Doctoral Thesis

Regulatory and contractual issues within the clean development mechanism of the Kyoto Protocol: an economic analysis

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Publication Date:
2009

Permanent Link:
https://doi.org/10.3929/ethz-a-005915145

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Regulatory and Contractual Issues within the Clean Development Mechanism of the Kyoto Protocol
An Economic Analysis

DISS. ETH Nr. 18589

Regulatory and Contractual Issues within the Clean Development Mechanism of the Kyoto Protocol
An Economic Analysis

ABHANDLUNG
zur Erlangung des Titels

DOKTOR DER WISSENSCHAFTEN
der
ETH ZÜRICH

vorgelegt von

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2009
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Acknowledgements

This dissertation is the result of my research at the Chair of Economics at ETH Zurich. My thanks go first to Prof. Renate Schubert for giving me the opportunity to write this thesis and for showing a lot of patience in the process. I am also very grateful to Prof. Stefanie Engel for being the co-advisor for this thesis. My thanks also go to Prof. Guy Kirsch who, over several years, sharpened my capacity in systemic thinking in general and in particular with respect to climate policy institutions.

This book was improved by conversations with a large number of people. I am particularly grateful to Katharina Bening, Julia Blasch, Dr. Adrian Bruhin, Dr. Mark Leuchtmann, Julia Ohndorf, Dr. Uta-Maria Ohndorf, Moritz Rohling, Prof. Clemens Steegborn, and Raoul Steiger. Furthermore, many discussions were extraordinarily helpful, as they touched an area of expertise which is beyond an economist’s usual training. In particular, I would like to thank Fabienne Braune for the mind-boggling conversations on the different methods for mathematical proofs. Many thanks go to Mischa Brennwald, Susanne Haefeli-Hestvik, and Dr. Kjell Oren, for the valuable insights into the world of carbon trading, verification, and climate policy negotiations. For explanations on the lawyer’s perspective on different issues in contract law, I am grateful to Dr. Daniel Kautenburger-Behr, Oliver Gollner, Karin Messmer, and Dr. Wolfgang Ohndorf.

Special thanks go to Ian MacKenzie, PhD and Charles Palmer, PhD with whom I continue my work on carbon contracts, which is the major topic of the second part of this thesis.

Last but not least, this dissertation would have taken a very different turn, had it not been for Dr. Matthias Gysler who awakened my interest in formal economic contract theory. Many thanks for the endless debates on the books and papers we used to read together.
Abstract

This thesis features a set of theoretical micro-economic analyses of the Clean Development Mechanism (CDM) of the Kyoto Protocol. This market-based mechanism is conceived to foster greenhouse gas emission reductions in developing countries. The corresponding offsets can be used to meet the Kyoto-targets in developed countries. It is argued that, while the great lines of the international climate policy regime are subject to constraints of political feasibility, there exists still some room for institutional optimization on the instrument-level of the CDM. As a contribution to this objective some of the most important incentive problems arising in the context of the CDM are analyzed.

After establishing the case for a regulatory analysis of the CDM, we present a model providing important insights into the optimal monitoring and regulatory requirements. The main objective is here to minimize the risk of non-additionality of projects under the plausible assumption of incomplete enforcement. As it turns out, the optimal monitoring strategy for credit-based systems like the CDM differs from the one which is proposed in the literature for cap-and-trade regimes. An important insight from this analysis is that the regulator should explicitly include criteria on the verifiability of projects in the eligibility requirements of the CDM.

Due to the CDM’s institutional particularities, many incentive problems are devolved to the level of the individual contract between project participants. These problems of incomplete enforcement, moral hazard, and adverse selection are analyzed in a set of contract models. The existence of such problems are shown to be a plausible reason for the observable underprovision of upfront financing within CDM contracts. Furthermore, the model results are discussed in the context of the ongoing discussion of CDM contract damages and risk-sharing. It turns out that incentive problems associated with the CDM will generally lead to over-insurance of the carbon seller if the contract damages are constrained. This further reduces the set of feasible contracts featuring up-front finance. In a conclusion, all theoretically derived results are discussed in the context of recent developments on the carbon offset market.
Zusammenfassung


Introduction

Climate change due to anthropogenic greenhouse gas emissions is most probably the largest global environmental externality that humanity will have to face within the next 100 to 200 years, because the associated net damages are potentially very large. Hence, over the last two decades, the necessity to mitigate human-induced climate change has occupied a high rank in the public agenda. These increased concerns have triggered a first international policy response. On January 1st, 2008, the first binding international climate policy agreement entered into force, which aims at a reduction in greenhouse gas emissions. This agreement is usually referred to as the Kyoto Protocol.

Long before its entry into force, the Kyoto Protocol has been subject to very different reactions within the academic world. Its supporters saw it as an important first step to a sequentially negotiated long-term climate policy.\(^1\) On this end of the spectrum of comments the focus was often laid on the idea that "getting the foot in the door is critical"\(^2\). Critics of the Protocol on the other hand opposed the agreement as being a "deeply flawed agreement that manages to be both economically inefficient and politically impractical"\(^3\). As far as a scientific appraisal of the Protocol is based on economic considerations, it needs to be specified what the features of an optimal climate policy are. A first approach to identify an efficient climate policy consists of determining when and where to optimally reduce greenhouse gases, and by what amount. Such analyses of theoretically optimal reduction paths are undertaken within the field of climate economics. Climate Economists calculate such an optimum mostly through computable Integrated Assessment models designed to map changes in greenhouse gas concentration onto the resulting costs.

Unfortunately, within climate economics there is still a considerable degree of dissent on the theoretically optimal reduction path. This is primarily due to the complexity of the decision problem engendered by human-induced climate change. Damages as well as mitigation costs are potentially very high, but uncertain. Furthermore, the burden is asymmetrically distributed over time and space, with developing countries likely to be affected the most. Moreover, the major share of the damages are likely to affect future...

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1 See, for example, Grubb et al. (2002).
2 Najam et al. (2003), p. 222
3 McKibbin and Wilcoxen (2002), p. 107. Interestingly, the vocabulary used here resembles to the language used in the political sphere. US-president Bush identified the Protocol as being "fatally flawed in fundamental ways". (Bush (2001))
generations. All this implies that modelers have to make value judgments, which are potentially disputable.

For example, the choice of the discount rate used presupposes a judgment on how to trade off damages inflicted on future generations with abatement costs to be incurred in the near future. This choice has a strong influence on the model results, as the Integrated Assessment models are particularly sensitive to the discount rate applied. As Yohe et al. (2007) report in IPCC (2007a), a change in the discount rate from 3 to 0 percent can induce changes in the estimates of the Social Cost of Carbon over four orders of magnitude.\(^4\) Note that this range lies well within the interval of conceivable and justifiable discount rates.\(^5\) Consequently, any judgment of the Protocol’s allocational efficiency over time that is based on specific model results is necessarily not irrefutable. Under the assumption that such a cost-benefit test had been made for the Protocol, Cline (2004) reports that the underlying discount rate would be below 2.5 percent. It can only be speculated if this value—or any other value that might be calculated within a cost-benefit analysis—corresponds to the actual level of caring for future generations in the specific context of climate change. Given that even experts are far from a consensus, it is unlikely that the average voter and his representative are able to exactly state their true valuation of expected damages in the far future. On the other hand, the ratification of the Kyoto Protocol might well represent the closest thing to a revelation of moral preferences on the climate change issue that can be obtained in practice. Following this line of thought, any judgment on the intertemporal efficiency of the Kyoto Protocol based on economic cost-benefit-analyses might be right, but could also be wrong.

In addition to the intertemporal dimension, the efficiency of the Kyoto Protocol should also be assessed with respect to the spatial attribution of abatement measures. Evidently, economic efficiency would require to abate in those regions where mitigation is least costly. On this dimension the Kyoto Protocol is likely to perform poorly in the first period of its existence, i.e. from 2008 to 2012. Given the fact that the Protocol, in its initial form, does not set any reduction targets for developing countries, a first-best optimal allocation of abatement over the world’s regions is not possible. It is however to be admitted that the regional allocation does not only influence the efficiency of climate policy, but also ultimately affects the engendered level of distributive justice. Again, these issues of distribution need to be addressed within theoretical considerations as well.\(^6\)

\(^4\)See Yohe et al. (2007), as well as Tol (2005).

\(^5\)The respective interval lies for example within the range identified by Weitzman (2001), for which ’experts’ on discount rates can ”justify any reasonable social discount rate by some internally consistent story.” (Weitzman (2001), p. 261)

\(^6\)As the the largest part of climate change in the 20th century and in the near future is due to emissions stemming from developed countries, it seems morally intuitive that, in the near term, developed countries should also bear the largest share of mitigating the risk of dangerous levels of climate change. As Gardiner (2004) reports, this view is also supported by scholars of moral philosophy, who are ”virtually unanimous in their conclusion that the developed countries should take the lead role in
result from political negotiations. The design of international regulations as a response to global externalities is difficult. As there exists no international body of legislation, questions like climate change need to be regulated within treaties which have to be ratified by the legislators of sovereign countries.

Hence, if global cooperation on a specific issue is sought for, the treaty has to be designed in a way that is acceptable to all parties. However, as the gains and costs from climate policy are asymmetrically distributed, very different interests have to be balanced. In this context it is likely that a Pareto-efficient inclusion of the poorer countries would be associated with transfers too large to be politically realizable. The general approach of the Kyoto Protocol—fixing individual reduction targets for countries and allow for trading of the thusly defined emission rights—is particularly suitable to balance the different country interests. In the domain of political feasibility the Kyoto approach outperforms other, potentially more efficient, measures, like a global carbon tax.\textsuperscript{7} Hence, from a political economy perspective, the distribution of the burden within the current allocation of the Protocol is less visible than if the same distributional outcome were to be achieved through an explicit inclusion of developing countries with large monetary transfers.

Along this line of argumentation, the exclusion of poorer countries from emission targets might represent a next-best solution. A negotiated compromise, like the Protocol—which results from political bargaining, featuring mutual concessions and horse-trading—could indeed reflect the boundaries of what is politically feasible. Thus, the transfers that are implicit to the Kyoto Protocol might not be as "arbitrary"\textsuperscript{8} as it seems from the ideal stance of a benevolent dictator, which is usually taken within Integrated Assessment models. One might hence be tempted to conclude that the outcome of the international climate policy negotiations represents, in fact, the result of an optimization under the constraint of political feasibility. Yet, this line of thinking would inevitably result in a Panglossian conception of the international negotiations, where the Kyoto Provisions already represent the best of all outcomes achievable in this world. This would imply that the current climate policy institutions are immunized against any academic criticism.

\textsuperscript{7}See, for example, Boehringer (2003).

\textsuperscript{8}Nordhaus (2005), p. 10
is a growing institution that was subject to iterative specifications within the last 10 years, this premise is quite plausible. Departing from these considerations, we focus our analysis entirely on the one Kyoto-instrument that allows to exploit some of the low-cost mitigation potentials located within developing countries. This instrument is referred to as Clean Development Mechanism, or CDM. Yet, the market that is created through this mechanism is to a considerable degree dependent on the restrictions that are set by the international climate policy regime as a whole. Hence, an isolated analysis of this mechanism would be only of limited relevance. We proceed, thus, within this thesis by examining the different institutional tiers that determine transactions within the CDM. The guiding metaphor used to illustrate our approach is the institutional cascade where the upper institutional levels constrain the set of potential solutions with respect to the concrete design of the Clean Development Mechanism.

The reason for which we concentrate our analysis on the Clean Development Mechanism is quite obvious. The Mechanism allows industrialized countries to finance projects contributing to the mitigation of climate change, which are situated within developing countries. In principle, the project developers in developing countries are remunerated for their efforts to reduce—or temporarily absorb—emissions of greenhouse gases. As the greenhouse effect depends only on the concentration of greenhouse gases and not on the origin of the emissions, it is sensible to foster emission reductions in those regions where they can be achieved at lowest cost. The basic economic rationale of the Mechanism is hence compelling, as the potential gains in efficiency are considerable. In 2007, even before the entry into force of the Kyoto Protocol, the CDM leveraged 33 billion in ‘clean technology’ investments in developing countries.\(^9\) This investment level is already non-negligible if it is taken into account that in the same year the aggregated inflow of Foreign Direct Investment into the developing world was about 500 billion USD.\(^10\) These numbers indicate that the future contribution of the Clean Development Mechanism to a cost-efficient climate policy will not only be of symbolic nature.

**Incentive problems within the Clean Development Mechanism**

As we will argue within this thesis, the specificities of the institutional setup of the Kyoto system is prone to lead to significant incentive problems within the Clean Development Mechanism. Given the exemption of developing countries from mandatory emission targets, there exists a considerable degree of leeway to opportunistically exploit information asymmetries. Some of the most interesting problems that arise in this context are subject to the formal analyses presented within this thesis, which are supposed to contribute to the discussion on the ‘institutional efficiency’ of the Kyoto provisions.

Linking the Clean Development Mechanism with Kyoto’s cap-and-trade system is associated with some difficulties. The Mechanism is conceived as a credit-based system,
i.e. the amount of certificates generated by a project is defined through the difference between a hypothetical baseline and the reported project emissions. The baseline is to describe the emissions that would have occurred if the project had not been implemented. Thus, the project developers could in principle overstate the actual emission reductions stemming from a specific project, either by choosing an inadequately high baseline or by understating the actual project emissions. In Kyoto terms, the project would hence be ‘non-additional’, as the issued certificates would not represent actual offsets. This problem of potential cheating is aggravated through the fact that developing countries do not have to comply to any emission targets. In fact, buyer and seller have an incentive to overstated the emission reductions in order to maximize the amount of credits received. The project investor, i.e. the buyer, necessarily prefers a higher amount of offsets per project. The seller country is interested in the technology transfer component of the project. As a higher amount of possible projects is likely to attract a larger share of foreign direct investment, the host country has also an incentive to overstate the emission reductions.

As a consequence, the Clean Development Mechanism is subject to a complicated set of rules which is to ensure that the certificates stemming from projects represent also the actual amount of emission reductions. However, these rules cannot guarantee full enforcement of truthful reports. Given this incompleteness in enforcement the question arises how the regulator is to set the monitoring intensity under the restriction of a limited budget. The economics of environmental regulation has, up to the present, rather neglected the problem of incomplete enforcement as far as credit-based systems are concerned. Within this thesis, we present a model designed to shed some light on this issue.

The issues of opportunistic behavior created through the specificities of the climate policy framework also trickle down to the level of actual transactions on the market. The contracts concluded to specify transfers under the CDM are susceptible to problems related to information asymmetries and limited enforcement. As a result, most of the existing ‘Emission Reduction Purchase Agreements’ do not provide for upfront financing of CDM projects. This is particularly problematic for CDM Project Developers with restricted access to the credit market. Yet, a support of this group of sellers would be particularly important for attaining the secondary objective of the Mechanism, which is to foster sustainable development.

In light of the above-depicted problem, it is to be asked if there exist contract designs that can help to overcome problems of opportunism and mend to the lack of upfront financing. In principle, opportunistic behavior within contractual settings can be deterred through the stipulation of Contract Damages. Depending on the specification of contract clauses featuring damages, problems of asymmetric information and limited enforcement could be mitigated by such clauses. However, in the context of the CDM, the level of and the conditions for contract damages have been controversially discussed. In the second part of this thesis, we will discuss the different efficiency effects of such
clauses. Furthermore, we will propose a set of models to analyze second-best efficient levels of contract damages under the assumption that the project developer is risk averse. It will be shown that constraints on contract damages will not only reduce the set of contracts featuring upfront payments, but also lead to an overinsurance of the seller.

Guiding Principles and Research Questions

The principal objective of the analyses presented within this thesis is to contribute rather constructively to the ongoing discussion on the institutional design of the Clean Development Mechanism. The applied methods are to be attributed to the field of institutional economics in the larger sense. First, we will provide non-formal accounts of the interrelations between the different institutional tiers which determine the context for decisions on the CDM market. The subsequent formal analyses are based on methods used within the economics of regulation, Law and Economics, and the economic theory of complete contracts. We use these methods to analyze some of the most interesting incentive effects of credit-based systems in general and the Clean Development Mechanism in particular. The results are used to derive several suggestions that are to increase the overall efficiency of the emerging carbon markets. The main focus of the regulatory analysis is, as depicted above, laid on the optimal monitoring of the regulator given incomplete enforcement. The guiding questions are here:

- How does the optimal monitoring of the regulator within credit-based systems in general—and the Clean Development Mechanism in particular—differ from the optimal solutions for other policy instruments analyzed in the literature?
- What are the specific conclusions for a regulator facing budget restrictions and incomplete enforceability in the context of the Clean Development Mechanism?

The analysis related to the contractual level of the Clean Development Mechanism focuses, as explained above, on the contract damages as a decision variable. The questions guiding these considerations are:

- What are the predominant contractual setups within CDM transactions? In what way do the actual Kyoto provisions shape the de facto liability for invalidated certificates within CDM contracts?
- Can the general lack of upfront financing within these contracts be explained by potential problems of opportunism?
- How can Emission Reduction Purchase Agreement be optimally designed in order to allow for higher levels of upfront financing of CDM Projects?
- Can the institutional shortcomings of the Clean Development Mechanism be mended through well-designed combinations of contract prices and damages?
Introduction

Structure

The general structure of this thesis follows the sequence of research questions laid out above. The 'meta'-structure of the of the thesis is organized in two parts. The first part introduces the institutional setup of the Kyoto Protocol as well as the Clean Development Mechanism, and provides a formal analysis from the stance of the regulator. The second part deals with the contractual issues laid out above. The overall 'organizing principle' is hence to move down the institutional cascade from the general framework to the more specific rules guiding the actual transactions on the market.

The first chapter presents the overarching regulatory framework of the Kyoto Protocol, which represents the most general stratum within the institutional cascade. Emphasis is laid on the presentation of the market mechanisms and the factors that determine the good traded on these markets, i.e. carbon offsets. It is also discussed how these general provisions pre-determine the more specific rules regarding the CDM market.

In the second chapter the specific regulations on the Clean Development Mechanism are introduced. Within this chapter we define the different project types and present the corresponding project verification and monitoring rules. Special emphasis is laid on the rules for forestry projects. Based on this description the regulatory problem under incomplete enforcement is introduced. The chapter also gives an interpretation of the more or less implicit attribution of liability which is de facto devolved to the lower institutional level of the individual contract.

Chapter Three presents a basic model to analyze the optimal monitoring policy of the regulator. The model is generally formulated and is likely to apply to most credit-based systems. The results of this analysis are discussed within the context of the specificities of the Clean Development Mechanism. The chapter also concludes the first part of this thesis.

The second part of this thesis on contractual issues within the Clean Development Mechanism starts with chapter Four. Within this chapter the notion of the 'Emission Reduction Purchase Agreement' is introduced and discussed in context of the primary market for CDM certificates. Furthermore, the chapter gives a brief overview on the different incentive problems to which the lack of upfront financing can be attributed.

In chapter Five, the economics of contract breach are generally presented and discussed in context of the Clean Development Mechanism. We shortly describe the different approaches for stipulating contract damages by two public sector buyers in the early years of the CDM. Moreover, we introduce the major arguments that were brought forward against higher levels of contract damages within Emission Reduction Purchase Agreements.

Chapter Six presents a set of models on risk sharing contracts under perfect and imperfect enforcement. The contract damages are introduced as a choice variable. It is argued that carbon contracts in developing countries rather correspond to a setting
Introduction

with imperfect enforcement. Hence, in cases of opportunistic breach the optimal level of contract damages could well lie above the value of the contract to the buyer.

In chapter Seven we present a model dealing with problems of asymmetric information. The model features adverse selection and moral hazard on precaution against default risks in CDM contracts. We analyze the optimal level of contract damages for cases where this combined form of opportunistic behavior is predominant. Under these conditions, we show that constraining contract damages will reduce the set of feasible and incentive-compatible contracts.

The last chapter features a discussion of our results in the context of the recent developments on the CDM market. The analyzed incentive problems identified at the different levels of the institutional cascade for the CDM indeed represent major challenges. The analyses presented within this thesis can contribute to tackle these challenges and increase the effectiveness of the Mechanism in future steps of its implementation.
Part I.

International Climate Policy and Regulatory Issues within the Clean Development Mechanism
1. The Kyoto Protocol and its Emissions Trading Framework

The specific design of the Clean Development Mechanism is to a large extent pre-conditioned by the basic regulatory approach of the Kyoto Protocol. Due to the exemption of developing countries from any obligations, these countries are also automatically excluded from most incentive mechanisms that are to increase the cost efficiency of international climate policy. The CDM is meant to mend to this institutional shortcoming by providing an alternative to exploit at least some of the vast low-cost reduction potentials within developing countries. However, as will be argued in the following chapters, the Mechanism’s susceptibility to problems of opportunism are, in principle, a direct consequence from the very fact that the CDM host countries do not have any reduction obligations.

In light of these problems and the reduced allocative efficiency of the Kyoto framework as a whole, it is—from an academic stance—quite tempting to entirely reject the Kyoto approach and call for an implementation of a different policy. We will, however, argue that many of the institutional shortcomings of the Kyoto Protocol are the result of political restrictions, which have constrained the result of the international climate policy negotiations. While the necessity of an inclusion of the big emerging economies in the medium-term is undisputable, it turns out to be difficult to realistically propose very different policies without challenging the general consensus that led to the Kyoto provisions. The analyses attempted within this thesis are hence based on the the insight that the Kyoto Protocol represents the only consistent and enforceable international climate policy regime that actually exists. Departing from this premise, the general lines of the current regulatory framework are being taken as given.

With this in mind, it is quite obvious that an analysis of the Clean Development Mechanism is to take into account the specific institutional context within which the Mechanism is situated. The effectiveness of the Clean Development Mechanism in fostering abatement projects in developing countries is necessarily dependent on the performance of other Kyoto provisions. This is particularly true for the rules that guide the general Kyoto emissions trading framework, as there will be only a positive willingness to pay for CDM certificates if the reduction targets are stringent enough to trigger a demand for carbon offsets. As a consequence, the exchange in certificates under the Clean Development Mechanism is conditioned by a ‘cascade’ of institutions ranging from the very general United Nations Framework Convention on Climate Change to the specific Emis-
1. The Kyoto Protocol and its Emissions Trading Framework

The main objective of this chapter is to introduce the upper levels of the institutional cascade—setting hence the stage for the analyses in the following chapters. Furthermore, we will provide some arguments to substantiate the premise that the current framework is a result from the political constraints.

The chapter is structured as follows. The first section provides a short overview of the highest level of the ‘institutional cascade’—the United Nations Framework Convention on Climate Change—and gives a short account of the history of the international climate policy. In section 1.2 the general features of the Kyoto Regime are introduced. The emphasis is laid on those provisions that have a direct impact on the lower-level institutions. Section 1.3 presents the general mode of operation of the Kyoto market mechanisms. The CDM, being one of these market mechanisms, necessarily interacts with the general emissions trading rules. These institutional interactions are laid out from an institutional economics perspective in section 1.4, which also concludes this chapter.

1.1. The Convention and the History of Climate Policy

In order to avoid an early deadlock in the negotiations due to some unsurmountable conflicts of interest, the design of international regulative frameworks is often organized in several stages. The first step represents a definition of overall objectives and principles that are acceptable to all parties involved. The results of this phase are usually documented in a so-called framework convention, which is formally a source of international law, but does not include any binding commitments. In a second stage the convention is complemented with a supplemental protocol featuring binding commitments. In principle, the design of the international climate policy regime followed exactly the same pattern. The international community first established the main lines and principles of international climate policy within the United Nations Framework Convention on Climate Change (UNFCCC). The Convention was then complemented by the so-called Kyoto Protocol, which features mandatory targets for emission reductions.

To date, the UNFCCC has been ratified by 191 countries, including the United States. As a consequence, the Convention is undisputedly the most comprehensive agreement on mitigating anthropogenic climate change. The UNFCCC’s stated objective is the “[...] stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system”\(^2\). The Convention includes a non-binding commitment to reduce developed country emissions to "earlier levels of anthropogenic emissions of carbon dioxide and other greenhouse gases.\(^1\)

\(^1\)For a more detailed analysis of the procedural nature of international law-making, see Birnie and Boyle (2002).

\(^2\)UNFCCC (1992), Article 2
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This objective was to be met by the end of the 1990s. However, these non-binding appeals have not been very successful, as greenhouse gas emissions continued to increase within this time frame. This shortcoming was aimed to be corrected by amending the UNFCCC with the Kyoto Protocol.

While the Convention’s direct impact on emission reduction policies was rather limited, it continues to play an important role in the design of international climate policy. First, it is to be emphasized that the Kyoto Protocol represents an amendment to the Convention. Thus, from a legal point of view the Kyoto Protocol exists only in the larger context of the UNFCCC. More importantly, the Convention represents the largest possible consensus on Climate Policy, which lays the institutional basis for further climate policy negotiations. As practically all countries in the world are a party to the UNFCCC, the regular meetings held between the Convention’s parties are the most comprehensive forum for these negotiations. Hence, within our guiding metaphor of the institutional cascade, the UNFCCC represents the most general level of international climate policy institutions. The interactions on this upper institutional level are best retraced by giving a short account of the historical development of international climate policy negotiations.

Historical Background

In the late 1970s, climate scientists became more and more concerned with the hypothesis that human activity might contribute to the phenomenon of the ‘greenhouse effect’. With increasing scientific evidence the problem of human-induced climate change was also assigned a part on the international political agenda. As a consequence, the Intergovernmental Panel on Climate Change was created as an independent scientific body with the assignment to assess the magnitude and timing of the assumed climate change and to estimate the environmental and socio-economic impacts. The IPCC, organized under the auspices of the World Meteorological Organization and the United Nations Environment Programme, was to assess the scientific evidence on climate change, including contributions by scientists that were skeptical with respect to the hypothesis of human-induced climate change.

In 1990, the IPCC’s First Assessment Report concluded that anthropogenic emissions substantially increased greenhouse gases in the atmosphere, the most important anthropogenic greenhouse gas being carbon dioxide. The report stated that, in the absence of corrective actions, anthropogenic climate change would be likely to increase in the future. In response, the UN General Assembly mandated governments to negotiate a Framework Convention on Climate Change. As a result of these negotiations, the UN-

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3 UNFCCC (1992), Article 4.2(a)
4 In 1979, the World Meteorological Organization (WMO) organized the first ‘World Climate Conference’. The conference concluded with the appeal “to foresee and to prevent potential man-made changes in climate that might be adverse to the well-being of humanity” (WMO (1979)).
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FCCC was concluded on May 9th 1992. The Convention was opened for signature at the UN Conference on Environment and Development (UNCED) in June 1992 in Rio, entered into force on 21 March 1994, and has since been ratified by 192 countries.\(^5\)

The Convention’s members meet regularly at the so-called 'Conference of the Parties', often simply referred to as COPs, which are held approximately every one and a half year. At COP3 in Kyoto, Japan, in December 1997, the climate negotiators adopted a Protocol amending the UNFCCC and introducing mandatory emission reduction targets for developed countries and countries in transition to a market economy. These countries, listed in Annex I of the UNFCCC, were committed to reduce the sum of their greenhouse gas emissions by at least 5 percent below 1990 levels over the period between 2008 and 2012. The agreement also includes the possibility for trading emission rights, which is being discussed in more detail in section 1.3. Following the convention to name such Protocols after their lieu of origin, this agreement is usually referred to as 'Kyoto Protocol'.

As the initial wording of the Protocol did not specify the institutional details—in particular with respect to emissions trading, accounting of CO\(_2\) sinks, the compliance mechanism, and several other highly disputed issues—the following COPs were to specify the Protocol’s provisions in further detail. The negotiations during COP6 and COP7 in The Hague, Bonn and Marrakech in the years 2000 and 2001 led to a generous accounting of carbon sinks and unrestricted trade in emission rights, decreasing the environmental effectiveness of the Protocol. As these negotiations coincided with the US government’s declaration to oppose the Protocol, which happened in March 2001, Boehringer and Vogt (2004) interpret the resulting 'weaker' provisions as being the consequence of the increased veto power of Russia and the country group of Canada, Australia, New Zealand and Japan.\(^6\) The most controversial issue that has been agreed to in this phase of the negotiations is the unrestricted trade of emission allowances. While unrestricted trade is to be welcomed from the perspective of the efficiency of the market, it reduces the environmental effectiveness of the protocol significantly, as Russia and the Ukraine could sell huge amounts of surplus emission rights. This surplus is often referred to as 'hot air', as it does not represent a reduction in greenhouse gas emissions due to policy efforts but is due to the contraction of economic output within the period of economic transition in the 1990s. The Protocol’s choice of the base year, 1990, has thus turned out to be unfortunate.\(^7\)

Still, the outcome of COP7 and the subsequent meetings resulted in a specification of the institutional framework that turned out to represent an acceptable basis for consensus.

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\(^5\)See UNFCCC (2009).

\(^6\)On the general history of the Kyoto negotiations up to COP7, see IISD (2001).

\(^7\)Up to the present, it seems unclear to what extent the purchase of such 'hot air' emission rights is politically acceptable within the potential buyer countries. For a discussion, see Hepburn (2007).
for all countries involved. Thus, the Kyoto Protocol entered officially into force in 2005 and has been ratified, up to the present, by 183 countries. With the ratification by Australia in December 2007, the USA remain the only industrialized country not having ratified the Kyoto Protocol. The Protocol itself is not designed to have any 'expiration' date, but, for the time being, commitments under the Protocol have only been specified for the first five-year time frame, from 2008 to 2012, which is also referred to as 'first commitment period'. In the following we will give a more detailed account on the regulatory and institutional foundations of the Kyoto Protocol.

1.2. The Kyoto Protocol

The Kyoto Protocol regulates emissions for six of the most important anthropogenic greenhouse gases. As these gases differ with respect to their radiative forcing and their mean retention period in the atmosphere, their comparability with respect to their climate impact needs to be assured. Within the Protocol the corresponding normalization is made with respect to the 'global warming potential' of one metric tonne of carbon dioxide. The resulting measure is called 'CO\textsubscript{2} equivalent' or, in short, CO\textsubscript{2}e.

The Kyoto Protocol’s general approach to reduce greenhouse gas emissions is to fix targets for emissions of selected countries. These quantity restrictions are expressed as levels of allowed emissions, or 'Assigned Amounts', measured in tonnes of CO\textsubscript{2} equivalents. The emission caps are formulated as percentages of 1990 emissions and have to be met on average within the five-year commitment periods. The current targets are binding for the first commitment period from 2008 to 2012. The Kyoto Protocol asks to comply to the reduction targets by primarily implementing domestic actions. However, neither the Convention nor the Protocol make any prescription on the national policies implemented to meet these targets.

8The results of COP7 in Marrakech—also known as 'Marrakech Accords', (See UNFCCC(2001a-d).)—represent the largest part of the institutional specification that is necessary to transpose the general Kyoto provisions into actual policy. Currently, most of these specifications have been implemented.

9See UNFCCC (2009).

10The previous US administration has instead introduced the so-called "Climate Change Plan" including additional funding for research in the fields of climate sciences and technology research, as well as a so called CO\textsubscript{2}-intensity target. The US intensity target of an 18 per cent reduction of Carbon emissions per GDP implies, however, a de facto increase of CO\textsubscript{2} emissions. For a further analysis of this policy, see Pew Center (2002).

11These gases are: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride. See Kyoto Protocol (1997), Article 3.8.

12Kyoto Protocol (1997), Art. 5

13Very often, especially in economic texts, the unit of reference is 'Carbon (C)', which is calculated using the amount of carbon molecules within a specific amount of CO\textsubscript{2}. One metric tonne of 'Carbon' corresponds to 3.67 tonnes of CO\textsubscript{2}.

14See Kyoto Protocol (1997), Articles 3 and 6.
In order to increase cost-efficiency in emission reductions, the Protocol includes several provisions that guarantee some flexibility in meeting the targets. The most important are the different forms of emissions trading, presented in section 1.3. Yet, before we turn to these different certificate markets, it is useful to describe those provisions of the Protocol which represent the necessary institutional groundwork for the Kyoto markets. This is the main objective of the following subsections.

1.2.1. Countries in the Kyoto World

Those countries that have emission reduction targets are listed in the *Annex B of the Protocol*. The respective Assigned Amounts are calculated as the emissions of a base year minus the country-specific emission reduction as stipulated in Annex B. The base year for this reduction is for the most important greenhouse gases, like \( \text{CO}_2 \) or methane, the year 1990. The reduction commitments vary across the different Annex B-countries. Switzerland, for example, has agreed to a 8 percent reduction of \( \text{CO}_2 \)e with respect to the base year, as did the EU. Japan and Canada's reduction each have a target of 6 percent. The lowest commitment has been incurred by Iceland, which is allowed to increase its base year emissions by 10 percent. It is to note that only 37 countries are listed in Annex B of the Protocol. All other signatories to the Protocol are referred to as Non-Annex B-countries and do not have any mandatory emission reduction obligations. The Non-Annex B-countries are exclusively members of the developing world.

As a consequence, in context of the Kyoto framework the world can be divided into three different country groups. Annex B-countries, non-Annex B-countries, and countries that have not ratified the Kyoto Protocol. The 'Kyoto World’ presents itself—as of the end of 2008—as depicted in figure 1.1. Note that while the USA are a member to the UNFCCC, they have refused to ratify the Protocol at present. Thus, the US have to be considered outside of the Kyoto system.

The Protocol’s differentiation between Annex B and Non-Annex B-countries is a reflection of the principle of *common but differentiated responsibility*, stipulated within Article 3.1 of the UNFCCC. This principle implies that, in an initial step, the major efforts to reduce greenhouse gases should be made by the group of developed countries. The basic moral justification for this principle is two-fold. First, in a historical view, North America and Europe have produced since 1850 around 70 percent of all the \( \text{CO}_2 \) emissions due to energy production, while the share of developing countries was less than one quarter. Thus attributing to the industrialized countries a larger responsibil-

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15For hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride the base year is, due to the lack in availability of earlier data in some countries, the year 1995.
16For a list of all commitments per country, see Annex B of the Kyoto Protocol (Kyoto Protocol (1997), p. 23).
17Australia ratified the Protocol on December 3rd 2007. Since then the US remain the only country listed in Annex B that has not ratified the Protocol.
18See, for example, Stern (2006).
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Figure 1.1.: The Kyoto World in 2008

It is to emphasize that the differentiation in country commitments featured within the Protocol is not likely to be allocationally efficient. However, it represents a political compromise accepted by a large majority of countries. The discrimination in obligations as well as the exemption of developing countries in the first commitment period represent, in fact, a system of implicit side payments sustaining the international coalition on climate policy. Moreover, the Kyoto Protocol is designed as a multi-period agreement that permits an iterative adjustment of emission reductions over time, which is a precondition for intertemporal efficiency. In principle, the Kyoto process also allows for
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the possibility of setting mandatory targets for developing countries in the future, which will be discussed in section 1.2.6.

1.2.2. Kyoto Bodies

Over the 10 years of its existence, the Kyoto process has led to a very detailed institutional framework providing the rules necessary to induce the Annex I-countries to meet their targets, as well as the different possible ways to do so. Just as any legal framework, the Kyoto Protocol has led to the development of its own specific vocabulary and abbreviations which makes it difficult for outsiders to comprehend the full implications of the different detailed rules. For the economic analyses attempted within this dissertation the explanation and use of some of these Kyoto-specific terms cannot be avoided, but are reduced to a minimum.

The Kyoto Protocol itself comprises only about 23 pages stipulating the general rules of the Kyoto system. The detailed provisions have been negotiated within the regularly held ‘Conferences of the Parties’ (COPs) of the UNFCCC. The formal legal basis for these provisions are the ‘Decisions of the COP’ being usually accepted by the representatives of all present member countries. Since the official entry into force of the Kyoto Protocol in February 2005, any arrangements specifying the Protocol’s provisions are being decided by the ‘Meeting of the Parties’ (CMPs) of the Kyoto Protocol. COPs and CMPs usually coincide, such that non-signatories to the Protocol attend the COPs but not the sessions of the CMPs. Thus, within the COPs, discussions on future commitments with parties of the UNFCCC that have not ratified the protocol are still possible and, in fact, ongoing.

Most of the administrative efforts that are related to the implementation of the Kyoto Protocol are attributed to the Secretariat of the UNFCCC, situated in Bonn, Germany. The Secretariat is, for example, to monitor the implementation of the commitments under the Protocol through collection, analysis and review of information and data provided by the parties. It also maintains the registries for the issuance of for the various forms of emission credits presented in section 1.3.4. Furthermore, there exist several subsidiary bodies that are important to the Protocol, like the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation of the Protocol (SBI), which are committees of elected experts elaborating specific provisions recommended to the COPs/CMPs. Another important committee is the CDM Executive Board which will be presented in chapter 3.

It is to note that the Secretariat and the subsidiary bodies have only an advisory role within the process of elaboration of rules. The formal authority capable of making binding specifications and amendments to the Protocol are the COPs/CMPs which usually take their decisions by unanimity.\footnote{To provide for a potential lock-down of the negotiations by a small majority the Protocol allows for a three fourth majority, for cases where "all efforts at consensus have been exhausted" (Kyoto Protocol (1997), Article 21.4).}
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1.2.3. Measurement and Accounting of Country Emissions

The general regulative approach of the Kyoto Protocol, i.e. setting quantitative targets, necessitates detailed information about the actual emissions of member countries. The Protocol, thus, requires the Annex I-countries to have a national system for the estimation of anthropogenic greenhouse gas emissions in place.\(^{20}\) The yearly estimate has to include emissions by sources and removals by sinks and is to be based on agreed methodologies. The member countries should for example use the guidelines for aggregation and uncertainty analysis developed by the IPCC.\(^{21}\) The uncertainty is usually expressed as the 90 percent interval expressed in percentage of the mean estimate. The anthropogenic emissions from Switzerland, for example, are reported for 2005 to be 53'636 kilotonnes \(CO_2\) equivalents \(\pm 3.34\%.\(^{22}\) This level of measurement uncertainty seems indeed to be acceptable for quantity regulations to be effective.

With the beginning of the first commitment period, the Annex I-countries are obliged to publish their greenhouse gas inventories on a yearly basis.\(^{23}\) These inventories have to be published within a pre-agreed common reporting format ensuring the comparability of the greenhouse gas data.\(^{24}\) Furthermore, under the provisions of the UNFCCC, the Annex I-countries have to submit additional information within their so-called 'National Communications'. These National Communications must include, in addition to the inventory, a description of steps taken to comply to the Protocol and a specific estimate of the effects that these steps will have on anthropogenic emissions.\(^{25}\) Again, in order to ensure comparability between countries, the members are asked to follow common reporting guidelines.

