interactions between the regimes and the substances they control.

While the KP delimited its mandate to gases not controlled by the MP, it did not provide further institutional links to the ozone regime (Oberthür, 2001). Oberthür et al. (2011) find that the creation of the KP, in conjunction with the maturation of the ozone regime, created potential for policy contradictions between the regimes. On the most part, each regime would attempt to manage these issues unilaterally, without coordination with the other regime (Oberthür et al., 2011). Cooperation, when it took place, was often in the form of informal discussions (Oberthür, 2001). The future interactions between the two regimes were built against this backdrop, with conflicting interests between the regimes arising on several occasions.

The initial level of fragmentation based on the mandates of the two regimes had features of both low and medium-high fragmentation. In terms of ODSs, the MP was the core institution, with the KP subordinate in mandate. This shows a low level of fragmentation in terms of institution roles, and the objectives of the regimes were in line with each other in relation to ODS phaseouts. However, several institutions were active setting their own agendas, objectives and standards on HFCs, which were

often conflicting. Ad hoc coordination took place between the regimes, but this was not constant, and only hierarchical in relation to ODSs.

4.1.3 HCFCs as replacements to ozone depleting substances

Problem shifting from ozone to climate

As CFCs were phased out, they were replaced by other substances with lower ozone depleting potential, including HCFCs and HFCs (Roberts, 2017; Velders et al., 2009). HCFCs were considered transitional substances as they were still ODSs, although with lower ozone depleting potential than CFCs (Depledge, 2007; Montzka et al., 2015; Velders et al., 2009). Similarly, HCFCs are potent GHGs, although again less so than CFCs (Depledge, 2007). When agreeing on the CFC phaseout, industries insisted on the possibility of using HCFCs as substitutes for a smooth transition (Oberthür et al., 2011).

Due to their high GWP, HCFCs continue to have significant impacts on the climate regime, despite reducing the problem of ozone depletion. The MP promoted the use of these substitutes rather than encouraging the development and adoption of more climate-friendly alternatives, therefore creating problem shifting from the ozone regime to the climate regime (Oberthür, 2001; Oberthür et al., 2011). Roberts (2017) argues that the MP is responsible for the GHG emission increases caused by the commercialization of HCFCs and HFCs, which may negate the climate benefits attained by the UNFCCC, as well as offset the climate benefits of the MP by up to 10%.

Addressing the problem shifting created by HCFCs

In 1990, parties to the MP requested an evaluation on the GWP of controlled substances (Oberthür et al., 2011). This was followed by the first phasedown schedule for HCFCs in the Copenhagen Amendment to the MP in 1992 (Depledge, 2007). This was done primarily to protect the ozone layer, despite the climate impacts of these substances being known (Oberthür, 2001; Oberthür et al., 2011). Indeed, several authors find that the GWP of HCFCs was not considered, or was subordinate to, protecting the ozone layer in these early negotiations, in part leading to their widespread adoption to speed up the phaseout of CFCs (Oberthür et al., 2011; Roberts, 2017). Despite the first phasedown schedule for HCFCs, in 1992 the parties to the MP supported HCFCs and HFCs over more climate appropriate alternatives by considering not only the direct but also indirect global warming effects of substitutes. This made HCFCs and HFCs attractive as they had high energy-efficiency, despite their high GWP (Oberthür et al., 2011).

Oberthür (2001) finds that at the turn of the millennium, HCFCs were left “somewhat in limbo” between the ozone and climate regimes (pp. 367). This was because they were excluded from the KP despite their high GWP, while the MP had determined a relatively slow phaseout for them by 2040. Meanwhile, their production and consumption had grown substantially as they replaced CFCs in developed countries in the 1990s (Montzka et al., 2015; Oberthür, 2001). As this began to wane coming into the 2000s due to controls under the MP, production in developing countries increased exponentially (Montzka et al., 2015). In the early 2000s, the parties to the MP were reluctant to address the policy contradictions with the KP in relation to HCFCs (Oberthür et al., 2011). One reason for this was that stringent controls on HCFCs were difficult to implement while they were still necessary to phase out CFCs (Depledge, 2007).

However, in 2007, the Technology and Economic Assessment Panel of the MP (TEAP) found that an accelerated HCFC phaseout schedule would be both technically and economically feasible, while also bringing noticeable climate benefits (Oberthür et al., 2011). Consequently, the MP decided to

accelerate the phaseout of HCFCs for both developed and developing country parties (Depledge, 2007; Montzka et al., 2015). This brought the phaseout date for HCFCs to 2020 in developed and 2030 in developing countries, with intermediate steps for reductions before then (Andersen et al., 2013; Velders et al., 2009).

At this point, the role of HCFCs as GHGs had become a much more important consideration for the parties to the MP according to several authors (Andersen et al., 2013; Depledge, 2007; Montzka et al., 2015; Roberts, 2017; Roberts & Grabiel, 2009; Velders et al., 2012). Montzka et al. (2015) find that the impact of the 2007 adjustments on the recovery of the ozone layer is less than 5 years, therefore implying that reductions in GHG emissions impacted the decision to adopt the accelerated phaseout schedule. In the same year, Velders et al. had published a paper suggesting that an accelerated HCFC phaseout would have significant climate benefits compared to the KP, highlighting the role the MP could play for climate mitigation (Depledge, 2007; Velders et al., 2007). The political atmosphere had begun to shift as climate change gained salience in the international arena (Oberthür et al., 2011). Major countries showed interest in making use of the climate benefits of the MP, including the US and China, which had phased out its CFC production and consumption ahead of the 2010 deadline (Depledge, 2007; Oberthür et al., 2011).

However, several authors note that the eventual effect of the 2007 adjustments on the climate remained contingent on the GWP and energy efficiency of substitutes to replace HCFCs (Depledge, 2007; Molina et al., 2009; Montzka et al., 2015; Oberthür et al., 2011). Accordingly, the parties to the MP showed concern for climate impacts and decided to promote the use of alternatives that would minimize them (Norman et al., 2008; Velders et al., 2009). They requested a report from the TEAP on the alternatives to HCFCs and HFCs, as well as a joint workshop with the UNFCCC (Depledge, 2007; Roberts & Grabiel, 2009). Despite the concern shown for climate impacts, in effect the major replacement for HCFCs became HFCs (Bergeson, 2017; Velders et al., 2009). These, as well as the problem shifting they caused between the regimes, are discussed in the next section.

Addressing the problem shifting caused by HCFCs led to low fragmentation between the two regimes. This is because the MP remained the core institution in setting the agenda, objectives and standards on HCFCs. This was in line with the mandates of the regimes, and showed the core role of the ozone regime in holistically addressing ODSs, not only when they were relevant for ozone, but also when concurrent climate benefits could be attained. The climate regime had no significant role in addressing HCFCs due to its subjugated mandate when it came to ODSs, although some coordination took place in the form of a joint workshop.

4.1.4 High global warming potential HFCs as replacements to ozone depleting substances

Problem shifting from ozone to climate

HFCs became the fastest growing GHGs globally as they replaced the HCFCs that were phased down under the MP (Andersen et al., 2013; Hurwitz et al., 2016; Michaelowa et al., 2019). Projections suggested that their emissions would offset the climate benefits of the ODS phaseouts by 2050, also partially offsetting the climate benefits of the accelerated HCFC phaseout in 2007 (Andersen et al., 2013; Roberts & Grabiel, 2009; Velders et al., 2007). Furthermore, HFC emissions could offset the emissions reductions of the Nationally Determined Contributions (NDCs) under the PA (Roberts, 2017).

This continued and increased the problem shifting from the ozone to the climate regime, as HFCs have no ozone depleting potential, but have a GWP hundreds or thousands of times that of CO_2 (Roberts, 2017). Due to not having any ozone depleting potential, HFC production was not controlled under the

MP, and they were promoted as highly useful substitutes to ODSs (Oberthür, 2001; Oberthür et al., 2011). Transfer from ODSs to HFCs was supported financially by the Multilateral Fund of the MP (Oberthür, 2001). As with HCFCs, some industries and parties to the MP claimed they assumed the availability of HFCs as substitutes when agreeing to ODS phaseouts. It was argued that the reductions of HFCs in line with the KP could lead to slowing down ODS phaseouts or cause compliance problems under the MP (Oberthür, 2001). This instance of problem shifting has perhaps received the most attention in literature on the interactions between the two regimes.

Addressing HFCs under the two regimes – scientific cooperation

Including HFCs under the KP mandate led to a situation where the main substitutes to ODSs were controlled for emissions reductions under the climate regime. While this could regulate the transition from HCFCs to HFCs to some extent in developed countries, developing countries could increase their HFC emissions with little restrictions as they were not subject to the binding targets of the KP (Michaelowa et al., 2019). Furthermore, the MP was pursuing policy that promoted the use of HFCs as part of the phaseout of ODSs, therefore creating conflicting obligations on member states on whether they should be reducing or increasing the use of HFCs in relevant industries.

A few authors discuss the action taken by the two regimes as their interaction gained attention in the late 1990s and early 2000s. In 1999, and again in 2005, the TEAP from the ozone regime and Intergovernmental Panel on Climate Change (IPCC) from the climate regime came together to make scientific assessment reports on the impacts of the promotion of HCFCs and HFCs on the climate. This was first encouraged by a UNFCCC Conference of the Parties (COP), and soon after by the MP Meeting of the Parties (MOP) (Oberthür, 2001). Andersen et al. (2013) identify the conclusions of the report as follows: The KP should allow the use of HFCs as ODS replacements when other feasible options are not available, while the MP should avoid the use of HFCs when alternatives exist. However, Oberthür (2001) finds that the MP MOP focused on a separate assessment by TEAP, which was "somewhat biased" toward the use of HFCs (pp. 369). Velders et al. (2007) find that parties to the MP showed interest in finding dual benefits of the two treaties, but mitigating climate change mostly arose incidentally as the ozone issue was addressed.