As required by Article 8 of the Protocol, all reports are being reviewed by expert teams appointed by the UNFCCC Secretariat with respect to their completeness and accuracy. The results of the reviews of the National Communications are documented within the 'in-depth review reports' which are made available to the public by the Secretariat.\(^{26}\) The main objective of these reviews is to facilitate the work of the COP/CMP in assessing the status of compliance by the Annex I-parties.

The most recently published inventory data of Annex I-countries give already interesting insights with respect to the actual emission trends since 1990. While emissions grew within the industrialized countries, including the U.S., by 14.9 percent, countries in transition achieved a reduction of 35.2 percent. These two different trends result in

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\(^{20}\) Kyoto Protocol (1997), Article 5


\(^{22}\) BAFU (2007)

\(^{23}\) Kyoto Protocol (1997), Article 7.3

\(^{24}\) The most important guidelines for these reports are IPCC (2006) and IPCC (2000).


\(^{26}\) UNFCCC (2002a), Decision 7
an overall reduction by 3.1 percent for all Annex I-countries combined.\textsuperscript{27} In light of these numbers, the skepticism with respect to the problem of ’hot air’ seems necessarily justified. The National Communications also include estimates on the effects of future policies and Kyoto compliance status of Annex I-countries, given all planned measures turn out to be as effective as previewed. Under these assumptions, the reductions of all Annex I-countries having ratified the Protocol would add up to 11 percent of base year emissions in the first commitment period. These reductions will, however, be distributed unevenly, such that emissions trading will necessarily take place even under these very optimistic assumptions.

1.2.4. Flexibility within Kyoto

The architects of the Kyoto provisions laid great importance on flexibility with respect to the fulfillment of the commitments within the Protocol. Annex I-countries are, for example, allowed to overshoot the reduction targets in any year between 2008 and 2012, as long as they exceed their target by the respective amount within the other years of the same commitment period. Furthermore, the Protocol allows for so-called ‘bubble building’, i.e. a group of countries is able to achieve the sum of the single-country reductions jointly. An example for this is the current burden-sharing agreement within the EU. The EU redistributed the reduction targets among its member states according to another apportionment than initially agreed to within Annex B, while the sum of the reductions for the EU as a whole remains the same.\textsuperscript{28}

The Kyoto Protocol’s flexibility is, however, restricted by the five-year time frame of the first commitment period. Hence, it is formally not possible to transfer reductions from subsequent commitment periods to fulfill the commitments for 2008-2012.\textsuperscript{29} The possibility of such a backward transfer in time, often referred to as ‘borrowing’, would surely increase the theoretically possible efficiency of the Protocol, as abatement technologies are likely to become less costly in the future. However, permitting such a transfer would open the floodgates to opportunistic behavior of the Protocol’s parties. If borrowing were allowed, the parties could claim to postpone the reductions, and then leave the agreement at a later stage without ever fulfilling their commitments. Furthermore, as all parties were to face such incentives, the follow-up agreements on the period after 2012 would be prone to fail in establishing effective commitments. Thus, borrowing is just one example where some of the theoretically possible efficiency had to be sacrificed in order to guarantee the functioning of the institutional framework.

\textsuperscript{27}UNFCCC (2007b)
\textsuperscript{28}Thus, Germany for example is to reduce its emissions by 21 percent instead of by the agreed Kyoto target of 8 percent, while Spain can expand its emissions by 15 percent. For an economic analysis of the EU burden sharing agreement, see Aidt and Greiner (2002) or Marklund and Samakovlis (2007).
\textsuperscript{29}However, the compliance provisions of the Kyoto Protocol could be interpreted as a backdoor for borrowing. See section 1.2.5.
The opposite to borrowing is the so-called 'banking'. This term refers to a forward transfer of emission reductions in time, which means that an over-fulfillment of the Kyoto targets in the current commitment period can be carried over to subsequent commitment periods. Within Article 3.13 the Kyoto Protocol explicitly allows for banking activities. As this sort of transfer is not associated with problems of asymmetric information and opportunistic behavior, the issue of banking is unproblematic from an institutional economics point of view.

The highest degree of flexibility within the Protocol is provided by the inclusion of the so-called Flexible Mechanisms, that are presented in more detail in section 1.3. The Flexible Mechanisms allow for various forms of trading emission allowances and greenhouse gas offsets. The efficiency of the Protocol is thus increased by an explicit incentive for reduction and removal of greenhouse gases in those regions where the marginal costs of abatement are low. However, the Kyoto Protocol restricts the use of the Flexible Mechanisms by stating that "any such trading should be supplemental to domestic action". At COP7 in Marrakech the supplementarity restriction was, however softened. The Marrakech Accords stipulate that domestic actions "shall constitute a significant element" of the emission reductions by Annex I-countries. From a legal point of view, the restriction is, hence, quite dilatable. Switzerland, for example, interprets this passage as a permission to meet its target by acquiring about 50 percent of the greenhouse gas offsets abroad.

As already mentioned, the Kyoto Protocol does not prescribe a specific national policy to meet the reduction targets. On the national level, Annex I-countries are free to chose the instrument of their choice to meet their commitments. Hence, there is the possibility to transpose the Kyoto caps into national ceilings for specific economic sectors and introduce an emissions trading system. This approach was chosen by the European Union for energy-intensive sectors. Another approach is to rely on voluntary agreements by the industry, associated with a credible threat of a CO₂ tax. This is currently implemented in Switzerland with respect to stationary combustion.

In general, the design of the Kyoto approach, i.e. setting targets and timetables for tradable emission reductions, has an important advantage with respect to its political feasibility. The approach allows for a decoupling of the climate target and the underlying distributive issues. While the aggregated target for all Annex I-countries determines the environmental effectiveness of the Protocol, the cost burden is distributed unequally among the different parties. The asymmetric distribution of the individual reduction requirements combined with the possibility to trade securitized emission reductions allow for a more or less implicit redistribution from countries with a higher preference intensity for mitigation to those revealing a lesser degree of need for climate policy. If lower-cost

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30 Kyoto Protocol (1997), Article 17
31 UNFCCC (2002b), Decision 15
countries are able to sell potential excess emission rights, they might be less reluctant to join the agreement in the first place. Hence, the Flexible Mechanisms not only increase the cost efficiency of the Kyoto Protocol, but also guarantee its political acceptability.\footnote{For further insights on this decomposition of effectiveness and the incentive for participation within climate policy agreements, see for example Boehringer (2003) or Lange (2006).}

### 1.2.5. Compliance Regime

On the international level there exists no superordinate sovereign to enforce agreements between countries. Consequently, every international treaty is to include a mechanism inducing compliance by its parties. In the context of the Kyoto Protocol the mechanism that fulfills this enforcement function is formally referred to as 'compliance regime'. Most of the compliance regime was defined at COP7 in Marrakech,\footnote{UNFCCC (2002c), Decision 24} and confirmed by the first Meeting of the Parties in 2005 in Montreal.\footnote{UNFCCC (2005b), Decision 27} The basic institution of the Kyoto compliance regime is the \textit{Compliance Committee} that consists of two branches: the Facilitative Branch and the Enforcement Branch. The Facilitative Branch represents rather a cooperative approach to compliance, as its main role is to provide advice and assistance to Annex I-parties who are in danger of non-compliance. The Enforcement Branch, on the other hand, is able to set stronger incentives to enforce adherence to the Protocol, as it decides on the sanctions for non-compliant Annex I-parties. Both branches are composed of 10 members coming from each of the five different UN world regions. The decisions of both branches are taken by a two-thirds majority. However, the decisions of the Enforcement Branch become only effective if the vote represents also a double majority of both, Annex I- and non-Annex I-parties.\footnote{UNFCCC (2005b), Decision 27, IX}

The responsibilities between the two branches are clearly defined. The Facilitative Branch is, for example, responsible for all issues dealing with the supplementarity requirements to be fulfilled in the context of the Flexible Mechanisms.\footnote{UNFCCC (2005b), Decision 27, IV (5b)} This hints to the fact that the Protocol’s member countries rather tend to allow larger volumes of trading than initially conceived, which will necessarily increase the efficiency of emissions trading \textit{as a mechanism of allocation}. All issues of non-compliance to the reduction commitments and serious issues of false reporting are under the purview of the Enforcement Branch. As these are the issues that have the potential of affecting the efficiency of Kyoto’s carbon market \textit{as an institution}, the sanctions that can be imposed by the Enforcement Branch are of particular importance. If at the end of a commitment period an Annex I-party is not in compliance with its reduction target, it is granted 100 days to remedy to this situation, for example through the acquisition of the respective amount of Kyoto certificates. In cases of persisting non-compliance, the country is required to

\begin{itemize}
  \item \footnote{For further insights on this decomposition of effectiveness and the incentive for participation within climate policy agreements, see for example Boehringer (2003) or Lange (2006).}
  \item \footnote{UNFCCC (2002c), Decision 24}
  \item \footnote{UNFCCC (2005b), Decision 27}
  \item \footnote{UNFCCC (2005b), Decision 27, IX}
  \item \footnote{UNFCCC (2005b), Decision 27, IV (5b)}
\end{itemize}
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exceed its target for the next commitment period by the amount of the excess emissions multiplied by 1.3. The non-compliant country must then regularly inform the Enforcement Branch on its efforts to achieve compliance within a 'compliance plan'. As an additional sanction, the Enforcement Branch can also suspend the country’s eligibility to participate in the Kyoto Flexible Mechanisms, which means that all emission reductions would have to be achieved solely through domestic measures.

The Kyoto Protocol’s compliance system is acclaimed to be "among the most comprehensive and rigorous systems of compliance for a multilateral environmental agreement." While this assertion is undoubtedly true, the compliance mechanism has still been subject to some serious criticism. Firstly, the target-related sanction imposed by the Enforcement Branch represents, in a purely economic view, a facility for borrowing certificates from future periods with an interest rate to the amount of the penalty, i.e. 30 percent. This might, especially in cases with myopic decision makers, not be sufficient to completely deter governments from non-compliance. The validity of this argument is, however, questionable. A rational decision-maker would only accept to borrow certificates at an interest rate of 30 percent if he expects a strong decrease in marginal abatement costs in future periods. In such cases, however, borrowing from future periods does not decrease but increases the efficiency of the carbon market as theoretical considerations and the modeling literature have shown.

A second and more substantial criticism is the fact that the compliance mechanism currently implemented might increase the incentive for strategic behavior in the choice of the reduction target for the next commitment period. If the violator is to exceed his reduction target in the future commitment period by 1.3 times the excess emissions he might want to compensate for this penalty by insisting on a more generous emission allocation. However, the risk of strategic behavior is not limited to the current sanctioning mechanism but would also have to be accounted for within other possible schemes. In fact, any sanction that can be expressed in monetary terms could induce the non-compliant party to try to negotiate less stringent emission targets in order to compensate for the loss.

38 UNFCCC (2005b), Decision 27, XV (5)
39 UNFCCC (2007a)
40 See Hourcade and Ghersi (2002) for a similar argument. Hourcade and Ghersi plead for an inclusion of trade sanction as an additional mechanism for deterrence. However, it is unclear if this solution would violate WTO regulations.
41 This argument has to be qualified when facing decision makers expecting not to be re-elected in the subsequent legislative period.
42 See, for example, Godal and Klaassen (2006).
43 This critic has been expressed by Boehringer (2003). He further criticizes that the violator needs to agree to the imposed sanction, which would render the accord susceptible to renegotiation. (See also, Finus (2001)) This criticism seems, however, not applicable to the compliance procedure currently in place.
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It remains to be seen if the compliance regime is effective enough to enforce the Kyoto reduction targets and the associated emission rights. From a theoretical point of view, other compliance procedures might yield higher efficiency, but the existing regimes performed also reasonably well within various numerical simulations.\(^44\) Again, it is also to be noted that the compliance regime is, as it stands, the result of a political process. It might thus be argued that a stronger compliance mechanism was not politically feasible.

A significant particularity of the compliance regime is its dependence on the continuation of the Kyoto approach in the foreseeable future. The main sanction of the Kyoto system is the punitive overfulfillment of the subsequent target by 30 percent. This sanction will only have a deterrence effect if it can be reasonably expected that there will be a ‘next’ commitment period. As it is stressed within the literature on incomplete enforcement, a rational actor will discount the sanction by its probability of occurrence. Therefore, if the probability of a sanction in the future depends on the continuation of the Kyoto regime, the level of compliance will depend to a large part on the expectations with respect to the realization of the second commitment period. The validity of this argument is even to be extended beyond 2017. As the parties could also choose not to comply in the next commitment period, the expectations on the longer term are decisive. Theoretically, the given compliance mechanism would perform best if the Kyoto regime is perpetuated indefinitely. In all other cases end-game phenomena would reduce the incentive to comply. For this reason the following section will shortly digress on the future development of the international climate policy scheme.

1.2.6. Future Development

As explained above, the provisions of any ‘post-Kyoto’ regime would have a direct repercussion on the effectiveness of the current regulation. If such a new scheme failed to include a sanctioning mechanism for parties non-compliant in the last commitment period Kyoto’s effectiveness would be considerably reduced. This aspect is often neglected within the discussion on potential ‘post-Kyoto’ regimes. It might be suspected that this omission is in the interest of those parties that are currently projected to overshoot their targets in the first commitment period. It could also be argued that using the term ‘post-Kyoto’ represents a concession to the former US government which has positioned itself as being ‘anti-Kyoto’. In any case, the current discussion on future regulation might be better referred to as ‘post-2012’-talks as this reflects better the direction taken by the actual negotiations.

In recent years, the future of international climate policy has been the subject of several high-level meetings, e.g. the recent summits of the G8 or the UN. These talks, however, brought along little but some general declarations of intent.\(^45\) The negotiations within

\(^{44}\)See Godal and Klaassen (2006).

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the UNFCCC, being the intended forum for such talks, are more advanced in fathoming the possibilities for concrete steps. Indeed, while at the beginning of the post-2012 talks, "many negotiators" seemed "to be waiting on a possible new US administration in 2009 before looking for 'progress' there"\(^46\), the current development hints to the emergence of a consensus between the parties.

The negotiations within the last COPs/CMPs were marked by the differing positions of developed and developing countries with respect to the scope of commitments of each of these country groups. The Annex I-countries, including the USA, are reluctant to discuss further commitments for themselves before emerging economies have not agreed upon some some restrictions of their greenhouse gas emissions. These emerging economies, like China and India, in turn, would prefer the Annex I-countries to first commit to further reduction targets for the period after 2012. In order to increase the chances of a conclusive agreement, the negotiators agreed at COP11/CMP1 in Montreal to start two parallel processes sketching out the basis for future international climate policy agreements. The general idea of this two-track approach is to take advantage of the two-tiered structure of international agreements in the climate policy field by initiating parallel talks within both fora, the Convention as well as the Kyoto Protocol.

The first approach, the so-called Dialogue on Long-Term Cooperation Action to Address Climate Change by Enhancing Implementation of the Convention was established under the UNFCCC. Given that the Convention’s membership is almost universal, this Dialogue provides a suitable platform for discussion of next steps in the international effort. For that reason this Dialogue is informally referred to as 'UNFCCC-track' toward a post-2012 agreement. As the USA are a member to the Convention but not to the Protocol, the launch of the Dialogue reflects the recognition that the current Annex B-countries are not likely to accept new targets without a stronger inclusion of the USA, as well as the larger emerging economies. The Dialogue is an open exchange insofar as it is laid-out to "be undertaken without prejudice to any future negotiations, commitments, process, framework or mandate under the Convention"\(^47\). As a consequence, its main objective is to provide a forum to those countries reluctant to take on mandatory reduction targets.

As it presented itself at COP13 in Bali, the UNFCCC track focuses on the four issues adaptation, mitigation, technology transfer, and financing. During the negotiations, the most important point of disaccord was the mitigation section, where disagreement between developing and developed countries became apparent.\(^48\) After a heated debate the Convention’s parties agreed "to launch a comprehensive process [...] addressing [...] nationally appropriate mitigation actions by developing country parties in the context of

\(^{46}\)IISD (2006), p. 20
\(^{47}\)UNFCCC (2006a), IV, paragraph 54
\(^{48}\)See for example Michaelowa and Wucke (2007).
sustainable development, supported by technology and enabled by finance and capacity building in a measurable, reportable and verifiable manner.”

Within a second approach, parallel negotiations have been initiated between the members to the Kyoto Protocol. As required by article 3.9 of the Protocol the negotiations on the developed country commitments for the second commitment period have started within the so-called ‘Ad Hoc Working Group on Further Commitments for Annex I Parties (AWG)’. This approach is also informally known as ‘Kyoto track’. The stated objective of these negotiations is "ensure that there is no gap between the first and the second commitment periods under the Kyoto Protocol”.

Furthermore, contrary to the more or less arbitrarily defined current targets, the targets for the second commitment period are supposed to be based on scientific findings with respect to emission reduction paths leading to a stabilization of greenhouse gas concentrations in the atmosphere. Hence, referring to the IPCC’s Fourth Assessment Report, the AWG notes that global emissions must be reduced to "well below half of levels in 2000". This statement, in turn, is judged by many observers as an implicit recognition with respect to the necessity of developing country commitments.

At Bali, in December 2007, the Kyoto Parties agreed informally on a target corridor of 25-40 percent emission reduction from 1990 to 2020.

The two-track approach currently used in the international climate policy negotiations, showcases the advantages of the two-tiered framework for negotiation, i.e. a soft-law framework convention on which a hard-law protocol is based. By using this two-track approach all relevant parties, particularly the US, can be reintroduced into the negotiations on future Climate Policy regimes, without endangering the achievements made within the Kyoto Protocol so far. While it is difficult to make any predictions on the actual outcome of the ongoing negotiations, it might well be that both tracks lead to the same formal agreement. As Article 9 calls for a periodical review of the Protocol, the outcome of the UNFCCC track could also be integrated into the Kyoto Protocol. Thus, returning to the initially discussed questions, the ’post-2012’ regime does not necessarily mean to be ‘post-Kyoto’.

Whatever its name may be in the future, it is quite certain that—given the fact that the current regulative framework is essentially built ‘from scratch’—a large part of the Kyoto rules will need refinement based on the learnings in the years to come. As has been laid out above, the UNFCCC and its Kyoto Protocol are designed to account for such refinements by allowing specifications of the different rules to be decided by the majority of the parties. Hence, as far as the academic discussion is concerned, it might be more realistic to consider the Kyoto rules as a continuously evolving institutional

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49 UNFCCC (2007e), Decision 1
50 UNFCCC (2006b), paragraph 24
51 UNFCCC (2006b), paragraph 16
52 See, for example Pew Center (2006) or IISD (2006).
53 See for example Michaelowa and Wücke (2007).
framework and not as a one-shot game, as some of its critics seem to perceive it.\footnote{See, for example, Nordhaus and Boyer (2000) or McKibbin and Wilcoxen (2004).} This is particularly true for the different emissions trading mechanisms that will be discussed in the following section.

### 1.3. Kyoto Market Mechanisms

Probably the most innovative aspect of the Kyoto negotiations was the idea to enable Annex I-parties to meet their commitments by acquiring securitized rights representing greenhouse gas reductions in other countries. The inclusion of the different market mechanisms is likely to significantly reduce the cost of the Kyoto Protocol, as it enables the reduction of greenhouse gases in those countries with the lowest marginal abatement cost. Thus, the so-called ‘where’-flexibility, i.e. the spatial efficiency of the Kyoto provisions, increases considerably with the Kyoto market mechanisms. For this reason, the different market-based instruments implemented within the Protocol are also referred to as Flexible Mechanisms.

While the Protocol is the first international environmental agreement to introduce permit trading systems, the overall idea is not new to the economist. In fact, the conceptual idea behind emissions trading was already stated in Coase (1960), who noted that externalities are reciprocal in nature and that an internalization might, hence, be accomplished just as efficiently by a market as by more direct forms of state regulation. The first theoretical applications of this fundamental concept to an environmental problem have been elaborated by Dales (1968) and Montgomery (1972). Actual applications of this concept within national environmental policies are still rare, which is likely to change with a successful implementation of the Kyoto Flexible Mechanisms.\footnote{The implementation of the EU Emissions Trading System can, for example, interpreted as a direct extension of the Kyoto markets to the company level.}

In the early stage of the Kyoto negotiations, the inclusion of emissions trading in the Protocol was strongly supported by the United States, which had positive experience with such schemes under the Clean Air Act Amendments.\footnote{See Leaf et al. (2003).} In light of the fact that the Protocol’s major traits were shaped by the US proposals, the country’s refusal to ratify the agreement bears hence some irony.\footnote{David Doniger, a former Kyoto treaty negotiator, comments the situation as follows: “The system is made in America, and the Americans aren’t part of it.” (cited in Pohl (2003))} Interestingly, during the negotiations the inclusion of emissions trading was strongly opposed by many parties, particularly China and the Group of 77 developing countries. These countries were mainly concerned about issues of sovereignty and feared a ‘buy-out’ of low-cost emission reduction potentials which would be unavailable in future periods where developing countries would be obliged into binding agreements as well. Another criticism was brought forward by environmentalist groups who had ethical concerns about emissions trading resembling the
sale of indulgences by the catholic church in the early sixteenth century.\textsuperscript{58} Within the
negotiations these concerns were taken into account by the supplementarity provisions
of the Protocol, requiring the Annex I-parties to achieve the largest share of emission
reductions through domestic actions.\textsuperscript{59} The softening of these conditions within the
Marrakech Accords can also be interpreted as an increase in general acceptance of the
principle of emissions trading.

The Kyoto Protocol’s division of the world into Annex I-countries with reduction
commitments and non-Annex I-countries without such commitments renders a unified
system of permit trading impossible. Instead, to include all parties into the system
and yield a high level of ‘where’-flexibility, the Protocol includes three different forms
of market mechanisms: the Kyoto Emissions Trading, Joint Implementation, and the
Clean Development Mechanism. The main focus of the analytical second part of this
thesis is laid on the Clean Development Mechanism. Yet, many aspects of this mechan-
anism can only be understood in the greater context of the general principles guiding
all Kyoto mechanisms. In a reference to the metaphor of the ‘institutional cascade’, the
overall emissions trading framework is, thus, to be presented first. Therefore, in the
following subsections, the different market mechanisms and the principal institutions for
the exchange of securitized emission rights will be shortly presented.

1.3.1. Emissions Trading under Kyoto

Article 17 of the Kyoto Protocol establishes the possibility for trading of emission rights
between Annex I-countries. This system, subsequently referred to as \textit{Kyoto Emissions
Trading}, is the mechanism that is closest to the original idea of an exchange in emis-
sion permits. As Annex I-countries have set individual emission reduction targets, the
definition of emission rights as a tradable good is straightforward. The defined emission
ceilings for these countries can easily be interpreted as allocating emission rights to the
Annex I-countries. Hence, each country ‘owns’ the right to emit a specific amount of
greenhouse gases.\textsuperscript{60} These rights are divided into units—each equal to one tonne of
carbon dioxide equivalent—and securitized under the name of \textit{Assigned Amount Units
(AAUs)}\textsuperscript{61}. As constituted in Article 17 of the Kyoto Protocol, the Annex B-parties can

\textsuperscript{58}For this line of argumentation, see, for example, The Economist (2006).
\textsuperscript{59}See Sands (2003).
\textsuperscript{60}It is to mention that the Marrakesh Accords recognize that "the Kyoto Protocol has not created
or bestowed any right, title or entitlement to emissions of any kind on Parties included in Annex
I"(UNFCCC (2002b), decision 15). Hence, in a strictly legal sense, the emission targets do not
define property rights for greenhouse gas emissions. From an economics point of view, however, the
emission allowances must be interpreted as property rights, because the Kyoto framework clearly
defines emission quantities and enforces the attributed emission reductions within its compliance
mechanism. For a more thorough, but critical, exposition of this interpretation, see Cooper (2001).
\textsuperscript{61}UNFCCC (2002b), Annex 1, 1(c)
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trade the AAU in accordance to their needs with respect to carbon offsets. Article 17 of the Kyoto Protocol restricts the participants within this emissions trading scheme to "the parties included in Annex B". As a consequence, at least within the Kyoto Emissions Trading framework, only governments of the Annex B-countries can participate in the exchange of AAUs. As it is up to the national governments to transform their commitments into sensible domestic reduction schemes, a transformation into tradable reduction units for trade on the company level is possible. The European Union’s Emissions Trading System (EU ETS), for example, allocates emission rights to companies within specific sectors that can be traded on a company-level EU market for such certificates.

Figure 1.2 shows the basic principle of Kyoto Emissions Trading for a two-country world. In this figure the actual emissions of country 1 are projected to exceed its emission target. Country 2, on the other hand, will ‘over-perform’, i.e. its actual emissions are smaller than the target it agreed to within the Kyoto Protocol. Hence, as the AAUs are tradable, country 2 can sell its excess quantity of GHG offsets to country 1. As a consequence, both countries are able to meet their targets.

![Figure 1.2: The principle of the Kyoto Emissions Trading in a two-country-world](image)

The Kyoto Emissions Trading system is a typical example of the so-called ‘cap and trade’-systems, i.e. there exists a specific ceiling for emissions defined for each trading partner. Consequently, the overall emissions within the system are equal to the sum of these individual targets, i.e. the overall emissions are ‘capped’ as well. It is this restriction of emissions that transforms the reduction of emissions into a scarce and valuable good. As the allowed emissions are securitized, it is possible to trade the emission reductions in the form of certified emission rights.
The economic intuition behind such a ‘cap and trade’-system, like the Kyoto Emissions Trading, is depicted in Figure 1.3. The figure shows the marginal abatement costs (MACs) of two different countries in relation to different levels of emission reduction. For both countries the emissions cap, that is the reduction target, is represented by a vertical line. Without trade, both countries’ reduction costs for meeting their individual target correspond to the area that is limited by the reduction target line and the MAC curve. Hence, if country 1 is to meet its target by applying only domestic measures, its costs are higher than the costs of country 2. Thus, figure 1.3 shows a similar situation as figure 1.2 with country 1 being a potential buyer of emission rights, while country 2 represents a seller. With unlimited trade, country 2 would reduce more emissions than necessary to meet its Kyoto commitment. In a world with perfect competition, as depicted in figure 1.3, the excess reduction is determined by the price that can be achieved on the market. Country 2 would then increase its emission reductions up to the point where its MACs are equal to the market price of one unit of GHG reduction. For country 1, the situation is reversed. It would reduce its emission reduction measures to the point where its MACs equal the price of one emission reduction unit. The gray area depicted in the left diagram shows the cost reduction that country 1 can achieve by buying the respective amount from country 2. The gray area in the right diagram represents the gains from trade for country 2. Hence the overall efficiency gain from trade is represented by the sum of both of these gray areas. Note that under the assumption of perfect competition, the marginal abatement costs will be equal when all potential trading has taken place.

Figure 1.3.: An efficient emissions trading market in a two-country-model

The efficiency gains from the Kyoto emissions trading system are likely to be very large. Nordhaus (2005), for example, reports model results for the hypothetic case that the first commitment period is extended until 2100. In this case the accumulated abatement
cost estimates without any trade amount to about 12 trillion USD. Annex I-trading reduces these costs by more than half to less than 6 trillion USD. However, it is often argued that under the realistic assumption of uncertainty, other policy instruments—like a global carbon tax—might dominate emissions trading markets with respect to efficiency. Given the structure of the uncertainty on damages and abatement costs it is likely that a global carbon tax would be—at least under full enforcement—more efficient. The assumption of full enforcement is however highly problematic, as a tax system would generate a plethora of new control problems. Countries could for example, reduce the incentive effect of a carbon tax by reducing other taxes on fossil fuels or by subsidizing carbon-intensive industries. In contrast, within an emissions trading scheme the problem of limited enforcement is likely to be less imminent.

The most important advantage of the Kyoto emissions trading approach lies, once more, in the field of political feasibility. The efficient global carbon tax would require a mechanism of considerable open side payments to be politically acceptable to countries that are less interested in climate policy. These side payments, in turn, would be directly visible to the voter of the ‘donor countries’. Within the Kyoto approach, the mutual concessions are implicit to the different levels in reduction targets and hence less visible. Another advantage lies in the fact that the initial allocation of Assigned Amount Units for Annex I-countries is basically free of charge. Hence, the country would only have to pay the permit price for its excess emissions and might even be capable to gain some of the scarcity rent in the future. A global tax, in contrast, would be levied on every unit of carbon emitted. Thus, this difference in the distribution of rents makes it more likely that large emitters prefer the emissions trading scheme over the carbon tax.

The same argument might be brought forward on the level of CO₂-intensive industries within countries. In this case, the logic of economic rent-seeking would lead to increased lobbying activities in favor of emissions trading and against a carbon tax. Thus, given the restrictions of political feasibility and the enforceability of a global carbon tax, the Kyoto approach based on emissions trading seems more likely to persist in the future.

Certified emission permits can not only be generated within a cap-and-trade system but also by implementing specific projects for emission reductions. Within the Kyoto framework two such mechanisms are implemented. Both, Joint Implementation and the Clean Development Mechanism generate certificates stemming from reduction or sink projects and are thus also attractive to the corporate world.

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62 The basic argument used in this context stems from Weitzman (1974). Newell and Pizer (2003) and Hoel and Karp (2002) have extended Weitzman’s framework to include the specificities of stock pollutants accumulating over time. Both studies also include an analysis of the specific case of the greenhouse effect and find that—under the standard assumptions of climate economics—a global carbon tax would be more efficient than emissions trading.

63 See Boehringer (2003).

64 See Ellerman (2005).

65 On this issue, see also Hepburn (2007).
1. The Kyoto Protocol and its Emissions Trading Framework

1.3.2. Joint Implementation

The mechanism of Joint Implementation (JI), stipulated in Article 6 of the Kyoto Protocol, has been introduced during the negotiations of the Protocol to further increase the ‘where-flexibility’ of the international climate policy regime and achieve additional cost reductions.\(^{66}\) Article 6 provides that, any Annex I-party may transfer to, or acquire from any other Annex I-party ”emission reduction credits resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of greenhouse gases in any sector of the economy”\(^{67}\).

Projects under Joint Implementation generate a specific kind of certificates, the so-called Emission Reduction Units (ERUs), one unit of which represents a carbon offset of one tonne of CO\(_2\)e. However, a JI project only generates certificates if the associated emission reductions are additional, i.e. it has to be proven that the reduction would not have occurred if the project had not been realized. Furthermore, the government of an Annex I-country can authorize private legal entities, like companies, to participate within the JI. For such cases, the liability for the proper implementation of the formal JI requirements lies within the responsibility of governments of the countries involved in the transaction. As already mentioned, the inclusion of market mechanisms has met some resistance during the negotiations of the Protocol. This led to the specification that offsets stemming from JI are to be regarded as ”supplemental” meaning that the main share of emission reductions are to be achieved by domestic actions.\(^{68}\)

The basic mode of operation of the JI is depicted in figure 1.4. The legal basis for a specific JI project is the agreement between the governments or companies of two Annex I-countries. In the case represented here, the agreement implies that the agent from country 1 provides the investment of a reduction project situated in country 2. Such a project might, for example, involve investments leading to the reduction of the CO\(_2\)-intensity of a cement factory plant by employing more recent technology.\(^{69}\) The agent in country 2 (representing the host country in figure 1.4) agrees to implement the project. After the realization of the investments, the respective emission reductions are being monitored and verified by an independent verifier. The project the enters the certification process, at the end of which a amount of ERUs, corresponding to the

\(^{66}\)In the early years of the negotiations, i.e. before 1998, the term ‘joint implementation’ was often used to describe any kind of (financial) cooperation between countries leading to transferable certified emission reductions. In the current literature the term is exclusively used to refer to the specific mechanism stipulated in Article 6 of the Protocol. This convention is adopted in the current text as well.

\(^{67}\)Kyoto Protocol (1997), Article 6 (1)

\(^{68}\)Kyoto Protocol (1997), Article 6 (1d)

\(^{69}\)The first JI project has been approved on March 29, 2007. It is situated within the Podilsky cement factory in the Ukraine. By substituting the current clinker production by processes that reduce the energy consumption by 53 percent, the project is projected to reduce 3 million tonnes of CO\(_2\) equivalents within the first commitment period. For a detailed description of the project, see de Klerk (2007).
realized reductions, are issued. The generated ERUs are then transferred to the project investor in accordance with the initial agreement.

![Diagram of Joint Implementation in principle](image)

Figure 1.4.: Joint Implementation in principle

With further development of the carbon market, another structure for the JI, the so-called unilateral projects, might become more frequent. JI projects are considered as unilateral if project investor and project developer are either identical or both based within the host country. The generated ERUs are then sold on the secondary carbon market.\(^{70}\)

### 1.3.3. Clean Development Mechanism

The Clean Development Mechanism (CDM), defined by Article 12 of the Kyoto Protocol, represents a second project-based market mechanism that allows Annex I-countries to finance emission reduction or forestry projects within non-Annex I-countries. CDM emission reduction projects generate a specific form of carbon offsets, the so-called Certified Emission Reductions (CERs).\(^{71}\) In order to keep the CDM market in consistence with the other mechanisms, one unit of CERs can be used to offset one tonne of \(CO_2\) equivalents of emissions within an Annex I-country.

\(^{70}\)In general, unilateral JI projects are not different from unilateral CDM projects, the structure of which is described in the next chapter. A more detailed description of the processes required for a JI project is beyond the scope of this thesis. A large part of the necessary procedures resemble to simplified versions of the ones depicted for the CDM in section 2.

\(^{71}\)Due to the non-permanence of carbon sinks, the rules for forestry CDM are different. See section 2.4.2 for an exposition of the specificities of afforestation and reforestation within the CDM.
The group of potential host countries, i.e. the Non-Annex I-parties, consists exclusively of countries situated in the developing world. Hence, along with the objective of generating cost-efficient carbon offsets, the CDM is supposed to serve a second purpose which is "to assist parties not included in Annex I in achieving sustainable development." The basic idea behind this secondary objective of the Clean Development Mechanism is the transfer of ‘cleaner’ technologies being less intensive on greenhouse gas emissions per unit of output to countries of the developing world. The relative importance attributed to this secondary objective is also reflected in the name of the mechanism.

As depicted in Figure 1.5 the general principle of the CDM is almost identical to Joint Implementation. The most important difference is that CDM projects are situated in developing countries. As with JI, the CDM project investor being a government of or a legal entity situated in an Annex I-country (partially) finances a CDM project to be implemented in the host country. The project developer in the host country can also be either its government or a legal entity. The resulting offsets are being monitored and then verified by an independent verifier, the so-called Designated Operating Entity (DOE). The resulting CERs are then issued according to the reported and verified offsets. These CERs are then handed over to the project investor in accordance to the initial agreement.

![Figure 1.5.: The CDM in principle](image)

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72 Kyoto Protocol (1997), Article 12(2)
73 The possibility of the involvement of the private sector within the CDM is explicitly stipulated in Art. 12(9) of the Kyoto Protocol.
1. The Kyoto Protocol and its Emissions Trading Framework

In parallel to the above-depicted mode of operation, there is the possibility for unilateral CDM projects, where project investor and project developer are based within the non-Annex I-country. In these cases the resulting CERs are being sold on the secondary market for certificates in order to finance the project.\(^\text{74}\) Just as for the two other Flexible Mechanisms, offsets stemming from CDM are formally to be considered as 'supplemental' to the domestic reduction efforts of Annex I-countries. Without such a restriction and under the assumption of low transaction costs, implementing the CDM would resemble a system of unrestricted trading across all Kyoto-parties, i.e. Annex I-countries as well as non-Annex I-countries. For such a system large efficiency gains are likely to occur. The estimates of the accumulated abatement costs in Nordhaus (2005) for a worldwide trading scheme fall to about 1.6 trillion USD, compared to 12 trillion USD in the no trading case. Thus, while transaction costs and the supplementarity condition reduce the efficiency of overall Kyoto trading, it is still to be expected that the CDM will significantly lower the overall cost of the Kyoto regulations.

Concluding our short account of the Kyoto markets, it is to be emphasized that emissions trading markets in general, and the Kyoto mechanisms in particular, do not represent a mechanism to fully internalize an externality in the sense of the Coasian bargaining solution. As mentioned earlier, the emission targets of the different countries do not result from scientific considerations on a specific target concentration of greenhouse gases in the atmosphere. The Kyoto targets are rather the result of political negotiations reflecting a compromise on the underlying distributional issues. In such a context, markets for emission rights can only serve the more limited function of achieving cost-efficiently a pre-specified emission level.\(^\text{75}\) The remainder of this section is to give a short overview over the set of institutions that are to guarantee a smooth functioning of the Kyoto carbon markets as a whole.

1.3.4. Kyoto Registry System

The Kyoto carbon market can only work smoothly if the sales and acquisitions of the different certificates are tracked and verified. To fulfill this function the Kyoto System includes, similar to stock exchanges or other market places for securitized assets, a registry system. Registries record the holdings of the different Kyoto units for all market participants within a structure of accounts. Furthermore, the registry system performs the function of 'settling' emissions trades by booking units from the accounts of sellers to those of buyers. Hence, the Kyoto registries form the infrastructural backbone for the carbon market and provide the necessary information to determine the status of compliance for every Annex I-party at the end of each commitment period.

\(^{74}\) The different possible control structures for CDM projects are described in section 4.1.

\(^{75}\) This was already pointed out by Montgomery (1972) who was one of the first to bring forward the idea of emissions trading.
After the expiration of the commitment period, the check to ensure that Annex I-parties are in compliance with their emission targets will take place by comparing each party’s emissions during the commitment period with their holdings of the different certificates. The mode of operation of the Registry system has been set up within the Marrakech Accords at COP7 and were confirmed at the first Meeting of the Parties in Montreal. The Registry System consists essentially of three different components: The National Registries, the International Transaction Log, and the CDM Registry.

**National Registries:** Each Annex I-party to the Protocol has to establish a National Registry that contains accounts for the holdings of ERUs, CERs, and AAUs of the party itself as well as of any legal entity authorized by the party to participate within the market mechanisms. This registry must also contain accounts for setting units aside for compliance purposes (retirement) and removing units from the system (cancellation). Purely domestic transfers and acquisitions are settled between the sub-accounts of the respective National Registry. Transfers from or to other Annex I-parties are booked accordingly within the different National Registries involved. The implementation of a National Registry takes the form of a standardized electronic database. All registries are interconnected through a global network architecture, which is to ensure the accurate and transparent exchange of data between National Registries.