Meanwhile, the parties to the UNFCCC eventually decided to leave the matter of HFC use to individual member states when deciding how to implement their KP commitments. This meant that member states could choose to increase HFC use to follow their commitments to reduce ODSs under the MP, if other GHG emissions were reduced in line with KP commitments. This viewpoint was especially advocated by countries with vested interest in HFC production (Oberthür, 2001). As a result, Oberthür (2001) finds that the impact of the 1999 report was rather limited, mainly with an increase on available information, and awareness of issue linkage. Oberthür et al. (2011) note that in the climate regime, communication and cooperation with the ozone regime was encouraged, but little other action was taken. They argue that the joint report did, however, have an impact on the debate on accelerating HCFC controls under the MP, and provide information on HFC-23 destruction projects under the KP Clean Development Mechanism (CDM) (discussed in the next section).

The second report was released by the same scientific bodies in 2005. This followed reluctance from the ozone regime member states on addressing the contradictions with the KP in the early 2000s (Oberthür et al., 2011). This report was more comprehensive than the first, but provided little previously unknown information (Andersen et al., 2013; Oberthür et al., 2011). However, by this time the climate change issue had risen in salience on the international arena, and the HFC-23 destruction

issue under the KP had gained more attention (Oberthür et al., 2011). This contributed to the accelerated HCFC phasedown under the MP, which was discussed in the previous section.

Addressing the problem shifting caused by HFCs by including them under the KP led to medium-high to high level of fragmentation. This is because the MP and KP set conflicting objectives in terms of HFCs, with the former promoting their use and the latter promoting their reduction. While the KP was officially the core institution to address HFCs, the MP was actively pursuing an opposing agenda without subjugating its actions to the objectives of the climate regime. However, ad hoc coordination took place in the form of several joint scientific reports, although with limited results. This suggests addressing HFCs in this way also has elements of the criteria for medium-high level of fragmentation.

Addressing HFCs under the Kyoto Protocol Clean Development Mechanism leads to problem shifting to the ozone regime

As specific GHG emissions targets under the KP were only included for developed countries, the only incentive for developing countries to reduce HFC emissions in the 2000s was through the KP Clean Development Mechanism (CDM) (Roberts & Grabiel, 2009). The CDM is one of the flexibility mechanisms under the KP, allowing developed countries with emission targets to buy credits from the reduction of CO_2 equivalent emissions in developing countries (Oberthür et al., 2011; Schneider, 2011). CDM projects came to include the destruction of HFC-23, which is a by-product of HCFC-22 production. This meant that the primary product HCFC-22 was controlled under the MP as an ODS, while the by-product was controlled under the KP due to its high GWP as a GHG (McCulloch, 2005).

Actors from both the climate and ozone regimes displayed concern over the potential perverse incentives of CDM projects for HFC-23 destruction (Depledge, 2007). These concerns were based on the high benefit that could be reaped from HFC-23 destruction compared to the costs of the process, which might distort the profits created by HCFC-22 production (McCulloch, 2005). HFC-23 destruction could attain high credits because it had a very high GWP, which meant that the profits gained from CDM credits could equal or even double the value of the HCFC-22 produced, creating substantial revenue to HCFC-22 plant operators (McCulloch, 2005; Oberthür et al., 2011; Schneider, 2011; Schneider, 2007; Wara, 2008). This this had the potential to lead to increased production of HCFC-22 for the sake of gaining CDM credits, as noted by several authors (Norman et al., 2008; Oberthür et al., 2011; Roberts & Grabiel, 2009; Schneider, 2011, 2007; Wara, 2008). Such increase in the HCFC-22 production would have negative impacts on the ozone layer due to the ozone depleting properties of HCFC-22, therefore creating problem shifting from the climate regime to the ozone regime (Oberthür et al., 2011). So far, this has been the only instance of problem shifting that has taken place in this direction between the two regimes.

While the CDM includes several project types, Schneider (2011) argues that the destruction of HFC-23 was the most important project type under the CDM. It has been estimated that the destruction of HFC-23, along with the destruction of by-products in the production of adipic acid, accounted for almost 55% of CDM credits issued by 2008 (Wara, 2008). Another estimate put the destruction of HFC-23 and N_2O at 22% of the credits (Schneider, 2007). This notable market share in the CDM makes the HFC-23 issue an important point to consider in the discussion on problem shifting between the climate and ozone regimes, as it significantly impacts the environmental performance of the CDM (Wara, 2008).

HCFC-22 had a major role in replacing CFCs in refrigeration after they were phased out under the MP, becoming one of three most abundant HCFCs (Depledge, 2007; Montzka et al., 2015; Velders et al.,

2009; Wara, 2008). HCFC-22 has a GWP of 1,700, making it a strong GHG, although much less potent than HFC-23, which has a GWP of between 11,700-14,800 (Schneider, 2011, 2007; Velders et al., 2009). The unwanted by-product HFC-23 was usually vented out into the atmosphere in developing countries when there was no regulation to prohibit this (Schneider, 2011; Wara, 2008). However, by 2005 practically all HCFC-22 producers in developing countries had entered their projects under the CDM system (Wara, 2008). Meanwhile, in developed countries, HFC-23 was often destroyed voluntarily by industry after noting the high risks of emissions and low costs of HFC-23 abatement (Wara, 2008).

The possible perverse incentives of HFC-23 destruction created debate in the CDM from an early stage (Oberthür et al., 2011; Wara, 2008). These concerns were first addressed unilaterally within the KP (Oberthür et al., 2011). The methodology was revised several times because of fears that more HCFC-22 would be produced for the sake of claiming credits, and in 2004, the method for HFC-23 destruction under the CDM was placed on hold by the CDM Executive Board (McCulloch, 2005; Wara, 2008). In 2005, the KP COP recognized the risk that issuing credits to HFC-23 destruction could lead to excess production of HCFC-22 and HFC-23, which should not be encouraged by the CDM (Schneider, 2011). Following this, it was decided that only existing HCFC-22 plants would be eligible under the CDM methodology, while new plants established after 2002 would be excluded (Oberthür et al., 2011; Roberts & Grabiel, 2009; Schneider, 2011; Wara, 2008). The KP COP requested guidance from the Subsidiary Body for Scientific and Technical Advice to the UNFCCC on how to proceed with the inclusion of added HCFC-22 capacity (Wara, 2008). However, discussions on the inclusion of new plants stalled, and no conclusion had been reached by 2010, leaving new plants outside of the scope of the CDM (Oberthür et al., 2011; Schneider, 2011).

Excluding new plants from the CDM reduced the perverse incentives to increase HCFC-22 production according to two studies (Oberthür et al., 2011; Wara, 2008). However, some argue that if these plants were left out of the CDM, their HFC-23 emissions would continue increasing as there would be no incentives to destroy HFC-23 (Roberts & Grabiel, 2009; Wara, 2008). Furthermore, as long as new plants were not explicitly excluded from future funding under the climate regime, there might have been continued incentives to build inefficient production facilities in the hopes of gaining credits in the future, therefore extending the perverse incentives (McCulloch, 2005; Wara, 2008). In addition to excluding new plants, safeguards were established for existing plants to reduce perverse incentives by the CDM. These included caps on the ratio of HFC-23 created in the production process, and limits to the amount of HCFC-22 eligible for crediting at historical values between 2000-2004 (McCulloch, 2005; Schneider, 2011). Therefore, increases in HCFC-22 production were not eligible for CDM credits, which Schneider (2007) finds reduced the perverse incentives for excess production.

The discussion among KP parties on the role of the CDM in HFC-23 destruction was not only driven by the potential for problem shifting to the ozone regime. While the perverse incentives to increase HCFC-22 production were considered, other criticism of the CDM credits afforded to HFC-23 destruction included economic inefficiency, large windfall profits to few companies, low contribution to secondary benefits and sustainable development, and low contribution to energy transition (Oberthür et al., 2011; Schneider, 2007; Wara, 2008). Roberts and Grabiel (2009) argue that the HFC-23 question adversely impacted the functioning of the entire CDM carbon market due to flooding the market with cheap credits. This suggests that the problem shifting that the climate regime was creating for the ozone regime was only one of the reasons why the CDM Executive Board and the KP COP addressed this issue. Furthermore, as the delay on the rules on new HCFC-22 plants shows, addressing the problem shifting was done only partially, while further decisions could not be reached or did not receive continued attention.

Meanwhile, the HCFC phaseout under the MP, as discussed above, was found to have its own impacts on the perverse incentives of the CDM. As the schedule for HCFC phasedown was sped up in 2007, the production of HCFC-22 also became subject to phaseout by 2030 (Schneider, 2011). Reductions in HCFC-22 production would automatically lead to reduced HFC-23 emissions (Oberthür et al., 2011). As a result, Oberthür et al. (2011) find that the potential for gaining CDM credits for HFC-23 projects was limited by the accelerated phaseout schedule under the MP. Depledge (2007) also finds that phasing out HCFCs would mitigate climate change, as the emissions of the by-product HFC-23 would decrease. She argues that this would be the simplest way of addressing the perverse incentive problem under the CDM. In this way, it can be argued that eventually the ozone regime had a significant role in addressing the problem shifting taking place from the climate regime, although this was not the main purpose of the HCFC phaseout. However, Schneider (2007) finds that crediting existing HCFC-22 production may have created incentives to continue HCFC-22 production, rather than switch to other alternatives, even as the HCFC phaseout was accelerated under the MP in 2007. Furthermore, Schneider (2011) argues that the cap assumes a continued growth of HCFC-22 demand. However, production of HCFC-22 could fall below the cap value as a result of the accelerated phaseout of HCFCs under the MP. If that happened, he argues that the CDM would continue to offer incentives to produce HCFC-22 when its production would otherwise decline.

A definitive solution to the HFC-23 problem came in 2016, when the Kigali Amendment to the MP mandated the destruction of HFC-23 in production processes to the level of 99% (Michaelowa et al., 2019). This, in conjunction with the HCFC phaseout, got rid of the perverse incentive problem (Depledge, 2009). This was found to be more cost-effective than addressing the issue under the climate regime, as the main product HCFC-22 was already under the scope of the MP (Roberts & Grabiel, 2009). In addition, this policy includes the HFC-23 produced from feedstock use of HCFC-22, which was left unregulated under the HCFC provisions of the MP (Roberts & Grabiel, 2009). The inclusion of HFCs under the MP is further discussed in the next section.