**CDM Registry:** As the certificates stemming from CDM projects are not generated within Annex I-countries, National Registries are not suitable to account for newly issued CERs. Hence, the so-called CDM Registry was put in place, which includes a system of accounts for non-Annex I-parties. The CDM Registry is under the responsibility of the CDM Executive Board and administered by the UNFCCC secretariat. All CDM host countries as well as each authorized legal entity within these countries need to have a permanent holding account at the CDM Registry. This account contains the CERs that have been recently issued to the respective party. The CDM Registry is connected to all National Registries via a secured global network. Hence, as soon as the host country sells CDM certificates to an Annex I-country, the respective amount of CERs is booked from the CDM Registry into the buyer’s National Registry. An important function of the CDM Registry is to guarantee the traceability of the different CERs. To ensure this, each CER has a unique serial number and can only be held in one account at a given time. Furthermore, the transaction history of each unit of CERs can be unambiguously

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76 See UNFCCC (2007c).
77 UNFCCC (2005b), p. 28, paragraph 19
78 CDM Executive Board (2004), sub-item 3(d)
79 Entities authorized to participate in a CDM project activity like companies can also apply for a temporary holding account in the CDM registry. (UNFCCC (2005b) p. 27, paragraph 5)
80 UNFCCC (2005b), p. 27, paragraph 4
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retraced by use of unique account numbers, which comprise also a party/organization identifier.\textsuperscript{81}

**International Transaction Log:** All transactions within the National Registries and the CDM Registry are recorded through the International Transaction Log (ITL), which is established and maintained by the UNFCCC secretariat. Similar to the registries the ITL is implemented in the form of a standardized electronic database. The principal function of the ITL is to verify the validity of transactions of ERUs, CERs, and AAUs as they are proposed by the Annex I-countries. The ITL double-checks all transactions proposed by registries to ensure they are consistent with rules agreed under the Kyoto Protocol. This validity check includes all phases in the lifecycle of certificates, i.e. their issuance, transfer and acquisition, as well as their cancellation and retirement. If a transaction is found not to be in order, the respective registry is required to stop the transaction.\textsuperscript{82}

The interconnections for processing transaction data between the different components of the registry system are represented in figure 1.6. All transactions between or within registries are interconnected, which also ensures the real-time logging through the ITL. The general process for a transaction is as follows. Each registry sends proposals for transactions to the ITL. The ITL checks each proposal and returns to the registry its approval or rejection.\textsuperscript{83} If the transaction is validated the respective accounting entries are made in all registries involved. In the event that a transaction is rejected, the ITL indicates which ITL check has failed and the involved registries are required to terminate the transaction. Such a termination implies that the certificates involved are invalid for their intended use. After the Kyoto commitment period is finished, the end status of the unit holdings for each Annex I-party will be compared with the party’s emissions over the commitment period in order to assess whether it has complied with its emission target under the Kyoto Protocol.

In summary, it can be stated that the registry system assures that all Kyoto units remain attributable to a single holder and can be traced to their point of origin. As far as incentive problems are concerned this is of major importance, because the possibilities for opportunistic behavior within the international accounting system seem to be minimized. Thus, on the level of the market place the quality and homogeneity of the good ‘carbon offsets’ is guaranteed. The main problems of opportunism will rather occur on the level of verification and enforcement, being addressed in more detail in the following chapters.

\textsuperscript{81}UNFCCC (2005b) p. 27, paragraph 5
\textsuperscript{82}UNFCCC (2005b), paragraph 38, and paragraphs 55-56
\textsuperscript{83}Within this process the ITL checks for a plethora of possible inconsistencies. This includes all important checks with respect to the eligibility and limits of CERs or temporary CERs, as described in sections 1.4.1 and 2.1.2. (UNFCCC (2005b), p. 31 paragraph 42)
1.4. Kyoto Markets and Institutional Interactions

Generally, markets under perfect competition are the allocative mechanism preferred by economists, because—ideally—scarce resources are attributed to those utilizations that generate the largest value or utility for society. Herein lies the advantage of the Kyoto Flexible Mechanisms in comparison to potential regulations based on 'command-and-control' regulations. Stipulating different standards for emissions, such that the efficient level is attained for all emitters, would require an enormous amount of information with respect to costs and preferences of all actors involved. As this is generally beyond the capacity of governmental control, emission standards can be considered as being—in most cases—inefficient. In contrast, with the creation of a market for emission rights the allowances are re-allocated to the highest-value utilization simply by the interaction of supply and demand. The coordination of the final allocation is left to the decentralized mechanism of the market. Hence, from the point of view of Marshallian microeconomics, the role of the climate policy makers is reduced to the choice of the overall level of emissions.

Going beyond the neoclassical notion of 'the market', it becomes clear that the Flexible Mechanisms differ from the standard market model in several respects. In fact, the
efficiency of the Kyoto emissions trading framework crucially depends on the institutional framework laid out above. Given that emission rights and carbon offset certificates are in principle an artifact—created through climate policy—the different institutional interactions pre-determine the achievable level of efficiency gains. In the following, we describe the most important of these interactions within the above-presented upper tiers of the institutional cascade and establish the connection to the CDM-specific provisions presented in the subsequent chapter.

1.4.1. Emission Rights as a Commodity

Within economics, it is generally accepted that the most important prerequisite for a market system to function is the proper definition of property rights.\(^\text{84}\) Obviously, the interplay of demand and supply will only yield efficient results if the decentralized decision makers have incentives strong enough for them to take efficient decisions. Hence, buyers and sellers need to have a stake in the transaction, which is guaranteed with the transferability of a bundle of rights defined with respect to the usage of a resource.\(^\text{85}\) Within an emissions trading system the transferable right consists, in principle, of the right to emit a specific amount of a particular substance.

The commodity traded within the Kyoto Emissions Trading regime is the Assigned Amount Unit, which "is equal to one metric tonne of carbon dioxide equivalent, calculated using global warming potentials"\(^\text{86}\). The other Kyoto certificates, like ERUs and CERs, are defined accordingly, representing each the reduction or absorption of one tonne of \(\text{CO}_2\) equivalents. Hence, to put it simply, all certificates are associated with a right that entitles an Annex I-party to offset the respective amount of its own greenhouse gas emissions. As the legal object associated with this right is sufficiently specified, Kyoto certificates surely represent—in their securitized form—transferable property rights.\(^\text{87}\)

However, in order to ensure that Kyoto certificates represent a scarce—and thus valued—commodity, this scarcity needs to be induced through regulation. In this context, the most important provision is the mere existence of reduction commitments of the industrialized countries. Indeed, the scarcity of Kyoto certificates is created through the fact that Assigned Amount Units for Annex I-countries are not abundant. In the absence of the Clean Development Mechanism, the aggregated Annex I-country emissions would have to equal the sum of the Kyoto emission targets.

\(^{84}\)See, for example, Eucken (1952), Nutter (1968), or Alchian and Demsetz (1973). Furubotn and Richter (2005) provide a good overview over the whole discussion on markets and property rights.

\(^{85}\)However, in a modern society with a higher degree of division of labor, a plethora of potential agency problems can exist, that might reduce the efficiency of actual decisions. We will turn to this problem in the context of CDM in the second part of this thesis.

\(^{86}\)UNFCCC (2002b), Decision 18, Annex 1, 1

\(^{87}\)For a more thorough explanation of tradable permits as a commodity and the associated requirements to the emissions trading regime, see Ellerman (2005).
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The different Annex I-countries’ reduction targets also play a decisive role with respect to the distribution of the scarcity rent. In fact, the initial allocation of the Assigned Amount Units through the Kyoto provisions represents a form of ‘Grandfathering’, i.e. the permits are, de facto, attributed freely to the Annex I-countries. As a consequence, countries and sectors using CO₂-intensive production technologies face a lower extraction of rents than with other instruments yielding a similar level of reduction, like emission taxes or auctioned emission permits. Moreover, as the commitments to reduce emissions vary across the different Annex I-parties, the expected net gains from trade in emission rights will also vary. Thus, through the asymmetries in the attribution of AAUs, the Kyoto Agreement includes in fact an indirect mechanism for side payments. This additional potential for mutual concessions might also have contributed to the successful conclusion of the Kyoto negotiations, despite all the drawbacks encountered along the process.

The primary indicator for the intensity of the artificially created scarcity in emission rights is the certificate price on the inter-country Kyoto Emissions Trading market. This is an important insight for the analysis of the Protocol’s project-based mechanisms, in particular the Clean Development Mechanism. In fact, the only reason for which CDM certificates have a value is that they represent a substitute for the AAUs traded within the Kyoto Emissions Trading System. This is due to the fact that Certified Emission Rights and the certificates stemming from the other flexible mechanisms are fully fungible, i.e. a specific amount of certificates from one mechanism is capable of offsetting as many GHG emissions as the same amount of certificates stemming from any other mechanism. This principle, often referred to in the catchy phrase ‘a tonne is a tonne’, is supposed to ensure a maximum of ‘where-flexibility’ within the Kyoto system.88

The principle of fungibility does, however, not imply that the different certificates can be considered as perfect substitutes. In fact, some Kyoto rules are likely to limit the full interchangeability of the certificates. For example, in order to deter large levels of non-compliance, the so-called ‘commitment period reserve rule’ limits the amount of Assigned Amount Units tradable by a country within the Kyoto Emissions Trading System. According to this rule, an Annex I-country has to keep a reserve of quotas equal to at least 90 percent of its assigned amount or the full amount of its most recent emissions inventory, whichever is lowest.89 There are also limits to the use of CERs to offset country emissions. As already mentioned, offsets stemming from non-domestic projects are supposed to be supplemental to domestic efforts. This represents a de facto quantity restriction for CERs, which is likely to have an influence on the price differentiation

88 A single unit of any Kyoto certificate represents a metric ‘tonne’ of CO₂ equivalents (UNFCCC (2002b), Annex 1, 1) that corresponds exactly to 1000 kg. A metric tonne should not be confounded with the unit ‘ton’ used in the USA, which corresponds to 907.18474 kg.
89 UNFCCC (2001), Decision 5, Article 17
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between the different Kyoto certificates. Furthermore, the use of certificates from the particularly cost-effective forestry projects are subject to an additional restriction. On average the credits stemming from such activities can only be used up to an amount of 1 percent of the a country’s base year emissions to meet the Kyoto targets. For the yet immature market, it is likely that these influences on the price are still negligible, as the overall market volume for CERs is still comparatively small.

1.4.2. Measurability and Enforceability

Given their artificial nature, AAUs will only be positively valued if the reduction targets are compared to the actual emissions of the Annex-I parties. It is only by the fact that there exists a difference between actual emissions and the Assigned Amounts that a transfer in emission rights becomes economically sensible for the single actor on the market. Hence, in order to give a meaning and a value to the emission rights, the accounting and reporting system presented in section 1.2.3 plays a crucial role. In practice, there are varying degrees of measurement uncertainty for different greenhouse gases within various sectors as well as a plethora of potential systematic errors in the estimation. The single unit of emission reduction—which is the underlying commodity to a Kyoto certificate—might hence not be as homogeneous as often perceived. As a consequence, opportunistic or non-deliberate misrepresentation of emission data could lead to a significant distortion of the market, which would reduce its allocational efficiency. In this view, the homogenized accounting and reporting rules of the Kyoto Protocol are not only a necessity for the achievement of the Kyoto reduction commitments as a whole, but also for the smooth and cost-efficient functioning of the different emissions trading markets.

Furthermore, markets can only fulfill their allocative function if the property rights to the exchanged goods are enforced by the sovereign. In the context of Kyoto Emissions Trading, this enforcement is associated with the compliance to the Protocol by the Annex I-countries. In fact, a 'right to emit' is only meaningful if emissions that are not backed by such a right are subject to a sanction. If non-compliant parties were not sanctioned at all, the ownership of emission rights would not generate any additional value and emissions trading markets would become obsolete. Consequently, the allocative efficiency of emissions trading does directly depend on the effectiveness of the Kyoto compliance system. The Kyoto compliance system, as described in section 1.2.5, depends to a large part on the continuation of the Kyoto approach. This is due to the fact that the main instrument of punishment within the Kyoto compliance regime is the obligation to reduce

90 This will also hold for the firm-level oriented EU ETS. The EU 'Linking Directive' directly translates the supplementarity conditions of different the EU member countries into a restriction for the firm’s carbon portfolios. See EU (2004).
91 See UNFCCC (2005b), decision 16, paragraph 14.
92 For an analysis of the different restrictions on carbon trading in general see Godal and Klaassen (2006).
an amount of 1.3 times the excess emissions in the following commitment period. While in comparison with other international agreements, this punishment is comparably strict, it remains to be seen if its deterrence effect is sufficiently large.

1.4.3. Consequences for the Design of the CDM

In light of the arguments laid out above, it is quite obvious that the Clean Development Mechanism is dependent on the general Kyoto provisions depicted in this chapter. Clearly, the effectiveness of the Clean Development Mechanism in fostering abatement projects in developing countries is dependent on the demand for Certified Emission Rights. As this demand is triggered by the scarcity of AAUs, there will only be a positive willingness to pay for CDM certificates if Annex I-countries have reduction targets stringent enough to trigger a demand for carbon offsets. The perceived stringency of these targets, in turn, depends on the effectiveness of the compliance mechanism for the Protocol as a whole. The weaknesses of this causal chain, however, directly translate into potential problems on the level of the CDM.

First, the enforceability of adherence to the Kyoto targets is only guaranteed if the Kyoto approach is continued over an indefinite time horizon. Consequently, the amount of investments within the CDM is also dependent on the expectations with respect to the future of the international climate policy regime. The currently persisting uncertainty on the future international regulation affects CDM contracts over larger time-spans, for which the determination of a rationally justifiable price is nearly impossible. Hence, up to the present, there exists only a small amount of future contracts on CDM certificates beyond the end of the first commitment period.\(^{93}\)

Second, as the most important sanction within the Kyoto compliance mechanism is related to the emission reduction target, this sanction cannot be imposed on CDM host countries. As will be argued in the following chapters, this lack in enforceability has decisively influenced the design of the Clean Development Mechanism. For example, the liability for replacing invalidated certificates was attributed to the buyer, which is of particular importance for CDM Forestry projects.\(^{94}\) Furthermore, as collusion between host country and project developer cannot be deterred, the former cannot be attributed supervisory power over the latter. This engenders additional problems with respect to the definition and enforcement of Certified Emission Rights. Yet, in order to guarantee a certain level of effectiveness, the Mechanism is subject to a complicated system of rules and regulations. These CDM-specific institutions will be presented in the following chapter.

\(^{93}\)See section 2.1.3. For an analysis of regulatory uncertainty on the investment behavior of firms, see IEA (2007).

\(^{94}\)See section 2.4.
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Obviously, an efficient international climate policy regime would set incentives for reducing emissions for all countries in the world. For many developing countries, the introduction of mandatory reduction targets in the near future is rather unlikely. Hence, the CDM is—and will be in some form—the only instrument to incentivize reductions within the largest part of today’s Non-Annex I-countries. While the CDM represents only an imperfect substitute for a full-fledged trading with developing countries, it is still expected to achieve considerable cost-reductions for worldwide reduction of greenhouse gases.\(^1\)

The insights gained in the previous chapter already hint to the fact that an analysis of the regulatory specificities of the Clean Development Mechanism also necessitates to consider its interdependencies with the superordinate Kyoto framework. Consequently, the considerations exposed within this chapter continue to be guided by the metaphor of the *institutional cascade*. The main focus will be laid on the intermediate institutional level, i.e. the specific provisions through which the Clean Development Mechanism is implemented. As will be exposed, the rules guiding the CDM ensure—and in a sense create—the scarcity of the traded good, i.e. carbon offsets, which are in the case of the CDM securitized in the form of *Certified Emission Reductions*, or CERs.

Yet, the generation of these offsets and the subsequent primary trade of the respective certificates is associated with problems of potentially opportunistic behavior, the latter being generally characterized as individual "self-interest seeking with guile"\(^2\). Such problems usually occur in the context of information asymmetries and can be expected to significantly reduce the efficiency of the Mechanism. For this reason, the main focus of this thesis is on the analysis of potential adjustments to the lower level institutions which could help reducing some of the most important problems of opportunism associated with the CDM. It is important to note that this vulnerability of the Clean Development Mechanism to opportunism is not necessarily the result of a flawed design. As will be argued below, most of these problems arise as a consequence of the context within which the CDM is situated. In this sense, the analyses following in the subsequent chapters can also be understood as a constructive contribution for fostering the efficiency of the Clean Development Mechanism within the politically feasible.

The chapter is structured as follows. In the first section the general principles of the Clean Development Mechanism are exposed. The main focus is laid here on the

\(^1\) See, for example, Brechet and Lussy (2006).
\(^2\) Williamson (1985), p. 30
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calculation of credits generated within the different classes of CDM projects and some other important specificities of the market. Section 2.2 presents the most important regulatory actors which are to ensure that the Mechanism fulfills its objectives. We then turn, in section 2.3, to the specific regulatory process that is to be followed in order to generate Certified Emission Rights. As it turns out, the process engenders particularly high transaction costs in order to reduce opportunistic overreporting of offsets. Another important problem of opportunism is addressed within section 2.4 which deals with the attribution of liability for non-generated or non-delivered offsets. Here, emphasis is laid on the regulations for CDM forestry projects, which are likely to amplify problems of opportunistic under-delivery of certificates. Section 2.5 summarizes our discussion of the upper and intermediate levels of the institutional cascade by providing an overview over the different interactions of the different institutional strata. The last section concludes by summarizing the identified incentive problems which will be the subject of the analytical part of this thesis: the problem of potential overreporting of emission reductions, and problems of asymmetric information on the contract level to which the liability problem is devolved.

2.1. General Principles

The general principles of the CDM are stipulated within Article 12 of the Kyoto Protocol. The purpose of the Clean Development Mechanism is, as stated in the same article, "to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments"\(^3\). The Mechanism is, hence, to generate a 'twin benefit'. On the one hand, CDM projects contribute to reducing costs of meeting the Annex I-targets. On the other hand, the host country is to gain from the increased technology transfer generating spin-offs beneficial for development. Evidently, this idea of transferring 'cleaner' technologies to developing countries also inspired the naming of the Clean Development Mechanism. It remains to be seen how large the contribution of the CDM for development will be. The projections for transfers within the first commitment period, presented in section 2.1.3, indicate that the CDM can play a substantial role in increasing foreign direct investments in developing countries. Capoor and Ambrosi (2008) estimate that between 2002 and 2007 the CDM has triggered foreign direct investments amounting to 3.8 times the value of the expected certificates issued for the same time span. The cumulated investments leveraged by the CDM amounted to 59 billion USD or 44 billion Euro by the end of 2007.\(^4\) The level of foreign direct investments triggered by the Clean Development Mechanism

\(^3\)Kyoto Protocol (1997), Article 12(2)
\(^4\)According to Capoor and Ambrosi (2008), in 2007 alone, the CDM has leveraged about 33 billion USD or 24 billion Euro of investment in the field of clean energy.
in the future depends on the results of the international climate policy negotiations, as future willingness to pay for CDM certificates depends on the stringency of Annex I-countries’ reduction targets.

2.1.1. Additionality and Calculation of Credits

As laid out in the preceding chapter, the CDM is a credit-based mechanism. The fundamental idea underlying such systems is to reward those emitters that put more effort in reducing emissions than their competitors. In a standard credit-based system, as described by Ellerman (2005), the regulator first sets a maximum level in emissions not to be exceeded by the operators of an emission source. All facilities that emit less than required by this standard are eligible to credits amounting to the difference between the maximum allowed emission level and actual emissions. These securitized emission reductions can then be used to offset emissions from another facility that, by itself, would not meet the regulatory requirements. Consequently, as Shabman et al. (2002) and Ellerman (2005) point out, credit-based systems represent a form of flexibilization of the classical command-and-control regulation, as the regulator is to decide what efforts are eligible for the generation of credits.

The CDM differs from such a standard credit-based system in several respects. The CDM is designed to incentivize single projects to reduce or absorb greenhouse gas emissions. Hence, there exists, a priori, no common maximum standard to which the project emissions can be compared. This is, in fact, a direct consequence of the current Kyoto framework that exempts developing countries from reduction obligations from which a maximum standard for specific industries could be derived. Under these conditions, the operationalization of the CDM proved to be a considerable challenge to the architects of the mechanism, resulting in a sophisticated process for project admission. Before turning to these rules in more detail, it is useful to explain how the amount of credits generated by a project are determined.

The basic precondition for an effective operation of the CDM is that projects under the CDM generate emission reductions that would not have happened otherwise. The Kyoto Protocol requires the emission reductions within CDM to be "additional to any that would occur in the absence of the certified project activity." This is generally referred to as the additionality-condition. In order to be eligible for the CDM the project’s additionality of the emission reductions or absorptions must be proven by the project developer. The most common interpretation of this principle is the 'financial additionality', which implies that without the CDM the project activity is unlikely to be the most financially attractive to the project parties. Hence, for financially additional projects the Net Present Value of the activity—including all opportunity costs—would be negative, if the value of the generated certificates were not taken into account.

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5Kyoto Protocol (1997), Article 12.5(c)
6See CDM Executive Board (2008).
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In terms of emissions, the additionality criterion is operationalized through the definition of a ‘business-as-usual’ scenario compared to which the actual project emissions are assessed. In Kyoto terms, the scenario is referred to as baseline. Figure 2.1 illustrates the role of this baseline in the calculation of CERs generated by a reduction project. The figure depicts the development of emissions over time with respect to an emission source that is subject to a CDM project. With the start of the project the actual emissions are reduced to a new emissions path over time. These project emissions are measurable and verifiable, and need to be reported to the regulator. The amount of certificates generated through the project is defined by subtracting the actual project emissions from the baseline emissions. The baseline emissions, however, are not actually measurable and have to be calculated under the assumption that the project had not been realized.

![Figure 2.1.: The baseline as determinant for the definition of CERs](image)

The determination of the baseline over a longer time frame is difficult. It involves anticipating future technological developments and investments in cleaner technologies. In general, it is to be assumed that the firm developing the project is better informed on these issues than the regulator. As a consequence, the decision on setting the ‘correct’ baseline is subject to asymmetric information. Thus, the stipulation of project baselines should be subject of a thorough process of control and an elaborate procedure for acceptance by the regulator.

In practice, not only the baseline emissions are subject to information asymmetries, but also the reported project emissions. Hence, both determinants of the generated credits need to be meticulously verified, as there is considerable leeway for opportunistic
overreporting of reductions. We will turn to the rules that determine the verification cycles of a CDM project in section 2.3.

2.1.2. Projects eligible for CDM and Time Frames

In principle, there are two types of projects that have a positive impact on climate change mitigation. The first group consists of reduction projects that actually reduce the emissions through changes in the production technologies used. The second project group includes the implementation of technologies that either capture greenhouse gases from an emission source or directly absorb them from the atmosphere. These projects can be referred to as sink projects where greenhouse gases are typically not destroyed, but stored in one form or the other. In the Kyoto context, such technologies are referred to as being ‘non-permanent’, as the absorbed gases could potentially be re-released into the atmosphere.

Within Article 12 of the Kyoto Protocol the main focus is rather laid on reduction projects. The technologies allowed within such projects are not further specified. In principle, all technologies capable of achieving reductions in the 6 groups of greenhouse gases regulated by the Protocol are eligible for CDM projects. However, at COP6bis in Bonn the parties agreed to refrain from using nuclear facilities for the generation of credits under the CDM.\footnote{See UNFCCC (2001).} The exclusion of nuclear power generation is mainly due to political reasons, because nuclear technologies are not universally accepted as a viable solution to mitigate climate change. In fact, there exists a trade-off between the reduction of expected external costs from climate change and the externalities associated with the nuclear option. Consequently, a change in preferences of those parties that were opposing the inclusion of nuclear technologies might well lead to a re-inclusion of these technologies into the CDM in the future.

Currently implemented or planned projects cover a wide range of different reduction technologies. Based on a database including all submitted or registered CDM projects—referred to as the ‘CDM pipeline’—UNEP/Risoe (2009) gives estimates of the contributions of different project types to the expected overall offsets through the CDM until 2012. From the projects in the ‘pipeline’ as of June 2009, an overall offset of about 2’750 million CERs can be expected. Roughly 30 percent of the registered offsets stem from projects reducing non-\(\text{CO}_2\) industrial greenhouse gases, like hydrofluorocarbons and nitrous oxide. The implementation of such projects was quite common in the early phase of the CDM, as a large number of offsets were achievable at relatively low cost.\footnote{See Capoor and Ambrosi (2007).} The projects were, however, criticized with respect to their low level of technology transfer and their limited potential for fostering sustainable development.\footnote{See PointCarbon (2008).} As a result of political reactions to this criticism, a larger amount of less disputed project types has entered...
the pipeline. Consequently, renewable energy projects—including hydropower—would account for about 31 percent of all expected CDM offsets in 2012, while energy efficiency projects would have a market share of about 12 percent.\footnote{According to PointCarbon (2008), renewable energy was the largest transacted project category in 2007, accounting for 29 percent of total confirmed transaction volume. Within the same year, energy efficiency almost tripled its market share to 20 percent.}

Sink projects are more restricted with respect to their eligibility for CDM than reduction projects. The main problem is the non-permanence of these projects that requires additional regulation. For the time being, the only sink projects for which such a consistent regulation exists are those involving ‘Afforestation and Reforestation’, generally referred to as A/R-projects. A detailed account of the specific rules for these projects will be given in section 2.4.2. As of June 2009, there were 5 afforestation projects and 44 reforestation projects in the CDM ‘pipeline’, expected to generate offsets of about 12'362 kilotonnes of \(CO_2\) equivalents until 2012.\footnote{UNEP/Risoe (2009)} This represents only a small share of 0.45 percent of the overall amount of CERs to be expected until 2012. Hence, up to the present, the contributions from CDM Forestry to climate change mitigation are only of marginal importance. However, from the perspective of cost-effectiveness, forestry projects should play a larger role within the CDM as these projects are associated with particularly low implementation costs.\footnote{See, for example, Neeff and Henders (2007).}

The low level of implemented forestry projects might also be a consequence of the quota mentioned in section 1.4.1, which prescribes that the amount of Forestry CDM certificates should not exceed 1 percent of an Annex I-country’s overall portfolio. While this requirement is rather unfortunate from the perspective of static cost optimization, it is obvious that forestry projects feature only a low level of technology transfer to developing countries. Hence, the basic motivation for restricting the use of forestry certificates was to strengthen the secondary goal of the Clean Developing Mechanism, that is fostering sustainable development in the host country. Still, given the relative importance of changes in land use for climate change mitigation, it is likely that forestry projects will play a larger role within the CDM in the future.

Potentially, Forestry CDM could also be enlarged by allowing for projects contributing to avoid deforestation. There are, however, large information asymmetries associated to such projects as it is difficult to determine if an area actually had been deforested in the absence of the project. Still, greenhouse gas emissions from deforestation account for about 20 to 25 percent of the world’s total emissions.\footnote{See Nabuurs et al. (2007).} Given this level of impact on climate change, deforestation is likely to be included in future regulation. Within the UNFCCC-negotiations, the issue is addressed through a process referred to as ‘Reducing Emissions from Deforestation in Developing Countries and Approaches to stimulate Action’ (REDD). At COP13 in Bali, the Kyoto parties officially commissioned the SB-
STA to depict possibilities to include deforestation in developing countries within the international climate policy regime.\textsuperscript{14} The proposals range from a regulation within a separate protocol to the inclusion into the Kyoto carbon markets.\textsuperscript{15} The latter solution would, indeed, render deforestation projects eligible within the CDM.

Another sort of sink projects could be based on technologies that capture greenhouse gas emission and prevent the gases to escape into the atmosphere. Such technologies, commonly referred to as ’Carbon Capture and Storage’ (CCS), hence represent a technical sink. The best known application of such technologies consists of diverting the CO\textsubscript{2} emissions from a stationary combustion source and store the gas within geological formations, like depleted natural gas fields or permeable rock formations. The eligibility of such technologies within CDM projects is currently discussed. At the second Meeting of the Parties in Montreal, the technical advisory bodies were commissioned to inquire on the most important issues to be resolved in this context.\textsuperscript{16} As it turned out, CCS is associated with a plethora of technical, methodological, and legal problems that have to be resolved in order to guarantee its eligibility under the CDM.\textsuperscript{17} One of the issues to be solved is the non-permanence of such technical sinks, which requires precise rules for monitoring and verification of leakage rates. Hence, many of the considerations that are associated with the non-permanence of forestry projects, described in section 2.4.2, might be applicable to technical sinks as well.

For the time being, the cost of CCS projects seem to range higher than other project options within the CDM.\textsuperscript{18} In the medium term, it might, however, play a significant role as an intermediate solution for climate mitigation, within the CDM as well as in general. Proponents of such technologies often point out that large scale mitigation options, like hydrogen-based transportation systems, will only be cost-effectively available in the long-term, i.e. in the second half of this century. Capture and Storage technologies might well be an option for bridging that time gap. Consequently, the future use of technical sinks within CDM projects is not unlikely.

### Crediting Periods for CDM

Given the general approach of the CDM, involving the stipulation of baseline scenarios, it is reasonable to restrict the time frame within which projects can generate credits. For reduction projects the Kyoto rules provide for two different crediting schemes. The first option is a time frame over a maximum of 10 years without any option of further renewal. The other possibility is to apply for a first crediting period of 7 years that can be potentially renewed twice. In order to be eligible for renewal within the latter

\textsuperscript{14}See UNFCCC (2007e), Decision 2.
\textsuperscript{15}See SBSTA (2007b) and SBSTA (2007a), Paragraphs 25-29.
\textsuperscript{16}UNFCCC (2007f), Decision 1
\textsuperscript{17}See SBSTA (2008).
\textsuperscript{18}For an assessment of the expected costs for such technologies see IPCC (2005).
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approach, it might become necessary to adjust the project baseline by taking newly available scientific knowledge into account.\textsuperscript{19} As a consequence of the slow absorption rates within Forestry CDM, different rules apply to the time frame of afforestation and reforestation projects. Here, again two different options are available. First, the project parties can choose to implement the project over a maximum of 30 years without any option for renewal. Second, a crediting period of 20 years can be chosen with the possibility to be renewed twice. Hence, the possible maximum duration of a forestry project is 60 years.\textsuperscript{20}

In order to avoid the discrimination of early movers, CDM projects were allowed to generate credits from the 1st of January 2000 onwards.\textsuperscript{21} It is also to be stressed that the crediting periods are set deliberately longer than the 5-year commitment periods in order to incentivize a higher amount of technology transfer. However, as some observers note, most projects are designed in a way that the project investment is paid back within the first commitment period. This is mainly due to the uncertainty that investors face with respect to the continuation of the Kyoto provisions, as will be explained within the following account of the recent developments on the CDM market.\textsuperscript{22}

2.1.3. Primary and Secondary Markets

Although the CDM is a relatively new mechanism, the volume in reductions and as well as in secondary trades of certificates are considerably high. UNEP/Risoe (2009) report that, as of June 2009, the ‘CDM pipeline’ included already 4417 projects. In 2007, the overall CDM market’s volume amounted to 947 million tonnes corresponding to a value of 12 billion Euro.\textsuperscript{23} In light of the fact that the first commitment period for the Kyoto Protocol only started in the beginning of 2008, this intensity in project implementation and trading is remarkable. Yet, trade in CDM certificates is likely to increase further in the years to come. Forecasts of market volume by the end of 2012 range from 1.4 to 2.7 billion CERs.\textsuperscript{24}

At present, the transactions of Certified Emission Rights can be divided into a primary and a secondary market. The primary market involves the actual financing of specific CDM projects by investors. In return for this project financing the project developer conveys the certificates generated by the project to the project investor. In most primary market transactions the CERs are valued at a price contracted within a so-called Emission Reductions Purchase Agreement. According to Capoor and Ambrosi (2008), the majority of primary market transactions in 2007 and early 2008 were in the range

\textsuperscript{19}See UNFCCC (2005a) Decision 3, Paragraph 49.
\textsuperscript{20}UNFCCC (2005a), Decision 3, Annex IV, Paragraph 23
\textsuperscript{21}UNFCCC (2002b), Decision 17, Paragraph 13
\textsuperscript{22}On this issue, see for example IEA (2007).
\textsuperscript{23}PointCarbon (2008)
\textsuperscript{24}See Capoor and Ambrosi (2008) and UNEP/Risoe (2009).
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of 8 to 13 Euro per tonne CO$_2$e, with an average of 9.90 Euro, or 13.6 USD, per tonne CO$_2$e. The buyer can use the purchased CERs to offset his own emissions, in which case he is referred to as compliance buyer. Alternatively, the buyer might re-sell the CERs at a higher price to a secondary buyer. Due to this flexibility, a large secondary market has developed, the volume of which already amounted to about 350 million tonnes in 2007.\(^{25}\)

One of the major objectives of the CDM is to induce investments in abatement on the private-sector level. Yet, in principle, only countries can directly participate within the Flexible Mechanisms. This explains why, in the early years of the CDM, a major share of buyers constituted of governments and multilateral funds whose major objective was to start-up the CDM market. In order to create a private sector demand for CDM certificates, the Annex I-countries need to interlink the CDM with their national climate policy regimes. Within the European Emissions Trading System (EU ETS), for example, the EU member countries explicitly gave permission to the participating companies to acquire CERs for meeting their ETS targets.\(^{26}\) Hence, with the increasing specification of the national climate policies in recent years, the share of private buyers has significantly risen. As reported in PointCarbon (2008), in 2007 about 78 percent of confirmed CDM transaction volume were purchased by private entities. The largest share of buyers, about 46 percent were situated in the United Kingdom, indicating that a sizable part of the volume were purchased by financial institutions. On the supply side, however, the market still exhibits a high level of concentration, with 62 percent of all CDM projects being based in China. China’s share of overall volume is however decreasing, while Brazil, Indonesia and Mexico have become more important recent years.\(^{27}\)

The market for forward contracts for transactions after 2012 is still underdeveloped. Given that the future of the international policy framework crucially depends on the international negotiations on the post-2012 framework, future regulation is genuinely uncertain. As far as the CDM is concerned, this translates into longer-term investment incentives that are, at best, diffuse. As a consequence, buyers using CERs mainly for compliance purposes—often referred to as compliance buyers—are almost exclusively interested in the time frame of the first commitment period.\(^{28}\) Forward contracts specifying transactions beyond 2012 are hence left to governmental or multilateral funds that specifically aim at fostering the further development of the carbon market.\(^ {29}\) As the volume of such funds is limited, it is likely that most CDM projects are designed to break even within the first commitment period. This significantly reduces the Mechanism’s

\(^{25}\)PointCarbon (2008)

\(^{26}\)See EU (2004).

\(^{27}\)PointCarbon (2008)

\(^{28}\)See PointCarbon (2008). The same study also reports that CER forwards for delivery after 2012 have been traded by only 8 percent of companies that have reduction obligations within the EU Emissions Trading System.

\(^{29}\)See Capoor and Ambrosi (2008).
potential to induce cost-effective reductions over a longer time frame, as projects that feature a potentially positive Net Present Value over a longer time frame are not considered by the investors. The lack of longer-term forward contracts can hence be attributed to the shortcomings of the upper level of the institutional cascade. The corresponding loss in efficiency should, hence, also to be considered within the discussion of a future climate policy regime.\footnote{However, a large majority of market participants expect a continuation of the CDM after 2012. Survey results reported in PointCarbon (2008) reveal that 80 percent of market participants consider it likely or very likely that there will be a CER demand after the first commitment period.}

2.2. Regulatory Actors

The commodity traded on the CDM market, the Certified Emission Rights, is by itself intangible and only comes into existence through regulation. As laid out in the previous chapter, a pre-condition for the tradability of carbon offsets is the unambiguous definition of property rights. Furthermore, these rights will only have a positive value if they are enforced. Hence, a high level of regulatory control is a defining feature of carbon markets in general. This is particularly true for credit-based systems, as certificates are calculated on the basis of project baseline and monitored emissions. In a comparison with Joint Implementation—the other credit-based Kyoto mechanism—the necessary level of control for the Clean Development Mechanism turns out to be even higher. Contrary to JI, a CDM host country does not have a mandatory target from which potentially overreported project reductions would be subtracted. Hence, a control of the truthfulness of the reported project reductions is not \textit{per se} in the interest of the host country. Consequently, the CDM necessitates a more stringent control. Addressing these concerns in the design phase of the Clean Development Mechanism has been a major challenge for the Kyoto negotiators. The result of these negotiations is a complex set of interactions between different regulatory actors.

Obviously, the most important players within the CDM are the seller and the buyer of the traded good, i.e. the certificates. Within the primary CDM market, buyer and seller are referred to as \textit{project investor} and \textit{project developer}. In the initial conception of the CDM, the project investor is situated in an Annex I-country and the project developer within the project’s host country. Apart from these two groups, the CDM involves a multitude of other actors, that could be divided into ‘constitutive’ and ‘executive’ authorities. In this terminology, decisions are ‘constitutive’ if they determine the legal set-up of the CDM framework itself. As with all Kyoto provisions, the constitutive authority lies exclusively with the Conference/Meeting of the Parties, in short COP/CMP, presented in the previous chapter.\footnote{Kyoto Protocol (1997), Article 12(4)} The ‘Decisions of the COP/CMP’ represent the binding legal framework for all issues related to the Kyoto Protocol. As far as the Clean
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Development Mechanism is concerned, these Decisions implement a set of sophisticated rules, supposed to regulate the market and organize the control mechanisms. Decisions within these control mechanisms are of 'executive' nature. In general, the executive authority lies with the actual regulators of a market. For the CDM in specific, the different regulatory functions are attributed to different actors which are shortly presented below.