The KP CDM initially led to a high level of fragmentation between the regimes. The two regimes had conflicting objectives as each was focused on the reduction of substances within their own mandate. This led to overlaps between the agendas of the regimes, without coordination of activities. A new instance of problem shifting was created from the climate to the ozone regime due to perverse incentives, which was then addressed unilaterally by the KP CDM by implementing eligibility criteria and excluding new HCFC-22 plants from credits. This was done with reference to the problem shifting but also to other problematic issues relating to HFC-23 destruction projects within the CDM, without consultation with the MP. However, the inclusion of new production plants was not effectively addressed. Eventually, the problem shifting was reduced by the HCFC phaseout under the MP, when the production of HFC-23 as a by-product was also incidentally reduced. The HCFC phaseout led to reduced need by the CDM to address the perverse incentives. This can be said to have reduced the conflicting agendas between the regimes, although several institutions remained active in standard setting with relevance to HFC-23 production. Therefore, this reduced fragmentation between the regimes to medium-high. Finally, mandating HFC-23 destruction under the Kigali Amendment led to a medium-low level of fragmentation. This is because the Kigali Amendment clearly states the objective to destroy HFC-23, which becomes binding on member states. This places it as the core institution on HFC-23 destruction, even though the KP, or more recently the PA, maintain their mandate over HFCs in general. The clear rules on HFC-23 destruction are also in the interest of the climate regime to reduce emissions, which indicate that there is no need to contest this policy despite overlap in mandate.

Addressing problem shifting caused by HFCs under the Montreal Protocol: leading to the Kigali Amendment

As stated above, the emissions of HFCs were to be reported to the UNFCCC due to their high GWP (Michaelowa et al., 2019). However, under the KP this was only expected from developed countries. In the 2000s, there were no limitations on HFCs in developing countries as they had no quantified targets under the KP; therefore the use of HFCs as ODS substitutes in these countries could grow uncapped through 2012 (Depledge, 2007). While the CDM had projects for HFC-23 destruction, this did not include any other type of HFCs. It was found from comparing atmospheric measurements to emissions reported to the UNFCCC that almost 50% of HFC emissions were from developing countries by 2012, highlighting the high percentage of HFC emissions outside the regulation of any treaty (Michaelowa et al., 2019; Montzka et al., 2015). Even in countries which had targets under both the MP and KP, Oberthür (2001) finds that in the early 2000s, balancing the objectives of the two regimes had been left to individual parties.

Due to these concerns, parties to the MP turned their attention to the climate impacts of HFCs soon after the 2007 adjustments on the HCFC phaseout (Roberts, 2017). This started the negotiations which culminated in the Kigali Amendment to the MP in 2016, which made HFCs the first non-ODSs controlled for phasedown under the ozone treaty. In 2008-2009, several forums including the Major Economies Forum and G8 Leaders Declaration called attention to HFC reductions and the role the MP could play in climate protection (Molina et al., 2009). Meanwhile, the parties to the MP engaged with the UNFCCC and other stakeholders in 2008 to discuss the possible alternatives to ODSs, as well as how to make use of the experience of the MP to address HFC impacts on climate, and enhance the ozone and climate benefits of the HCFC phaseout (Molina et al., 2009).

In 2009, two proposals were brought to the table to include HFCs under the MP (Canan et al., 2015; Molina et al., 2009; Roberts, 2017; Roberts & Grabiel, 2009). These were presented by Micronesia and other island states, as well as jointly by Canada, Mexico and the US. Both of these proposals suggested that HFCs could be left in the basket of gases controlled by the KP, so that they would be included under the mandate of both regimes (Molina et al., 2009; Roberts & Grabiel, 2009). However, in the end references to HFCs were deleted from the decision, and further information on low-GWP alternatives to ODSs was requested from TEAP (Depledge, 2009). At this time, there was also discussion on the HFCs under the UNFCCC ahead of the Copenhagen COP. The European Council proposed that the agreement reached there should entail an arrangement for the international emission reductions of HFCs (Molina et al., 2009). Therefore, MP as the preferred forum for HFC controls was not yet clear.

Indeed, the suitability of the MP in controlling HFCs was discussed broadly. On the one hand, they are not ODSs, raising questions on whether they fit under the mandate of the MP. They were also already controlled under the UNFCCC and the KP, which meant that the mandate of the two regimes would become more overlapping if the MP took up the HFC phasedown. Several countries, including India, China, and some Gulf countries, did not initially want to include non-ODSs under the scope of the MP (Depledge, 2009; Michaelowa et al., 2019; Roberts, 2017). India, for example, expressed concern that higher costs of replacements would impact developing countries disproportionately (Bergeson, 2017).

However, on the other hand, many arguments were raised in favour of an HFC phasedown under the MP. It was noted that with the exception of HFC-23, HFCs were products themselves. Therefore, they were manufactured purposefully like ODSs, rather than as unwanted by-products like most other GHG emissions (Molina et al., 2009). Some governments argued that taking action to decrease HFC emissions would work to preserve the climate benefits already achieved by the MP (Andersen et al., 2013). Meanwhile, leaving them unabated had the potential to offset the climate benefits of the NDCs

under the PA (Roberts, 2017). Many argued that the MP had a moral duty to address HFCs, as their widespread adoption was directly linked to phasing out ODSs (Depledge, 2009; Heath, 2017; Roberts, 2017; Roberts & Grabiel, 2009). Furthermore, this historical responsibility also suggested that HFCs would fit into the scope of the MP as it aims to reduce negative environmental effects from the phaseout of ODSs (Roberts & Grabiel, 2009).

Oberthür et al. (2011) argued that addressing HFCs under the MP could improve policy consistency between the two regimes. In this way, the MP could complement the KP by mandating limits on the production and consumption of HFCs, while the KP would be responsible for emissions (Montzka et al., 2015; Roberts & Grabiel, 2009). Roberts and Grabiel (2009) argue that the UNFCCC encourages cooperation with other international organizations where that is useful to its objectives, therefore suggesting that delegating part of its responsibility on HFCs would be appropriate. Furthermore, moving beyond the KP, no progress was made specifically on HFCs under the PA negotiations, shifting attention even further in the direction of the MP (Michaelowa et al., 2019).

Support for the HFC phasedown under the MP grew, and in 2012 more than 100 parties to the MP had shown support to phasing down HFCs and transferring to low-GWP alternatives (Andersen et al., 2013). This motivation was driven mostly by the climate impacts of HFC emissions (Bergeson, 2017). After several years of negotiations, an amendment concerning HFC phasedown was adopted in 2016 in Kigali (Birmpili, 2018; Heath, 2017). It was calculated that this phasedown could avoid up to 0.5℃ atmospheric temperature increase within the century (Birmpili, 2018; Roberts, 2017). Under this amendment, countries are divided into several groups with differing phasedown schedules, as has been common practice under the MP (Birmpili, 2018). By the 2040s, HFC production and consumption will be phased down by 80-85% (Birmpili, 2018). Furthermore, the destruction of HFC-23 will become mandatory insofar as its production as a HCFC-22 by-product continues (Michaelowa et al., 2019). Eliminating HFCs completely by 2040 would avoid around 60% of the atmospheric warming caused by HFCs, but as the Kigali Amendment does not mandate a full phaseout, less of this warming will be mitigated (Hurwitz et al., 2016). Even with the implementation of the Kigali Amendment, the reductions in HFCs by 2050 would not be enough to meet the objectives of the PA in avoiding dangerous climate change (Michaelowa et al., 2019).

There is a need for low-GWP alternatives to replace HFCs in relevant sectors (Roberts, 2017; Velders et al., 2007). These are being developed for individual sectors, and often include transition technologies based on other fluorinated gases with lower GWP, or a move to natural refrigerants such as ammonia, hydrocarbons, and CO_2 (Roberts, 2017). Not-in-kind technologies are also possible (Roberts, 2017).

Michaelowa et al. (2019) find that the adoption of the Kigali Amendment created an overlap of mandates between the MP and PA, as now HFCs are controlled under both regimes. This suggests a high level of fragmentation, as both regimes are now involved in setting the agenda and standards on HFCs. However, in terms of coordination the level of fragmentation may be medium-high, as the regimes are well aware of the overlap in mandate concerning HFCs, and may therefore coordinate policy. However, the extent of this has not yet been documented in literature and remains to be seen as the relatively new institutions take form.

Continuing the mandate of the Kyoto Protocol: Paris Agreement on HFCs

HFCs continue to be under the mandate of the PA, as they were under the KP. However, only few countries refer to them explicitly in their NDCs since 2015, and only China included a quantitative

reduction goal for HFCs (Michaelowa et al., 2019). Less than half of all NDCs contain economy wide GHG targets which include all the now 7 GHG categories under the UNFCCC, including HFCs, while 7 countries have planned policies for reducing HFC emissions without introducing quantified targets (Michaelowa et al., 2019). This indicates that HFC reductions targets for most countries are only made explicit by the Kigali Amendment of the MP, as discussed in the previous section. In addition to NDCs, HFCs may be included in national long-term low GHG emission development strategies. Developed countries have done so in line with the phasedown schedule of the Kigali Amendment, but so far only Mexico has done so from developing countries (Michaelowa et al., 2019). Only one article discusses the inclusion of HFCs under the PA, which leads to quite limited results. This may be due to the newness of the PA, or the shift in focus toward the Kigali Amendment of the MP in controlling the HFC phasedown.

In terms of fragmentation, the PA is continuing the role of the KP on setting the agenda, objectives and standards on HFCs. This suggests that the level of fragmentation was not much changed by this institutional arrangement to address HFCs. However, the shared mandate with the MP on HFCs after the Kigali Amendment means that the level of fragmentation between the regimes has increased compared to the time when the KP was the only institution addressing HFCs.