**CDM Executive Board**

The main executive body for regulatory issues is the Executive Board of the Clean Development Mechanism (CDM EB). The CDM EB supervises all issues related to the CDM and reports back to the COP/CMP.\(^\text{32}\) Within these reports the CDM EB is expected to make recommendations regarding further modalities and procedures for the Mechanism. The Executive Board consists of 10 individuals originating from the 5 UN-regions, elected for 2 years. While the EB’s decisions are supposed to be taken unanimously, a three-fourths majority is sufficient for decisions on disputed issues.\(^\text{33}\)

The Executive Board’s assignment involves all issues to guarantee the operability of the Mechanism. Most importantly, the CDM EB formally accepts or rejects a submitted project within the Clean Development Mechanism. Furthermore, the Executive Board approves new methodologies for baselines, monitoring plans, and the determination of project boundaries. The EB is also responsible for the accreditation of the third-party verifiers which are presented below. Finally, the CDM Registry is, as already explained in section 1.3.4, developed and maintained by the CDM EB as well. To fulfill these various functions the CDM has established several panels and working groups of experts in the various fields.\(^\text{34}\) The CDM EB is also to be supported by the Secretariat of the UNFCCC.\(^\text{35}\) As the workload associated with the regulatory tasks of the EB is likely to increase with the gain in importance of the CDM, the UNFCCC Secretariat is likely to take over the role of a supervisor for more detailed questions.

**Designated Operational Entities**

As the informational needs of the CDM Executive Board for the acceptance and the monitoring of projects are very high, the architects of the mechanism opted for a system of third-party verification. In Kyoto terms these external verifiers are referred to as Designated Operational Entities (DOEs). A DOE is either a domestic or an international legal entity that is accredited and—on provisional basis until confirmed by the Meeting of the Parties—designated by the CDM Executive Board to verify project information. In principle, there are two stages within the CDM project cycle where the services of a

\(^{32}\)See UNFCCC (2005a), Decision 3, Annex I, Paragraph 5.
\(^{33}\)UNFCCC (2005a), Decision 4, Annex I, Paragraphs 7-8, and 28
\(^{34}\)For a list of all panels established by the CDM EB, see http://cdm.unfccc.int/EB/Panels.
\(^{35}\)See UNFCCC (2005a), Decision 1, Paragraph 5.
DOE are needed. One is the validation of a project proposal, including the baseline used to calculate the emission reductions. The other is the verification and certification of the actual reductions achieved within the project activity.\footnote{UNFCCC (2005d), Decision 3, Article 27(a-b)} According to the standard rules, these two tasks have to be performed by different DOEs.\footnote{However, for projects that have the explicit permission by the CDM EB, both tasks can be taken over by the same DOE. (UNFCCC (2005d), Decision 3, Paragraph 27(e))} For all services the Designated Operational Entities are remunerated by the project parties. The CDM project cycle and the role of the DOEs will be explained in more detail in section 2.3.

To become a DOE the applicant must be designated by the COP/CMP based on the recommendation by the CDM EB. In order to be accredited the applicant must fulfill specified standards and needs to have "the necessary expertise to carry out the functions"\footnote{UNFCCC (2005d), Decision 3, Appendix A, Article 1 (f)} of a DOE. Consequently, all currently accredited Designated Operational Entities are private companies specialized in technical verification or financial auditing. For accreditation, the project activities are separated into 15 different sectoral scopes, for each of which the applicants need to qualify separately. The accreditation of the DOE for any sectoral scope is valid for 3 years. Furthermore, the accreditation is also separated for both of the DOE’s functions within the project cycle, i.e. validation and verification. Currently, none of the 18 accredited Designated Operational Entities has qualified for all 30 areas.\footnote{The list of accredited DOEs is to be made publicly available by the CDM EB and can be accessed at http://cdm.unfccc.int/DOE/list/index.html.}

Given the wide range and large scope of expertise necessary to validate and verify a project, the design of the CDM involving third-party verifiers seems sensible. Yet, the system would perform poorly without additional control. Consequently, the CDM EB has adopted rules that allow for ‘controlling the supervisor’. First, the rules imply a regular surveillance of the DOEs within the period of their accreditation. Second, the EB is authorized to conduct unscheduled surveillance activities of DOEs referred to as “spot-checks”.\footnote{See CDM Executive Board (2007), Paragraphs 72-101.} In the following chapter we present a model on the optimal frequency of such spot-checks given heterogeneous projects and a limited budget.

**Designated National Authorities**

One of the defining features of the CDM is that projects are required to contribute to the sustainable development of the host country. While this requirement is generally attractive, it turned out throughout the negotiations that its actual operationalization is extremely difficult. As the term sustainable development is only broadly defined, the question arises what measurable criteria should be applied for a sustainability check within the CDM. Different decision-makers might well have different notions of what 'a
contribution to sustainable development’ might mean. The problem was solved by leaving it to the host country to decide if a project contributes to its sustainable development. Hence, the first step in the accreditation process for CDM projects is the sustainability check by the host country. The sustainability check is conducted by the Designated National Authority (DNA), which is the host country’s agency officially appointed to all CDM-related issues.

The attribution of the sustainability check to the DNAs solved all related formal issues and was an important step toward the actual implementation of the Clean Development Mechanism. However, the problem of finding a commonly accepted methodology to assess the project’s impacts on the host country’s sustainable development is still unresolved.\(^{41}\) Hence, despite the efforts of developing countries and the scientific community, the DNAs will have to base their decision on their own good judgment.\(^{42}\)

### 2.3. The CDM Project Cycle

The different above-introduced actors interact within a sequence of controls that each project has to pass in order to generate credits within the Clean Development Mechanism. In the following, this sequence is referred to as CDM project cycle. The principal rules guiding project acceptance and verification have been set up within the Marrakech Accords and were refined within the subsequent COPs. These rules are suitable to reduce the incentive of overreporting, by implementing controls on both potential sources, i.e. baseline and project emissions. In the following, the stages of the CDM project cycle will be shortly depicted. The main focus in this account is set on the different control mechanisms designed to reduce problems of opportunistic behavior within the Clean Development Mechanism.\(^{43}\)

#### 2.3.1. Project Design Document, Validation, and Registration

Given that the Kyoto framework is based on an international treaty, the only actors qualified to act within these provisions are the Kyoto parties themselves, i.e. the countries. Consequently, private entities on the subnational level, like companies, can only participate within the CDM if they are officially endorsed by the Kyoto parties involved, i.e. the host country as well as the investor’s Annex I-country. This endorsement is to

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\(^{41}\) On this issue see for example Sutter (2003). Apparently, there exists also a willingness to pay for projects with certified *additional* benefits for sustainable development. One of these ‘high quality’ certifications for CDM projects is the WWF’s “Gold Standard” for which buyers pay an additional premium of 1 to 2 Euro per tonne. (PointCarbon (2008))

\(^{42}\) As a consequence, all issues that are expressed with respect to non-sustainable decisions within the CDM are de facto a criticism of the host countries’ interpretation of the term ‘sustainable development’, not of the mechanism itself.

\(^{43}\) For more detailed information suitable for the actual planning of a project, see for example IGES (2007).
be acquired through a process of country approval, which has to be undergone before the actual project registration. Each Kyoto party is free to choose the approval procedure. For the Annex I-countries this has two main advantages. First, the countries can choose to only endorse investors assuring a certain level of reliability, which reduces the risk of default on the level of the subnational entities. Second, the Annex I-country remains in control of the quota of certificates in its holding account that stems from the Clean Development Mechanism. As explained in section 1.4.1, such quotas exist implicitly for the CDM and explicitly for forestry projects. For so-called unilateral projects or multilateral projects that do not directly involve a specific Annex I-party, only the host country’s approval is required.\(^\text{44}\) As mentioned in section 2.2, the approval process must include a sustainability check by the host country’s DNA.

Once approval of the involved Kyoto parties is ensured, the project parties have to submit the Project Design Document (PDD), which represents the main source of information for the CDM EB deciding on the admission of the project. The CDM-PDD contains information on the project activity, as well as the project’s baseline and monitoring methodologies. Both of these methodologies have to be approved by the CDM EB in order to reduce the potential of overstated emission reductions. To further reduce opportunistic behavior, the Project Design Document needs to be validated by a Designated Operational Entity, acting as the external verifier. Through this predefined procedure of validation the DOE confirms that the project activity is expected to result in a reduction or absorption of greenhouse gases that is \textit{additional} to any that would occur in the absence of the proposed project activity.\(^\text{45}\) As explained in section 2.1.1, the amount of CERs generated by the project are determined by the difference of the baseline emissions and the actual project emissions. Hence, the baseline emissions, as well as the expected project emissions are required to be included within the Project Design Document.

At the current stage it is, for any new project, not very likely that there exists an already approved baseline methodology for the respective sector within the project’s host country. In such a case the DOE has to determine whether a new baseline methodology is to be used \textit{before} the submission for registration of the project. The new baseline methodology can either be based on historical emissions, the next-best non-additional technology, or the average emissions of similar activities.\(^\text{46}\) Any new baseline methodology needs to be submitted to the CDM Executive Board for review. If the EB considers the proposed methodology appropriate it is included in the list of approved baseline

\(^{44}\)See CDM Executive Board (2005a), Paragraph 57. A definition for unilateral and multilateral projects is given in section 4.1.

\(^{45}\)See UNFCCC (2005d), Decision 3, Paragraphs 35-52.

\(^{46}\)UNFCCC (2005d), Decision 3, Paragraph 48
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methodologies.\(^{47}\) The review of submitted baseline methodologies by the respective panel of the CDM EB requires often the acquisition of expertise within the technological field in question. PDDs are returned for review and need to be re-submitted. In economic terms, the submission of a new baseline methodology represents a positive externality for all subsequent projects using the same methodology within their PDD. As it was often the case within the CDM, early movers prepare the grounds for following projects.

Once a baseline methodology is accepted, a baseline scenario is to be calculated and the respective baseline emissions are derived according to specific guidelines.\(^{48}\) Ideally, these baseline emissions would include all emissions that are affected by the project. However, in practice, it often turns out to be difficult to compile a list of all potential second-order effects on overall emissions arising from the implementation of the project. It is, for example, difficult to foresee changes in life-cycle emissions of project inputs.\(^{49}\) For the sake of practicability, the scope of emissions to be considered within the baseline scenario are clearly delimited by specifying the project boundaries, which need to be explicitly included within the Project Design Document as well.\(^{50}\) This practice is likely to lead to a certain amount of leakage, defined as “the net change of GHG emissions which occurs outside the project boundary, and which is measurable and attributable to the CDM project activity”\(^{51}\). In order to guarantee the practicability of the Mechanism such concessions can, however, not be avoided. As soon as the Project Design Document is accepted, the project can be officially registered as CDM project. The official acceptance for registration is within the authority of the CDM Executive Board.

2.3.2. Monitoring, Verification and Issuance of CERs

Once a project is officially registered as a CDM project, the project emissions need to be regularly monitored from the official starting date onwards. The project parties are required to collect all relevant data to calculate the actual emissions under the project. All monitoring activities must be in accordance with the monitoring plan specified within the Project Design Document. In light of a newly arising development in measurement techniques or scientific knowledge, the monitoring plan can also be revised.\(^{52}\) The monitored emissions need to be independently reviewed by a Designated Operational Entity that determines ex post the emission level reported to the CDM Executive Board.\(^{53}\)

\(^{47}\) CDM Executive Board (2007), Art. 13, Paragraph 2. As of June 2009, 296 methodologies were submitted of which 122 have been approved, 150 rejected, and 24 are still being assessed. (UNEP/Risoe (2009))

\(^{48}\) See CDM Executive Board (2006).

\(^{49}\) See Brechet and Lussy (2006).

\(^{50}\) UNFCCC (2005d), Decision 3, Paragraph 52

\(^{51}\) UNFCCC (2005d), Decision 3, Paragraph 51

\(^{52}\) UNFCCC (2005d), Decision 3, Paragraphs 55 and 58

\(^{53}\) UNFCCC (2005d), Decision 3, Paragraph 61

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already mentioned, the validation of a project and the verification of project emissions has to be carried out by two different DOEs. This provision is likely to lead to a reduction in the probability of collusive misreporting as well as of systematic errors in the assessment of project emissions. The verification report provided by the DOE needs to include detailed information on the basis of which the truthfulness of the reported emission level can be assessed.\textsuperscript{54}

Based on its verification report, the Designated Operational Entity needs to officially certify the verified amount of greenhouse gas emission reductions. Through certification the DOE provides the "the written assurance [...] that a project activity achieved the reductions in GHG emissions as verified"\textsuperscript{55}. Formally, the deposition of the certification report represents a request for issuance of the respective amount of CERs to the Executive Board. Before the CERs are officially issued, there is the possibility for project parties or at least three members of the Executive Board to request a review. The possible reasons for requesting such a review are issues of fraud, malfeasance or incompetence of the verifiers.\textsuperscript{56} It is likely that such requests on the part of the Executive Board are based on its surveillance activities, like the 'spot-checks' mentioned in section 2.2.

In the standard case of unchallenged issuance the Executive Board and the CDM Registry administrator will take the necessary steps to issue the specified quantity to the project parties.\textsuperscript{57} It is to note that the amount of CERs received by the project parties does not exactly correspond to the offsets reported. For every project 2 percent of the generated certificates will be deducted as a contribution to the so-called 'Adaptation Fund', which is to fund adaptation measures in developing countries particularly vulnerable to climate change.\textsuperscript{58} An additional share of proceeds is deducted from the generated CERs to cover the administrative expenses of the CDM.\textsuperscript{59}

The complexity of the CDM project cycle hints to the fact that Mechanism’s level of regulatory control is associated with significant transactions costs. This is, for example, reflected by the duration of the process of approval. As of June 2009, the average time for approval of a new baseline methodology was 294 days.\textsuperscript{60} The registration procedure itself also takes a significant amount of time. UNEP/Risoe (2009) reports that the average time from request for registration until the actual registration of a project has increased in recent years from 50 to 116 days. This time lag increases if the EB requests a review of the project documents at the registration or issuance stages. Yet, with increasing

\textsuperscript{54}UNFCCC (2005d), Decision 3, Paragraph 62(a-h)
\textsuperscript{55}UNFCCC (2005d), Decision 3, Paragraph 61
\textsuperscript{56}UNFCCC (2005d), Decision 3, Paragraph 65
\textsuperscript{57}UNFCCC (2005d), Decision 3, Paragraph 66
\textsuperscript{58}See UNFCCC (2001), Paragraph 15(a), as well as Kyoto Protocol (1997) Article 12, Paragraph 8.
\textsuperscript{59}The share of proceeds to cover administrative expenses is USD 0.10 per CER issued for the first 15,000 tonnes of CO$_2$e and 0.20 USD per certified emission reduction issued for any amount in excess of 15,000 tonnes of CO$_2$e. (UNFCCC (2005c), Decision 7, Paragraph 37)
\textsuperscript{60}UNEP/Risoe (2009)
experience of the regulatory actors, the overall time of approval is likely to decrease. For example, the time lags associated with the host country endorsement were considerably reduced to an average delay of about 5.3 months. Still, the CDM project cycle causes a significant level of 'sand in the wheels' of the market for reduction projects.

It is, however, to be recognized that the time-consuming procedure is necessary in order to ensure that CERs reflect actual carbon offsets. Apart from the inclusion of developing countries into an international cap-and-trade system, it seems difficult to conceive of a fundamentally different approach within the CDM. Consequently, the general lines of the CDM project cycle are likely to persist, as they play an important role in decreasing the incentive of overreporting of reductions. From such an incentive perspective, it is important to understand which actors are to bear the costs of non-issuance or invalidation of CDM certificates. In the international negotiations this issue was addressed within the discussion of liability, addressed in the following section.

2.4. Liability and the Special Case of CDM Forestry

In the Kyoto context, the term liability is used to designate what party is to be held responsible if it turns out that a permit in circulation is not backed by a respective carbon offset. The question of who is to be held liable for the offsets has a direct influence on the prices and the volume traded within the emerging carbon markets. The Kyoto system includes—implicitly or explicitly—such a liability scheme for all Flexible Mechanisms. From an incentive perspective, the attribution of liability is of particular importance. One of the most important insights of the economic analysis of private law is that responsibilities for replacing a valuable good should be assigned in a way that guarantees that all involved parties have an incentive to exercise due care. Hence, in case a contingency realizes, the theory of efficient precaution requires that those parties should be held accountable which are able to influence the probability of occurrence of the respective eventuality. A liability scheme designed along these lines would minimize the inefficiencies stemming from potentially opportunistic behavior.

In the following, the concepts of liability implemented within the Protocol are shortly explained. It turns out that for CDM reduction projects, the attribution of liability on the country level seems to be rather unproblematic. However, sink projects where the carbon offset is non-permanent, pose a major challenge for the liability scheme. We will discuss this issue in more detail in the context of the current rules for CDM Forestry projects.

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62 See for example Cooter (1985).
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2.4.1. Liability Rules within Kyoto

The question of who is to be held liable in case of non-delivery of certificates was intensively discussed within the Kyoto negotiations, in particular with respect to Kyoto Emissions Trading. In the context of the latter it was argued that by implementing buyer liability, the buying country would have a reason to exert pressure on the seller not to 'oversell' beyond her target, which would increase the probability of overall compliance to the Kyoto Protocol. The validity of this argument is, however, questionable.

Certainly, buyer liability leads to an incentive for the buyer to prefer certificates stemming from more reliable sources. It is, however likely that the buyer has less information on underlying reduction efforts than the seller who is exerting these efforts. In such an asymmetric information setting, emissions trading would be subject to adverse selection, resembling a 'market for lemons'. Hence, certificates that do not represent actual abatement are necessarily cheaper than certificates whose price reflect actually incurred costs of abatement. To the extent that the buyer is not capable to differentiate between these two types of certificates, the cheaper 'bogus' certificates could crowd out certificates based on actual carbon reductions. More importantly, the level of emission reductions that determines the amount of AAUs available for sale is under the complete control of the seller. From this perspective, buyer liability would fail to set stronger incentives to the seller to actually implement emission reductions and transfer the respective certificates to the buyer. In line with this reasoning, the negotiators opted for implicitly attributing the liability for transfers Kyoto Emissions Trading to the seller. As explained in the last chapter, replacing potential shortfalls in AAUs is within the responsibility of the overselling country if it wants to avoid sanctioning. Hence, with respect to the Kyoto Emissions Trading the rules on the Registry System and the compliance mechanism combine to a system of implicit seller liability.

As far as the CDM is concerned, the attribution of liability seems not to be an issue—at least for the more common case of reduction projects. As explained above, standard CERs are only issued ex post, i.e. after the underlying emission reduction has been monitored, verified and potentially spot-checked. All issues with respect to potential non-validation of CERs are to be solved before the certificates enter the market. As a consequence, the host country's CDM Registry will only contain certificates for which the underlying offset has already taken place. Under these conditions, an Annex I-country can only acquire CERs that represent an actual offset, such that the specification of liability rules on the Kyoto level was in fact not necessary. This implies, however, that all issues that arise when a project generates less certificates than anticipated are

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63 For a more detailed exposition of this argument, see Zhang (2001).
64 Within the international negotiations, Switzerland proposed a similar post-verification trading system for Kyoto Emissions Trading, wherein only the surplus of a preceding commitment period were tradable. The proposal was turned down due to the opposition of Canada and the United States, who were the strongest supporters of the system currently in place. (See IISD (2000).)
devolved to the level of the contract between project investor and project developer. Hence, on the contract level, the problem of how to induce efficient precaution persists. If, for example, the contract exempts the seller from compensating the buyer for all eventualities, the seller has little incentive to exercise due care. This incentive problem becomes particularly imminent if a significant amount of upfront financing is involved. The persistence of the different incentive problems on the contractual level motivates the analyses in the second part of this thesis.

In contrast to CDM reduction projects where emissions are permanently avoided, sink projects, as presented in section 2.1.2, bear the risk that the absorbed or stocked amount of carbon is re-released into the atmosphere. This raises the question of who is to be held liable for those cases where the absorption is undone and the corresponding certificates are invalidated within an Annex I-country’s National Registry. Hence, for this class of projects, the architects of the CDM were not able to circumvent the attribution of liability on the country level. Currently, the only type of non-permanent projects for which explicit regulation exists within the current CDM provisions are those that involve afforestation and reforestation. This class of projects is based on the fact that forests absorb atmospheric carbon-dioxide through photosynthesis. As forest absorption of carbon dioxide is limited by the lifetime of the average tree and deforestation processes consequently lead to a re-emission of $CO_2$, the non-permanence of such projects is quite obvious. Even though the share of current forestry projects in the CDM pipeline is low, the rules for Afforestation and Reforestation Projects might, in the near future, well be adjusted for other non-permanent projects, like technical sinks or deforestation projects. This is reason enough to examine the provisions for A/R-projects and the resulting liability problem in more detail.

2.4.2. Provisions for Afforestation and Reforestation Projects

For Afforestation and Reforestation CDM projects, the problem of non-permanence has been solved by creating two different sorts of certificates which are issued after a verification of the absorbed amount of carbon dioxide: the Long-term CERs ($t$CERs) and the Temporary CERs ($t$CERs). At the beginning of a forestry project, the project participants can decide which type of certificates shall be issued for the project activity. Within both approaches the absorbed amount of carbon is regularly verified by a Designated Operational Entity, such that increases or decreases in carbon stock will be represented through the amount of currently valid certificates. Both approaches account for the non-permanence through a limited time of validity of the certificates, but differ with respect to the expiration dates of the temporary CERs.

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65 See UNFCCC (2005a), Decision 5.
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If the project participants choose the lCER approach a forestry project generates an initial amount of Long-term CERs at the first verification date. These lCERs remain valid over the whole project duration as long as the absorbed amount of $CO_2$ being reported is not lower than the amount represented by the Long-term CERs. As soon as the lCERs are issued, they can be used by an Annex I-country to meet its Kyoto targets. The carbon stock is reassessed at every subsequent verification date. In the standard case of a positive forest growth rate, the increase in carbon stock is reflected by the issuance of additional lCERs after each verification, remaining valid until the end of the project.\textsuperscript{66}

In contrast, Temporary CERs expire at the end of the commitment period subsequent to the commitment period for which they were issued. Therefore, they have to be replaced by the holding Annex I-country at the beginning of each commitment period. A project always generates the amount of tCERs corresponding to the absorption level that has been reported by the verifier in the latest verification report. As the absorption level will usually increase, the amount of tCERs stemming from a CDM forestry project will increase as well. Hence, with a positive forest growth rate the amount of newly issued tCERs will be higher than in the previous period. At the end of the project, no further tCERs are being generated.\textsuperscript{67}

Both approaches have in common that the respective certificates are only temporarily valid. At the expiration date of the certificates, i.e. at latest at the official ending of the project, the certificates are removed from the holding account of the National Registry of the buyer country. The thusly emerging deficit in the balance of this country needs to be covered by the acquisition of the respective amount of other Kyoto certificates.\textsuperscript{68}

Hence again, just as with the incentives created by the Kyoto system in general, the effectiveness of regulations with respect to non-permanence crucially depend on the continuation of the Kyoto approach.

In general, it is to be expected that afforestation or reforestation will lead to a continuous growth in carbon stocks over time. For this case the number of generated tCERs as well as lCERs will increase. However, there exists a plethora of unexpected events in the course of which the absorbed amount of carbon might be diminished. Such events are for example forest fires, storms, infestation by parasites, or illegal logging. The carbon sink could also be reduced through planned events like a partial or complete harvest of the forest. All these events would lead to a discontinuous flow of certificates from CDM Forestry projects, which in turn raises the question of who is to be held liable for the sudden reduction in carbon stock. The liability rule associated with Forestry CDM is implicit to the accounting rules applied with respect to the two types of certificates.

\textsuperscript{66}See UNFCCC (2005a), Decision 5, Paragraph 36 (b).
\textsuperscript{67}See UNFCCC (2005a), Decision 5, Paragraph 36 (a).
\textsuperscript{68}See UNFCCC (2005a), Decision 5, Paragraphs 41-50.
The mode of operation of these rules is best explained within an example featuring a sudden decrease in absorbed carbon, as depicted in Figure 2.2. As to the underlying situation, it is assumed that the project is implemented over 4 commitment periods, which—within the current conception—corresponds to 20 years. Within each commitment period the forest’s carbon stock is verified by a Designated Operational Entity. Between the first two verification dates the forest grows continuously such that the certified level of absorbed carbon corresponds to \( A \) after the first and to \( B \) after the second verification. Between the second and the third verification date the absorbed carbon is abruptly reduced through one of the above-listed events, e.g. a forest fire. Consequently the certified amount of absorbed carbon is reduced to the level \( C \). Throughout the remainder of the project the forest again grows continuously, leading to an amount of certified carbon absorption of \( D \).

Figure 2.2.: Forestry CDM certificates with discontinuous forest growth

The sequence of carbon storage depicted in figure 2.2 would be reflected within the flow of CDM certificates as follows. If the project participants opt for ICERs an amount of \( A \) Long-term CERs are issued after the first verification. At the second verification an additional amount corresponding to the difference between \( B \) and \( A \) is attributed to the project, while the ICERs issued in the first period remain valid. At the third verification the carbon stock has decreased, such that only an amount of \( C \) Long-term CERs remain valid. At this point, all certificates in excess of \( C \) are invalidated. The carbon increase observed at the last verification is accounted for through the issuance of an additional share of ICERs corresponding to the difference of \( D \) and \( C \).

For Temporary CERs, the amount of certificates issued for each period depends on whether the project participants claim the certificates for the commitment period within
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which the verification has taken place or the subsequent one. Under the assumption that verification date and issuance of the respective tCERs takes place within the same commitment period, the amount of tCERs issued for periods 1 to 4 would correspond exactly to the respective levels A to D. If the tCERs are being claimed for the period subsequent to the verification dates, the same levels would be issued with delay, i.e. for the commitment periods 2 to 5. Note that the Temporary CERs are only valid for one commitment period, and must hence be replaced by the buyer either by using the newly created tCERs or—at the end of the project—by any other Kyoto certificates.

With the above-depicted problem of a potential sudden decrease in Forestry CDM certificates, the liability issue is of particular importance. For Forestry projects the liability rule is implicitly defined through the rules that apply when a certificate is invalidated. In the following, we will shortly discuss these rules and shortly present the corresponding incentive problem that might arise.

2.4.3. Liability within Forestry CDM

In general, the non-permanence of carbon absorption within CDM Forestry projects is reflected through the fact that both sorts of certificates only have a limited lifetime. The certificates can either expire by the end of their validity, or—in the case of Long-term CERs—be invalidated. In both cases, the certificates need to be replaced in the holding account of the respective National Registry. When a replacement of tCERs or lCERs becomes necessary, the International Transaction Log notifies the Annex I-party one month prior to the certificates’ expiry. If the country fails to replace the certificates, the Transaction Log informs the UNFCCC Secretariat and the CDM Executive Board for review, which in turn report the act of non-compliance to the Compliance Committee and the Meeting of the Parties.

Once this process is under way, the country is judged within the non-compliance procedures, as described in section 1.2.5.

The expiry of Forestry certificates at the end of their validity is rather unproblematic. As the Annex I-country holding such certificates has complete knowledge of their limited lifetime, it is able to plan for their replacement in advance. The implied restriction to the certificates will be reflected in the prices for such certificates, which will in general be lower than for CERs stemming from reduction projects. Under a sufficiently well-functioning market, this difference in prices would already reflect the discounted replacement costs to be incurred at the end of the certificates’ lifetime.

The discontinuities in carbon storage, as presented in the previous section, represent a larger problem. In the case of the lCER approach, the Kyoto rules prescribe that Long-term CERs that no longer reflect a carbon stock have to be replaced within the

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69See UNFCCC (2005d), Decision 5, Annex, Paragraph 55.
70See UNFCCC (2005d), Decision 5, Annex, Paragraph 56.
71See, for example, Bird et al. (2005).
National Registry of the Annex I-country holding these certificates. This is equivalent to a de facto attribution of liability to the buyer country, as within the Kyoto system no mechanism exists enabling the buyer to hold the seller, or the host country, responsible for the loss. However, it is likely that the Annex I-country will subrogate against the primary buyer of the certificates, i.e. the project investor. Under the tCER approach, the sudden reduction in carbon stock will simply lead to a decrease in tCERs issued in the following commitment period. Consequently, the amount of certificates in the holding accounts of the Annex I-country remains unaffected by the unforeseen reduction. Hence again, it is the project investor who would suffer the loss in certificates, as he would have to replace the certificates in order to comply to his reduction obligation within the national climate policy scheme.

Hence, within both approaches, the responsibility for replacing invalidated CDM Forestry certificates is—directly or indirectly—attributed to the project investor. This liability attribution is likely to lead to inefficient levels of precaution. While the project investor has acquired the property rights in the certificates, the underlying offset, i.e. the forest, remains under the control of the project developer. This situation is prone to all agency problems that usually arise if ownership and possession are not attributed to the same party. Most importantly, it is less costly for the project developer to reduce the probability of occurrence for those contingencies which lead to a reduction in absorbed carbon, like for example forest fires. As a consequence, investments in precaution, like frequent patrols to prevent illegal slash-and-burn activities, should be made by the project developer. As these investments are not directly observable by the project investor, there exists a significant potential for moral hazard. This moral hazard will be particularly severe if the frontloaded part of the contract price for forestry offsets is large. To mitigate such incentive problems, the project investor is likely to share the responsibility for invalidated certificates through a careful design of the purchase contract. Hence, just as with CDM reduction projects, the de facto attribution of liability is devolved to the contract level.

As will be laid out in the second part of this thesis, the potential to correct incentive problems on the contract level is quite limited, which raises the concern why the architects of the CDM Forestry provisions opted for buyer liability in the first place. It is unlikely that this liability scheme is the result of careless design. After all, the negotiators have implemented seller liability within Kyoto Emissions Trading which indicates that they were aware of the underlying incentive problems. This suggests that the implementation of buyer liability within CDM Forestry is rather a result from institutional restrictions than from a thoughtless design. Recalling that the most stringent sanctions within the Kyoto system only bite for Annex I-countries, this liability scheme seems to directly result from the specificities of the compliance mechanism. Indeed, within the Kyoto framework there exists very little leverage which would permit to enforce an

72See UNFCCC (2005d), Decision 5, Annex, Paragraph 53.
2. The Clean Development Mechanism

The above considerations exemplify the importance of setting the CDM regulations into the broader context of the overall international climate policy framework. In the following section we will summarize our account of the CDM institutions by outlining the general interactions within the 'institutional cascade' which condition actual investments within the Clean Development Mechanism.

2.5. Interactions within the Institutional Cascade

The main purpose of the previous as well as the current chapter was to establish the institutional context of the CDM which is relevant for the formal analyses carried out in the subsequent chapters. As suggested by our guiding metaphor of the 'institutional cascade', it turned out that the Clean Development Mechanism is to a large extent conditioned through the superordinate institutional framework. Furthermore, many incentive problems are 'delegated downwards' to the level of the individual contract between buyer and seller of CDM certificates. For analytical purposes it is hence useful to differentiate three different tiers of the institutional framework: an upper inter-country level, an intermediate CDM regulatory level, and a lower contractual level which determines the terms of the actual transaction on the market.

The structure of the incentives set within the CDM are the result of the interaction of all three tiers of this institutional framework. To establish the case for the subsequent analyses, it is useful to summarize the most important interactions between the different tiers. Hence, within this section, we will conclude our account of the institutional framework by outlining the principal interactions of the relevant actors on the different institutional levels. Figure 2.3 gives a simplified overview over those interactions that are necessary to generate credits within the Clean Development Mechanism. The upper part of the figure displays actors and processes on the inter-country level, emphasizing the role of the the Kyoto Registry System. All interactions related to the specific CDM project are depicted in the lower half of figure 2.3. This involves the actual implementation and financing of the project on the corporate level of the countries involved, as well as the verification and control specified through the international Kyoto provisions.

The institutional interactions are best described by starting at the level of the single project, i.e. the lower part of figure 2.3. The project investor is generally a private entity which has to fulfill a reduction obligation toward the Annex I-country. In order to achieve these reductions at lower cost, the project investor decides to finance a CDM project in the host country. In return, he expects to receive the property rights on the CERs generated by the project. The project investor, hence, concludes a contract with the project developer specifying the terms of this exchange. The Kyoto provisions do
not impose any direct restrictions on these terms, such that the agreed sharing of costs and generated surplus is formally only restricted by the contract law of the respective place of jurisdiction. However, as will be explained in the second part of this thesis, the set of feasible contract designs might well be constrained by the fact that cross-border contract enforcement in the real world is incomplete.

The project developer needs to register the project activity under the Clean Development Mechanism, following the procedures of the CDM cycle described in section 2.3. In order to qualify for the CDM, the project needs to fulfill some specific requirements, like fostering the sustainable development of the host country. For reasons already explained, the sustainability check is undertaken by the host country’s Designated National Authority. Yet, the most important requirement for a CDM project is the already-mentioned additionality condition, the adherence to which is checked within a scrutinized control mechanism. The primary institutions for controlling a project’s compliance with the CDM requirements are the third-party verifiers, the Designated Operational Entities. The DOEs validate and monitor the project activity, as well as its baseline. Once these controlling activities are successfully completed, the DOEs file—for each of these tasks—a report to the CDM Executive Board. The CDM EB functions as the ‘supervisor of the supervisor’, admitting and spot-checking the Designated Operational Entities. In case
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The DOE’s verification report on the project’s carbon offsets is undisputed, the CDM Executive Board finally issues the respective amount of Certified Emission Reductions.

As already emphasized, the carbon offsets will only turn into valuable certificates if they qualify as such along the lines of the upper tiers of the institutional framework. As explained in section 1.4, the level of demand for Certified Emission Rights is directly dependent on the general Kyoto provisions, in particular the Annex I-country targets and the compliance mechanism. As a consequence, in the analytical differentiation of figure 2.3 between a corporate and an inter-country level, we can distinguish two different interactive flows with respect to the CDM certificates: the processing of certificates within the Kyoto accounting system and the attribution of property rights in the generated certificates. After issuance, the Certified Emission Reductions are booked into the CDM Registry. The property rights to the certificates are—more or less directly—attributed to the project parties. Project developer and project investor distribute the rights to the CER according to the purchase agreement. In the standard case, the project investor will claim the total amount of CERs in order to either fulfill his own reduction obligations within the Annex I-country or to sell the certificates on the secondary market. In both cases the Certified Emission Reductions will be finally booked into the National Registry of an Annex I-country using the certificates to fulfill its own reduction obligations within the Kyoto regime.

In light of the institutional interactions laid out above, the role of CDM certificates can be analyzed either from an inter-country perspective or from the angle of the individual contract. On the inter-country level, they represent a substitute for Assigned Amount Units, enabling an Annex I-country to meet its reduction targets in a more cost-efficient manner. If CERs are analyzed from the contractual perspective, they simply represent a marketable commodity, the value of which is to incentivize the generation of carbon offsets. Yet, it is to note that within both interpretations CERs are in fact an artifact created through regulation. As a consequence, it is not guaranteed that the certificates represent actual carbon offsets which would not have occurred in the absence of the Clean Development Mechanism. This characteristic of CDM certificates induces some—potentially severe—incentive problems that are likely to significantly reduce the Mechanism’s efficiency. As a conclusion we will present in the following section those incentive problems that were identified in our account of the overall CDM framework.

2.6. Conclusion: Arising Incentive Problems

The main concern of this thesis is to analyze some of the conditions that are necessary for deterring opportunistic behavior within the CDM, while achieving an efficient second-best level of developing country investment in mitigation. For this purpose, our outline of the institutional context of the Clean Development Mechanism indicated that it is useful
to analytically differentiate between the different strata of the ‘institutional cascade’. We distinguished three different institutional tiers: the inter-country level, the CDM regulatory level, and the level of the contract between seller and buyer of certificates. Given the intensive interaction between the institutional strata, it is quite obvious that the incentives set on the upper institutional levels necessarily constrain the efficiency achievable at the lower levels.

As far as the inter-country level is concerned, the strategies for opportunistic behavior seem to be rather gross. The most fraudulent of these strategies would probably be a direct manipulation of the holding accounts within the National Registry. As far as it can be foretold at present, the use of this strategy is, however, effectively deterred through the control system established within the international accounting system. Each CER has a unique serial number and can be traced back to its origin.\(^\text{73}\) A manipulation of the international registry and logging system would require a large scale fraudulent intervention on the level of information exchange, which is unlikely to remain undetected.

A more promising strategy for opportunistic behavior on the level of the Annex I-country is probably an outright non-compliance with the reduction target. In such a case, the country would be sanctioned through the Kyoto compliance mechanism. The harshest sanction possible within this mechanism is associated with the country’s future reduction target. The country could avoid the sanction either by negotiating this target down or simply by opting out of the Protocol. The costs for choosing these options are, in principle, dependent on the reputational drawbacks that such actions would entail for the country within the field of international politics. How effectively Annex I-countries are deterred from non-compliance remains to be seen in the future.

As our considerations depart from the premise that a change in the main lines of the Kyoto regime is considerably restricted through the political feasibility, the main focus of our analyses is on potential efficiency gains at the lower institutional levels. In the following chapters, we provide an analysis of selected incentive effects occurring within each of the two lower strata of the institutional cascade. At the CDM regulatory level, we investigate the problem of opportunistic overreporting of emission reductions. At the contract level, we will analyze the incentive effects associated with a potential non- or under-delivery of certificates by the seller. In the following we will shortly summarize the interdependencies within the institutional cascade which lie, in fact, at the basis of these two incentive problems.

### 2.6.1. Opportunistic Overreporting – Responses at the Regulatory Level

From the perspective of institutional efficiency, it is particularly striking that all major players within the CDM have an incentive to overstate the emission reductions in order to receive a larger amount of CERs. It is, for example, obvious that the project parties

\(^{73}\)See UNFCCC (2005c), Decision 12, Paragraph 4.
have better knowledge than the regulator of the next-best alternatives to the project on which the baseline scenario should be built. A similar information asymmetry exists with respect to the actual project emissions. Hence, the method to calculate the number of certificates explained in section 2.1.1 leaves room for both, overstating the baseline or understating actual project emissions. As the project investor and the project developer could share the additional rent from the overstated certified reductions, both parties have the opportunity and the incentive to collude in overreporting the carbon offset.

The problem of potential overreporting has a direct influence on the efficiency of the carbon market. As one CER represents the same amount of carbon offset as one AAU, the full fungibility of CERs and the other certificates can only be justified if the underlying good, i.e. the carbon offset, is more or less homogeneous. Hence, the regulatory framework must ensure that the CERs reflect the underlying carbon offsets as precisely as possible. However, an attribution of the control function to the CDM host country would not be incentive compatible. Clearly, a larger amount of certificates per project is also within the interest of the host country, because the incentive to invest in this country would increase accordingly. Furthermore, there exists only little leverage within the Kyoto system to deter collusive behavior on the part of the host country. As a consequence, the Mechanism relies primarily on a system of third-party verification.

As explained in section 2.3, the Designated Operational Entities, that is the verifiers, control both potential sources for overreporting: the baseline and the actual project emissions. The impartiality of the DOEs is however not a priori guaranteed. Both, the validator of the project proposal, as well as the verifier of the project emissions, are remunerated by the project parties. Consequently, both actors might be tempted to either fraudulently certify the overreporting or more or less actively ‘shirk’ during the process of verification. Hence, again, there exists a problem of potential collusion. This problem might even be amplified through the fact that the DOE market exhibits a high level of concentration, such that beneficiary effects of competition on the quality of verification are likely to be limited. In principle, this collusion problem might be mitigated by the fact that the validation and verification of the project must be performed by two different DOEs. Insofar as these processes reveal redundant information, the current system resembles to a system of reciprocal supervision. Such systems are, as Laffont (2000) shows in a complete contract framework, suited to significantly reduce problems of collusive behavior.

Still, in order to sufficiently deter the risk of collusive behavior, a ‘second-order’ supervision of project parties and verifiers is necessary. Such a second-order control is implemented through the fact that the CDM Executive Board can effectuate unannounced ‘spot-checks’ on all project sites. However, given the limited budget of the CDM Execu-

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74 Currently, three companies (TÜV Süd, Det Norske Veritas Certification, Société Générale de Surveillance) account for about 80 percent of services in validation, as well as verification within CDM. (See UNEP/Risoe (2009).)
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tive Board, its specialized panels, and the UNFCCC Secretariat, the probability that a specific project is subject to such a spot-check is smaller than one. Hence, the enforcement of the truthfulness of reports on emission reductions achieved through the CDM is necessarily incomplete. We will further pursue this issue in the following chapter 3, where we present a model designed to describe the optimal control rate by the regulator given a limited budget and heterogeneity of projects. Chapter 3 also concludes the first part of the thesis which deals with the analysis of the upper levels of the institutional cascade. The second part is dedicated to the lower institutional level of CDM contracts to which some of the most important incentive problems of the CDM are devoted. The process of this devolution is shortly summarized in the following.

2.6.2. Opportunism on the Contract Level

Investing in CDM projects is not free of risk. In fact, a plethora of contingencies could conceivably arise which endanger the actual delivery of Certified Emission Reductions to the compliance buyer. As with any commodity, it is hence to be specified who is to be held liable for potential shortfalls in generated or delivered CERs. As argued in section 2.4, the architects of the CDM were able to circumvent the problem of attributing liability for reduction projects at the inter-country level. For Forestry CDM this approach was not viable, as the problem of non-permanence requires an invalidation of the certificates once the underlying carbon sink ceases to exist. For this type of projects, the architects of the CDM have opted for a system of buyer liability. As argued above, this choice is likely to be a result from the fact that the Kyoto architecture does not provide for enforcing specific claims toward CDM host countries. As a consequence, the implementation of buyer liability seems to be the best solution given the actual institutional constraints.

We further argued that for both project types, the current practice implicitly assigns the responsibility for replacing non-delivered or invalidated certificates to the project investor. For reduction projects and Forestry tCERs this liability attribution is immediate, as the project investor would have to replace the shortfall in certificates by a respective substitute in order to comply with the national climate policy scheme. In case of CDM Forestry projects, this devolution will be indirect. In case of invalidation of tCERs, the project investor is likely to be held accountable as well, because the affected Annex I-country will probably subrogate against the investor for the respective loss in carbon offsets. Evidently, attributing the liability to the project investor will often be not incentive compatible, because it increases the potential for opportunistic behavior on the part of the seller. Given that many events that could potentially lead to a sudden decrease in carbon storage are better controlled by the project developer, holding the investor liable could result in situations prone to moral hazard. This is particularly imminent with forestry projects, as the seller continues to exert control over the carbon sink, while the certificates are already used to meet the buyer’s target. Furthermore, given an imperfect enforceability of contracts in developing countries, the project devel-
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oper might be tempted to either refuse delivery of already generated CERs or to use project resources for other means.

These incentive problems could be potentially mitigated within a careful design of the contract between project developer and project investor. As a consequence, it is interesting to explore to what extent the institutional shortcomings of the upper institutional levels can be corrected at the contract level. We will address the issue of optimal CDM contract design under the above-mentioned problems in the second part of this thesis. As it turns out, the underlying problems of asymmetric information could explain the underprovision of upfront financing within such contracts. We will analyze these issues within a set of formal models where special emphasis is laid on the role of contract damages which represent an instrument of re-attributing liability on the contract level.
3. Incomplete Enforcement within the CDM - a Model

As laid out in the preceding chapter, the Clean Development Mechanism is particularly vulnerable to problems of incomplete enforcement. These problems arise due to information asymmetries between the regulator and the project participants, creating an incentive to overstate emission reductions. Hence, the overall abatement level is likely to be lower than predicted within neoclassical setups, where the optimal amount of emission reductions is achieved through market forces. Under the standard neoclassical assumptions the interaction of supply and demand leads to an equalization of marginal abatement costs and the certificate price. However, if the the above-mentioned information asymmetries are taken into account the level of abatement achievable through credit-based systems, like the Clean Development Mechanism, might significantly decrease.

Within this chapter, an analytical model of a credit-based system is presented that takes potential overreporting of emission reductions into account. The main focus is laid here on the optimal decisions of the regulator, given the impossibility to fully enforce compliance to the Mechanism. Just as with any microeconomic model, the framework presented here is not a mapping of one-to-one real world situations. Its major objective is rather to identify the specific effects of the above-mentioned information asymmetries on the decisions of a rational benevolent regulator. In the context of the Clean Development Mechanism, the role of such a regulator is taken up by the CDM Executive Board and its supporting panels. As a consequence, the decisions of the external verifiers—the Designated Operational Entities—are not explicitly modeled. This simplification is justifiable on the grounds that the CDM verification mechanism is not capable to fully deter opportunistic overreporting. This incomplete deterrence can be attributed to two different reasons. First, even a thorough verification might not reveal opportunistic behavior in reporting, as information asymmetries between project participants and the verifier could persist. Second, given the fact that the DOEs are remunerated by the project participants, potential collusion in reporting of emission reductions cannot be excluded.

The chapter is structured as follows. In section 3.1 the general problem of opportunistic false reporting in environmental regulation is introduced. Special emphasis is laid here on the specificities of credit-based systems—like the CDM—which, up to the present, have been neglected in the literature. The presentation of the formal model starts with
section 3.2, where the abatement and reporting decisions of a rational project developer are derived. Section 3.3 presents the optimal monitoring policy of a regulator disposing of an unlimited budget. Interestingly, even if endowed with an unlimited budget, the regulator would not achieve perfect enforcement in reporting. In section 3.4, optimal monitoring is analyzed under the more realistic assumption of a limited budget. It turns out that under a credit-based system the optimal monitoring strategy significantly differs from a cap-and-trade or a tax system. The chapter concludes with a discussion of the model results.

3.1. Incomplete Enforcement of Emission Reductions

The basic problem with any environmental regulation aiming at the reduction of emissions is that emitters can either understate their actual emissions or overstate the emission reductions achieved. Given that these levels are not fully observable to the regulator, emitters have an incentive to misreport these values. In the case of a per-unit tax on emissions, for example, the reported emissions represent the basis from which the overall tax burden for the regulated entity is derived. While a reduction of emissions is associated with abatement costs, fraudulent misreporting of emissions might represent an attractive alternative for reducing the amount of taxes paid. In a cap-and-trade emissions trading system, the situation is similar. Here, the emitter has an incentive to increase the difference between the stipulated emissions cap and the reported emissions. Given that emission permits have a positive market value, an increase in this difference augments, ceteris paribus, the benefits for net sellers and decreases the costs for net buyers. Again, emitters might be tempted to overreport actually achieved emission reductions, in order to maximize the amount of disposable permits.

As already laid out in the preceding chapter, the potential for fraudulent reporting is even higher in credit-based systems, like the Clean Development Mechanism. In such a system, the amount of certificates generated is determined by the difference between baseline emissions and reported project emissions. Hence, a fraudulent manipulation is possible 	extit{ex ante}, through an overstatement of the baseline, as well as 	extit{ex post}, through an understatement of actual project emissions. For this reason, both determinants of generated certificates are subject to a scrutinized verification within the CDM project cycle. Yet, it is likely that information asymmetries between project parties and the regulator persist. The baseline, for example, should ideally represent the scenario based on what would have happened without the implementation of the project. Clearly, any such plans for the project site are private information—a priori unknowable to the regulator—and are not necessarily truthfully revealed within the Project Design Document. As laid out in the last chapter, the information asymmetry with respect to the baseline is also at the basis of the discussion on the 	extit{additionality} within the CDM. In
addition to this baseline problem, the possibility of underreporting the actual emissions persists, just as for the other environmental policy instruments mentioned above.

As a consequence of the problem of opportunistic misreporting, any environmental policy needs to include an enforcement mechanism to be effective. In general, such a mechanism involves the monitoring of actual emissions through the regulator and a sanctioning of discovered fraudulent misrepresentation. In a resource-constrained world, however, full enforcement of environmental policies is unlikely. As monitoring of emitters is costly, the effectiveness of the enforcement mechanism is constrained by the budget available to the regulator. Under these circumstances, it is more efficient to increase the deterrence effect by increasing the expected sanction through a tightening of the penalty.\(^1\) However, even if the budget constraint of the regulator does not bite, there might be situations within which enforcement remains incomplete. This is the case if the information asymmetry between emitter and regulator is structured in such a way that the probability of discovering fraudulent misreporting is lower than one.

Given the importance of enforcement for the effectiveness of environmental policies, research interest in incomplete enforcement has increased in recent years within the field of environmental economics. A shift in interest can also be observed with respect to the policy instruments considered. Early research on incomplete enforcement of environmental regulation has mainly focused on the comparison of emission taxes and pollution standards. The first formal model on this issue was developed in Harford (1978), which was extended in Harford (1987) to include self-reporting by firms. Within more recent research the analyses are extended to the comparative performance of the different environmental policy instruments under incomplete enforcement. Schmuitzler and Goulder (1997) focus on the difference between emission taxes and output taxes. Macho-Stadler and Perez-Castrillo (2006) analyze the optimal enforcement policy in the context of per-unit emission taxes. Malik (1990), Keeler (1991), Macho-Stadler (2006), and Stranlund (2007) also include cap-and-trade programs in their analysis.

Credit-based systems, however, have been so far neglected in the literature. To our knowledge, there exists no formal model deriving optimal monitoring for such systems. This might be due to the fact that credit-based systems only recently gained in importance, which is, in turn, to a large extent a result of the successful implementation of the Kyoto markets. On the other hand, the non-consideration of credit-based systems in the literature is particularly unfortunate in light of the elevated potential for fraudulent misreporting within such schemes. The model presented on the following pages is meant as a contribution to reduce this research gap. The basic framework builds heavily on the model developed in Macho-Stadler and Perez-Castrillo (2006), who analyze incomplete enforcement in the context of emission taxes. However, the adjustments made for representing a credit-based system do significantly alter both, the analysis as well as

\(^1\)This argument is one of the main postulates derived from the economic theory of crime. See Becker (1968).
the results. As will be explained below, the major difference between tax schemes and credit-based systems is the fact that the objective function of the regulator changes with a switch from one system to the other. As the received credits are used to offset emissions elsewhere, a regulator interested in environmental integrity has to minimize not only the emissions, but the overall overreported amount of emission reductions. This minimization is subject to the constraint that the project parties, in turn, minimize their costs. For this reason the subsequent outline of the model starts with deriving the decisions of the single projects.

3.2. The Decision of the Project Parties

In the following sections a scheme is considered within which private actors can submit emission reduction or absorption projects generating credits that can be used to offset emissions occurring at an emission source which is not associated with the project. This setup describes, hence, schemes like the CDM where the generated credits are sold on a primary or secondary carbon market. As depicted in section 3.1, the amount of credits generated is determined through the difference between baseline emissions and reported project emissions. As both determinants can be manipulated, the information asymmetry between project participants and regulator might lead to positive difference between claimed offsets and actual emission reductions.

3.2.1. Decision under Full Enforcement

Throughout the following pages it is assumed that there exists a continuum of abatement projects for each of which the respective project participants have invested in a specific abatement technology determining a minimum level \( e \) and a maximum level \( \overline{e} \) of emission reductions achievable within the project, where \( e, \overline{e} > 0 \). Within these limits the project participants choose the actual level of reductions \( e \); hence \( e \in [e; \overline{e}] \).\(^2\) This assumption implies that the respective project is already accepted within the credit-scheme, but can generate different levels of emission reductions, dependent on the abatement effort levels incurred. A relaxation of this assumption will be discussed in section 3.4.2. The above depicted set-up adequately describes a large range of project types. For example, the reductions generated through fuel switching, reforestation, or energy efficiency-projects are not only dependent on the initial project investment, but also on the efforts incurred to actually implement the project itself.

It can be reasonably assumed that emission reductions cannot be generated without costs. Hence, any level of emission reductions is associated with a respective amount of

\(^2\)For example, a project might involve a fuel-switch within a power plant from coal to natural gas. In this case the upper and lower level of project emissions are pre-determined by the actual base demand of electricity, the applied emission factor, and the plant’s capacity.
abatement costs. The abatement cost function of the project is denoted as \( c(e) \), with \( c'(e) > 0, c''(e) > 0 \), for all \( e \in [\xi; \tau] \).

In order to establish a benchmark for the model results under incomplete enforcement, it is useful to first describe the decision of the project participants for the case where the actual project reductions are fully observable. In this case the project participants report the emission reductions that have actually occurred, i.e. \( e \). The reported emission reductions are, as described in the preceding chapter, certified and can then be sold on the market for the price \( p \), which is assumed to be constant and publicly known. In this case, the project participants will minimize the net costs \( C(e) \) of the project as follows:

\[
\min_{e} C(e), \text{ with } C(e) = c(e) - pe
\]

Note that under the assumed full-information case, the firm reports exactly the emission reductions actually achieved, and receives thus exactly \( e \) certificates, which can be sold on the market for the price \( p \). Hence, net costs \( C(e) \) consist of the costs of reducing the emissions \( c(e) \) and the reduction of overall costs through the revenue from selling the thusly generated certificates. From the first order condition associated with (3.1), which determines the optimal level of emission reduction, follows:

\[
c'(e^*) = p
\]

Equation (3.2) represents the well-known result that under perfect competition with full information the marginal abatement costs will be equal to the certificate price. The resulting first-best optimal level of emission reductions is denoted by \( e^* \). This level will be used as a benchmark for the following analysis.

### 3.2.2. Decision under Incomplete Enforcement

If incomplete enforcement is introduced within the above-described framework the project participants’ decision might change. In case of information asymmetries between the regulator and the project developer, the latter can chose any level of emission reductions \( \hat{e} \) but report to have actually reduced more. Note that, with rational actors, reported emission reductions \( z \) will never be less than the actual reductions \( \hat{e} \) as the value of the certificates is positive. It is also assumed that for all projects there exists a maximum level of plausible emission reductions \( \tau \), i.e. for reports above this level no certificates will be issued. In the context of the CDM, this upper limit can be interpreted as restrictions to plausible baseline emissions established by the CDM Executive Board. Thus, formally the reported emission reductions are defined as \( z \in [\hat{e}, \tau] \).

In order to increase the incentive for truthful reporting, the regulator has the possibility to monitor the projects. The probability of being monitored for truthful reporting, the regulator has the possibility to monitor the projects. The probability of being monitored for each project type is \( \alpha \), with \( \alpha \in [0; 1] \). It is assumed that this probability is known to the project participants. In an application to the Clean Development Mechanism, \( \alpha \) would be determined
by the expected frequency of 'spot-checks' on each project type by the CDM Executive Board. The different projects are assumed to differ with respect to their 'verifiability', which is expressed through a project-specific probability $\beta$. If $\beta$ is 1 and the regulator monitors the project he is capable to determine without further problems whether the firm has overreported or not. The closer $\beta$ is to 0, the more improbable is the success of such an assessment. Hence, the intensity of the information asymmetry is assumed to vary across the different project types and might become large enough that a verification through the regulator does not necessarily lead to the discovery of misreporting. Assuming different levels of verifiability is quite plausible if it is kept in mind that for any given project overreporting can be the result of either a misstated baseline, under-reported project reductions, or both. In order to be able to isolate the effects of such differences in verifiability, it is assumed in the following that this is the only variable in which projects differ. In all other parameters the different projects are treated as being identical.

In case overreporting is discovered the project participants are required to pay back the revenue from overreported reductions and in addition to pay a fine. The regulator is assumed to make the fine contingent on the 'magnitude of the lie' $x$, which is defined as $x = z - e$. The relationship between the overreported amount and the corresponding fine is determined by the legislator of the scheme and defined through the penalty function $\theta(x)$, with $\theta(0) = 0$, $\theta'(x) > 0$, and $\theta''(x) > 0$ for $x > 0$. Note that in order to have a deterrence effect, this function is a priori known by the regulated project parties. The assumption that the penalty is convex in the magnitude of the offense is quite realistic, as it seems to be in line with legal practice under many different circumstances.\(^3\)

With incomplete enforceability of truthful reports, the project participants’ optimal decision problem is altered. Taking into account the assumptions on the expected penalty made above, the minimization problem for each project type is defined as:

$$\min_{e,z} C(e, z, \alpha, \beta),$$

where $C(e, z, \alpha, \beta) = c(e) - pz + \alpha\beta p(z - e) + \alpha\beta \theta(z - e)$

It is hence taken into account within the cost function that in case overreporting is discovered, the project participants will have to give back the excess certificates and pay a fine according to the progressive penalty schedule $\theta$. The first order conditions for (3.3) are:

$$\frac{\partial C}{\partial e} = c'(e) - \alpha\beta p - \alpha\beta \theta'(z - e) = 0$$

\(^3\)The assumption of convex punishment is widely used in a large part of the literature on incomplete enforcement. See, for example, Harford (1978), Harford (1987), Sandmo (2002), Cremer and Gahvari (2002), and Macho-Stadler and Perez-Castrillo (2006).
\[
\frac{\partial C}{\partial z} = -p + \alpha \beta p + \alpha \beta \theta'(z - e) = 0 \quad (3.5)
\]

The solutions to these necessary conditions indeed determine a local minimum, as is proven in the mathematical appendix. It is however to be noted that the optimization program in (3.3) is, in fact, also constrained through the domains of the variables \( z \) and \( e \). Depending on the values for the overall probability of discovery, i.e. \( \alpha \beta \), the project participant’s optimization can hence result in a corner solution. This is definitely the case if the probability of discovery is zero. In this case, the project participants would chose the maximum plausible amount for the reported emissions, i.e. \( z = \overline{z} \), while actually choosing the minimum possible amount of emission reductions, i.e. \( e = e^* \). This result reflects a complete unenforceability of truthful reporting and can, in fact, only occur with either an inactive regulator or a complete lack of verifiability of the project.

For those cases where the probability of discovery is positive, the expected penalty in case of discovery provides an incentive to reduce the overreported amount \( x \), which is defined as \( x = z - e \). To achieve such a reduction in \( x \) the project parties can either increase the amount of actual emission reductions, or decrease the amount of reported reductions, or both. In order to understand the optimization of the participants, it is to bear in mind that a reduction in \( z \) would entail a decrease in issued certificates by a corresponding amount. Hence, the ‘cost’ for reducing reported emissions is equal to the price of the certificates \( p \). As a consequence, with increasing values of \( \alpha \beta \), cost-minimizing project parties will always prefer to hold \( z = \overline{z} \) and to rather increase their actual reductions \( e \) as long as the marginal cost of abatement remain lower than the certificate price \( p \). Consequently, a reduction in \( z \) will only occur if \( e \) is reduced to the level \( e^* \), i.e. the first best optimal reduction level which is implicitly defined through equation (3.2). Hence, only if \( \alpha \beta \) are high enough to induce \( e^* \) the level of \( z \) chosen will be determined through condition (3.5). Finally, if the probability of discovery is high enough, the expected penalty will be large enough to completely deter opportunistic overreporting, such that \( x = 0 \).

These intuitive considerations are expressed more formally within proposition 3.1, also defining the respective thresholds for the monitoring probability. The proposition represents in fact an adaptation of the findings of Macho-Stadler and Perez-Castrillo (2006) to the case of credit-based emissions trading.

**Proposition 3.1** For a given price of certificate \( p \), audit probability \( \alpha \), a penalty function \( \theta(x) \), and a level of overreporting \( x = z - e \), the optimal emission and report decisions \((e^0, z^0)\) for the project of type \( \beta \) are:

(a) If \( \alpha \beta = 0 \), then \( e^0 = \overline{e} \) and \( z^0 = \overline{z} \).

(b) If \( \alpha \beta \in ]0, \frac{p}{p + \theta'(e^*)}[, \) then \( e^0 \in (\overline{e}, e^*) \) and \( z^0 = \overline{z} \), with
3.3. Optimal Monitoring Policy with an Unlimited Budget

Given the optimizing behavior of the project participants as derived above, a rational regulator needs to identify an optimal monitoring strategy. In order to model the monitoring decision with an existing project pool, the regulator is assumed throughout this chapter to face a population of already registered projects. As explained before, the different projects are supposed to vary only with respect to their verifiability, which is parameterized by $\beta$. The project specific probability $\beta$ is distributed over the interval $[0,1]$ according to the density function $f(\beta)$, with $f(\beta) > 0$ for all $\beta \in [0,1]$, and the cumulative function $F(\beta)$.

The objective of the enforcement agency is to minimize overall emissions, occurring within the regulatory scheme. When choosing the level of audit pressure for each project type, the regulator needs to account for the fact that credit-based systems fundamentally differ from other environmental policy instruments. Within cap-and-trade emissions trading or an emissions tax system, the only variable that is to be minimized are the actual emissions of the scheme’s participants. Consequently, actors situated within area

\[ c(e^0) - \alpha \beta p - \alpha \beta \theta'(\tau - e^0) = 0. \]  \hspace{1cm} (3.6)

(c) If $\alpha \beta \in \left[ p + \theta'(e^* - e^0), \frac{p}{p + \theta'(0)} \right]$, then $e^0 = e^*$ and $z^0 \in [e^*, \tau]$ as defined by:

\[ -p + \alpha \beta p + \alpha \beta \theta'(z^0 - e^*) = 0 \]  \hspace{1cm} (3.7)

(d) If $\alpha \beta \geq \frac{p}{p + \theta'(0)}$, then $e^0 = e^*$ and $z^0 = e^*$.

Proof: See mathematical Appendix.

Figure 3.1 depicts the changes in levels of actual abatement and of reported reductions chosen by the project parties for different levels of probability of being punished. As implied by the proposition, the probability features several thresholds leading to a change in cost minimizing behavior. The figure also depicts the probability ranges within which the cases (a) to (d) hold. As expressed within proposition 3.1 (a), a zero probability of being punished induces the reduction and reporting levels that maximize overreported emissions. Within range (b) the project participants prefer to increase the level of actual reductions, while holding $z$ at the maximum plausible level $\tau$. With further increase of the probability of being discovered, the actual reductions are held at the level $e^*$ while the reported reductions are reduced, as depicted in field (c). With a high enough probability of punishment, the parties are completely deterred from overreporting, as expressed within proposition 3.1 (d).
(c) of figure 3.1 would not require a further increase in the monitoring probability $\alpha$. For a credit-based system, like the Clean Development Mechanism, restricting enforcement on the actual emissions would not necessarily minimize overall emissions. Given that the credits generated through the projects are being used to offset emissions elsewhere, an over-issuance of such credits due to false reporting would lead to an undesired increase in global emissions compared to the full enforcement case. Hence, unlike other environmental policy instruments, credit-based systems require the regulator to minimize not only the actual reductions $e$ but also the reported reductions $z$.

Within the model presented here, optimal enforcement implies a minimization of over-reporting, expressed through $x = z - e$, over the whole project population, parameterized by $\beta$. For simplicity, the cost of one unit of audit is normalized to one. To determine the optimal enforcement policy, the enforcement agency decides on auditing each type of firm, i.e. it chooses $(\alpha(\beta))_{\beta \in [0,1]}$ in order to solve the following program.
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\[
\min \int_0^1 z(\beta) - e(\beta)d\beta \quad (3.8)
\]

such that

\[
\int_0^1 a(\beta)f(\beta)d\beta \leq B \quad (3.9)
\]

and

\[
e(\beta), z(\beta) \in \arg\min C(\beta, \alpha; e, z) \quad (3.10)
\]

Hence, to choose an optimal monitoring scheme, the agency needs to take into account its budget constraint (3.9), and the profit maximization of the single project participants, expressed through constraint (3.10). Within this section we only consider the second constraint to be binding.

As the choices of \( z \) and \( e \) for the different projects depend on the overall probability of being punished \( \alpha \beta \), the optimal level of \( \alpha \) varies for each project type according to its individual probability of verifiability \( \beta \). Hence, taking the project parties’ optimization into account, for each threshold identified in proposition 3.1, a specific value of \( \alpha \) can be defined. First, we define:

\[
\hat{\alpha}(\beta) \equiv \frac{p}{\beta[p + \theta'(\bar{e} - e^*)]} \quad (3.11)
\]

as the minimum probability that induces an emission level of \( e^* \). As \( \alpha, \beta \in [0, 1] \), this probability level is only ‘feasible’ when \( \hat{\alpha}(\beta) \leq 1 \), i.e. \( \beta \geq \hat{\beta} \), where:

\[
\hat{\beta} \equiv \frac{p}{[p + \theta'(\bar{e} - e^*)]}
\]

A firm with \( \beta < \hat{\beta} \) pollutes more than \( e^* \) even at audit probability \( \alpha = 1 \), since the probability of being discovered even if audited is very low.

Second, we define:

\[
\check{\alpha}(\beta) \equiv \frac{p}{\beta[p + \theta'(0)]}
\]
as the minimum audit probability that induces a report \( z = e = e^* \), i.e. truthful reporting. Again, this probability level is only 'feasible' if \( \hat{\alpha} \leq 1 \), i.e. \( \beta > \hat{\beta} \), where:

\[
\hat{\beta} \equiv \frac{p}{|p + \theta'(0)|}
\]

Taking these different thresholds into account, it becomes clear that the assumed structure on the information asymmetries between regulator and project participants does not allow for the realization of the full information outcome. For low levels of \( \beta \) even an audit probability of \( \alpha = 1 \) is not sufficient to induce truthful reporting. Consequently, even with an unlimited budget the minimum global pollution level that an agency can achieve, is restricted by the informational constraints. This maximum level of global emission reductions induced by the credit-scheme given an unlimited budget can be defined as:

\[
e^{\text{MAX}}_\beta \equiv \int_0^{\hat{\beta}} (e^{**}(\beta) - \tau)f(\beta)d\beta + \int_{\hat{\beta}}^{\hat{\beta}} (e^* - z^{**}(\beta))f(\beta)d\beta + [1 - F(\hat{\beta})]e^*, \quad (3.12)
\]

where \( e^{**} \) and \( z^{**} \) are implicitly defined by

\[
c_e(e^{**}) - \alpha \beta p - \alpha \beta \theta'(e^{**}) = 0, \text{ for } \beta \in (0, \hat{\beta}]
\]

and

\[
-p + \alpha \beta p + \alpha \beta \theta'(z^{**} - e^*) = 0, \text{ for } \beta \in (\hat{\beta}, \hat{\beta})
\]

The first term in (3.12) measures the overall impact on reductions of projects which will overpollute and overreport even if the monitoring probability \( \alpha \) is equal to one. These projects are situated in field (b) of figure 3.1. The second term expresses the impact on reductions of projects within field (c), achieving the optimal level of actual reductions but which can not be completely deterred from overreporting. The last term adds the reduction level of projects that are induced to fully comply to the terms of the mechanism.

The definition in (3.12) can be used to calculate the minimum budget necessary to achieve \( e^{\text{MAX}}_\beta \). We denote this minimum budget by \( \bar{B} \), which is defined through:

\[
\bar{B} \equiv F(\hat{\beta}) + \int_{\beta}^{1} \hat{\alpha}(\beta)d\beta \quad (3.13)
\]

Proposition 3.2 immediately follows:

**Proposition 3.2** When \( B \geq \bar{B} \) the cost-minimizing agency sets an audit policy that satisfies \( \alpha(\beta) = 1 \), for \( \beta \in [0, \hat{\beta}] \) and \( \alpha(\beta) \in [\hat{\alpha}(\beta), 1] \) for \( \beta \in [\hat{\beta}, 1] \).
Proposition 3.2 has an important implication for the design of audit policies for credit-based systems. In case such a scheme includes projects with large information asymmetries between project participants and the regulator, an increase in budget does not necessarily lead to a reduction in overreporting. As soon as the budget level $\hat{B}$ is reached, the marginal rate of deterrence equals zero. Hence, even if a maximization of reductions is the only objective of the agency, efficiency requires that the auditing budget of the regulator should be capped at $\hat{B}$.

### 3.4. Monitoring with a Limited Budget

In practice, it is likely that the number of audits which can be performed by the regulator is constrained by his budget. After all, budget $\hat{B}$ implies that all projects situated in regions (b) and (c) in figure 3.1 are audited with probability one. In the context of the Clean Development Mechanism, for example, this would mean that the Executive Board will carry out audits for projects with a lesser potential of verifiability with certainty. This would not be in line with the declared approach to carry out ‘spot-checks’ for project control which are by definition associated with a probability lower than one. It is hence realistic to assume that the budget constraint (3.9) of the regulator’s optimization problem is binding. Thus, in the following it is assumed that $B \leq \hat{B}$.

Within the budget-constrained optimization, it is again to be taken into account that the regulator is not only interested in achieving an optimal level of actual reductions $e$—as would be the case for other policy instruments—but that the specificities of the credit-based approach require to take also the reported reductions $z$ into account. Again this is due to the fact that issued CDM certificates are used to offset emissions elsewhere. The regulator needs hence to decide for which project types an increase in spot-check frequency would result in the largest decrease in overall emissions. In this context, it is of particular importance whether the monitoring budget should rather be spent on firms in region (b) or (c) in figure 3.1. It is by considering this trade-off that the present considerations differ most from the analysis of incomplete enforcement of environmental taxes, as carried out by Macho-Stadler and Perez-Castrillo (2006). Generally, for any two projects with probability of verification $\beta_1$ and $\beta_2$, a marginal shift $\delta$ in monitoring effort from project 1 to project 2 is (weakly) efficient if:

$$ -f(\beta_1) \frac{\partial x}{\partial \alpha_1} \delta + f(\beta_2) \left( \frac{\partial x(\alpha_2 \beta_2)}{\partial \alpha_2} \right) \frac{f(\beta_1)}{f(\beta_2)} \delta > (\geq) 0 \quad (3.14) $$

with
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\[ x(\alpha\beta) = \begin{cases} 
\frac{\tau - e}{e - e(\alpha\beta)}, & \text{for } \alpha\beta = 0 \\
\frac{\tau - e(\alpha\beta)}{p + \theta'(\tau - e^*)}, & \text{for } 0 < \alpha\beta < \frac{p}{p + \theta'(\tau - e^*)} \\
z(\alpha\beta) - e^*, & \text{for } \frac{p}{p + \theta'(\tau - e^*)} \leq \alpha\beta \leq \frac{p}{p + \theta'(0)} \\
0, & \text{for } \frac{p}{p + \theta'(0)} < \alpha\beta \leq 1
\end{cases} \]

Note that the rational regulator will never increase monitoring pressure for firms which are already in full compliance. Consequently, the case \( \alpha\beta > \frac{p}{p + \theta'(0)} \) will never occur. Furthermore, for positive \( \alpha \), the case \( \alpha\beta = 0 \) can only occur if \( \beta \) is zero. Choosing \( \alpha = 0 \) for this case is straightforward. Hence, identifying an efficient auditing policy through condition (3.14) mainly involves a trade-off in monitoring pressure between the two regions (b) and (c). This requires the comparison of the respective slopes of \( e(\alpha) \) and \( z(\alpha) \). As both of these functions result from the optimizing behavior of the project participants in response to the ex ante communicated \( \alpha \) for each project type, these slopes can be derived from (3.4) and (3.5) by applying the Implicit Function Theorem.

The corresponding partial derivatives are:

\[ \frac{\partial e}{\partial \alpha} = \beta \cdot e'(\alpha\beta) = \beta \cdot \frac{p + \theta'(\tau - e(\alpha\beta))}{c'(e(\alpha\beta)) + \alpha\beta\theta''(\tau - e(\alpha\beta))}, \quad \text{for } \alpha\beta \in ]0, \frac{p}{p + \theta'(\tau - e^*)} [ \ (3.15) \]

and

\[ \frac{\partial z}{\partial \alpha} = -\beta \cdot z'(\alpha\beta) = -\frac{p + \theta'(z(\alpha\beta) - e^*)}{\alpha\theta''(z(\alpha\beta) - e^*)}, \quad \text{for } \alpha\beta \in [\frac{p}{p + \theta'(\tau - e^*)}, \frac{p}{p + \theta'(0)}] \ (3.16) \]

Hence, as it is to be expected, within both regions (b) and (c) the amount of overreported reductions \( x = z - e \) is decreasing in the overall probability of discovery. As both slopes are a function of the penalty \( \theta(x) \), and \( \frac{\partial e}{\partial \alpha} \) additionally depends on the abatement costs \( c(e) \), identifying the optimal auditing policy for each \( \beta \)-type firm is only possible if additional assumptions are made. However, even the quite general forms of (3.15) and (3.16) allow to derive the following proposition.

**Proposition 3.3** Under a limited budget \( B < \bar{B} \), optimal monitoring policy implies that there exists a threshold \( \beta_1(B) > 0 \), such that the regulator chooses \( \alpha = 0 \) for \( \beta \leq \beta_1(B) \). Projects with \( \beta > \beta_1(B) \) will always be monitored with \( \alpha > 0 \).

*Proof:* See mathematical appendix.

Proposition 3.3 allows a first interesting insight in the optimal distribution of audit pressure. It states that a budget-constrained rational regulator will never audit
those projects that are most difficult to monitor, while all other projects will always be
monitored with positive probability. It is, however, not possible under the given assump-
tions to make any further propositions on the intensity of monitoring pressure for those
projects with levels of verifiability lying above that threshold. Hence, further insights
can only be gained if the analysis is restricted by making additional assumptions. Yet,
before turning to these assumptions it is useful to first introduce some simplifications
in notation. Denote with $q$ the marginal penalty to be paid if project participants are
captured overreporting by the amount $x(\alpha, \beta)$. Hence:

$$ q(x) \equiv p + \theta'(x) $$

Further we define $\rho$ as the ratio of the marginal penalty to its first derivative.

$$ \rho(x) \equiv \frac{q(x)}{q'(x)} $$

Taking these changes in notation into account we make the following assumption.

**Assumption 3.1** For $x = z - e$, with $e \in [\bar{e}; \bar{\tau}]$ and $z \in [\bar{e}, \bar{\tau}]$ where $\bar{e}$ is the actual level
of emission reductions achieved by the project, assume that $\rho(x)$ is weakly increasing in
$x$. Hence:

$$ \left( \frac{q(x)}{q'(x)} \right)' \geq 0 \iff q''(x) \leq \frac{q'(x)^2}{q(x)} $$

Note that by the assumptions initially made in section 3.2, both, $q(\cdot)$ and $q'(\cdot)$ are
strictly larger than zero. Hence assumption 3.1 is, for example, fulfilled in the case of
a polynomial penalty function of the form $\theta(x) = m \cdot x^n + \sum_{i=0}^{n-1} a_i \cdot x^i$, with $m > 0$, $a_i \geq 0$, and $n \geq 2$. As shown in the mathematical appendix, Assumption 3.1 is a
sufficient condition for both, $e'(\alpha)$ and $-z'(\alpha)$, to be decreasing in $\alpha$ for any $\beta > 0$.
This allows us to identify two other thresholds which are important for determining the
optimal monitoring policy. The nature and conditions for existence of these thresholds
are stated within within the following proposition.

**Proposition 3.4** Under Assumption 3.1 and given a limited budget $B < \bar{B}$, the optimal
monitoring policy of the regulator is characterized by the following:

(i) For $\beta_l(B) < 1$, and if

$$ \beta_l(B) < \frac{z'(\alpha_l(1))}{e'(0)} = \frac{q(\bar{\tau} - e^*)}{p} \cdot \frac{q(\bar{\tau} - e^*) \cdot e''(\bar{e})}{q'(\bar{\tau} - e^*) \cdot q(\bar{\tau} - \bar{e})} \quad (3.17) $$

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there exists a threshold $\beta_m(B) > \beta_l(B)$ such that $z < \tau$ for all $\beta > \beta_m(B)$. The
value of $\beta_m(B)$ is non-decreasing in $B$. Furthermore, for all cases where $\beta_l(B)$ is
strictly larger than $\frac{z'(\hat{\alpha}(1))}{e'(0)}$, the value of $\beta_l(B)$ is non-increasing in $B$.

(ii) For $\beta_l(B) < 1$, and if

$$
\beta_l(B) < \frac{z'(\hat{\alpha}(1))}{e'(0)} = \frac{q(0)}{p} \cdot \frac{q(0) \cdot c''(e)}{q'(0) \cdot q(e - e)}
$$

(3.18)

there exists a threshold $\beta_h(B)$, such that the regulator induces $z = e$ for firms with
$\beta \geq \beta_h(B)$. The value of $\beta_h(B)$ is non-increasing in $B$.

(iii) For any $B_0$ for which $\beta_l(B_0)$ fulfills condition (3.17) (condition (3.18)), the con-
dition is also fulfilled for any $\beta_l(B)$, for which $B > B_0$.

Proof: See mathematical Appendix.

Proposition 3.4 states the conditions for the existence of the ranges (c) and (d) un-
der a limited budget. The budget constraint determines in fact the level of $\beta_l$—the
threshold from which on the regulator prefers to refrain from monitoring the projects.
The existence of this threshold $\beta_l$ is a precondition for the existence of the other two
thresholds defined in the proposition. In fact, as is shown in the mathematical appendix,
the conditions for the existence of these additional thresholds are derived through the
comparison of the slopes of $x = z - e$ for the highest $\beta$-values of the set of monitored
projects, i.e. $\beta = 1$, and the set of non-monitored projects, i.e. $\beta_l$. Note that for any
given combination of certificate price $p$, abatement cost function $c(e)$, and penalty func-
tion $\theta(z - e)$ the right hand sides of (3.17) and (3.18) are constant. As, under the given
assumptions, the regulator has full information on these determinants, the existence of
both thresholds is unambiguous once the lower threshold level $\beta_l(B)$ is known.