4.1.5 Global warming potential of ODS and HFC banks – unaddressed problem shifting

ODSs have accumulated over decades in chemical stockpiles, insulation foams, or equipment at end of life (Molina et al., 2009; Roberts, 2017; Roberts & Grabiel, 2009). These materials are known as ODS banks, and they continue to release GHG emissions slowly into the atmosphere, which can be significant if not abated (Depledge, 2009; Roberts, 2017). Roberts & Grabiel (2009) find that in the 2010s the emissions from ODS banks had the potential to offset the GHG emissions reductions of the KP in its first commitment period.

As the MP has focused on the production and consumption of ODSs, banks of ODSs have been left outside of its scope (Roberts & Grabiel, 2009). This can be considered an instance of problem shifting from the ozone regime to the climate regime, as the MP was the most logical regime for implementing controls on ODS banks. The MP is the only regime with a mandate on ODSs, and its text implies a comprehensive regulation of the substances under its control (Roberts & Grabiel, 2009). This has been used to argue that ODS banks are the historical responsibility of the MP (Roberts & Grabiel, 2009). Roberts (2017) finds that the inactivity of parties to the MP in addressing ODS banks stems from their historical uninterest to reduce climate impacts. Velders et al. (2007) find that when the destruction of ODS banks has taken place, this was to mitigate ozone depletion, with impacts on climate taking place as a side effect. On the other hand, the climate regime has not been able to address this issue due to its subordinate mandate to MP in relation to ODSs (Roberts & Grabiel, 2009).

The majority of CFCs and a large portion of HCFCs in refrigeration and air conditioning banks were expected to be emitted between 2010-2015 (Roberts & Grabiel, 2009). This problem shifting to the climate regime has likely happened irreversibly, although newer literature within the selected articles did not confirm this. Furthermore, HCFCs in developing countries were expected to continue accumulating for decades to come (Roberts & Grabiel, 2009). While ODSs in these sectors were released quickly, insulating foams retain the ODSs they contain until end of life, and therefore may be managed on a longer time scale (Roberts & Grabiel, 2009).

The MP started to explore opportunities for ODS bank abatement in the late 2000s, as interest in climate implications of the ozone regime grew (Roberts & Grabiel, 2009). In 2008, parties to the MP

agreed on starting pilot projects for ODS bank destruction (Molina et al., 2009). However, the MP did not include nor fund projects for the destruction of ODS banks on a large scale, and the Multilateral Fund has only afforded limited funding to pilot projects (Depledge, 2009; Roberts & Grabiel, 2009). Norman et al. (2008) find that even the limited offset credits available had not been implemented by member states by 2008. A TEAP report in 2009 urged controls on ODS banks, with analysis of different sectors based on the effort, costs, and benefits related to destroying banks (Roberts & Grabiel, 2009). A workshop was held in collaboration with the UNFCCC on the costs and benefits of ODS bank recovery and destruction (Roberts & Grabiel, 2009). However, this did not lead to official inclusion of ODS banks under the MP.

Due to the inability of either regime to address this instance of problem shifting, ODS banks have been left unregulated on the international level (Roberts & Grabiel, 2009). Any attempts to reduce ODS banks have therefore taken place at the discretion of member states, and mostly in developed countries (Roberts & Grabiel, 2009). While unregulated, the size of ODS banks is declining due to the phaseout of CFCs and HCFCs under the MP (Michaelowa et al., 2019). On the other hand, HFC banks continue to grow due to accumulation in the same industries in all member states to the MP (Roberts & Grabiel, 2009). While these banks were part of the discussions under the MP, the Kigali Amendment eventually does not include clauses on the destruction of HFC banks (Michaelowa et al., 2019; Roberts, 2017).

Roberts (2017) finds that countries had little incentive to invest in destroying banks, while the emissions of other GHGs continued to rise unabated as negotiations under the UNFCCC stalled before the PA. After the adoption of the PA, he finds there has been renewed interest to tackle the banks under the MP, but this has not yet been implemented in amendments or adjustments. TEAP reported on scenarios related to ODS and HFC banks in 2018, indicating continued research on the options to reduce these GHG emissions (Michaelowa et al., 2019; Roberts, 2017). Michaelowa et al. (2019) argue that financing for the destruction of HFC banks could also be afforded under the PA, due to the joint mandate on HFCs.

The problem shifting caused by ODS banks has had a twofold effect on the level of fragmentation between regimes. On the one hand, it can be said to have led to a high level of fragmentation. This is because ODS banks have been left in a regulatory gap between the regimes, despite having relevance for both the climate and ozone regimes. On the other hand, the MP would be the core institution for controlling ODS banks, insofar as this was done by any institution. This is because the climate regime is subordinate to the MP when it comes to ODSs, and cannot set an agenda or objectives on this issue by itself. Indeed, the ozone regime has been the only one taking any action to reduce emissions from ODS banks. This suggests a low level of fragmentation in terms of the roles of institutions. When it comes to HFC banks, they could be controlled by the climate regime due to its mandate, and be included for financing under the PA (Michaelowa et al., 2019). On the other hand, there is continued research conducted on them under the MP. This suggests a high level of fragmentation, as several institutions are involved but there is little coordination.

4.1.6 Geoengineering – an instance of future problem shifting?

Geoengineering, or deliberate interventions in the Earth's climate to reduce global warming, have been suggested by some as a way to moderate the warming effects caused by climate change (Larson, 2016; Talberg et al., 2018). These proposals are usually based on the argument that current commitments on GHG reductions are not enough to meet the objectives of the climate regime (Heckendorn et al., 2009; Talberg et al., 2018). While there are several proposals on geoengineering,

the one that relates to both the ozone and climate regimes is solar radiative management through the injection of sulphates or other aerosol particles into the stratosphere (Keith et al., 2016). The aim is to reflect away some of the sun's rays, therefore reducing the heating of the atmosphere (Heckendorn et al., 2009; Talberg et al., 2018). This method is attempting to copy the effects of large volcanic eruptions, which are known to cool the Earth's atmosphere for some time (Heckendorn et al., 2009; Larson, 2016). However, to be effective in combatting climate change, the injections of aerosols would need to be continuous (Heckendorn et al., 2009). Despite many uncertainties, this method of geoengineering is one of the most widely discussed, and considered to be more feasible than other options (Larson, 2016).

Employing geoengineering at large scales is likely to have negative side effects on the environment, only some of which can be anticipated (Larson, 2016; Talberg et al., 2018). Due to the associated and largely unknown risks of stratospheric injections, even most proponents are calling for further research (Keith et al., 2016; Larson, 2016). Increased aerosol concentrations in the stratosphere would according to some simulations lead to heating of the lower stratosphere and increased water vapour (Heckendorn et al., 2009; Keith et al., 2016). This would have impacts on ozone loss, and potentially slow the recovery of the ozone layer by several decades (Heckendorn et al., 2009; Keith et al., 2016; Larson, 2016). Studies have found that injections of sulphates at a scale with relevant climate impacts could lead to 1-13% reductions in the ozone column (Keith et al., 2016). Some simulations have indicated that the ozone loss caused by sulphate aerosols could lead to more ozone loss than the emissions of ODSs in human use, and would continue to deplete the ozone layer even as anthropogenic ODS emissions decrease under MP phaseout schedules (Heckendorn et al., 2009). This means that were it employed, this type of geoengineering would create a significant instance of problem shifting from the climate regime to the ozone regime. Some have argued that the risks to the ozone layer could be reduced by using aerosols other than sulphates (Keith et al., 2016). However, so far sulphates have received the most attention for geoengineering based on aerosol injections.

There is currently no international governance framework to regulate geoengineering (Larson, 2016; Talberg et al., 2018). Instead, it is governed by a range of uncoordinated international institutions which were designed for other purposes (Talberg et al., 2018). There has been debate on whether the United Nations framework would provide a suitable forum to address this issue, or whether other voluntary arrangements would serve the purpose better (Larson, 2016). Many find that an international treaty on the issue would be premature, as scientific uncertainties still abound. Furthermore, it is unlikely to happen soon due to competing viewpoints, and questions on moral issues (Larson, 2016; Talberg et al., 2018). On the other hand, others argue that governance should be developed in conjunction or in advance of deployment, due to justice issues and risks related to these technologies (Talberg et al., 2018).

Talberg et al. (2018) find that both the climate regime and the ozone regime carry relevance for the governance of geoengineering. The UNFCCC supports least costly alternatives for climate policy, and notes that such measures should not be delayed because of the lack of full scientific certainty. Some scholars have interpreted this as openness to consider geoengineering when it is less costly than alternatives. Meanwhile, the PA establishes a goal of keeping global warming below 2℃ of pre-industrial levels, as well as reaching net zero emissions after mid-century. Prioritizing these goals could mean that geoengineering would become an option if actions to reduce CO_2 emissions are not sufficient to reach these goals, provided that this solution is considered to remain within the context of sustainable development (Talberg et al., 2018). Despite these considerations, geoengineering has not yet been seriously proposed by the climate regime as here defined. However, the IPCC found in its Fifth Assessment report in 2013 that there is medium confidence that stratospheric aerosols could

counteract some climate impacts from GHG emissions (Larson, 2016; Talberg et al., 2018). While noting this, the report does not promote geoengineering. On the other hand, the MP is relevant to aerosol injections insofar as they may modify the ozone layer (Talberg et al., 2018).

Considering the lack of official position from either regime on geoengineering, it is hard to say whether this instance of problem shifting will materialize in the future. However, including geoengineering as an instance of problem shifting, albeit a potential one, showcases one issue which may become relevant for the interaction between the climate and ozone regimes in the future. Furthermore, it is an instance of problem shifting from the climate to the ozone regime, which have been scarce so far. Often studies on the effects of climate policy must take a forward-looking stance, as measures are not yet implemented in practice (Von Stechow et al., 2015). Being mindful of future interactions can help reduce the negative impacts of problem shifting by creating policy that considers the potential impacts before they take place.

The current state of policy on geoengineering can be said to have a high level of fragmentation. The regimes have potentially conflicting objectives relating to geoengineering, although it is not certain that the climate regime would promote geoengineering in the future. It is found to be a last resort option, in case other measures fail to mitigate dangerous climate change (Larson, 2016). Currently, geoengineering exists in a gap between regimes, despite relevance for both issue areas. Furthermore, no coordination has taken place, even on the level of discussions or scientific reports on the potential impacts of geoengineering.