However, the behavior of $\beta_l(B)$ with respect to increases (decreases) in $B$ might be
ambiguous. While it is safe to say that $\beta_l(B)$ decreases for large enough increases in
the budget $B$, this does not necessarily hold at the margin. Given that $x(\alpha \beta)$ features
a 'jump' at $\alpha \beta = \frac{p}{p + \theta(e - e'')}$, a small increase in budget might lead to abrupt changes
in the audit strategy. Assume, for example, that $B$ is marginally smaller than $\hat{\alpha}(1)$. 
Assume further that the gain from a decrease of $z$ in $z(\hat{\alpha}(1))$ for $\beta = 1$ is larger than the
sum of reduced overreporting for all other projects currently monitored. In this case any
additional marginal increase in budget, would—according to condition (3.14)—lead to a
decrease in overall monitored projects in favor of an increase in monitoring pressure for
projects with $\beta = 1$. While such discontinuities in $\beta_l(B)$ cannot be excluded, proposition
3.4 (iii) ensures that the upper threshold values continue to exist if the monitoring budget
is increased. In fact, as is shown in the mathematical appendix the only reason for which
the number of monitored projects might be reduced with an increase in $B$, is that the
two other threshold values $\beta_m$ and $\beta_h$ are decreased. Hence, there exists a trade-off between increasing the compliance of easy-to-verify projects or weakly increasing overall monitored projects.

Once the behavior of $\beta_l(B)$ is understood, the threshold conditions formulated within proposition 3.4 are quite intuitive. The first factor in conditions (3.17) and (3.18) represents the ratio of the marginal punishment and the marginal gain, i.e. the price of one certificate, for a project facing the probability of discovery inducing a report right at the respective threshold level. The larger this ratio, the more likely is the existence of the respective threshold under a limited budget. This relationship is plausible. If the power of the incentive to further reduce overreporting or to fully comply is high it is, ceteris paribus, rational to actually induce these levels of compliance. Note that given the definition of the marginal penalty the first factor in both conditions is always larger than 1.

The second factor within conditions (3.17) and (3.18) is also quite intuitive. It represents in fact the ratio of the marginal increase in marginal abatement costs at $\beta_l$ to the marginal decrease in marginal punishment at the respective threshold level (i.e. $\beta_m$ or $\beta_h$), each set in relationship to the marginal punishment at the same level of over-reporting. Note that an increase in marginal abatement costs lowers the incentive to increase the actual emission reductions, while an increase in the marginal penalty will raise this incentive. Consequently, the ratio represents a measure for the intensity of the achievable incentives at $\beta_l$ compared to the achievable incentives at the threshold level considered, i.e. $\beta_m$ or $\beta_h$. The harder it is to incentivize a change in behavior at $\beta_l$ the more likely it is that the regulator prefers to increase auditing pressure for projects with a higher degree of verifiability.

While proposition 3.4 provides interesting insights on the conditions under which the rational regulator decides to incentivize easier-to-verify projects toward full compliance, it is not suitable for identifying how a given budget should be optimally attributed to the different project types. As this is probably the most eminent question in the context of budget-constrained monitoring, we will present a few interesting insights to that matter in the following section.

### 3.4.1. Optimal Monitoring Pressure under a given Budget

The regulator interested in the minimization of overall overreporting needs to decide on the optimal auditing pressure for each $\beta$-type project. Evidently, the optimal monitoring strategy depends on the specific functional forms of the penalty function, the abatement cost function, and the price of the certificate $p$. A specification of these determinants would, however, imply a considerable loss of generality. For this reason, we will rather present those features of an optimal monitoring strategy, which can be gained from the general model. As is shown in the mathematical appendix the assumptions made so far are sufficient to allow for several important insights on the optimal monitoring pressure.
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\( \alpha \) for specific ranges of \( \beta \)-type projects. These insights are merged within the following proposition.

**Proposition 3.5** Under assumption 3.1 and if there exists a threshold value \( \beta_m \) the following holds:

(i) For \( \beta_0 < \beta_m \) and if \( \beta_0 \to \beta_m \) then \( \alpha(\beta_0) < \alpha(\beta_m) \)

(ii) If

\[
\frac{p}{q(e - e^*)} < \frac{q(e - e^*) \cdot c''(e)}{q(e - e^*) \cdot q(e - e^*)}
\]

all projects with \( \beta < \beta_m(B) \) will be monitored with probability \( \alpha = 0 \).

(iii) For \( \beta \in [\beta_m, 1] \) the monitoring probability \( \alpha \) is strictly decreasing in \( \beta \).

(iv) For \( \beta \in [\beta_l, \beta_m] \) the sign of \( \frac{d\alpha}{d\beta} \) is ambiguous under the given assumptions. Yet, the following is true:

(a) if \( c(\cdot) \) and \( \theta(\cdot) \) are quadratic functions a sufficient condition for \( \alpha(\beta) \) being strictly increasing (decreasing) for \( \beta_l < \beta < \beta_m \) is:

\[
c''(e) > (<) \alpha \beta \cdot \theta''(e - e^*) \quad \forall \; e \in [e_l; e^*]
\]

(b) if \( \alpha(\beta) \) is strictly decreasing for \( \beta_l < \beta < \beta_m \) and if \( c''(e) \) is close to zero, the optimal \( \alpha \) for \( \beta \) close to \( \beta_l \) is larger than for any \( \beta \geq \beta_m(B) \).

**Proof:** See mathematical Appendix.

Proposition 3.5 (i) implies that the optimal audit pressure at the threshold level \( \beta_m \) — from which on the projects will always achieve the optimal reductions — is strictly larger than for projects with a slightly lower level of \( \beta \). In fact, the function of optimal audit pressure \( \alpha(\beta) \) features a discontinuity at \( \beta_m \), involving an upwards shift of the optimal audit pressure at this point.

Proposition 3.5 (ii) states the condition for which the threshold level \( \beta_l \) for positive audit pressure is only marginally lower than the threshold for projects achieving the optimal level of emission reductions. Consequently, in such a case, there will be no projects situated within the (b)-range of figure 3.1. Condition (3.19) is quite intuitive. At the left-hand side is the ratio of marginal gains and punishment from misreporting one unit for projects of type \( \beta_m \). Note that this ratio is always smaller than one. The right hand side of condition (3.19) consists of the already introduced incentive measure comparing the strength of incentives at \( \beta_l \) and \( \beta_m \). The measure is larger than one if a marginal change in punishment \( \beta_l \) would lead to a larger change in marginal abatement costs than the decrease it would yield in marginal punishment at \( \beta_m \). Hence,
proposition 3.5 (ii) states that the regulator refrains completely from monitoring projects with $\beta < \beta_m$ if such monitoring would lead to a lower change in overreported emissions than could be achieved with incentivizing a decrease in $z$ for projects with $\beta \geq \beta_m$.

A very important result with respect to the optimal monitoring strategy is implied within proposition 3.5 (iii). In fact, it states that independently of the existence of the upper threshold level $\beta_h$ the regulator chooses to reduce the audit pressure with increasing verifiability. Hence, even if it is possible to incentivize projects with high $\beta$ to fully comply, the regulator might decide to use his monitoring budget to rather increase pressure on the projects with a lower degree of verifiability.

The behavior of $\alpha(\beta)$ for a decrease in $\beta$ for $\beta_l < \beta < \beta_m$ is more ambiguous. While it is clear from proposition 3.5 (i) that the optimal audit pressure feature a sudden decrease if $\beta$ decreases further than $\beta_m$, the given assumptions are insufficient to determine if $\alpha(\beta)$ is increasing or decreasing for projects with a verifiability lower than $\beta_m$. Proposition 3.5 (iv) sheds some light on the optimal monitoring policy for projects with such an intermediate degree of verifiability. Under the standard assumption of cost and penalty functions being quadratic, optimal audit pressure in this range of verifiability depends in principle on how strict the punishment is compared to the respective abatement costs. For a relatively lax quadratic penalty function, the first inequality in condition (3.20) implies that an increase in actual emissions would lead to a larger increase in marginal abatement costs than it would decrease the marginal penalty. Hence, under these conditions, the change in incentive to misreport is larger than the change in disincentive stemming from the punishment. As a consequence, it would be inefficient to increase audit pressure for lower degrees of verifiability, as the gains in compliance would be smaller than for projects with higher degrees of verifiability. The opposite is true if the punishment function is sufficiently stricter than the abatement costs function, which is reflected within the bracketed inequality in condition (3.20). In this case, the difference in incentive change increases with decreasing $\beta$. Hence, simply spoken, if the punishment is sufficiently large, it becomes optimal for the regulator to exercise an ever higher audit pressure for lower levels of verifiability within the range of $\beta_l < \beta < \beta_m$. Interestingly, if the cost function is close enough to linear, the audit pressure will be largest for projects with a $\beta$ close to $\beta_l$. Hence, the optimal audit policy of the regulator crucially depends on the punishment scheme that is foreseen by the legislative body.

In order to summarize the most important findings implied by the propositions 3.3 to 3.5, it is useful to visualize the optimal monitoring policy chosen by the regulator under different setups. In figure 3.2 we hence depict two different situations for both of which the budget level $B$ is smaller than $\overline{B}$ but large enough to ensure the existence of the threshold levels $\beta_m$ and $\beta_h$. Consequently, in both of these setups all possible levels of compliance (or misreporting) are realized. The depicted situations 1 and 2 differ, in fact, only with respect to the form of the abatement cost function and its relationship to the penalty function, leading to the different monitoring strategies $\alpha_1(\beta)$ and $\alpha_2(\beta)$. 89
We first describe the qualitative relationships in monitoring pressure which is common to both of these setups. As stated in proposition 3.3, in all cases the range of projects with the lowest degree of verifiability will not be monitored at all. At first sight, this might be considered as counter-intuitive as it could be argued that projects with low verifiability would require a high level of monitoring. However, given that the regulator is to maximize overall emission reductions under a constrained budget, it turns out to be more efficient to completely ignore projects below the threshold $\beta_l$. Note that this would also be the case for an environmental tax scheme as analyzed by Macho-Stadler and Perez-Castrillo (2006).

Furthermore, in both situations depicted in figure 3.2, the optimal auditing pressure features the upwards jump at $\beta_m$, stated in proposition 3.5 (i). From this point onwards optimal monitoring pressure is always strictly decreasing in the degree of verifiability, as stated in proposition 3.5 (iii). Hence, the easier the projects are to verify, the lower is the optimal monitoring probability for the respective project types. This is particularly intuitive for those projects that are in complete compliance, i.e. projects for which verifiability is larger or equal to $\beta_h$. As these projects report truthfully, an increase in monitoring probability would not lead to further increases in overall emission reductions.

Figure 3.2.: Optimal auditing pressure for different assumptions on abatement costs
For projects with an efficient emission level but an untruthful report, situated between $\beta_m$ and $\beta_h$, the relationship in monitoring intensity is more interesting. As already stated, with a credit-based system a regulator interested in reducing overall emissions needs to take into account both, reductions in overreporting through the report $z$, as well as actual emissions $e$. Hence, the fact that this trade-off results in an unambiguous qualitative relationship for monitoring projects situated in field (c) of figure 3.1 is quite an important finding. Another interesting result is the fact that for cases for which condition (3.19) holds, the monitoring pressure for all $\beta$ lower than $\beta_m$ would be zero. Consequently, the optimal monitoring function would only consist of the right hand branch of both depicted functions if the curvature of the abatement cost function were large enough. Hence, if the increase in marginal abatement cost is particularly large, the optimal monitoring would require to entirely refrain from monitoring all projects that would not yield the efficient level of reductions $e^\ast$.

The only ambiguity that exists in the qualitative relationship of optimal monitoring is with respect to levels of verifiability situated between thresholds $\beta_l$ and $\beta_m$. As stated in proposition 3.5 (iv), optimal monitoring might either increase or decrease in the degree of project verifiability. This ambiguity can be resolved if functional forms for the penalty and the abatement costs are specified. The optimal monitoring strategy $\alpha_1(\beta)$, depicted in figure 3.2, applies to a situation where the increase and curvature of the quadratic cost function is relatively large compared to the penalty function. This represents a case for which the unbracketed version of condition (3.20) holds. Under such circumstances, the optimal monitoring probability is strictly increasing in $\beta$ for the respective range. In contrast, situation 2 represents a case where the abatement cost function is close to linear, while the penalty function is comparatively strict. Hence, for $\beta_l < \beta < \beta_m$, the monitoring function $\alpha_2(\beta)$ is decreasing and reaches its largest values for $\beta$ close to $\beta_l$, as stated in proposition 3.5 (iv)(b). The differentiation between these two cases hence showcases that the regulator’s optimal strategy not only depends on his budget, but also on the relationship between abatement costs and punishment.

While the abatement costs are usually beyond the control of a regulatory framework, the penalty can be—at least in principle—easily adjusted. However, in the real world it is likely that there exist legal and political constraints with respect to the level of punishment. Clearly, the rule of law requires commensurability in legal sanctions, such that the set of applicable penalties is considerably reduced. As far as the CDM is concerned, it is also to note that sanctions beyond the rules of private law would have to be accepted within the COPs. The present Kyoto rules do not explicitly specify a penalty schedule for over-reporting of emissions. Yet, the model results presented above emphasize the importance of stipulating specific sanctions in order to assure a certain level of effectiveness for the CDM. However, as with all Kyoto rules, provisions on sanctions for the CDM are subject to the constraints of political feasibility. Depending on whether these constraints allow for lax or stricter sanctions the CDM Executive Board would have to decide on a monitoring strategy which rather resembles to $\alpha_1(\beta)$ or $\alpha_2(\beta)$.
in figure 3.2. We will further discuss the stringency of the penalties currently applicable by the CDM Executive Board within the last chapter of this thesis.

3.4.2. Regulation with Project Admission

The CDM has long been and in fact remains a matter of political dispute within the Kyoto negotiations. Even in the potential buyer countries, the use of Certified Emission Rights for meeting the Kyoto targets is not undisputed, as some observers still challenge the morality of reducing emissions in third-world countries.\(^4\) As a consequence, the sudden discovery of large scale fraud within a CDM project would significantly undermine the credibility of the whole Kyoto emissions trading regime as an instrument to achieve emission reductions. Hence, it is plausible that the architects of the Mechanism might want to reduce the risk of discovery of fraud. As the above-presented model results have shown this is unlikely to be effectively achievable with project monitoring alone.

In this context it might be interesting to further reduce the potential of overreporting by adjusting the rules for project admission. As explained in the previous chapter, the CDM Executive Board can refuse the admission of a project if the Project Design Document or the proposed Baseline Method do not correspond to the specified standards.\(^5\) It is hence quite plausible that project admission standards could also include a minimum level of verifiability. Such a standard could apply to both sources of overreporting identified above, the baseline as well as the verification of project emissions. As will be discussed in the last chapter of this thesis there exist serious doubts on the additionality of some of the CDM projects which were admitted within the early years of the Mechanism. Such issues could be effectively reduced in the future by including provisions on the verifiability of the baseline within the rules for project admission. Similar rules could also be established for the project verification plan, i.e. the part of the Project Design Document which specifies the rules for accounting and verification of actual project emissions.

The above-presented model results can be used to gain valuable insights for determining sensible cut-off levels for project admission. In the context of this model, the Kyoto architects would have to decide on a maximum tolerable level of opportunistic misreporting given a specified budget for the CDM Executive Board. It is, for example, conceivable that the regulator implements a ‘no tolerance’ constraint, which would exclude all projects with a verifiability lower than the minimal $\beta_h(B)$. In this case all projects would be in perfect compliance. Another intuitively sensible cut off-level would be $\beta_m(B)$, implying that all projects will achieve the optimal level of emission reductions, while cheating within the reported level would not be perfectly deterred. Based on the experiences made up to the present, project admission standards would have to be made

\(^4\)See, for example, The Economist (2006).
\(^5\)Currently, the probability of rejection for a submitted project is about 5 percent. (UNEP/Risoe (2009))
more stringent until only projects with a verifiability larger or equal to the respective threshold remain. As will be laid out in the last chapter the currently increased scrutiny within project admission can be interpreted as a strategy to do just that.

Note that, for the time being, the justification for the inclusion of a minimum level of verifiability within the project admission standards can only be based on the political justification depicted above. In light of the fact that there exists no consensus on the allocatively optimal level of emission reductions, determining a specific cut-off level based on welfare considerations would be particularly problematic. Hence, as long as the exact level of the social cost of carbon is still disputed, the optimal regulation under incomplete enforcement remains just as undetermined as the optimal level of abatement.

3.5. Conclusion

The model presented within this chapter allows some interesting insights into the nature of optimal monitoring for credit-based systems, like the Clean Development Mechanism. While the assumption of identical abatement costs for all projects is surely oversimplifying, it allows the focus on the regulator’s optimal monitoring strategy given projects featuring different degrees of verifiability. It was shown that under these circumstances even with an unlimited monitoring budget, overreporting of reductions can not be completely disincentivized. The most interesting results are, however, achieved under the more realistic assumption of a budget constraint. For this purpose, the analysis above has been restricted to a specific class of punishment functions, which includes polynomial penalties.

While under an unlimited budget all projects with positive verifiability will be monitored, the situation significantly changes under the assumption of a budget constraint. For this case, it is shown that a rational regulator will completely refrain from monitoring those projects that are most difficult to verify. Furthermore, for those projects that are induced to achieve the optimal level of reductions the monitoring pressure reduces with increasing verifiability of the projects. Both results are in line with the findings by Macho-Stadler and Perez-Castrillo (2006) who analyze incomplete enforcement of emission taxes. However, unlike emission taxes, the general principle of credit-based emission trading systems implies that the regulator cannot refrain to simply maximize the actual emission reductions but needs to also to reduce the level of overstatement within the projects’ reported reductions. This is due to the fact that certificates issued on the basis of the reports will be used to offset actual emissions elsewhere. Hence, contrary to the tax case, the regulator needs to minimize the overall level of overreporting.

Due to this difference in the objective function of the regulator, the optimal monitoring strategy derived above significantly differs from those proposed in the context of emission taxes or a cap-and-trade system. First, given a large enough budget, the regulator will induce full compliance within the range of the easiest-to-verify projects. Second,
3. Incomplete Enforcement within the CDM - a Model

with decreasing verifiability, the optimal audit pressure features a "jump" downwards as soon as the region of those projects is reached, for which the regulator decides not to incentivize the optimal level of emission reductions. Within this region of lower verifiability it depends on the exact interaction of incentives and disincentives to increase compliance. The disincentives are determined through the abatement cost function while the incentives stem from the punishment, which is assumed to be increasing and convex in the overreported amount. Depending on the functional forms of these two functions it is either possible that optimal auditing pressure increases or decreases with a reduction in verifiability. Third, due to the above-described discontinuity in auditing pressure, it might be possible that a small increase in budget leads to a decrease in audited projects. A large enough budget rise, however, will broaden the set of projects being monitored.

The monitoring budget, in fact, determines also the number of projects that are situated within the different regions of compliance. This leads to the interesting insight that the regulator could include a specific level of verifiability within the project admission criteria. This would guarantee that a maximum amount of overreporting will never be exceeded under a given budget. The latter result might be especially interesting in the case of the Clean Development Mechanism, which is by far not undisputed. The discovery of large fraudulent overreporting within that mechanism would certainly entail a large damage to its credibility. Hence, including such politically justified cut-offs within a formal analysis would represent, just as the introduction of differences in abatement costs, an interesting field for future research.

We will turn back to the issue of monitoring and sanctioning within the CDM in the last chapter of this thesis, where some of the learnings from this chapter will be further discussed in the context of the actual institutional framework. Yet, before entering this discussion, it is useful to first analyze the challenges that are being faced at the lowest institutional level of the CDM framework. The following second part of this thesis is hence dedicated to the analysis of the contractual issues that arise in the context of the Clean Development Mechanism.
Part II.

Contracts and Upfront Financing within the Clean Development Mechanism
4. Contracts within the CDM

As with any market, the overall efficiency of the Clean Development Mechanism largely depends on the terms of exchange between buyer and seller. The specific rules guiding each single interaction are established within the contract between the project parties, which hence represents the lowest institutional level of the CDM. As laid out in chapter 2, many incentive problems which arise due to the design specificities on the upper institutional levels of the Mechanism are devolved to the lower level of the specific CDM contract. For this reason it is important to understand how these incentive problems might be resolved within actual contracts. The primary objective of this part of the thesis is the analysis of some of the most interesting issues that arise in this context.

While the initial concept of technology transfer within CDM projects was rather departing from more integrated structures, the current development of the CDM market shows a strong tendency toward simpler purchase contracts. The predominant contractual form is the Emission Reduction Purchase Agreement, or ERPA. Ideally, such purchase contracts would promote the Mechanism by providing project developers with start-up financing for environmentally valuable projects. As will be laid out in this chapter, most buyers on the primary market are, however, reluctant to provide such upfront financing. It will be argued that this reluctance is likely to be the consequence of problems of opportunism that arise partly due the institutional devolution established within the previous chapters.

At the same time, investments in the context of the CDM are subject to a plethora of different risks. Consequently, an efficient and feasible CDM contract would have to represent a trade-off between risk-sharing and the provision of incentives to overcome opportunistic behavior. These trade-offs and the corresponding second-best contract design represent the main area of interest of the analyses attempted in the following chapters. The major purpose of this chapter is hence to ‘set the stage’ for these analyses by providing an exposition of the context within which CDM contracts are situated.

The chapter is organized as follows. Section 4.1 presents the financing structures that are predominant within CDM projects. The different categories in CDM-specific risks are exposed in section 4.2. In section 4.3 follows a discussion on how these risks are dealt with within a typical ERPA. As will be shown the actual contract provisions differ from a theoretically optimal first-best risk-sharing scheme. Section 4.4 introduces the different problems of opportunism that arise in the context of CDM transactions. Given different risk preferences of buyer and seller, potential opportunistic behavior
engenders particular challenges to the contract design. These challenges are discussed in the concluding section 4.5.

4.1. Financing Structures for CDM

The general idea of the CDM is to incentivize reduction or sink projects within developing countries that are financed by parties from Annex I-countries. Initially the projects’ organizational structure was interpreted as being purely bilateral. The bilateral concept describes project types where the project developer in the host country and the project investor cooperatively select the project and jointly implement the different project phases. Furthermore, within bilateral structures the participation of the project investor is often conceived to include the delivery of the project technology as well as the respective know-how. This conception of the CDM was based on the experiences with the ’Actions Implemented Jointly’ (AIJ), a program to test the suitability of project based mechanisms for climate policy in the late 1990s.\(^1\)

In the bilateral case the project developer and the project investor are two independent legal entities agreeing on a CDM project. The project developer receives an investment from the project investor in order to implement a CDM project in a non-Annex I-country. This investment can be simply of monetary nature but was initially conceived to include a technology and know-how transfer as described above. The investor receives in return the CERs generated by the project. Figure 4.1 illustrates such a relationship for a project developer based in the Annex I-country and the project investor being based in an Annex I-country.

\[\text{Figure 4.1.: Stylized representation of a bilateral CDM project}\]

While such a bilateral structure is illustrative for the underlying idea of a transfer of clean technologies to developing countries, the architects of the Mechanism realized that other financing structures might prevail. Consequently, the rules agreed upon at COP7

\(^1\)See Baumert and Kete (2000).
Contracts within the CDM

in Marrakech allow for a broader range of financing structures than reflected within the bilateral concept. One possible financing scheme of interest is a fully integrated relationship with projects organized and financed within a transnational company. In such cases the project is developed within a subsidiary of the company situated in the developing country, while the financing and transfer of technology is assured through the head office in an Annex I-country. The Marrakech Accords also allow for projects financed by a partner from a developing country. Such projects are commonly referred to as being unilateral as all project parties are situated in the host country. Furthermore, CDM projects can also be financed by a fund that pools contributions from different industrialized country parties. As a more profound understanding of the financing structure is useful for the analyses within the following chapters, we will shortly present stylized versions of the two concepts that are of particular interest here, i.e. projects based on purchase contracts and carbon funds.

Unilateral Projects and ERPAs

Unilateral projects differ from the initial concept of project financing. As depicted in figure 4.2, the financing of the project is entirely assured by a party situated within the developing country. The developing country investor might, but does not necessarily have to, coincide with the project developer. In general, purely unilateral projects are likely to be very attractive within specific host country settings. In case the risk premium for foreign direct investments associated with the host country is high, unilateral projects might represent a viable alternative in order to incentivize reduction projects within the respective country. Furthermore, such settings could significantly reduce costs from bureaucratic hurdles often associated with foreign direct investment. Yet, generally, the rate of transfer in knowledge and know-how is expectedly lower than within the originally intended bilateral project structure.2 A purely unilateral setup would be a situation within which the project developer procures all the financing to cover the front-loaded costs and yields a profit by selling the CERs directly on the secondary carbon markets. In such a setting, the project developer might yield the highest possible revenue for the emission reductions, but also bears all the risk of changes in certificate prices and production costs. As a consequence, the terms of transfer between the project developer and the Annex-I party-buyer of the credits are stipulated within a simple purchase contract.

In fact, the purchase contract is the dominant type of agreement within the primary CDM market as a whole. In most cases the terms of the different transactions are formulated within a so-called Emission Reduction Purchase Agreement (ERP A). Usually, within such an ERPA the contract parties agree to exchange the generated CERs against a specified per-unit price. As an ERPA allows for further specifying the buyer’s obligation, this contractual structure does also lend itself to situations that compare more to

\[\text{For a more profound exploration of these issues, see Jahn et al. (2003).}\]
the bilateral than the unilateral setup. An ERP A can, for example, also include clauses on upfront payments or technology transfers. Consequently, in practice, purchase contracts rather cover a continuum ranging from the wholly integrated bilateral model to the pure-form unilateral CDM. Still, the implementation process of the Kyoto provisions has led to a predominance of project settings that tend rather to the unilateral setting. In the trial-phase of the Mechanism, many observers CDM have attributed this preference for unilateral projects to the sluggish implementation of investment incentives for companies from Annex I-countries as well as the regulatory risk that longer-term investments might yield no future returns in case the the Kyoto provisions are not continued after 2012. For the same reason, contracts with a time horizon beyond 2012 are still rare.

### Carbon Funds

In order to reduce the risk exposure of the project investor it is also possible to pool the resources of many buyers into a mutual fund. This setup is sometimes referred to as *multilateral CDM*. Such funds played an important role in the 'trial phase' of the Mechanism from 2000 to 2007, representing the largest buyers of CERs in these years. By buying larger amounts of CERs from different sellers the fund’s members bore the political risk of the non-implementation of the Kyoto Protocol but reduced their exposure to the risks of a single project. Usually, a carbon fund is not directly

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4See for example Jahn et al. (2003) or Capoor and Ambrosi (2007).
5See sections 2.1.3 and 4.2.
6See Baumert and Kete (2000).
involved in technology transfer. The best known examples for such funds are the World Bank’s Prototype Carbon Fund (PCF) and the Dutch CERUPT system.\(^8\)

Figure 4.3 depicts the basic mode of operation of multilateral CDM. The fund, pooling the resources of institutional and private-sector buyers from Annex I-countries, concludes a multitude of purchase agreements with different project developers. In order to reduce systematic risk, a fund will generally aim for investments within different developing countries and different sectors.\(^9\) The sum of the CERs acquired by the fund are distributed to the fund’s investors in accordance to their financial contribution.

\[\text{Figure 4.3.: Carbon Fund}\]

Cochran and Leguet (2007) estimate that in 2007 about USD 9.5 billion had been invested in 58 carbon funds. Within the same study it is projected that the total capitalization of such funds could increase to about USD 13.8 billion in 2008. The important characteristics of the capital inflow within this sector of CDM financing is a significant increase in the number of funds in recent years, having increased their engagement not only on the secondary, but also on the primary CDM market. The success of multilateral financing schemes is necessarily to be attributed to the fund’s capacity to spread

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\(^8\)See section 5.6.

\(^9\)There exist, however, funds specialized in specific CDM projects, like the World Bank’s BioCarbon Fund.
the project-related risks through diversification. These risks and their effects on the contractual terms within ERPAs will be addressed in the following section.

4.2. Risks associated with CDM Projects

The main purpose of concluding an ERP is to specify the terms of the underlying transaction, which is, in principle, the transfer of monetary resources against Certified Emission Rights on the primary market. Typically, the ERP stipulates a fixed per-unit price and a contracted quantity of certificates to be transferred. However, contrary to spot transactions of CERs on the secondary market, ERPAs are usually forward contracts, i.e. the certificates and the underlying carbon offsets are still to be generated. As a consequence, at the time of contracting it is uncertain if the contracted amount of certificates can actually be delivered. The actual transfer is hence subject to a plethora of different risks some of which are CDM-specific. These risks can be categorized into host country risks, Kyoto regulatory risks, and project-specific risks. In the following these different risk types are shortly presented.

Host Country Risk: Just as foreign direct investment in general, investments in CDM projects might become subject to changes in policy or regulation in the host country which could potentially lead to a decrease in returns. The most drastic example for such a 'political' risk is the threat of a complete expropriation of the project’s assets. Werksman et al. (2001) identify a potential for expropriations in the natural resources sector of developing countries, which might constitute an additional risk to CDM projects in general and forestry projects in particular. These authors caution against CDM agreements that could be viewed as “extortionate” at a later period, as this “could motivate a host government to directly expropriate either CDM projects or the contractual rights to the credits they may produce.” While such direct expropriations are likely to remain rare, the risk of a partial indirect expropriation through ad hoc changes in taxes or additional regulatory measures should not be underestimated.

In some situations and especially over a longer time horizon, it might be difficult to assess which deals might be considered being unfair at a later stage and how the economic policy of the host country might change in the future. In this context, the CDM requirements for a thorough sustainability assessment preceding the actual project implementation could represent a device to mitigate risks of partial or complete expropriation in the future. This is especially true as far as potential local opposition to the nature

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11 Werksman et al. (2001); Further on the topic see also Ratliff (2005).
12 As Werksman et al. (2001) point out, such an indirect expropriation occurring in the context of new regulations could, for example, “appear through changes in the project baseline due to unforeseeable environmental regulations or—more ill-natured—the refusal of entry to the third-party verifier that is prescribed by the Kyoto rules.” (Werksman et al. (2001), p. 12)
of the project is concerned, which can be anticipated through such an assessment. The most imminent threat to CDM investments are, however, potential limitations to the enforceability of contract terms that could arise within developing countries. We will turn to this specific risk in section 4.4.2.

**Kyoto Regulatory Risks:** Risks that are associated with the current and future implementation of the Kyoto framework and the associated rules regarding the CDM can be subsumed under the category of Kyoto regulatory risks. In the early years of the Clean Development Mechanism from 2000 to 2004, the most important regulatory risk was associated with the uncertainty of the Kyoto Protocol coming into effect. This 'Kyoto Risk', which was usually borne by the buyer of early-mover certificates,\(^\text{13}\) has ceased to exist since the entry into force of the Protocol.

While the validity of CDM credits is currently assured until the end of the first commitment period in 2012, the uncertain future of the Protocol's provisions beyond that date translates directly into investment risks within the carbon market in general and the CDM in specific. As laid out in section 2.1, a positive valuation of Certified Emission Rights will only continue to exist if the current international climate policy approach is pursued further beyond 2012. In addition to this fundamental regulatory uncertainty, CDM projects also suffer from the fact that even if a continuation of the Kyoto approach is ensured, the more specific rules currently guiding the CDM could still change. For example, the requirements for baseline calculation or for technologies viable for CDM might change, such that the continuation of certain projects could become unprofitable in the future. These regulatory uncertainties render a quantification of risks for projects with an investment horizon beyond 2012 very difficult. As a consequence, market participants have virtually ignored the phase after 2012 within the consideration of the Net Present Value for CDM projects.\(^\text{14}\) Hence, as far as CDM investment contracts are concerned, the regulatory uncertainty engendered that there exist only very few agreements having a horizon beyond 2012. In fact, the few sellers that are seeking upfront financing for a project over a longer time frame need to display a very high level of creditworthiness, as Wells and Phillips (2008) report.

**Project-related Risks** In the following, the category of project-related risks refer to all other risks that might lead to a situation where a particular project does not yield the planned amount of CERs. These risks can be subdivided into two sub-categories.

First, there is the risk that a project does not generate the planned amount of carbon offsets. This might be due to problems within the technical implementation of the project or a non-continuation of the project activity due to other (non-regulatory) reasons. For example, a planned project involving fuel-switching might encounter unsurmountable

\(^{13}\)See Streck (2005) and van der Weerd (2005).

\(^{14}\)See section 2.1.3.
technical problems or turn out to be economically non-viable. Similarly, the absorption rate of a forestry project might be unexpectedly reduced by storms or forest fires. Hence, in such cases the amount of credits generated by the project can be smaller than the contracted amount. Usually, these risks are reflected within the contracted per-unit price within the project’s ERPA. Furthermore, these risks vary with the project technology, as some technologies are more exposed to contingencies than others. Wind projects, for example, yielded a higher per-unit price than other technologies in 2007, partly due to their reliability in performance.\textsuperscript{15}

Second, there exists the possibility that the project does generate the pre-agreed offsets, but fails to fulfill the regulatory requirements of the Clean Development Mechanism. As UNEP/Risoe (2009) reports, the probability of a successful issuance is about 96.3 percent for registered projects. Projects in earlier stages of the CDM cycle face a probability of 18.5 percent of a negative DOE validation and a 5 percent chance of being rejected by the EB. From the point of view of market regulation, these relatively high levels of project-specific regulatory risks are not necessarily to be considered as bad news. If for a single project the probability of failing to pass through all stages of the project cycle is expected to be high, this can be interpreted as a signal that the regulatory control of CDM projects is comparatively effective.

In some existing CDM contracts, the risk that the parties may not be able to establish legal title to the carbon offset of the project is borne by the buyer.\textsuperscript{16} In these contracts the exchanged commodity consists of so-called Verified Emission Reductions (VERs), which is in fact a right only defined by the contract itself but cannot directly be used to offset greenhouse gas emissions within a regulatory regime. It is only when the project has successfully passed the CDM process, that the VERs can be transformed into CERs. Particular institutional buyers, like the World Bank’s Prototype Carbon Fund, are willing to fully bear the project-specific risks associated with the CDM process.\textsuperscript{17} It is, however, unlikely that corporate compliance buyers would fully ensure the seller against such risks if the latter has full control of the accreditation, verification and issuance processes, as in these cases the contract would be particularly prone to moral hazard.

\section*{4.3. Managing and Sharing of Risk within the Contract}

According to market data, the valuation of the above-listed risks is considerable. The earlier a project is situated in the project cycle, the higher is the risk premium included in the secondary-market futures price. In 2007, projects situated in earlier stages of the CDM cycle fetched between 8 and 10 Euro per tonne $CO_2e$, while contracts on

\textsuperscript{15}See PointCarbon (2008).
\textsuperscript{16}See for example Streck (2005).
\textsuperscript{17}See Streck (2005).
CERs from registered projects yielded prices between 11 to 13 Euro per unit.\textsuperscript{18} This price spread is a good indicator for the valuation of the risks that are associated with getting a project through the CDM process. The project-specific risks arising with the actual implementation of a project are assessed to be, on average, significant as well. According to PointCarbon (2008) actually issued CERs fetched between 14 and 17 Euro on the secondary market. The corresponding discount is also in line with Capoor and Ambrosi (2008), presenting evidence for an issuance risk premium of about 3 Euro per tonne.

Given such large risk premia, the question arises, how the contract parties manage and share these risks. One obvious hedging strategy against contingencies would be the use of third-party insurance. Indeed, several institutions offer insurance products covering the different risks associated with futures on CERs.\textsuperscript{19} However, in a survey conducted by Capoor and Ambrosi (2007), most market participants declared that using such vehicles for CDM risk management was not very popular. The market for insurance products was often described as being ‘little developed’ at that point in time, while the insurance products were considered being ‘very expensive’. It might, however, well be that with increased maturity of the carbon market, the supply of insurance vehicles will undergo further phases of development as well.

If third-party insurance is perceived to be too expensive the next-best alternative would necessarily be to design the contract according to an efficient risk-sharing between both contract parties. In a first-best world without information asymmetries, such a contract would require that the party which is less risk-averse bears a larger share of the risk. In the extreme case of a risk-neutral buyer and a risk-averse seller, efficient risk-sharing would imply that the buyer fully ensures the seller against all contingencies. Indeed, it can be reasonably argued that the degree of risk-aversion of the buyer is likely to be significantly lower than the seller’s. First, note that most compliance buyers will be rather large in size, as an inclusion of smaller entities into a national emissions trading scheme would be inefficient due to the large transactions costs of such a system. The seller, by contrast, is usually a smaller entity whose income largely depends on the project activity. Second, the buyer is capable of diversifying his risk over many different projects within his carbon portfolio.\textsuperscript{20} As a consequence, the buyer’s single investment decisions will be made as if he were risk-neutral. According to Capoor and Ambrosi (2008) portfolio management is indeed the predominant hedging strategy on the emerging market for project-generated credits. Within the portfolio approach the default risk is hence diversified and optimized through project type selection and geographical diversification. To carry out this optimization most buyers estimate expected

\textsuperscript{18}See PointCarbon (2008).
\textsuperscript{19}See Capoor and Ambrosi (2007).
\textsuperscript{20}Such a hedging strategy was, for example, suggested by Bosquet (2005), who argued that the buyer could foresee possible shortfalls within the management of his offset portfolio by taking into account the probabilities of under-performance of different sellers.
deliveries adjusted for risk. The valuation of default risks varies among the project types and might be considerably high. As Capoor and Ambrosi (2008) report, the expected delivery discount factor applied to the contracted project types lies within the range of 15-50 percent or more. The portfolio diversification strategy is usually complemented by acquiring call or put options on carbon certificates to manage problems of underdelivery or overcommitment of the whole portfolio.