4.2 Falsification of hypotheses

The identification of instances of problem shifting show that there are more instances of problem shifting from the ozone to the climate regime than in the other direction. While this gives strong support to the idea that instances of problem shifting are directional between regimes, it does not seem to have a strong impact on the level of fragmentation. It can be seen from the analysis that addressing most instances of problem shifting has led to at least some increase to the level of fragmentation between the regimes. This was usually because addressing problem shifting was done with limited coordination, and often included adding another institution with the role to set the agenda, objectives, and standards on an issue. Table 3 shows a summary of the findings on the level of fragmentation from each policy addressing problem shifting between the regimes.

However, there are two cases in which addressing an instance of problem shifting led to a lower level of fragmentation. First is phasing out HCFCs under the MP, which reduced the problem shifting to the climate regime while maintaining the core role of the MP in addressing HCFCs. Second, addressing the HFC-23 question eventually led to lower fragmentation, as new policy was added over time. The CDM initially created high fragmentation, which was somewhat reduced with the accelerated HCFC phaseout schedule, and eventually the Kigali Amendment mandated the destruction of HFC-23, leading to medium-low fragmentation. However, this development in the level of fragmentation is particular to HFC-23, rather than all HFCs. The inclusion of HFCs under both the KP/PA framework and the MP through the Kigali Amendment led to a medium-high to high level of fragmentation. Therefore, the reduction of fragmentation relating to HFC-23 can be said to be because of the initially high level of fragmentation caused by the CDM, which caused conflicting agendas with the ozone regime, while later policy reduced this conflict.

It can be seen that the direction of problem shifting for both of the instances where fragmentation was reduced was from the ozone regime to the climate regime. Therefore, while there is no overall

trend showing that all instances of problem shifting from the ozone regime to the climate regime lead to reduced fragmentation, as suggested by the first hypothesis, some of the instances of problem shifting from the ozone regime to the climate regime did lead to reduced fragmentation. Therefore, the first hypothesis is not confirmed, but it applies to some instances of problem shifting from the ozone to the climate regime. Meanwhile, no instances of problem shifting from the climate regime to the ozone regime reduced fragmentation. Therefore, the second hypothesis that problem shifting from the climate regime to the ozone regime leads to increased fragmentation is confirmed.

Table 3. Summary of the level of fragmentation caused by addressing instances of problem shifting.

Instance of problem shifting	Direction of problem shifting	Policy causing problem shifting	Policy addressing problem shifting	Year of policy	Level of fragmentation
HCFCs	Ozone→ climate	CFC phaseout under the MP	HCFC phaseout under the MP	1992, 2007	Low
HCFCs (HCFC-22)	Ozone→ climate	CFC phaseout under the MP	HCFC phaseout under the MP	1992, 2007	Medium-high
HCFCs (HCFC-22)	Climate→ ozone	CFC phaseout under the MP	Limitations on the eligibility criteria under the KP CDM	2005	High
HFCs	Ozone→ climate	ODS phaseout under the MP	Kyoto Protocol basket of 6 gases	1997	Medium-high to high
HFCs	Ozone→ climate	ODS phaseout under the MP	MP Kigali Amendment	2016	Medium-high to high
HFCs	Ozone→ climate	ODS phaseout under the MP	PA Nationally Determined Contributions	2015	Little change
HFCs (HFC-23)	Ozone→ climate	CFC phaseout under the MP	KP Clean Development Mechanism	1997	High
HFCs (HFC-23)	Ozone→ climate	CFC phaseout under the MP	HCFC phaseout under the MP	1992, 2007	Medium-high
HFCs (HFC-23)	Ozone→ climate	CFC phaseout under the MP	MP Kigali Amendment	2016	Medium-low
ODS Banks	Ozone→ climate	Unmanaged ODS banks	Unaddressed	-	High due to regulatory gap; Low due to roles of institutions
HFC Banks	Ozone→ climate	Unmanaged HFC banks	Unaddressed	-	High
Climate engineering	Climate→ ozone	Proposals of aerosol geoengineering	Potential future problem shifting	-	High

While the hypotheses are partly falsified, the underlying argument that problem shifting to the climate regime would be addressed more effectively finds some support from these findings. Overall, the majority of instances of problem shifting have been addressed by the regimes sooner or later. The problem shifting from the ozone regime to the climate regime has been addressed in all instances except for ODS and HFC banks. HCFCs were mandated for phaseout under the MP since 1992, and with an accelerated schedule since 2007. Meanwhile, the HFC issue was mediated by the KP since the setting of its mandate, continues to be included under the climate regime through the PA, and more recently was added into the ozone regime by the Kigali Amendment to the MP.

However, it can be questioned whether the problem shifting from the climate regime has been addressed as effectively as that from the ozone regime. The first instance of problem shifting from the climate to the ozone regime concerned perverse incentives to increase HCFC-22 production due to the KP CDM. While the climate regime took action on the issue, it can be said that the created eligibility criteria for the CDM was an incomplete way to address the problem, as new production plants and capacity were excluded, and negotiations on the topic stalled. Eventually the accelerated HCFC phaseout schedule under the MP reduced this instance of problem shifting, followed by HFC reductions under the Kigali Amendment. However, the main purpose of these policies was to reduce problem shifting from the ozone regime to the climate regime, rather than vice versa. Therefore, if the intentions of the policy are considered, this instance of problem shifting was addressed only partially. Meanwhile, the climate engineering instance of problem shifting has not been addressed at all to date. Therefore, while there is not strong support for the hypotheses in the sense that problem shifting from one direction would lead to increased fragmentation and in the other would lead to reduced fragmentation, it is still possible that the direction of problem shifting has impacted the motivation to address problem shifting effectively.

5. Discussion

This section discusses the findings of the research and their implications. First, possible reasons for why the hypotheses, particularly the first hypothesis, did not apply to this case are considered. Next, implications for both theory and policy are presented. Finally, limitations of the research approach are discussed, and suggestions how future research could improve upon these points are presented.

5.1 Deviation from expectations

The findings are somewhat contrary to the hypotheses in terms of the impact directionality has on the level of fragmentation between regimes. A shift in political salience of the issues over time could help explain why the first hypothesis did not apply to this case. In the 1990s and early 2000s, climate change was found to have low political salience compared to ozone depletion (Benedick, 1998; Thoms, 2003). Climate change was considered to be highly uncertain, while addressing it would require changes to core economic activities (Thoms, 2003). Countries had highly varying levels of vulnerability and ability to adapt, which created drift in state interests. It was found that in the 1990s, climate change was not a high priority for most countries (Benedick, 1998). The issue was seen as very complex and impacts seemed distant, reducing interest from the general public. This also had implications to regulation implemented by national governments and companies, which felt little pressure to take action (Benedick, 1998; Thoms, 2003). Lacking media coverage on climate change in the 1990s also played a role in low issue salience (Thoms, 2003).

On the other hand, the ozone issue had shocked the public with images of the ozone hole, and the link between ozone depletion and human health was easier to understand (Thoms, 2003). The media

was active in communicating scientific findings to the public. In fact, public awareness had a major role in driving down demand for products containing CFCs, even before international regulation had materialized (Benedick, 1998). It can be argued that the higher political salience of the ozone issue before the 2000s may have played a role in allowing problem shifting to take place from the ozone regime to the climate regime.

Coming into the 2000s, climate change gained more attention on the international agenda and among the public (Thoms, 2003). This led to the creation of new governance arrangements, or considering broader climate impacts under existing institutions (van Asselt, 2014). By the end of the decade, some were already arguing that small increases to ODS emissions could be allowed if this led to large enough climate benefits (Norman et al., 2008). This indicates a shift in political salience between the two issue areas over time, with climate now having become a major issue in media and among the public, along with high salience in international negotiations. This had a role in addressing the problem shifting caused by the ozone regime, as climate implications were important arguments for speeding up the HCFC phaseout and for including HFCs under the ozone regime (Oberthür et al., 2011). On the other hand, geoengineering has arisen as a potential solution to reduce climate change impacts, despite the negative consequences it could have on the ozone layer. Therefore, the changing political salience of the two issues over time could be one reason that impacted the problem shifting that took place, and the motivation to address it. This could explain why the first hypothesis did not apply in this case, as climate change was not consistently prioritized.

Another factor that may have impacted the findings in relation to the hypotheses is interests of member states. State interests could push or stall negotiations on policy to address problem shifting under either regime. Even though the two regimes have almost complete overlap in membership, several countries have pursued different policies under the two regimes (Roberts & Grabiel, 2009). Hickmann (2014) finds that national interests have considerably impacted the production and interpretation of scientific findings relating to both the ozone and climate regimes, which has led to countries emphasizing either the precautionary principle or the uncertainties related to environmental hazards to pursue their own policy agenda. For example, the US took an active role in creating a treaty on ODSs, but was much more reluctant to do so on GHGs due to industrial interests (Benedick, 1998; Hickmann, 2014). Therefore, addressing problem shifting from the ozone to the climate regime has not necessarily always been a priority for all member states. This could have impacted why addressing problem shifting took a long time, and the roles of institutions were kept largely separate without extensive coordination under the two regimes, leading to high fragmentation.

For example, when the inclusion of HFCs under the MP was first discussed, there were several countries which did not want to mix the mandates of the two regimes, and were against including any explicitly climate related policy under the ozone regime. India, China and some Gulf countries wanted HFC controls to remain exclusively under the climate regime (Depledge, 2009; Michaelowa et al., 2019). China expressed concern over the legal implications of creating overlap between the regime mandates, while India argued proposals on HFCs were outside of the scope of the MP and should not be considered (Depledge, 2009). The US had also long been reluctant to include climate issues under the ozone regime, but had shown more support to addressing the issues together since the 2007 accelerated phaseout of HCFCs (Depledge, 2007). Here it is important to also note that the commitments on HFCs under the KP were not binding on developing countries or the US, which did not ratify the Protocol. Meanwhile, controls on HFCs under the MP are binding on all parties (Depledge, 2009). This may also explain some of the reluctance to address HFCs under the MP. The decisions under the MP are taken by consensus, which indicates that the opposition from member states can have important implications on the policy which is adopted (Roberts & Grabiel, 2009).

Eventually proposals to include HFCs under the MP gained support from major countries, including the US, the EU, and China (Depledge, 2009; Montzka et al., 2015; Oberthür et al., 2011; Roberts & Grabiel, 2009). Increased interest in addressing climate questions among member states of the ozone regime therefore contributed to the creation of the Kigali Amendment (Bergeson, 2017). This would not have been possible if member states continued to strictly separate the issue areas and therefore the mandates of the two regimes. Leadership by major countries can drive international consensus, and therefore lead to policy to address problem shifting (Benedick, 1998). While interest in climate rose over time, there was not a major country that originally was pushing for addressing the problem shifting to the climate regime since the early days of regime interaction. This can also have impacted the fact that problem shifting was allowed to take place from the ozone to the climate regime, and addressing it occurred with a time lag.

5.2 Theory implications

This thesis questioned the previous assumption that problem shifting is symmetrical between two regimes. The findings support the idea that problem shifting is directional, bringing more nuance to the conceptualization of problem shifting. The biophysical link between issue areas contributes to the direction problem shifting may take, but the policy taken under different regimes can also create problem shifting. This was found to be the case from the ozone regime, which prioritized the speedy phasedown of ODSs without due consideration to the climate impacts of substitutes. On the other hand, there has been less problem shifting taking place from the climate regime to the ozone regime, but these instances have not necessarily been addressed effectively. As different instances of problem shifting have arisen and been addressed over time between the regimes, it is too simplistic to assume that problem shifting between regimes is symmetrical and equal in extent, even when it may have taken place in both directions. The findings also show that problem shifting is not necessarily addressed by just one regime, but that both the regime that created the problem shifting, and the one that received it, may create policy to address it. This policy may be created to address the problem shifting explicitly, or reduce problem shifting even though it was originally created for another purpose. This indicates the importance of considering the developments in regime interactions over time to get a comprehensive picture of the direction of problem shifting between two regimes.

While problem shifting is found to be directional between two regimes, this does not appear to have a strong connection to the level of fragmentation. Johnson and Urpelainen (2012) assumed that this would be the case; member states would have a common interest in minimizing problem shifting in either direction to avoid its negative consequences, and therefore it would not matter which regime was causing the problem shifting. Mutually supportive policies that are coordinated between the two regimes would therefore follow. In the current situation the suggestion makes sense for the climate-ozone regime pair. Addressing problem shifting under the respective regimes has not been accompanied by extensive policy coordination, but it is logical that addressing the negative consequences of problem shifting on the issue area of either regime would be in the interest of member states, as the two regimes have overlapping membership.

However, this was not necessarily the case throughout the interactions of the two regimes over time. Several member states wanted to keep the regimes separated until relatively recently, as discussed in the previous section. Therefore, the member states did not always display an interest in reducing the negative impacts of problem shifting between the regimes, despite being members of both regimes. They would rather prioritize the objectives of the regime which was in line with their national interests, whether that be a competitive advantage with ODS-replacing chemicals, or renewable energy

technology (Hickmann, 2014). Eventually the interlinkages of the issue areas were acknowledged more broadly by member states, and addressing climate issues under the MP was accepted. This was seen as a useful delegation of responsibilities from the perspective of the climate regime, since member states had started to see how the ozone regime could contribute to climate mitigation efforts. In the end, addressing the negative consequences of problem shifting in this case was perhaps facilitated by the overlapping membership of the two regimes, as member states had incentives to attain the objectives of both regimes. It is possible that in a different case where the membership of different regimes was not as uniform, key member states might continue to promote problem shifting in one direction over the other, rather than address it.

The findings on regime fragmentation are quite different than in previous literature. Johnson and Urpelainen (2012) found that significant problem shifting between regimes would lead to regime integration. The findings here, however, show signs of increased fragmentation for most instances of problem shifting. Johnson and Urpelainen found that the ozone and climate regime are relatively well-integrated due to their hierarchical structure, with the KP being subjugated to the MP. However, it can be argued that this only applies to ODSs, and there is higher fragmentation in terms of other instances of problem shifting such as HFCs, and no clear hierarchy between the regimes in their mandate on them. Therefore, a higher level of fragmentation can be seen when taking into account all the interactions between the regimes, rather than just ODSs. According to the findings of this paper, addressing problem shifting often led to the inclusion of more institutions with an agenda, objective, or standard setting role, which showed up as increased fragmentation.

Furthermore, addressing problem shifting has in most instances been implemented by one regime or the other unilaterally, without extensive policy coordination. This is surprising in relation to the theory, which expected that addressing problem shifting would lead to integration and policy coordination between regimes. The lack of policy coordination can in part be explained by the member state interests discussed above, as several states promoted a focus on issues strictly within the mandate of certain institutions. When coordination took place, it was often informal and in the form of joint workshops and reports, rather than institutional linkages that were codified in treaties. Therefore, these interactions did not necessarily lead to policy coordination.

However, it is interesting to note that most instances of problem shifting have been reduced despite the lack of purposeful and consistent policy coordination. This implies that low fragmentation may not be necessary to address problem shifting between regimes, as long as the relevant regimes are aware of the negative impacts they have on other issue areas and are willing to minimize these. However, this awareness may not be present to the same extent in the interactions between other regimes, where the membership is not as overlapping as between the climate and ozone regimes.

Since the results indicate increased fragmentation from addressing problem shifting between regimes, it is important to consider what this could mean for achieving the governance objectives of the respective regimes. Some authors argue that fragmentation is negative for reaching governance objectives, because it allows regimes to create conflicting rules and decisions (van Asselt et al., 2008). Therefore, it is possible that further conflicting policies will arise between the regimes as problem shifting is addressed. Furthermore, if there is no hierarchy between fragmented regimes, they may undermine the decisions of another regime while prioritizing their own issue area (Keohane & Victor, 2011). This backdrop may allow regimes to create or legitimize problem shifting, which may again increase fragmentation if addressed by regimes unilaterally without coordination. Meanwhile, it has been argued that when several institutions are active on an issue, as is the case with several instances of problem shifting between the climate and ozone regimes, integration of policies could increase effectiveness in addressing key questions (Biermann et al., 2009).

On the other hand, fragmentation between regimes may also have some positive effects. Having a multitude of institutions working on an issue area may accommodate varying state interests when consensus is difficult to reach (Keohane & Victor, 2011; van Asselt et al., 2008). This can allow actors flexibility in negotiations, which may encourage participation by both states and business and civil society groups (Biermann et al., 2020). For example, talks on HFCs under the MP allowed for increased climate mitigation, without the baggage of the difficult KP negotiations on emission cuts. The US did not ratify the KP, but was increasingly open to addressing climate issues under the MP. As the findings show, problem shifting may be reduced even as addressing it increases fragmentation between regimes. However, acknowledging interlinkages between overlapping issue areas, rather than focusing on the individual objectives of each regime, is important even when the level of fragmentation is high.

5.3 Policy implications

Problem shifting can hinder the effectiveness of addressing interacting environmental problems as a whole. To reduce this risk, policy solutions need to take into account the interconnectedness of environmental problems, and pay attention to the problem shifting effects which may influence other regimes (van den Bergh et al., 2015). Between the climate and ozone regimes, the interaction between the issue areas and substances within the regime mandates has been known for a long time. Despite this, problem shifting has taken place in both directions, but particularly from the ozone regime to the climate regime. This could have been avoided, at least to some extent, through encouraging research and development of other alternatives to ODSs, which had lower or no GWP. Had the conflicting objectives with the climate regime been prioritized higher within the ozone negotiations, HFC growth in particular could have been stunted earlier. This would have released less overall emissions than what are now being phased down under the Kigali Amendment.

Going forward, these regimes could aim to be mindful of their interactions and create policy which does not conflict with the objectives of the other regime as much as possible. This includes any possible future debate on geoengineering under the climate regime, and suggests that alternative aerosol technologies should be studied very carefully before allowing methods that negatively impact the ozone layer (see e.g. Keith et al., 2016). Even though climate change is an important environmental problem to address, it is not sufficient to address it by itself without consideration of other environmental issue areas (Steffen, Richardson, et al., 2015). In other words, prioritizing climate change solutions at the expense of other environmental issue areas might not be in the best interest of overall environmental integrity, even as the need for timely action on climate change is now emphasized.

For other international environmental regimes where the interlinkages between issue areas are less known than with the regime pair of climate and ozone, regimes can invest in forward-looking research to map possible interactions and therefore reduce the risk of problem shifting before policy is put in place. This would improve the overall coherence of environmental governance on the international level, which is needed so that addressing problems does not compromise other environmental objectives in the process (Kim & Bosselmann, 2013). Considering the impacts of policy on interlinked issue areas may also change policy preferences, as a policy which may not be the best when looking at a single environmental issue turns out to be preferable overall when interactions with other problems are considered (Sterner et al., 2019). If problem shifting is left unaddressed, it may cause a threat to the functioning of the Earth system due to unpredictable and potentially cascading effects (Kim & van Asselt, 2016). Identifying the direction of problem shifting, as well as finding explanations

for why some regimes may be more fragmented than others, can contribute to a better understanding of the interactions between regimes. This helps identify points of intervention to address the challenges faced by international regimes. Ultimately this can lead to more coherent management of environmental problems on the international level, as many interacting environmental issues need to be addressed simultaneously (Steffen, Richardson, et al., 2015).

5.4 Limitations

There are some limitations to the approach taken in this research. First, the generalizability of results is limited due to the selection of only one regime pair as the case study. This may limit the extent to which the inferences made from this research apply to interactions between other regimes (Bhattacherjee, 2012). However, the focus on a single regime pair allowed for an in-depth analysis of the development of interactions between the regimes over time. This provided for useful data to consider the directionality of problem shifting and its changes over time. Following the development of the phenomenon under study in a longitudinal way is one of the strengths of a case study (Bhattacherjee, 2012). This research can therefore function as a first step in identifying the role that the direction of problem shifting may play in international governance. Further research with more case studies would contribute to creating a more comprehensive picture of the direction of problem shifting in the international environmental governance landscape.