Given that near-perfect risk-neutrality of the buyer can be assumed, first-best efficiency would require that the buyer bears the largest part of the risks associated with CDM projects. In this case the seller would be guaranteed a pre-agreed level of income that is independent of the actual delivery of credits. The usual implementation of such a risk-sharing agreement involves a contract including a frontloaded payment, covering at least a part of the project costs. However, only few real-world ERPAs include such a fixed price component, the so-called *upfront payment*. Such upfront payments are reportedly included in the contracts of the World Bank’s Prototype Carbon Fund and the Dutch CERUPT scheme, while they are more reluctantly used within pure private sector transactions.\(^\text{21}\)

As upfront payments are rather the exception, the seller only receives the expected income from the project—in form of the backloaded per-unit payment—if the above-exposed contingencies do not realize. Hence, in principle, in the largest part of private sector CDM agreements, the seller bears a significant share of the default risk. However, in order to reduce this risk to the seller, a common procedure is to contract only on a part of expected offsets from the project and to further include a call option for additional CERs within the contract. This practice, often referred to as ‘over-collaterization’ is usually associated with doing enhanced due diligence on counterparties from both sides of the market. Some of these contracts included a premium for the option,\(^\text{22}\) which is interesting in light of the theoretical results derived within the following chapters. The predominance of fully backloaded payments hints to the existence of significant problems of asymmetric information in the market, which will be presented in the following section.

### 4.4. Incentive Problems with Upfront Financing

The reluctance of private actors to include upfront payments within CDM purchase contracts raises serious questions on the effectiveness of the Mechanism. As already mentioned, the primary goal of the Clean Development Mechanism is to procure financing for the introduction of more effective abatement technologies in developing countries. In this context it would be of particular interest to procure start-up financing for the

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\(^{21}\)See section 5.6. In the rare cases where such upfront payments are granted in private sector transactions, the participants are wary to ensure that the counterparty was a very good credit risk, as Capoor and Ambrosi (2007) report.

\(^{22}\)See Capoor and Ambrosi (2007).
4. Contracts within the CDM

project through a contractual upfront payment. This, in turn, would be of importance for sellers with restricted access to credit markets like small- or medium-scale enterprises or farmers. Hence, the practice to procure upfront financing only for sellers with the highest levels of creditworthiness is not in line with the primary goal pursued with the Clean Development Mechanism.

The fact that only a small fraction of private sector contracts include provisions on upfront financing is unlikely to be the result of a lack of demand. According to Capoor and Ambrosi (2007) such upfront payments appear to be the norm within contracts on Joint Implementation projects. Given that both Mechanisms, JI and CDM, in principle only differ in the regional location of the host country, it seems plausible that upfront payments would also be a useful instrument for project financing in the context of the Clean Development Mechanism. In those CDM ERPAs where upfront payments were agreed to, a start-up financing of up to 50 percent of the ERP A value is not uncommon. Still, in many of these cases the buyer demanded the delivery of certificates to be backed up by guarantees from internationally rated banks. This indicates that the low level of ERPAs including upfront payments can be better explained by the reluctance of the buyers to risk larger losses in the case of non- or under-performance of the project.

From the perspective of the buyer, granting an upfront payment is evidently associated with problems of asymmetric information. First, receiving a part of the contracted price in advance necessarily decreases the seller’s incentive to exercise due care in the generation of the credits. As the seller’s level of precautionary measures mitigating the risk of default is unobservable to the buyer, and hence uncontractible, the problem of inducing an efficient level of due care represents in fact a moral hazard problem as it is usually analyzed within information economics. Second, the incomplete enforceability of contracts within developing countries might lead to an incentive to ‘take the money and run’ without delivering the contracted amount of certificates in return. As both incentive problems necessarily reduce the buyer’s disposition to procure an upfront payment, it is worthwhile to discuss them in more detail within the following sections.

4.4.1. Information Asymmetries and Moral Hazard

In the context of the Clean Development Mechanism, the moral hazard problem associated with contractual upfront payments might take different forms. In general, it is plausible to assume that, compared to the buyer, the seller has larger discretionary control over most of the above-described project-related risks. First, in a standard set-up as described in section 4.1, the seller is the party controlling the project’s underlying technology switch and is hence capable to influence the probability that the contracted actual offsets occur. For example, the technical capacity of electricity generation through wind or solar technologies also depends on where and how the respective equipment is
installed and employed. Hence, a higher level of effort in operating this equipment would increase the probability of generating a larger amount of carbon offsets. Second, as the seller is implementing the project she can also reduce the probability that the project fails to meet the requirements of the formal CDM project cycle by adhering more closely to the respective rules. It is plausible that the intensity of the moral hazard varies among the different types of risk. It is for example imaginable that one contingency leads only to a reduction in generated certificates while the realization of another might cause the project to fail completely in which case no certificates are issued.

Note that the susceptibility of CDM contracts to moral hazard is in fact a result from the process of institutional devolution addressed in chapter 2. Given that the attribution of liability is to a large extent avoided on the upper levels of the institutional cascade, the general CDM rules do not provide any additional incentive to the project developer to exercise due care. As a consequence, the responsibilities for potential shortfalls in certificates need to be addressed on the contract level. Clearly, from the buyer’s perspective the simplest way to avoid the moral hazard problem is to fully backload the certificate payments. In those cases where the full per-unit price for the certificates is only paid on delivery of the certificates, a seller maximizing her expected profits would automatically choose the efficient level of precautionary measures. Hence, the existence of information asymmetries provides one explanation why upfront payments are rarely used within private sector agreements. As this is in conflict with the Mechanism’s primary objective, more sophisticated contractual setups might considerably add to the effectiveness of the CDM. In chapter 7 we present a formal analysis of this issue in a complete contract model.

4.4.2. Incomplete Enforcement and opportunistic Breach of Contracts

Within the economic theory of complete contracts, which deals with problems of asymmetric information in contractual settings, it is usually assumed that contracts are fully enforceable by courts. However, for many cases this assumption is not an adequate mapping of reality. The judicial system in the real world is necessarily imperfect. Courts can err in their judgment, trials might be pending for years, and the injured party might simply choose not to enforce the contract because of excessive transaction costs. If contracts are not enforced with certainty there might arise situations of opportunistic contract breach. In the context of the CDM, this can be for example the case if the seller’s opportunity costs to the project unexpectedly increase. This problem is significantly amplified if a part of the contract price is paid in advance, creating the incentive to ‘take the money and run’. Hence, the potential for opportunistic contract breach on the part of the seller is another explanation for the low amount of CDM ERPAs including upfront payments.

The problem of incomplete contract enforcement is particularly imminent within CDM host countries, i.e. developing countries where the rule of law is in many cases less strin-
gent than in industrialized countries.\textsuperscript{24} Clague et al. (1999), Fafchamps and Minten (2001), and Anderson and Marcouiller (2002) provide some empirical evidence that the enforceability of contracts in developing countries is, indeed, restricted.\textsuperscript{25} As a result, many transactions in less stable jurisdictions are based on informal enforcement mechanisms or are merely self-enforcing.\textsuperscript{26} This provides an explanation for the fact that in those cases where CDM upfront payments are granted, the ERPAs involve developing country partners having developed a good reputation in the respective field.\textsuperscript{27}

As explained in chapters 1 and 2, the Kyoto framework does not provide additional leverage to enforce transactions within the CDM, as developing countries are exempted from the most effective sanctions. The enforcement of CDM contracts is hence entirely dependent on legal courts, which is associated with the problems laid out above. It might be argued that the problem of incomplete contract enforcement within developing countries could be overcome by situating the court of jurisdiction of the ERPA within the buyer country. In such a case, however, it is to be considered that the possibilities of a cross-border enforcement of the court’s orders in the host country are usually quite limited. The above-mentioned restrictions to the rule of law might reduce the probability of enforcement in the same way as it is the case for other cross-border agreements. As a consequence, the reluctance of buyers to provide upfront payments on a larger scale is quite comprehensible. In this context it is of particular interest to analyze potential contractual setups that are able to overcome the problems associated with incomplete enforcement of CDM contracts. In chapter 6 we present a formal analysis of contracts that have the potential to overcome the problem of incomplete enforcement while providing upfront financing for abatement technologies.

4.4.3. The Special Case of Forestry CDM

Both above-discussed incentive problems are also present in the case of Forestry CDM projects. As explained in section 2.4, if the amount of CO\textsubscript{2} absorbed by the forest is suddenly reduced the non-permanent certificates are invalidated within the National Registry of the buyer-country. As the Kyoto institutions do not provide for a recourse to the seller-country, the affected Annex I-country is likely to claim the lacking certificates back from the private entity which was using the certificates to fulfill its reduction obligations to the Annex I-country. This private entity is typically the compliance buyer.

\textsuperscript{24}In some cases the judicial system might also be too slow to be effective. In 2000, 25 million cases were pending in Indian courts. Given the average processing time of the courts, it would take about 324 years to settle all of these disputes, provided that no new cases were admitted. Bearak (2000), cited in Dixit (2003).

\textsuperscript{25}The limited enforceability of cross-border contractual relations can also partly explain the well-known home bias in international trade. See Belloc (2006) for an overview.


\textsuperscript{27}See Capoor and Ambrosi (2007).
of the non-permanent certificates. By this subrogation, the above-described problems of opportunism are again devolved to the contract level. In most cases, the influence of the project investor on forest management will be quite small. The forest management activities are likely to be within the responsibility of the seller or some agent sub-contracted by him. Investments in precaution against events that reduce the amount of carbon absorbed by the forest—such as forest fires, infestation with parasites or illegal logging—are controlled by the seller, which leads to the moral hazard problem. The problem of opportunistic contract breach could potentially occur as well, as changes in opportunity costs like rising timber prices might raise the incentive for a deliberate early harvest by the seller.\footnote{See Palmer et al. (2009) for a formal analysis of contracts ensuring forestry permanence given potential changes in the seller’s opportunity costs.}

However, it can be reasonably argued that the non-permanence of forestry carbon sinks renders the problems of opportunism even more imminent for Forestry CDM than for reduction projects. Note that Forestry CDM certificates are invalidated if the underlying sink ceases to exist. Hence, if the already absorbed carbon is re-released into the atmosphere due to opportunistic behavior of the seller, the buyer not only loses future certificate flows but also has to replace the certificates already acquired. Consequently, the buyer of such certificates has purchased a commodity the value of which remains under the control of the seller. This necessarily amplifies both problems of opportunism, because the loss the seller can potentially inflict on the buyer is ceteris paribus higher. This incentive problem is most obvious in the case of the lCER approach, exposed in section 2.4.2, under which the certificates are literally invalidated in case the absorbed amount of carbon is reduced. It might be argued that the problem does not occur within the tCER approach, as these certificates are invalidated anyway after one commitment period. However, in this case the buyer would have to replace the tCERs with certificates stemming from other sources, which also implies a de facto expropriation of his initial investment in the forestry project.

This increased susceptibility of CDM Forestry to opportunistic behavior might lead to an additional problem of asymmetric information. As the buyer faces a higher risk of expropriation, this risk will be reflected in lower prices for temporary CERs. This, in turn, could lead to a decrease in the implementation of higher-quality projects that usually engender higher costs. Therefore, the de facto attribution of liability to the buyer entails a problem of \textit{adverse selection} corresponding to a ‘market for lemons’. Consequently, the implementation of projects with higher levels of precaution would be disincentivized. Furthermore, the incentive to lower the cost of precaution will increase with project duration as the remaining future revenue flows decrease with the project’s progress in time. In the extreme case, there might be the possibility of an uncooperative end-game phenomenon, as project duration is limited.
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4.5. Conclusion: Challenges to Contract Design

In light of the above-depicted susceptibility of CDM contracts to opportunistic behavior, it is not surprising that typical ERPAs do not include upfront payments. Clearly, from a buyer’s perspective, a potential loss in investment due to opportunism can be effectively reduced by backloading all the contracted payments. It is quite intuitive that the potential for opportunistic breach of contract will be radically reduced if the seller does not receive any ex ante payment. Plainly speaking, in such cases, there simply is no money to ‘take and run.’ The same is true for the above-depicted moral hazard, which disappears if the entire contract price is only paid on delivery. Under these circumstances, the seller would choose the optimal level of care, at which the marginal precaution costs would equal the expected marginal income from certificate sales. Hence, by backloading all contractual payments the disincentives for opportunistic behavior are high-powered.

Usually such high-powered incentives would shift all the risks to the seller, which raises the question of how the sharing of risks is dealt with within typical Emission Reduction Purchase Agreements. As laid out in section 4.2, projects within the CDM are not only associated with standard investment risks, but are also subject to additional contingencies resulting from the regulatory context of the Mechanism. A common procedure to reduce the seller’s exposure to these risks, is the above-mentioned ‘over-collateralization’. This practice implies that the number of contracted certificates is smaller than the expected amount to be generated by the project, such that the downside risk is reduced. The risk-management of the buyer usually involves diversification of risk by managing the carbon portfolio accordingly. It is quite obvious that these strategies for dealing with risks are the result of an uncertain contractual environment. As the CDM market is still in the state of emergence, it still lacks a long reported history of relevant events which can be used for risk-assessment. Hence, the risk management strategies within ERPAs significantly diverge from the contractual setup usually assumed in economic contract theory.

However, under the above-depicted contracting practice, it is unlikely that the Mechanism’s full potential to foster emission reductions in developing countries can be tapped. First, given that contractual upfront payments are rather rare, the group of potential sellers of certificates having only restricted access to the credit market will lack the necessary start-up financing to successfully implement a CDM project. Second, it is unlikely that smaller sellers with a higher degree of risk-aversion will participate in the market, as their exposure to risk is only incompletely mitigated through the practice of over-collateralization. As a consequence, small- and medium-scale actors within developing countries are likely to remain completely locked out of the CDM market. This might be especially problematic for the achievement of the secondary goal of the Clean Development Mechanism, which is fostering sustainable development.

Continuing this line of reasoning represents an important challenge to the design of CDM contracts. Ideally, an ERPA would have to provide startup finance without
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Reducing the level of disincentives for opportunistic behavior on the part of the seller. In principle, this problem can be solved by including contract provisions that guarantee a pre-agreed compensation in case of non-delivery. In legal terms such compensations are referred to as *contract damages*. The level of these contract damages can then be set at an optimal level that disincentivizes both types of opportunistic behavior. First, the problem of opportunistic contract breach—describing situations where the seller accepts the upfront payment but refrains from delivering certificates in return—only arises if the expected punishment for contract breach is lower than the seller’s opportunity costs. As a consequence, the lower levels of enforcement probability in developing countries could potentially be counterbalanced by higher levels of contract damages. Second, the prospect to pay contract damages in case of non-performance of the contract increases the seller’s incentive to exercise due care and consequently reduces the moral hazard.

While including contract damages is, in principle, an effective means to include upfront payments in incentive compatible contracts, the actual contract design is to take two important issues into account. First, as laid out above, the seller is likely to have a higher degree of risk-aversion than the buyer. Hence, when specifying the contract damages it has to be taken into account that there exists a trade-off between incentives and the risk-sharing function of the contract. Second, there might exist a constraint on the level of damages that can be stipulated. For example, the contracts specified by the World Bank’s Prototype Carbon Fund, stipulate only very low levels of damages due to equity considerations. However, such a constraint on damages reduces the power of incentives that can be achieved within a contract. Hence, it is interesting to analyze contracts that take all the above-mentioned problems into account. In Chapters 6 and 7 we propose contract models to formally analyze the effects of the above-mentioned restrictions and discuss their implications for the provision of upfront payments within the CDM.

Yet, when including contract damages into economic contract models, it is to be recognized these damages can affect economic efficiency at several different margins. Furthermore, if the modeling exercise is to reflect real-world contracting it has to be taken into account that some provisions in contract law could further constrain the set of feasible contracts. Hence, before turning to the actual modeling exercise, it is useful to discuss the general economics of contract damages that have been derived in the field of Law and Economics. This will be the main focus of the following chapter.

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29 See section 5.6.
5. The Economics of Breach of Contract and selected ERPAs

The main concern of the contractual considerations within this thesis is to identify contract designs that ensure an upfront financing of the projects. As explained in the last chapter, it is likely that the largest part of compliance buyers are reluctant to provide upfront payments within ERPAs due to the large potential for opportunistic behavior they engender. We identified the stipulation of contract damages in case of contract breach as an instrument to deter such behavior. However, contract damages influence the efficiency of a contract in several different manners. These various effects of contract damages have been studied within the research field of Law and Economics. As it turns out, many of the general considerations made in this field are useful for our endeavor to analyze the incentive effects of contract damages in the specific context of CDM ERPAs. Within this chapter, we will shortly present the major insights of the Law and Economics literature and then briefly discuss two types of real-world ERP provisions in the light of these findings. As it turns out, legal reality is subject to a considerable level of differentiation. Hence, the different effects of contract damages are too complex to be analyzed within a single microeconomic model, which necessarily relies on simplifications in order to reduce real-world complexity. Hence, before providing an account of the effects of contract damages on efficiency, it is useful to categorize situations of breach and the legal remedies that are generally applied by courts of law.

The chapter is structured along the above-depicted lines. Section 5.1 presents the two different legal paradigms under which contract breach can occur. In section 5.2, we give an account of the different legal remedies that courts are to choose from in cases of non-performance. Section 5.3 presents a first criterion of optimality, which is derived from the theory of efficient contract breach. The antagonism between risk-sharing and incentives, introduced in the preceding chapter, is also subject to the considerations within Law and Economics. We will discuss this issue in section 5.4. Section 5.5 links the problem of incomplete enforcement to the economic analyses of punitive contract damages. In section 5.6, we shortly present the provisions on contract damages of two different carbon procurement schemes. Section 5.7 concludes.
5. The Economics of Breach of Contract and selected ERPAs

5.1. Paradigms of Breach within Legal Theory

Many contracts within developing countries rely rather on informal reputational enforcement mechanisms than on legal enforcement. For the CDM, the usability of such informal enforcement is quite restricted. Given that the CDM market is far from becoming mature, there is only a very limited amount of buyers having a positive record of successful project implementations. As a consequence, in most cases the contract parties would need to rely on formal enforcement through judicial courts to overcome the problems of opportunism introduced in the preceding chapter.

Legal enforcement of contracts involves the submission of the case to a court by the injured party. In case the court identifies an enforceable situation of breach, it will order specific remedies to make the injured party whole under the contract. The court’s decision on ordering remedies in case of breach is dependent on the context under which breach has occurred. To classify situations of breach, legal theory distinguishes between two paradigms: the ‘Loss Paradigm’ and the ‘Resale Paradigm’.

Within the Loss Paradigm the contract breach by the seller is the result of an unexpected increase in production costs. If the realized cost exceed the contract price the seller has an incentive to breach in order to minimize his losses. The Resale Paradigm refers to cases within which a seller has contracted to sell a commodity to a buyer, but subsequently decides to breach the contract and sell the good to a third party. Both paradigms refer, hence, to two very different different types of situation, for which potentially different levels of damages should be awarded.

Within the context of a seller’s breach of an CDM ERP A, both paradigms might apply. Obviously, the Resale Paradigm involves the problem of opportunistic contract breach. This problem is immanent to those situations, where the seller receives a higher third-party offer for the certificates. A similar situation arises if an alternative use of the projects resources would yield a higher payoff than adhering to the contract. This would be for example the case within a CDM Forestry setup, where rising food prices might render the terrain for agricultural production more lucrative.

From the economist’s perspective such a rise in opportunity cost is very similar to the case of selling generated certificates at a higher third-party offer, as in both cases the project resources are allocated to a use for which a higher valuation is signaled by market prices. Hence, in the following, we will use the term ‘Resale Paradigm’ in this broader sense which includes breach due to changes in all sorts of opportunity cost.

A breach of an ERP A might also occur along the lines of the Loss Paradigm, which is best explained for a situation where the seller has agreed to deliver a guaranteed

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1See section 4.4.2.
2Eisenberg (2004)
3Eisenberg (2004) lists a third paradigm that comprises reasons for a breaching buyer, which will, however, not be treated within this text.
4See Palmer et al. (2009) for a formal analysis of this issue.
amount of certificates. In such a case, the realization of a project-specific contingency might increase the project’s abatement cost to a level which renders the generation of the guaranteed amount unprofitable to the seller. Note that, with the inclusion of upfront payments, the specification of a delivery guarantee is a precondition for mitigating moral hazard, such that remedies applied within the Loss Paradigm are of particular importance for the efficiency of the overall contract.\footnote{Indeed, as Capoor and Ambrosi (2007, 2008) report, the limited number of commercial ERPAs that does feature upfront payments also include delivery guarantees.} It is, however, to be mentioned that in order to fulfill her contractual obligation, the seller can always purchase the shortfall in certificates on the secondary market. Hence, the maximum expected cost to the seller in case of breach are capped by the market price for identical certificates.

5.2. Court-ordered Remedies for Contract Breach

In order to understand the reasoning within the Law and Economics literature presented below, it is useful to inquire on the court’s standard remedies in case of non-performance of contracts. The following account of these remedies is mainly based on Miceli (1997) and Eisenberg (2004). Within both above-discussed paradigms of breach, the standard remedy that is usually imposed by courts is indeed awarding damages to the injured party. In the context of contract law, the term damages refers to an amount of money that is to be paid by the promisor to the promisee in case of breach. The basic legal principle guiding the courts in awarding damages to the non-breaching contractual party (the promisee) is the idea of compensation for injury or loss. Once the need for such a compensation by the breaching party (the promisor) is established, the court would decide upon the amount of damages to be awarded. In principle, there exist two possible states of nature with respect to which the damages can be measured: on the basis of incurred cost, and on the basis of foregone utility.

Under the cost conception, the uninjured state is defined as the state the injured party was in before the contract was agreed upon. In this case the damages compensate for all the costs that the promisee incurred in reliance on the promise. As a result, the promisee is restored to the position he was in before the contract was made. If the court follows the cost conception it will either award restitution damages or reliance damages. While restitution damages simply compensate for the upfront payment, reliance damages additionally compensate for contract-specific (reliance) investments made by the promisee.

Under the conception of foregone utility, the baseline for compensation is the situation the promisee would have been in if the promisor had not breached. Hence, the promisee is left indifferent, in subjective terms, between breach and performance of contract by the promisor. The damages associated with the indifference conception are called expectation damages. Awarding expectation damages raises the question of how the foregone utility
is measured. The standard measure of such damages is the market price-measure. The market price-measure implies that, in addition to the restitution of the contract price, the promisor has to pay the difference between the contract price of the commodity and its market price. An alternative to the market price-measure is the cover measure, which covers the difference between the contract price and the price of a substitute on the market. In cases of breach of an ERP A by the seller, both of these measures would correspond to a compensatory payment by the seller amounting to the market price of other Kyoto certificates having more or less the same product features.

In rare cases, instead of awarding damages, the court might order the breaching party to fulfill the contract. This remedy is referred to as specific performance and is only justifiably imposed in cases where monetary damages are supposed to be an inadequate substitute for performing the contract. This is usually the case if the contractible is a ‘unique good’, like a specific piece of art. Clearly, this reasoning does not apply to carbon certificates, for which identical substitutes are available on the market. Consequently, the following considerations do only take monetary damages into account. Instead of relying on the court to impose damages on a breaching promisee ex post, the contractual parties can include a clause on liquidated damages in the contract. In such a case, the amount to be paid in case of breach is stipulated within the contract. Liquidated damages can be stipulated to exactly compensate for anticipated losses in case of breach. If the compensation is anticipated correctly in the design phase of the contract compensatory liquidated damages correspond to expectation damages. In the following, we will hence use these terms synonymously. Liquidated damages can also be under- or over-compensatory. For the purposes of this chapter under-compensatory liquidated damages are defined as a monetary compensation that is below the expectation damages. Consequently, over-compensatory liquidated damages represent a monetary compensation that is higher than the contract value to the non-breaching party. Courts in Common Law countries, like the USA or the United Kingdom, however, do not permit over-compensatory damages, because ‘punitive’ contract clauses are forbidden in Common Law. However, contract law in Civil Law countries—like the countries of continental Europe—allows for over-compensatory liquidated damages.

The possibility to stipulate liquidated damages within the contract is of particular importance to the largest part of the considerations made in the following chapters. The main focus of our analysis is not at the level of court decisions, but at the contract level itself. We are hence interested in situations of breach that can be, in principle, anticipated by the contract parties. Within this anticipation, the foreseeable problems of opportunism and efficiency can be addressed by stipulating specific levels of contract

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6For a more profound discussion of these measures, see Eisenberg (2004).
7For a further discussion of the remedy of specific performance in Law and Economics, see Miceli (1997).
8See Rea (1984) for an economic analysis of this so-called ‘penalty doctrine’.
9See Hatzis (2003) for a deeper exposition on the differences between Civil Law and Common Law with respect to punitive contract damages.
5. The Economics of Breach of Contract and selected ERPAs

5.3. Efficiency of the Breach Decision

In general, a one-sided breach of contract without compensation is to be considered as inefficient since the costs of non-performance to the injured party are not taken into account within the decision to breach. Hence, in economic terms, the lack of compensation engenders an external effect which implies that contracts would be breached ‘too often’. Based on these considerations Shavell (1980, 1984) proposes a theory of efficient breach which seeks the level of damages necessary to fully internalize this externality. The theory applies in fact to both paradigms of breach discussed above.

Within our broad interpretation of the Resale Paradigm, the argumentation is straightforward. Consider a seller of CDM certificates whose opportunity costs unexpectedly increase after the contract was made. As laid out before, such an increase could either be due to a higher third-party offer for the certificates or a higher value of an alternative use of the project’s resources. If the seller is not forced to consider the foregone utility of the contract partner she will necessarily breach the contract as soon as the change in opportunity cost occurs. However, the valuation of the credits to the buyer will be usually higher than the agreed contract price, as it is either driven by his own abatement costs or the market price for identical certificates. Hence, in those cases where the seller’s opportunity cost lie above the contract price but below the valuation of the buyer, a breach of contract would be inefficient, because the sum of all payoffs or utility levels...
would not be maximized. By applying the standard Pigouvian argument on externalities, Shavell (1980) concludes that, in such situations, breach would be only efficient if the seller takes the valuation of the buyer fully into account, which is—at least under the assumption of complete enforcement—only guaranteed with expectation damages or exactly compensating liquidated damages. In the context of CDM ERPAs, the amount of damages to be awarded would hence represent the value of the non-delivered certificates on the secondary market.

The argument for situations under the Loss Paradigm is similar. As an example, consider an ERP A between a buyer and a seller on the exchange of CDM-generated certificates for a pre-agreed contract price. Such a contract will only be made if the buyer’s valuation of the certificates is at least as high as the contract price and the seller’s expected cost are at most as high as the contract price. Suppose now that due to the realization of a project-specific contingency, the seller’s costs turn out to be higher than the contract price, such that she has an incentive to breach. From a welfare perspective, however, breach would only be efficient if the cost also exceed the buyer’s valuation. Hence, again, if the seller has to pay fully compensating damages in case of breach she would only breach in those cases where it is efficient to do so. Evidently, this is the case with expectation damages, i.e. full compensation.

An interesting insight from Shavell’s theory is the fact that, in principle, there exist cases where non-performance of the contract is allocationally efficient. If the seller’s (opportunity) cost exceed the buyer’s valuation, adhering to the contractual obligations would not yield the social optimum.\(^\text{10}\) While this stance has met some resistance from legal scholars,\(^\text{11}\) more recent economic research on the matter has shown that from an efficiency perspective, the remedy of expectation damages performs reasonably well within a plethora of contractual setups.\(^\text{12}\) There are, however, several aspects that significantly alter the results on efficient levels for contract damages. First, the above-described theory only considers the efficiency of the breach decision itself. However, the level of damages in case of a contingency also alters the decision to sign the contract in the first place, especially under the realistic assumption that one or both of the parties are risk-averse. Second, within the theory of efficient breach it is implicitly assumed that as soon as breach occurs, the probability that a court awards damages is one. As both of these issues are of particular importance for the analysis of CDM ERPAs, they will be shortly addressed within the following two sections.

\(^{10}\)Note that full compensation is in fact the defining property of a social optimum in the sense of Pareto. For an more extensive discussion on the optimality of the expectation measure, see Shavell (2004).

\(^{11}\)See Eisenberg (2004) for an exposition of legal arguments against the idea that deliberate breach is normatively acceptable.

\(^{12}\)See, for example, Konakayama et al. (1986), Edlin and Reichelstein (1996), and Lee (2005).
5.4. Risk-Sharing versus Incentives

Within the theory of efficient breach it is usually assumed that both contract parties are risk-neutral, such that the problem of risk allocation does not matter. However, in real-world settings it is plausible that at least one party to the contract is risk-averse.\textsuperscript{13} As a consequence, there exists an insurance problem that is associated with the price of the contracted commodity as well as the choice of an efficient damage scheme. Both variables—contract price and damages payable in case of a contingency—have an influence on a risk-averse party’s disposition to agree to a contract.

In the context of ERPAs this problem is of significant importance, as many contributors to the discussion about risks in CDM-projects seem to assume that sellers are more risk averse than buyers.\textsuperscript{14} As explained in section 4.3, this is a plausible assumption, as the group of compliance buyers is almost exclusively composed of large entities, like large enterprises, carbon funds, and governments. This group will usually not exclusively depend on the certificates of one single project, but can assemble highly diversified carbon portfolios. As a consequence, the buyer’s degree of risk aversion with respect to one single project is likely to be quite low. For the sake of simplicity of the analytical considerations to follow, it can hence be assumed that the buyer is risk neutral. The seller, on the other hand, usually implementing one single project, does not have the possibility to spread risks over a large area of different activities. Her risk preferences are hence likely to have an influence on the decision to participate within a particular contractual setting.

If risk preferences are being taken into account the level of damages leading to efficient (ex ante) decisions to participate can differ from the one that leads to an efficient (ex post) level of contract breaches. If the contract is to be exclusively optimized with respect to risk-sharing, the economic rationale requires that the risk-averse party’s income is the same in both states, breach as well as non-breach. As a consequence, the level of damages to be paid within the two breach paradigms would usually differ. Under a setup resembling the Loss Paradigm, White (1988) shows that damages guaranteeing optimal risk-sharing are necessarily lower than the expectation measure.\textsuperscript{15} The intuition of this result is straightforward. A risk-neutral buyer would need to fully insure the risk-averse seller against all contingencies. Hence, the net gain from the contract in the state of low production costs must be equal to the rent in the case where breach is rational, which would correspond to the upfront payment less the payable damages. Under the Resale

\textsuperscript{13}It is theoretically also possible that at least one of the parties has a preference for risk. However, as Rea (1984) puts it, “[i]t seems likely that the parties to most contracts are risk averse or at least risk neutral. None of the commentators has pointed out a case in which gambling was the motivation for unreasonable damages, and it is unlikely that a preference for risk prevails in the commercial world.” (Rea (1984), p. 152)

\textsuperscript{14}See, for example, Mehta et al. (2003) and Streck (2005).

\textsuperscript{15}In most cases, none of the court-imposed remedies described above would lead to efficient risk-sharing. See Miceli (1997), p. 76ff.
Paradigm, Polinsky (1983) has shown that with exogenous prices the payable damages should be higher than expectation damages, as the buyer insures the seller against the variability of her opportunity costs.

Fixing the contractual damages exclusively under risk-sharing considerations is, however, in several respects problematic. First, as exposed above, damages higher or lower than full compensation would—at least under the assumption of full enforcement—lead to inefficient levels of breach. Second, most models on damages under optimal risk-sharing treat the contract price as being exogenous. It is, hence, not taken into account that actors with rational foresight could use the contract price instead of damages to fulfill any insurance function of the contract. Third, full insurance is not necessarily desirable, as for those contingencies over which the seller has a certain level of control the contract would be subject to the highest level of moral hazard.

A first approach to at least partly solve the above-mentioned issues was developed within Posner and Rosenfield (1977), and consists of holding the seller liable only for those contingencies for which she is the *superior risk-bearer*. The term ‘superior risk-bearer’ refers to the party which is able to bear the risk of non-performance at least cost. In the context of ERPAs, it is hence useful to discriminate among risks for which risk-sharing should be set to the optimal level. For example, for many risks mentioned under 4.2 that are not project-specific, the seller’s degree of influence is practically zero. For such risks, it might be useful to include a high level of insurance within the contract by explicitly exempting her from paying damages. The same logic would apply to those project-specific risks that are not influenceable by the seller. However, for those contingencies for which the moral hazard problem is imminent, the principle of the superior risk bearer would require that the seller has to pay full compensation, as she is able to influence the probability of occurrence.\(^{16}\)

While such a complete attribution of project-specific risks to the seller would lead to the intended increase of precaution measures, it also increases her business risk by the residual risk stemming from the incompleteness of control over the contingency. Consequently, allocating these risks completely to the seller might, again, lead to an inefficiently low level of contracts. The underlying dilemma to this problem is in fact identical to the problem of avoiding moral hazard while striving for efficient risk-sharing, which was depicted in the last chapter. Hence, independent of the terms used in the different fields of research, it is quite evident that judging contract damages only with respect to either risk-sharing or incentives is in many situations not optimal.

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\(^{16}\)The problem of inefficient precaution measures also plays an important role in the Law and Economics of tort law. Cooter (1985, 1989, 1991) pleads for a transfer of the very efficient *Hand rule* from tort law jurisprudence to the legal practice of contract disputes. The Hand rule implies "that a party was at fault if its cost of avoiding the accident was less than the resulting harm multiplied by its probability": (Cooter (1991), p. 14)
The same argument can be brought forward with respect to contract discharges, i.e. situations where the seller is excused from performing the contract without paying damages. Indeed, as White (1988) points out, discharging the promisor from her contractual obligations represents de facto a contract breach which is considered as legitimate. White concludes that contract discharge should be treated in the same way as breach situations under the above-described models of optimal risk-sharing. However, as these models do not take the potential moral hazard into account, efficiency of non-performance is, again, not guaranteed. Hence, as the objectives of risk-sharing and provision of incentives are obviously antagonistic, contracts where both problems are imminent should strive for a *trade-off* instead of completely ignoring one problem or the other.

The design of contracts featuring such trade-offs is the main area of research of the *economic theory of complete contracts*\(^\text{17}\) The standard moral hazard model in this branch of literature is, however, based on a slightly different setup than the ones depicted above. The main decision variable in this theory is the contract price. Furthermore, the contract is assumed to be fully enforceable, in the sense of a court of justice ordering the specific performance measure. Still, the findings from this branch of literature can be easily carried over to the discussion on optimal contract damages. The most important result of this theory is that under asymmetric information with non-observable levels of precaution and a risk-averse seller, a first-best allocational optimum cannot be achieved. The decision variables, be it the contract price or the level of damages in case of breach, should hence be chosen in a way that the constrained optimization yields a second-best efficient result. We will turn back to the trade-off between incentives reducing problems of asymmetric information and insurance in chapter 7, where the above-made arguments are supported by a formal second-best optimal contract model.

### 5.5. Punitive Damages and Incomplete Enforcement

All considerations on the optimality of contract damages presented above are generally based on the assumption that all cases of breach are 'automatically' being judged by infallible courts of law. As explained in section 4.4.2, this assumption does not adequately reflect reality. In general, and in particular within developing countries, it is rather to be assumed that the probability of enforcement is lower than one. Under this assumption, the level of ex ante optimal contractual damages is significantly altered.

The effect of incomplete enforcement of contracts is similar to the problem analyzed within the economic theory of crime. This theory departs from the principle that in order to fulfill the function of deterrence, the punishment has to be the higher, the lower the probability of conviction is.\(^\text{18}\) The same line of reasoning is also applied within

\(^{17}\)See Laffont and Martimort (2002) for an overview.

\(^{18}\)The foundations of the economic theory of crime have been laid by Becker (1968).
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the economic theory of tort law. A transposition of these findings to the problem of optimal contractual damages can be based on the following reasoning: A rational expected utility-maximizer would breach the contract as long as the gain from breach exceeds the expected cost, i.e. the damages multiplied with the probability that the contract is being enforced. The probability of contract enforcement depends on the reliability and the cost of the dispute resolution mechanism, i.e. the courts, as well as on its capability to actually compel the breaching party to pay the damages. Hence, in order to efficiently deter opportunistic behavior within a contractual relationship with incomplete enforcement, the damages in case of breach would have to include a punitive element that increases with the probability of non-enforcement. As laid out in section 5.2, contracts could provide for such a reduced enforceability by including clauses on liquidated damages exceeding the compensation of foregone utility by a 'punitive multiple'.

As already explained, such punitive damages are deemed illegal within Common Law countries, while courts in Civil Law countries can award overcompensation. This major difference in legislation between the two different systems of private law has been the subject of a lively discussion among scholars of Law and Economics. While, at first sight, it is unclear why the courts should not accept agreements that the contract parties have mutually agreed upon, Rea (1984), Chung (1991), Stole (1992), and others have identified situations within which punitive damages lead to inefficiencies. However, it is important to note that these models do not not take the problem of incomplete enforcement into account. Their applicability to the case of CDM ERPAs, where this problem might be imminent, is hence rather limited.

In the context of CDM ERPAs where the probability of an enforced court-order in cases of contract breach is likely to be lower than one, an a priori exclusion of overcompensating damages could lead to inefficient levels of contract breaches and precaution measures. If the seller’s expected cost from non- or under-performance are lower than the expected valuation of the buyer, the promisor would not take into account all of the buyer’s costs from breach. In other words, the externality which is at the basis of the theory of efficient breach is not fully internalized. To support this argumentation, we present a formal model for breach under the Resale Paradigm in chapter 6.

An additional argument—based on information economic considerations—can be made in favor of punitive damages. Kronman and Posner (1979) point out that penalties fulfill a signaling function. Those sellers ready to sign a contract featuring overcompensating damages convey information about their reliability. The penalty would then represent a 'risk premium' that could settle the credibility balance with respect to other sellers.

As Cooter (1989) reports, the punitive component of damages granted in such cases can be up to 300 times higher than the compensating component.

The notion of the punitive multiple has been introduced by Cooter (1989) who uses it to explain punitive damages in tort cases, but can also applied in the context of contractual agreements.

See Hatzis (2003) for an overview.
that are reputed to be more reliable. This theoretical argument, as well as the other considerations made above, might be useful when analyzing contractual settings on the carbon market.