Second, there are some limitations to the internal validity, or causality, of this research. The causality between variables in social science research is often difficult to prove unequivocally. Therefore, rather than prescribe the direction of problem shifting as the cause of changes to the level of fragmentation between regimes, the aim was to look at whether it could be one contributing factor. It is possible that while the direction of problem shifting does not seem to have clear impacts on the level of fragmentation, it may impact other features of regime interaction. Future research could look into whether the direction of problem shifting impacts the legitimacy of regimes, their power relations, or arising conflict between them, among other issues. Furthermore, analysing additional case studies could provide more conclusive evidence on whether there is any link between the direction of problem shifting and the level of fragmentation. As seen above, the political salience of the climate and ozone issue areas has not remained constant over time, which may have impacted whether problem shifting was allowed to take place, and when and how it was addressed. There might be a clearer prioritization of the climate regime over other issue areas, which could show different results in relation to the hypotheses.

Third, there are some limitations to the method of a secondary literature review. The available data is limited by the focus of previous research, which may also bias the findings to some extent due to the angle taken by other researchers (Verschuren & Doorewaard, 2010). While the interactions between the chosen regime pair were quite comprehensively documented, some gaps remain. For example, there has been little literature so far on how the PA is dealing with HFCs, and how that will interact with the Kigali Amendment phasedown. This leaves some gaps on understanding the current state of regime interactions. Furthermore, no literature was identified discussing the stance the ozone regime has taken on geoengineering proposals. Complimenting the secondary literature review with expert interviews or data collected from document analysis of recent meeting briefs could have provided additional information. This would also have contributed to source triangulation to confirm findings. However, including literature from a period of over 20 years gave a rather holistic picture of regime interactions.

6. Conclusion

This thesis looked into whether problem shifting between two regimes is asymmetrical in direction, and whether this has impacts on the level of fragmentation between the regimes. It was found that problem shifting is indeed directional; both the causation of problem shifting, as well as policy addressing it can be traced to one regime. This can shift over time, so that new instances of problem shifting may arise or be solved as the regimes interact and create new policy. Between the regime pair studied in this research, problem shifting can be said to mostly originate from the ozone regime, while there has been only one instance of problem shifting from the climate regime to the ozone regime, as well as the potential for future problem shifting in the form of geoengineering. Prioritization of each regime's own issue area has contributed to problem shifting, but the interlinkages between the underlying issue areas have been acknowledged more over time, leading to policies to address and reduce problem shifting.

Meanwhile, the findings do not suggest that the direction of problem shifting has significant impacts on the level of fragmentation between regimes. Addressing instances of problem shifting has usually led to increased fragmentation between the regimes regardless of direction, as there were more institutions addressing the same issue with limited coordination. Addressing problem shifting led to reduced fragmentation in two instances of problem shifting from the ozone to the climate regime but this was not found to be enough to confirm the first hypothesis on the direction of problem shifting to the climate regime. Meanwhile, the second hypothesis that problem shifting from the climate regime leads to higher fragmentation was confirmed but this has limited implications since the first hypothesis was falsified and problem shifting from the ozone to the climate regime can also lead to increased fragmentation. However, unlike what is suggested by theory, the findings imply that problem shifting can be addressed even with a relatively high level of fragmentation and little coordination between regimes. This can happen provided that the involved institutions are aware of their interlinkages to other issue areas and are willing to address problem shifting unilaterally.

The possible interlinkages of issue areas should therefore be considered when designing environmental policy, so that detrimental problem shifting between regimes can be minimized. As interactions between regimes can be complex and evolve over time, assuming problem shifting is a mirror image between two regimes is too simplistic, and should be considered critically when studying regime interactions in international governance. An awareness of how policies under one regime impact other issue areas can lead to more holistic international environmental governance, where the objectives of other regimes are not degraded in the pursuit of advantages in a single issue area.

References

Andersen, S. O., Halberstadt, M. L., & Borgford-Parnell, N. (2013). Stratospheric ozone, global warming, and the principle of unintended consequences-An ongoing science and policy success story. *Journal of the Air and Waste Management Association*, *63*(6), 607–647. https://doi.org/10.1080/10962247.2013.791349

Benedick, R. E. (1998). A New Global Diplomacy: Ozone Lessons and Climate Change. *Ozone Diplomacy: New Directions in Safeguarding the Planet*, 306–332.

Bergeson, L. L. (2017). The Montreal Protocol is Amended and Strengthened. *Environmental Quality Management*, *26*(3), 137–141. https://doi.org/10.1002/tqem.21496

Beyers, J., Dür, A., & Wonka, A. (2018). The political salience of EU policies. *Journal of European Public Policy*, *25*(11), 1726–1737. https://doi.org/10.1080/13501763.2017.1337213

Bhattacherjee, A. (2012). *Social Science Research: Principles, Methods, and Practices* (2nd ed.). https://doi.org/10.1351/pac198961091657

Biermann, F., Pattberg, P., van Asselt, H., & Zelli, F. (2009). The fragmentation of global governance architectures: A framework for analysis. *Global Environmental Politics*, *9*(4), 14–40. https://doi.org/10.1162/glep.2009.9.4.14

Biermann, F., van Driel, M., Vijge, M. J., & Peek, T. (2020). Governance fragmentation. In F. Biermann & R. E. Kim (Eds.), *Architectures of Earth System Governance: Institutional complexity and structural transformation* (pp. 158–180). Cambridge University Press. https://doi.org/10.1017/9781108784641

Birmpili, T. (2018). Montreal Protocol at 30: The governance structure, the evolution, and the Kigali Amendment. *Comptes Rendus - Geoscience*, *350*(7). https://doi.org/10.1016/j.crte.2018.09.002

Canan, P., Andersen, S. O., Reichman, N., & Gareau, B. (2015). Introduction to the special issue on ozone layer protection and climate change: the extraordinary experience of building the Montreal Protocol, lessons learned, and hopes for future climate change efforts. *Journal of Environmental Studies and Sciences*, *5*(2), 111–121. https://doi.org/10.1007/s13412-015-0224-1

Cardno, C. (2019). Policy Document Analysis: A Practical Educational Leadership Tool and a Qualitative Research Method. *Educational Administration: Theory and Practice*, *24*(4), 623–640. https://doi.org/10.14527/kuey.2018.016

Depledge, J. (2007). Adjustments: A double hit for ozone and climate. *Environmental Policy and Law*, *37*(6), 448–452.

Depledge, J. (2009). Montreal Protocol / MOP-21 The " Climate MOP ". *Environmental Policy and Law*, *39*(6), 274–281.

Donges, J. F., Winkelmann, R., Lucht, W., Cornell, S. E., Dyke, J. G., Rockström, J., Heitzig, J., & Schellnhuber, H. J. (2017). Closing the loop: Reconnecting human dynamics to Earth System science. *Anthropocene Review*, *4*(2), 151–157. https://doi.org/10.1177/2053019617725537

Faude, B., & Groβe-Kreul, F. (2020). Let's Justify! How Regime Complexes Enhance the Normative Legitimacy of Global Governance. *International Studies Quarterly*, *64*(2), 431–439. https://doi.org/10.1093/isq/sqaa024

Galaz, V., Crona, B., Österblom, H., Olsson, P., & Folke, C. (2012). Polycentric systems and interacting planetary boundaries - Emerging governance of climate change-ocean acidification-marine biodiversity. *Ecological Economics*, *81*, 21–32. https://doi.org/10.1016/j.ecolecon.2011.11.012

Gómez-Mera, L., Morin, J.-F., & Van de Graaf, T. (2020). Regime Complexes. In F. Biermann & R. E. Kim (Eds.), *Architectures of Earth System Governance* (pp. 137–157). Cambridge University Press. https://doi.org/10.1017/9781108784641.007

Hare, W., Stockwell, C., Flachsland, C., & Oberthür, S. (2010). The architecture of the global climate regime: A top-down perspective. *Climate Policy*, *10*(6), 600–614. https://doi.org/10.3763/cpol.2010.0161

Heath, E. A. (2017). Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (Kigali Amendment). *International Legal Materials*, *56*(1), 193–205. https://doi.org/10.1017/ilm.2016.2

Heckendorn, P., Weisenstein, D., Fueglistaler, S., Luo, B. P., Rozanov, E., Schraner, M., Thomason, L. W., & Peter, T. (2009). The impact of geoengineering aerosols on stratospheric temperature and ozone. *Environmental Research Letters*, *4*(4). https://doi.org/10.1088/1748-9326/4/4/045108

Hickmann, T. (2014). Science-policy interaction in international environmental politics: An analysis of the ozone regime and the climate regime. *Environmental Economics and Policy Studies*, *16*(1), 21–44. https://doi.org/10.1007/s10018-013-0068-4

Hurwitz, M. M., Fleming, E. L., Newman, P. A., Li, F., & Liang, Q. (2016). Early action on HFCs mitigates future atmospheric change. *Environmental Research Letters*, *11*(11). https://doi.org/10.1088/1748-9326/11/11/114019

Johnson, T., & Urpelainen, J. (2012). A strategic theory of regime integration and separation. *International Organization*, *66*(4), 645–677. https://doi.org/10.1017/S0020818312000264

Keith, D. W., Weisenstein, D. K., Dykema, J. A., & Keutsch, F. N. (2016). Stratospheric solar geoengineering without ozone loss. *Proceedings of the National Academy of Sciences of the United States of America*, *113*(52), 14910–14914. https://doi.org/10.1073/pnas.1615572113

Keohane, R. O., & Victor, D. G. (2011). The regime complex for climate change. *Perspectives on Politics*, *9*(1), 7–23. https://doi.org/10.1017/S1537592710004068

Keohane, R. O., & Victor, D. G. (2016). Cooperation and discord in global climate policy. *Nature Climate Change*, *6*(6), 570–575. https://doi.org/10.1038/nclimate2937

Kim, R. E., & Bosselmann, K. (2013). International environmental law in the anthropocene: Towards a purposive system of multilateral environmental agreements. *Transnational Environmental Law*, *2*(2), 285–309. https://doi.org/10.1017/S2047102513000149

Kim, R. E., & van Asselt, H. (2016). Global governance: Problem shifting in the anthropocene and the limits of international law. In E. Morgera & K. Kulovesi (Eds.), *Research Handbook on International Law and Natural Resources* (Issue May, pp. 473–495). https://doi.org/10.4337/9781783478330

Lade, S. J., Steffen, W., de Vries, W., Carpenter, S. R., Donges, J. F., Gerten, D., Hoff, H., Newbold, T., Richardson, K., & Rockström, J. (2020). Human impacts on planetary boundaries amplified by Earth system interactions. *Nature Sustainability*, *3*(2), 119–128. https://doi.org/10.1038/s41893-019-0454-4

Larson, E. (2016). The Red Dawn of Geoengineering : First Step Toward an Effective Governance for Stratospheric Injections. *The Duke L & Tech Rev*, *14*.

Liu, J., Mooney, H., Hull, V., Davis, S. J., Gaskell, J., Hertel, T., Lubchenco, J., Seto, K. C., Gleick, P., Kremen, C., & Li, S. (2015). Systems integration for global sustainability. *Science*, *347*(6225).

https://doi.org/10.1126/science.1258832

McCulloch, A. (2005). Incineration of HFC-23 Waste Streams for Abatement of Emissions from HCFC-22 Production: A Review of Scientific, Technical and Economic Aspects. *Prepared for United Nations Framework Convention on Climate Change*.

Michaelowa, A., Espelage, A., Hoch, S., & Acosta, M. (2019). *Discussion paper: Interaction between Art.6 of the Paris Agreement and the Montreal Protocol/Kigali Amendment*. Perspectives. https://doi.org/https://doi.org/10.5167/uzh-175388

Molina, M., Zaelke, D., Sarma, K. M., Andersen, S. O., Ramanathan, V., & Kaniaru, D. (2009). Reducing abrupt climate change risk using the Montreal Protocol and other regulatory actions to complement cuts in CO2 emissions. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(49), 20616–20621. https://doi.org/10.1073/pnas.0902568106

Montzka, S. A., Mcfarland, M., Andersen, S. O., Miller, B. R., Fahey, D. W., Hall, B. D., Hu, L., Siso, C., & Elkins, J. W. (2015). Recent trends in global emissions of hydrochlorofluorocarbons and hydrofluorocarbons: Reflecting on the 2007 adjustments to the montreal protocol. *Journal of Physical Chemistry A*, *119*(19), 4439–4449. https://doi.org/10.1021/jp5097376

Nilsson, M., & Persson, Å. (2012). Can Earth system interactions be governed? Governance functions for linking climate change mitigation with land use, freshwater and biodiversity protection. *Ecological Economics*, *75*, 61–71. https://doi.org/10.1016/j.ecolecon.2011.12.015

Norman, C., DeCanio, S., & Fan, L. (2008). The Montreal Protocol at 20: Ongoing opportunities for integration with climate protection. *Global Environmental Change*, *18*(2), 330–340. https://doi.org/10.1016/j.gloenvcha.2008.03.003

Oberthür, S. (2001). Linkages between the Montreal and Kyoto Protocols: Enhancing Synergies between Protecting the Ozone Layer and the Global Climate. *International Environmental Agreements: Politics, Law and Economics*, *1*(3), 357–377. https://link.springer.com/content/pdf/10.1023%2FA%3A1011535823228.pdf

Oberthür, S., Dupont, C., & Matsumoto, Y. (2011). Managing Policy Contradictions between the Montreal and Kyoto Protocols. In S. Oberthur & O. S. Stokke (Eds.), *Managing Institutional Complexity: Regime Interplay and Global Environmental Change* (pp. 115–141). The MIT Press. https://doi.org/https://doi.org/10.7551/mitpress/8577.003.0008

Oppermann, K., & de Vries, C. E. (2011). Analyzing issue salience in international politics: Theoretical foundations and methodological approaches. In K. Oppermann & H. Viehrig (Eds.), *Issue salience in international politics*. Routledge. https://doi.org/https://doi.org/10.4324/9780203816950

Pattberg, P., Widerberg, O., Isailovic, M., & Dias Guerra, F. (2014). Mapping and Measuring Fragmentation in Global Governance Architectures: A Framework for Analysis. *SSRN Electronic Journal*, *August*. https://doi.org/10.2139/ssrn.2484513

Roberts, M. W. (2017). Finishing the job: The montreal protocol moves to phase down hydrofluorocarbons. *Review of European, Comparative and International Environmental Law*, *26*(3), 220–230. https://doi.org/10.1111/reel.12225

Roberts, M. W., & Grabiel, P. M. (2009). A Window of Opportunity: Combating Climate Change by Amending the Montreal Protocol to Regulate the Production and Consumption of HFCs and ODS Banks. *Georgetown International Environmental Law Review*, *22*(1), 99.

Schneider. (2011). Perverse incentives under the CDM: An evaluation of HFC-23 destruction projects. *Climate Policy*, *11*(2), 851–864. https://doi.org/10.3763/cpol.2010.0096

Schneider, L. (2007). *Is the CDM fulfilling its environmental and sustainable development objectives? An evaluation of the CDM and options for improvement*. *November*, 1–75. https://www.oeko.de/oekodoc/622/2007-162-en.pdf

Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O., & Ludwig, C. (2015). The trajectory of the anthropocene: The great acceleration. *Anthropocene Review*, *2*(1), 81–98. https://doi.org/10.1177/2053019614564785

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R., Carpenter, S. R., De Vries, W., De Wit, C. A., Folke, C., Gerten, D., Heinke, J., Mace, G. M., Persson, L. M., Ramanathan, V., Reyers, B., & Sörlin, S. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, *347*(6223). https://doi.org/10.1126/science.1259855

Sterner, T., Barbier, E. B., Bateman, I., van den Bijgaart, I., Crépin, A. S., Edenhofer, O., Fischer, C., Habla, W., Hassler, J., Johansson-Stenman, O., Lange, A., Polasky, S., Rockström, J., Smith, H. G., Steffen, W., Wagner, G., Wilen, J. E., Alpízar, F., Azar, C., … Robinson, A. (2019). Policy design for the Anthropocene. *Nature Sustainability*, *2*(1), 14–21. https://doi.org/10.1038/s41893-018-0194-x

Talberg, A., Christoff, P., Thomas, S., & Karoly, D. (2018). Geoengineering governance-by-default: an earth system governance perspective. *International Environmental Agreements: Politics, Law and Economics*, *18*(2), 229–253. https://doi.org/10.1007/s10784-017-9374-9

Thoms, L. (2003). A comparative analysis of international regimes on ozone and climate change with implications for regime design. *Columbia Journal of Transnational Law*, *41*(3), 795–859.

Ürge-Vorsatz, D., Herrero, S. T., Dubash, N. K., & Lecocq, F. (2014). Measuring the co-benefits of climate change mitigation. *Annual Review of Environment and Resources*, *39*, 549–582. https://doi.org/10.1146/annurev-environ-031312-125456

van Asselt, H. (2011). Managing the Fragmentation of International Environmental Law: Forests at the Intersection of the Climate and Biodiversity Regimes. *NYUJ Int'l L. & Pol.*, *44*, 1205.

van Asselt, H. (2014). The evolution of global climate governance. *The Fragmentation of Global Climate Governance*, 15–28. https://doi.org/10.4337/9781782544982.00011

van Asselt, H., Sindico, F., & Mehling, M. A. (2008). Global climate change and the fragmentation of international law. *Law and Policy*, *30*(4), 423–449. https://doi.org/10.1111/j.1467-9930.2008.00286.x

van den Bergh, J., Folke, C., Polasky, S., Scheffer, M., & Steffen, W. (2015). What if solar energy becomes really cheap? A thought experiment on environmental problem shifting. *Current Opinion in Environmental Sustainability*, *14*(July), 170–179. https://doi.org/10.1016/j.cosust.2015.05.007

Velders, G. J. M., Andersen, S. O., Daniel, J. S., Fahey, D. W., & McFarland, M. (2007). The importance of the montreal protocol in protecting Earth's hydroclimate. *The National Academy of Sciences of the USA*, *104*(12), 4814–4819. https://doi.org/10.1175/JCLI-D-12-00675.1

Velders, G. J. M., Fahey, D. W., Daniel, J. S., McFarland, M., & Andersen, S. O. (2009). The large contribution of projected HFC emissions to future climate forcing. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(27), 10949–10954. https://doi.org/10.1073/pnas.0902817106

Velders, G. J. M., Ravishankara, A. R., Miller, M. K., Molina, M. J., Alcamo, J., Daniel, J. S., Fahey, D. W., Montzka, S. A., & Reimann, S. (2012). Preserving Montreal Protocol climate benefits by

limiting HFCs. *Science Magazine*, *335*(February), 922–923. https://doi.org/https://doi.org/10.1126/science.1216414

Verschuren, P., & Doorewaard, H. (2010). *Designing a Research Project* (Second edi). Eleven International Publishing.

Von Stechow, C., McCollum, D., Riahi, K., Minx, J. C., Kriegler, E., van Vuuren, D. P., Jewell, J., Robledo-Abad, C., Hertwich, E., Tavoni, M., Mirasgedis, S., Lah, O., Roy, J., Mulugetta, Y., Dubash, N. K., Bollen, J., Ürge-Vorsatz, D., & Edenhofer, O. (2015). Integrating Global Climate Change Mitigation Goals with Other Sustainability Objectives: A Synthesis. *Annual Review of Environment and Resources*, *40*, 363–394. https://doi.org/10.1146/annurev-environ-021113-095626

Wara, M. (2008). Measuring the clean development mechanism's performance and potential. *UCLA Law Review*, *55*(6), 1759–1804.

Yang, Y., Bae, J., Kim, J., & Suh, S. (2012). Replacing gasoline with corn ethanol results in significant environmental problem-shifting. *Environmental Science and Technology*, *46*(7), 3671–3678. https://doi.org/10.1021/es203641p