5.6. Provisions on Contract Breach within selected ERPAs

In principle, the considerations made in the previous sections with respect to court remedies can be transposed to the level of contract design. In fact, all of the above-made argumentational chains remain valid if the level of damages is not to be determined by a court, but through provisions of damages stipulated within the contract. Consequently, the above-presented theoretical considerations already provide a rough heuristic framework for assessing provisions on damages in real-world contracts. For understanding the underprovision of upfront finance within existing contracts, using this framework for the analysis of existing Emission Reduction Purchase Agreements would be helpful. In particular, the agreements made with private compliance buyers would give valuable insights, as they will be the primary driver of demand for carbon credits in the future. However, the details of private-sector agreements are usually not disclosed to the public. We will opt here for the next-best option and briefly discuss the general principles of the ERPAs of two main ‘public sector’-buyers. First, the World Bank’s Prototype Carbon Fund, and second, the procurement tenders of the Dutch government. Both buyers are of particular interest to the main concern in our contractual considerations, which is to ensure upfront financing within CDM contracts. Indeed, both of the institutions discussed below allow for upfront payments within their contracts.

5.6.1. Contracts of the World Bank’s Prototype Carbon Fund

Through the establishment of the Prototype Carbon Fund (PCF) in early 2000, the World Bank became one of the early actors in the emerging carbon market. The PCF is managed by the World Bank’s Carbon Finance Unit while the fund’s investors consist of a number of countries and transnational companies. The World Bank has also launched other Carbon Funds specialized in specific types of projects, like the Community Development Carbon Fund or the BioCarbon Fund. As the ERPAs under these specific funds follow the same basic model as the PCF, we will concentrate on presenting the provisions of PCF ERPAs, as they are described in UNEP/Risoe (2004) and Streck (2005). The PCF purchases either Verified Emission Reductions (VERs) or Certified Emission Rights (CERs) for a fixed per-unit price determined within the contract. In those cases where VERs are purchased the PCF bears practically all regulatory risks that are related to the transformation of emission reductions into CERs. Contrary to most private sector buyers the payment streams are also contracted over a timeframe beyond

22See World Bank (2005).
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2012 which is to ensure the viability of the project. It is to emphasize that the PCF grants upfront payments of up to 25 percent of the overall contract value if the Project Developer can demonstrate that such advance payment is necessary for the realization of the project.\textsuperscript{23}

The PCF’s contracts specify a fixed amount of offsets or certificates to be delivered. In order to reduce the share of project risk to be borne by the seller, the agreements are ”over-collateralized”, i.e. only a part of the planned offsets are purchased within the contract, while the surplus could be sold at future market prices where the PCF often has the right of ’first refusal’. This contract feature has two advantages. First, it represents a buffer that insures against underperformance. Second, the seller has an incentive to implement the project and over-perform on his promise. The latter implies that the moral hazard in precaution is mitigated.

Still, a significant potential for opportunistic behavior persists. In cases of non- or under-delivery of carbon offsets the PCF contracts provide, according to Streck (2005), for a large amount of flexibility in favor of the seller. If such a case becomes imminent, first a plan of action is to be proposed by the Project Developer in order to remedy the shortfall. In case of persistent under-delivery the PCF is allowed to terminate the agreement. The same is possible for the seller if the PCF fails to make timely payments. After a termination of the agreement, damages will only be sought if the breach is intentional or due to gross negligence. All risks related to non-deliberate contract breaches are therefore borne by the PCF. In those cases, where the seller’s influence on the probability of occurrence of a contingency is small, an allocation of risk to the PCF is indeed efficient, as the Fund is obviously the ’least-cost insurer’. However, in all other situations, there is potential for moral hazard in the form of non-provision of precaution. In these cases the PCF’s full-insurance policy is likely to be inefficient.

In fact, PCF contracts only foresee contract damages in cases of non-performance if the seller is obviously at fault. The amount of damages payable in theses cases is seemingly not stipulated in the contract. It is hence to be expected that the damages will be determined as a court measure, which is likely to be in the range of the expectation measure. This would fully compensate the buyer for his loss. Thus, in situations where a deliberate breach can be proven, the PCF scheme of damages will lead to efficient breach. However, if incomplete enforcement is taken into account the deterrence of opportunistic contract breach of the proposed scheme seems comparatively low, because the burden of proof for gross negligence or intentional breach would lie with the buyer.\textsuperscript{24}

\textsuperscript{23}See World Bank (2009).

\textsuperscript{24}It might however be that the World Bank has better resources to increase the enforcement probability than a private sector buyer.
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5.6.2. Contracts within ERUPT/CERUPT

The Netherlands have been the first country to organize carbon credit procurement tenders in order to meet their greenhouse gas reduction targets under the Kyoto Protocol and the corresponding EU commitment in a cost-efficient way. Within the trial-phase of the Kyoto Mechanisms, from 2000 to 2007, the Dutch government has published four calls for tender for JI certificates and one call for tender for CDM certificates. The JI-related purchase mechanism is referred to as Emission Reduction Procurement Tender (ERUPT), while the CDM-related purchases were organized within the so-called Certified Emission Reduction Unit Procurement Tender (CERUPT). Both purchase programs are closed since the entry of the Kyoto Protocol, i.e. as of January 2008. In the following, we will provide a brief overview of the provisions on damages within the ERUPT/CERUPT contracts as described by UNEP/Risoe (2004) and van der Weerd (2005).

In contrast to the PCF, the deliverable in ERUPT/CERUPT contracts are Kyoto-defined credits. Only if the Kyoto Protocol had not entered into force the Netherlands would have accepted Verified Emission Reductions. Hence, in this case the buyer accepted to bear the ”Kyoto Risk” while most other regulatory risks are attributed to the seller. Like some ERPAs of the PCF, the Dutch contracts usually include a call option at the market price on surplus certificates that might result from the project. Furthermore, both tender programs offer the possibility of advance payments of up to 50 percent of the contract value. The resulting increase in the risk of opportunistic behavior is being reduced by a system of penalty payments that has undergone several changes between the different tender procedures.

Within ERUPT/CERUPT, excuses for performance are mainly limited to force majeure events, like natural disasters or the nationalization of the project. All classes of such events are listed in the contracts. In those cases of under-delivery that are not excused within the contract, the seller either has to deliver suitable alternative credits or she is obliged to make penalty payments specified in the ERPAs. The structure of the penalty scheme varies between the CERUPT program and the different tenders of ERUPT. In the first two ERUPT tenders the penalty was independent of the shortfall and amounted to 2.5 percent of the total contract value, payable each month for which delivery remains outstanding. In the following ERUPT 3 tender, the penalty was set in relation to the shortfall and amounted to the fivefold of the price of the non-delivered credits. Upon subsequent delivery of the shortfall within one year, 60 percent of the penalty is to be reimbursed to the seller. For the last ERUPT tender the penalty was reduced to 120 percent of the market price of the non-delivered credits. The CERUPT tender had a similar scheme as the first two ERUPT tenders, but the penalty is only payable if less than 70 percent of the agreed credits are delivered.
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The penalties established in the different stages of the ERUPT/CERUPT programs will be in most cases overcompensating. However, according to van der Weerd (2005), the more recent contracts include a clause which allows the seller to cover the shortfall by delivering alternative credits instead of paying the penalty. This option would be identical to the expectation measure, as the seller could for example buy suitable credits on the market which would fully compensate the buyer. As a consequence, this contract clause guarantees efficient breach under the Resale and the Loss Paradigm. Given that the expected costs of breach under the assumption of incomplete enforcement are higher than for PCF contracts, the disincentives for opportunistic behavior are larger within the ERUPT/CERUPT scheme. However, as the penalty is de facto optional, deterrence of opportunistic contract breach under incomplete enforcement could be lower than optimal. Furthermore, as within ERUPT/CERUPT contracts a large part of the risk is shifted to the seller, the moral hazard in precaution, is in fact, minimized. This implies that damages cannot fulfill a risk-sharing function. The latter is, hence, to be fulfilled by the contract price, which would be expected to be higher under these circumstances. However, as Streck (2005) points out, ERUPT/CERUPT prices included only a small premium in comparison with payments under PCF contracts, which could also be explained with changes in exchange rates. One explanation for this curious fact might be that in the trial-phase of the CDM, the small offer of CDM projects exceeded the even smaller demand, such that sellers were in fact willing to incur larger risks without being compensated through a larger price differential.

5.6.3. The Debate on Contract Damages within ERPAs

The 'correct' level of contract damages to be included in CDM ERPAs has been the subject of a lively dispute, especially in the trial-phase of the Mechanism from 2000 to 2007. Many observers argued in favor of particularly low contract damages in order to reduce the sellers' exposure to risk.25 Streck (2005), for example, points out that potential sellers might consider damages which are based on future market prices—like full compensation under the cover measure—as "unfair". The underlying intuition to this argument is that with fixed contract prices the seller's gains from the contract are invariant, while a compensation in case of non-delivery can vary with—potentially very high—future market prices. At first sight, the validity of this argument might be difficult to accept. It is, in fact, a defining quality of a futures contract that the seller bears the upside risk while the buyer is to face the downside risk. Hence, in other contractual contexts the replacement of the deliverable in case of non-performance is rather the rule than the exception. This indicates that such damages are not contrary to existing 'fairness norms' in business. A seller facing a higher risk will simply ask for

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a higher price for the exchanged good, which would equalize his perceived advantages and disadvantages.

The above-depicted fairness argument is, however, sensible if the specificities of the trial-phase of the CDM are taken into account. In the early phase of the CDM, the demand for credits was driven by a rather small number of buyers. In such an oligopsonistic market, a buyer has usually larger bargaining power than the seller. Under such market conditions the seller might be able to extract larger parts of the added value from the contract. The level of extracted rents would be largest with sellers that have a high degree of risk aversion. This, in turn, can indeed be considered as being ‘unfair’. Thus, if viewed in this context, the PCF’s position with respect to contract damages was comprehensible. It is, however, to be questioned if this argument is still valid in the more liquid and continuously growing CDM market in the First Commitment Period.

In a sense, the large number of performance excuses in PCF contracts can also be interpreted as a contribution to the development of the carbon market. In the trial-phase of the CDM, it was particularly difficult to assess the risks of underperformance and adequately reflect it in the price of the offsets. Indeed, the lack of a knowledge base for risk assessment within the Clean Development Mechanism continues to represent an informational market barrier.26 In this view, the World Bank’s favorable conditions to the sellers represents an effort to attract a larger number of seller's and hence ‘kick-start’ the CDM carbon market. The provision on damages in PCF ERPAs can hence be viewed as a contribution to a public good, motivated by World Bank’s mission to “to pioneer the market for project-based greenhouse gas emission reductions while promoting sustainable development and offering a learning-by-doing opportunity to its stakeholders”27. Yet, it cannot be expected that purely commercial contracts involving compliance buyers will include the same provisions as the PCF ERPAs.

The above-made considerations also provide an explanation for the obvious difference in contract damages between PCF contracts and ERUPT/CERUPT agreements. Contrary to the World Bank, the Dutch government is, at the Kyoto level, obviously a compliance buyer. The primary objective of the Dutch ERPAs is hence to guarantee that the contracted certificates are actually provided by the seller. Thus, in light of the potential problem of opportunistic behavior presented in the last chapter, the inclusion of punitive damages within ERUPT/CERUPT contracts might be comprehensible. However, as the seller has the possibility to provide the buyer with alternative credits instead of incurring the penalty, it is to be asked what function the contractual penalty scheme might fulfill. For example, in the case of ERUPT 4 the problem can be formulated as follows: Why would the seller pay a penalty based on 120 per cent of the market price if he has the possibility to compensate the buyer by buying credits at 100 per cent

26See Ohndorf et al. (Forthcoming).
27World Bank (2009)
of this price? A comprehensible answer to these questions might lie in the signaling function of penalties. There might be cases in which the seller wants to signal that she is a credible and reliable partner for future contracts. If the seller is ready to deliberately overcompensate the buyer, this can be seen as an investment into a longer-term business relationship. Thus, by giving the choice between the penalty and a simple compensation the ERUPT/CERUPT contracts have enlarged the functionality of contract damages.\footnote{On the other hand, as Streck (2005) points out, such excessive penalties might have the opposite effect.}

From an economist’s viewpoint it is difficult to assess if the arrangements under ERUPT/CERUPT can be considered as being legally unfair. It is to mention that the ERUPT/CERUPT contracts are governed by Dutch private law, which contains a doctrine on reasonableness and fairness. Hence, if the fairness considerations depicted above are shared by the Dutch courts the enforceability of the penalty is questionable. However, from the perspective of the Mechanism’s institutional efficiency, a general refusal by courts to enforce punitive damages in the CDM context is likely to be harmful. As argued in the previous chapter, a compliance buyer will only be inclined to provide upfront financing within CDM contracts if opportunistic behavior can be disincentivized. Hence, if the deterrence function of contract damages is restricted, the effectiveness of the CDM as a means to provide investment for mitigation in developing countries will be limited. In the following two chapters we present several formal contract models designed to identify the strength of this effect.

\section{Conclusion}

A first ‘meta’-conclusion that can be drawn from the considerations presented in this chapter is that an economic analysis of contract damages within CDM ERPAs needs to be quite differentiated. In particular, it would be preferable to stipulate different levels of damages with respect to the different potential reasons for breach. Furthermore, a graduated scheme of contract damages should be considered for the different contingencies that might arise within the generation of CDM credits. From the theoretical considerations summarized in the first part of this chapter further important lessons can be drawn.

First, it is to be recognized that there are two different scenarios for a breach by the seller, each of which potentially engenders a different level of optimal contract damages. On the one hand the seller might decide not to perform the contract because of a rise in opportunity costs. As this implies situations where the seller receives a higher third-party offer, we attributed this class of situations to a broader interpretation of the legal ‘Resale Paradigm’. The second reason for contract breach is the unexpected increase in

\footnote{As the penalty clause is part of the ERUPT/CERUPT standard contracts, it might be seen as a sign of distrust from the part of the buyer, which would undermine a trustful relationship between buyer and seller.}
production costs, which also includes events where the generation of credits is de facto impossible. This type of situation is subsumed under the the legal 'Loss Paradigm'. Any economic analysis of contract breach would, in fact, have to specify which of these categories is addressed.

Second, contract damages affect the efficiency of a contract on different margins. An important differentiation to be made concerns the timing of the assessment. *Ex post efficient* contract damages would result in an efficient breach decision, given that the contract is already signed. If, however *ex ante efficiency* is striven for, the economic considerations focus on the level of damages necessary to optimize the expected contracted volume or the number of signed contracts. As the major motivation of this part of the thesis is the provision of a higher level of upfront financing, the main point of reference here and in the following chapters is *ex ante efficiency*.

Third, *ex ante efficiency*, in turn, can be defined with respect to two different objectives: optimal precaution and optimal risk-sharing. The latter is quite important in the context of CDM ERPAs, as we pointed out that the typical CDM buyer can be viewed as being rather risk-neutral, while the seller is typically risk-averse. However, in those cases where the seller has an influence on the occurrence of a contingency, the sole pursuit of optimal risk-sharing will lead to inefficient levels of precaution. On the other hand, contracts with high-powered incentives perform poorly with respect to the insurance function. Hence, a continuous trade-off between risk-sharing and incentives should be sought for. While this might be impossible in real-world contracts, a certain graduation in contract damages should at least be considered in the design of CDM ERPAs.

Fourth, it is quite surprising that the problem of incomplete enforcement of contracts has been widely neglected within the economic analysis of contract damages. Clearly, even in countries with a stringent rule of law, the enforcement of contracts is not 'a priori' guaranteed. Hence, while the incompleteness in contract enforcement is well recognized in other fields of economic research, there exists an apparent research gap in the analysis of optimal contract damages. In fairness, it is to be recognized that the non-consideration of incomplete enforcement might be due to the specific stance taken in the Law and Economics literature. The above-presented theoretical considerations are typically derived from analyses from the perspective of the legal court that has to decide on the remedy to apply in contract litigation. This implies that the injured party has already managed to overcome all the hurdles that render enforcement incomplete. However, if incomplete enforcement is introduced the analytical stance has to be broadened. In fact, the court decision would have to take into account that *at the time of contracting* the probability for actual enforcement of stipulated damages was in fact lower than one. Hence, an 'a priori'-exclusion of punitive damages has to be considered as being inefficient, as incentives to comply to the contract are potentially constrained.

In light of these theoretical considerations, section 5.6 provided a brief account of the contract damages featured in the real-world ERPAs by the PCF and ERUPT/CERUPT.
The most striking difference between both schemes lies probably in the very different weighting of the above-listed antagonistic objectives. While the PCF fully ensures the seller against almost all contingencies, the ERUPT/CERUPT contracts provide for relatively high-powered incentives. Viewed over the whole range of foreseeable contingencies, both strategies are unlikely to be efficient at all margins.

Among legal scholars, this difference in weighting of objectives has led to a discussion on the ‘fairness’ of contract damages within ERPAs. From an economist’s point of view, the fairness discussion transforms to the question whether an incentive-compatible combination of damages and contract price exists which is acceptable to the seller, given her risk-preferences. Hence, while taking into account the seller’s higher degree of risk-aversion, the disincentives deterring opportunistic behavior should be large enough. It is quite intuitive that an ‘a priori’-refusal to stipulate or grant higher levels of contract damages, will constrain the set of possible trade-offs. This is of particular importance for the guiding question of our contractual considerations, i.e. the design of feasible, incentive compatible contracts that guarantee upfront financing for the CDM. In the two following chapters we propose a set of formal contract models designed to provide further analytical insights with respect to the different issues discussed here. The subsequent chapter addresses the problem of stipulating contract damages under the broadly defined Resale Paradigm if enforcement is incomplete. Chapter 7 then provides a formal analysis of the trade-off between insurance and incentives given two simultaneous problems of asymmetric information and constrained contract damages.
6. Optimal Contract Damages under the Resale Paradigm with Risk Sharing

In the two preceding chapters it was argued that the low level of commercial CDM contracts providing for upfront financing can at least partially be explained by the lower enforcement probabilities in developing countries. Indeed, if the risk of opportunistic contract breach is imminent the buyer’s restraint to frontload parts of the payment is comprehensible. Still, upfront financing would be a desirable feature of the Mechanism as a whole. In this context it is interesting to analyze contract designs which are potentially capable to overcome the problem of incomplete enforcement.

As argued within the last chapter, an analysis of contract breach is dependent on the situation under which breach occurs. In this context, the most important distinction is between the legal ‘Resale Paradigm’ and the ‘Loss Paradigm’, introduced in the last chapter. In this chapter, we will analyze contract breach under the Resale Paradigm in its broad definition. This includes all contract breaches attributable to any increase of the seller’s opportunity costs, i.e. it is not only restricted to third-party offers for the contracted CDM certificates. In these situations, the reasonably assumed asymmetry in risk preferences between buyer and seller primarily raises the question on what level of damages guarantees efficient sharing of risk, given an uncertain development of the seller’s opportunity costs. This is of particular importance for CDM contracts, as the seller’s risk aversion is at the basis of arguments against higher levels of contract damages. However, as argued within the two preceding chapters, if the buyer is to prevent a potential disappropriation of the upfront payment he would have to stipulate damages which exceed the value of non-delivered certificates by a ‘punitive multiple’.

In this chapter we present a model to analyze the optimal level of contract damages in the Resale Paradigm with a risk-averse seller and a risk-neutral buyer. The chapter is organized as follows. The next section presents a generalization of the standard model on optimal risk-sharing damages under the Resale Paradigm with full enforcement. Interestingly, it will be shown that even under full enforcement the optimal risk-sharing could require damages to exceed full compensation of the buyer. Section 6.2 introduces a framework taking into account that contract enforcement can often not be taken for granted. This section also establishes a relationship between the optimal risk-sharing damages and the enforcement probability. In section 6.3 the framework is extended by introducing a constraint on the liquidated damages not to exceed a specific value. It
is shown that, if the buyer is to effectively prevent opportunistic contract breach, the optimal contract will over-insure the seller, hence rendering the contract’s risk-sharing inefficient. The main effects of incomplete enforcement on the contract are discussed in section 6.4. Section 6.5 concludes this chapter.

6.1. Optimal Risk-Sharing under Full Enforcement

In order to establish a benchmark, it is useful to first identify the general features of an efficient risk-sharing under the Resale Paradigm of contract breach under the assumption that the contract is fully enforceable. Therefore, within this section a model will be developed, which is suitable to identify the effects of potential changes in the seller’s opportunity costs on the efficient risk-sharing contract damages. The following model represents a generalization of the model presented in Polinsky (1983).

6.1.1. Contractual Setup

Consider the following CDM contract setup. A CDM project developer (the seller) and an Annex I-country buyer agree to the exchange of a fixed amount of \( q \) certificates within a purchase contract. The monetary value of \( q \) to the buyer is denominated as \( y \). Based on the considerations made above, the buyer is assumed to be risk-neutral. Consequently, his utility function, denoted as \( v(\cdot) \), represents a linear transformation of monetary values. Note that the buyer’s valuation of the certificates is driven by the certificate prices on the market. This is due to the fact that the opportunity costs to paying the contract price are not the buyer’s own marginal abatement costs, but the market prices for identical certificates. Indeed, a buyer whose marginal abatement costs are lower than the contract price would abate and sell the acquired CDM certificates on the market. In contrast, if the buyer’s marginal abatement costs exceed the contract price he would use the contracted certificates for fulfilling his reduction target instead of buying certificates on the market. Hence, the buyer’s constant valuation \( y \) is to be interpreted as being the value of the contracted certificates on the secondary CDM market.

The seller is assumed to be risk-averse, with utility function \( u(\cdot) \), where \( u(0) = 0 \), \( u'(\cdot) > 0 \), and \( u''(\cdot) < 0 \). The seller’s project costs for generating the corresponding carbon offset are \( c(q) \), which are assumed to be larger than zero. In order to entirely concentrate on the Resale Paradigm in its broader interpretation, it is assumed throughout this chapter that there exists no uncertainty neither on the amount of certificates generated by the project, nor on the associated production costs. Consequently, neither \( q \) nor \( c(q) \) represent choice variables in the underlying optimization problem.

The contract parties agree to a contract price per certificate \( k \). The overall payment \( kq \) is paid in two tranches. A share \( \alpha \) is paid upfront, while a share \( \beta \) is paid on delivery, where \( \alpha + \beta = 1 \). At the timing of the contract, the seller’s reservation utility
6. Optimal Contract Damages under the Resale Paradigm with Risk Sharing

<table>
<thead>
<tr>
<th>$q$</th>
<th>agreed quantity, fixed in advance</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
<td>buyer’s gross benefit if contract is completed, e.g. reduction in abatement cost, $y \in Y \subset \Omega$</td>
</tr>
<tr>
<td>$k$</td>
<td>contract price for the amount $q$, with $k \in Y$, and $k \leq y$</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>share of contract price paid in advance</td>
</tr>
<tr>
<td>$\beta$</td>
<td>share of contract price paid on delivery, with $\alpha + \beta = 1$</td>
</tr>
<tr>
<td>$d$</td>
<td>damages payable in case of breach</td>
</tr>
<tr>
<td>$\omega$</td>
<td>monetary value of opportunity costs, $\omega \in \Omega$, where $\Omega = {\omega_1, \ldots, \omega_n} \subset \mathbb{N}$</td>
</tr>
<tr>
<td>$B$</td>
<td>breach set, $B = {\omega</td>
</tr>
<tr>
<td>$c(q)$</td>
<td>seller’s cost to produce $q$</td>
</tr>
<tr>
<td>$v(\cdot)$</td>
<td>buyer’s utility function ($v' &gt; 0, v'' = 0, v(0) = 0$)</td>
</tr>
<tr>
<td>$u(\cdot)$</td>
<td>seller’s utility function ($u' &gt; 0, u'' \leq 0, u(0) = 0$)</td>
</tr>
<tr>
<td>$\varphi(\omega)$</td>
<td>probability mass function over $\omega$</td>
</tr>
</tbody>
</table>

Table 6.1.: Parameters and variables of the optimal risk-sharing model

is $\pi$, which is normalized to zero. If the contract is concluded and the production costs are incurred the seller’s opportunity costs might change. At the timing of the contract, the monetary value of the ex post outside option is a random variable $\omega$, which is discretely distributed with the probability mass function $\varphi(\omega)$. Support and distribution of $\omega$ is public knowledge. The actual level of these opportunity costs is revealed after the seller has incurred the production costs $c(q)$. Consequently, $\omega$ can either be interpreted as a third party offer for the certificates or as opportunity costs which are not directly related to the project activity. It is for example imaginable that price changes on other markets render an alternative use of the project’s resources more profitable. This might be, for example, the case in Forestry CDM, where a large increase in prices for agricultural products could lead to a more profitable alternative land use.$^1$ For the reader’s convenience the parameters and variables used within this model are listed in table 6.1.

In case the seller chooses not to perform the contract due to a more favorable outside option, the buyer can bring the case to court. It is reasonably assumed that without stipulation of damages within the contract, the court would at least award ‘restitution damages’ as defined in section 5.2. As this level of damages is unlikely to guarantee full insurance, the contract parties opt for stipulating damages $d$ within the contract. The level of these damages is determined at the timing of the contract, but can be made contingent on the actual realization of $\omega$. Hence, if a specific level of opportunity costs $\omega_i$ realizes and the seller decides to breach, she has to pay damages $d_i$ as specified in

$^1$For a formal analysis of contracts with a risk-neutral seller and a productive upfront payment in CDM Forestry, see Palmer et al. (2009).
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the contract. As explained in the previous chapter this would correspond to the legal instrument of 'liquidated damages'. Within this section it is further assumed that the contract is enforced with certainty, i.e. the damages will be payable in all considered cases of non-performance. This assumption is relaxed in the following section.

For simplicity it is further assumed that the project generates certificates only once. This might be interpreted as a setup, where the project is only implemented over one validation cycle. The general findings can, however, easily carried over to projects with more than one issuance period. Furthermore it is assumed that both actors do not discount utility flows over time. This assumption does not significantly alter the model results, but considerably simplifies notation.

Figure 6.1.: Timing of contract with changing opportunity costs under full enforcement

The contract timing, depicted in figure 6.1, is divided into four different stages. First, the buyer offers a contract specifying \( q, k, \) and the set of damages \( d \) contingent on the different levels \( \omega \). Given that the seller’s ex ante outside option \( \pi \) is normalized to zero, the seller will accept the contract if \( kq \geq c(q) \). If this is the case the seller receives \( \alpha kq \) at time \( t=1 \), which can be used for covering part of the costs \( c(q) \), which are incurred within the implementation stage of the project at \( t=2 \). At time \( t=3 \) the level of the opportunity costs \( \omega \), which were uncertain at the time of contracting, are realized. The seller can then chose to perform or breach the contract. In the former case she receives the backloaded part of the contract payment, \( \beta kq \). In case of breach, the seller receives the monetary value of the outside option, i.e. \( \omega \), but has to restitute the upfront payment and to pay damages \( d \) to the buyer.

6.1.2. Model Results

Under the above-described conditions an incentive to breach arises if the opportunity costs \( \omega \) realized at \( t=3 \) turn out to be larger than the seller’s monetary gain from the contract, i.e. \( kq \). Note that, as full enforcement is assumed, the upfront payment \( \alpha k \) would have to be restituted in case of breach. The set \( B \) of realizations of \( \omega \) for which breach occurs is hence defined as follows:

\[
B \equiv \{ \omega \mid \omega > kq \}
\]  \hspace{1cm} (6.1)

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Note that the support of $\omega$ might well include values larger than the buyer’s valuation of certificates $y$. Consequently, there might exist situations where breach is efficient, in the sense of Shavell (1980). Under the contract considered here, the expected utility of the buyer is as follows:

$$V(k, d) = \sum_{\omega \in B} v(y - kq)\varphi(\omega_i) + \sum_{\omega \in B} v(d_i)\varphi(\omega_i)$$

(6.2)

Hence, if the opportunity costs of the seller turn out to be lower than the contracted transfer the contract is performed and the buyer’s utility is determined by his net payoff $(y - kq)$. In case of contract breach, the buyer is restituted his ex ante payment $\alpha kq$, and receives contract damages, which could potentially be zero. Note that the realized value of $\omega$ is public information, such that the contract damages $d_i$ are made contingent on the actual level of the seller’s outside option.

Correspondingly, the expected utility of the seller is:

$$U(k, d) = \sum_{\omega \notin B} u(kq - c(q))\varphi(\omega_i) + \sum_{\omega \in B} u(\omega_i - d_i - c(q))\varphi(\omega_i)$$

(6.3)

The thusly defined expected utility implies that the seller receives the upfront payment $\alpha kq$ in all states of the world. In case of contract performance, the buyer additionally pays the agreed ex post share of the contract price, i.e. $\beta kq$. As $\alpha + \beta = 1$, the seller’s net payoff is in this case $kq - c(q)$. Note that, due to full enforcement, in all cases of breach the seller is assumed to restitute the upfront payment $\alpha kq$, such that the contract price is not relevant for the respective utility level. Hence, if the contract is breached the seller receives the value of the outside option $\omega_i$, and has to pay the contract damages $d_i$. Note that the costs of production $c(q)$ are incurred before the actual level of the outside option is realized. This allows for $\omega$ to be interpreted as a third-party offer.

Given that this analysis is mainly concerned with the effects of contract damages on optimal risk-sharing, the distribution of the gains from the contract is subject to an additional simplifying assumption. In the following it is assumed that the buyer holds all the ex ante negotiation power by making a take-it-or-leave-it offer. This approach is standard within the economic theory of complete contracts. As will be discussed in section 6.1.3, this assumption primarily affects the optimal contract price, but does have no effect on the structure of the optimal risk-sharing damages. Given this assumption, the problem can be modeled as an optimization of the buyer’s expected utility subject to the ex ante participation constraint of the buyer.

As the buyer’s ex ante participation constraint is normalized to zero, her participation is assured if the following is fulfilled.

$$U(k, d) = \pi \geq 0$$

(6.4)
The buyer’s optimization problem can hence be represented by the following program:

\[ \max_{k,d} V(k, d_i), \quad \text{subject to (6.4)} \quad (P_1) \]

The solution of the program is straightforward. Denote with \( \mathcal{L}(k, d_i) \) the corresponding Lagrangian, and with \( \lambda \) the Lagrange multiplier for the seller’s participation constraint. Pointwise optimization yields two sets of first order conditions:

For any realization \( i \) of \( \omega \), where \( \omega_i \notin B \):

\[ \frac{\partial \mathcal{L}}{\partial k} = v'(y - kq) \cdot \varphi(\omega_i) - \lambda u'(kq - c(q)) \cdot \varphi(\omega_i) = 0 \tag{6.5} \]

For any realization \( i \) of \( \omega \), where \( \omega_i \in B \):

\[ \frac{\partial \mathcal{L}}{\partial d_i} = \frac{\partial \mathcal{L}}{\partial k} = v'(d_i) \cdot \varphi(\omega_i) - \lambda u'(\omega_i - d_i - c(q)) \cdot \varphi(\omega_i) = 0 \tag{6.6} \]

It is easy to see that \( \lambda \) is positive and the participation constraint (6.4) binding. Note further that the \( k^* \) satisfying equation 6.5, also determines the contract price which optimally separates breach from non-breach cases. To see this, it is important to recall that the buyer can always choose the contract damages \( d_i \) such that (6.6) is satisfied. Hence, any deviation from \( k^* \) would imply that \( \frac{\partial \mathcal{L}}{\partial k} \) becomes positive, while (6.6) remains satisfied. A proof that \( k^* \) is optimizing program \((P_1)\) is, hence, straightforward.

Solving for \( \lambda \) in (6.5) and (6.6) leads after substitution to the following Borch condition:

\[ \frac{v'(y - kq)}{v'(d_i)} = \frac{u'(kq - c(q))}{u'(\omega_i - d_i - c(q))} \tag{6.7} \]

Hence, as within other risk sharing agreements, the ratios of the marginal utilities of the contract parties must be equal for all states of the world. Condition (6.7) can be used to solve for the optimal damages. Taking into account that with a risk-neutral seller \( v'(\cdot) \) is constant, the condition rewrites as:

\[ \frac{u'(kq - c(q))}{u'(\omega_i - d_i - c(q))} = 1 \iff u'(kq - c(q)) = u'(\omega_i - d_i - c(q)) \]

Hence, as \( u(\cdot) \) is strictly monotonically increasing, the optimal damages contingent on the realization of the opportunity costs \( \omega_i \) is:

\[ d_i^* = \omega_i - kq \tag{6.8} \]

Substituting (6.8) into (6.4) yields the optimal contract price:

\[ k^* = \frac{c(q)}{q} \tag{6.9} \]
Hence, under the given assumptions the contract price \( k^* \) is chosen to exactly cover the production costs. The damages are stipulated within the contract such that the seller disgorges all of the buyer’s additional gains from breach. The contract has hence the effect that the buyer completely insures the seller’s income at the level of her reservation utility against any changes in opportunity costs. This confirms that the results from Polinsky (1983) also hold in a more general framework.

6.1.3. Discussion of the Full Enforcement Case

The above-presented results for the optimal contract price and damages are obviously not very favorable for the seller. In both cases, performance or breach, the seller is exactly compensated for her costs of producing the agreed amount of certificates. From the perspective of a legal scholar, it might be particularly worrying that the damages payable in case of breach might well exceed the contract value \( y \). It is, however, to note that adjustments for equity concerns would primarily lead to changes in the contract price \( k^* \). The fact that the seller is not to receive a positive rent from the contract is basically driven by two assumptions: a) the normalization of the reservation utility to zero, and b) the sharing rule, according to which the seller can extract all the rent from the contract. Adjusting for equity concerns within the optimization would lead to changes in the level of \( k^* \), but leave the formula for the optimal damages (6.8) unaltered. As a consequence, changing these assumptions would influence the optimal damages only insofar, as the optimal damages \( d_i \) are dependent on \( k \), through the second term in (6.8). Hence, even if equity concerns are taken into account, the optimal risk-sharing damages derived from this model can well exceed the buyer’s valuation of the contract. The contract’s liquidated damages could, thus, well exceed the damages that are usually granted by courts, like expectation damages. Consequently, given high realizations of the opportunity costs \( \omega \), the above-derived damages might well be considered as being ‘punitive’.

As discussed in 5.6.3, such punitive damages for CDM ERPAs, featuring damages beyond the buyer’s expected contract gain, were severely criticized as being unfair. The underlying reasoning to this criticism is that smaller Project Developers, being more vulnerable to negative contingencies, should not be additionally burdened with punitive payments in ‘bad’ states of the world. Hence it was argued that due to the higher risk aversion of the seller, contract damages within ERPAs should not be punitive. However, as the above-derived results show, this reasoning would be misleading in those situations where the Resale Paradigm applies. In fact, if the uncertainty within the contract is primarily on the future development of the seller’s opportunity costs, a risk-neutral buyer fully insures the seller against negative realizations of her next-best option. As implied by the above-proposed model, the buyer guarantees to the seller an income corresponding to her reservation utility. Such full insurance, however, implies that the buyer is also to be granted all the gains from positive realizations of the opportunity costs, like
for example a higher third-party offer. Consequently, under the Resale Paradigm the seller’s risk aversion has the opposite effect on the optimal damages. In such situations, there is a case in favor of potentially 'punitive' damages.

The results from the model presented above also lend themselves to some more general remarks on the economics of contract damages. As was exposed in the last chapter, depending whether efficiency is considered before or after the signing of the contract, the level of optimal damages might vary. Under the above-proposed scheme the seller would be indifferent between breaching and performing the contract as soon as $\omega \in B$, where $B$ is defined as in (6.1). While the resulting damages yield optimal ex ante risk sharing, they would not automatically guarantee that breach is efficient. Following Shavell (1980), contract breach is considered to be Pareto-efficient if the sum of the expected utilities of the contract to the buyer and to the seller is maximized. Consequently, breach of contract will be only efficient if non-performance raises the sum of the values enjoyed by the buyer and the seller. In case of performance the value of the contract is determined by the buyer’s valuation of the good exchanged under the contract. Hence, the set of situations $B$ where breach is efficient can be defined as follows:

$$B^* \equiv \{\omega | \omega > y\}$$ (6.10)

As $y \geq k$, it follows that $B^* \subseteq B$. Hence, the above-proposed damage scheme does not automatically lead to efficient breach. If breach is to be efficient, the above-presented contract would have to include a clause, setting the level of damages for $\omega_i \notin B^*$ to $d_i = y$. These considerations further lead to the conclusion that, in fact, a contract defined by $k^*$ and $d_i^*$ would not be renegotiation-proof. For a realization of $\omega_i \notin B^*$, both parties would have an incentive to renegotiate the contract and adjust the sharing of surplus.

Another general conclusion that can be drawn from the above-presented results, is that efficient risk-sharing under the Resale Paradigm cannot be guaranteed in judicial systems that prohibit punitive damages. Hence, the so-called ‘penalty doctrine’ in the Anglo-Saxon case-law countries, mentioned in the previous chapter, bears potential for contractual inefficiencies. These inefficiencies are likely to increase in cases where contract enforcement cannot be guaranteed. The following sections presents a model to analyze the required damages that deter opportunistic contract breach.

6.2. Incomplete Enforcement and unconstrained Damages

As pointed out in the previous chapter, the discussion on punitive damages in the general contract literature focuses almost exclusively on models based on the assumption of
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complete enforcement. An application of such standard contract models to CDM ERPAs is, hence, of limited explanatory power. CDM projects are by definition based within developing countries where the rule of law is often less stringent than in industrialized countries. In principle, the reduced probability of enforcement can be compensated by increasing the liquidated damages in the case of breach.

In the following, we present a model of contract breach under the Resale Paradigm featuring upfront payments. Like in the previous section the contract is to insure a risk-averse seller. Furthermore, the contract is to prevent the problem of opportunistic contract breach. It will be shown that constraining damages will reduce the efficiency of the contract.

6.2.1. Contractual Setup

The basic contract setup is similar to the full enforcement-case presented in the previous section. A risk-averse seller and a risk-neutral buyer agree on a purchase contract to exchange \( q \) units of CDM carbon certificates against an agreed contract price \( k \). Again, the contract price is paid in two tranches, where \( \alpha k \) is the initial, frontloaded payment, and \( \beta k q \) is paid on delivery. It is assumed that the seller has limited access to the credit market such that the upfront payment is necessary to start-up the project. The required minimum amount for project kick-off is denoted as \( g \). Formally, the corresponding constraint for optimization is as follows:

\[
\alpha k \geq g, \text{ where } g > 0
\]  

This constraint implies that the buyer is to cover part of the seller’s project costs \( c \) before the implementation of the project. The constraint can also be interpreted as a requirement to technology-transfer. In this case, the frontloaded transfer represents the provision of material or immaterial capital, which would be unavailable to the seller without the contract.

Similar to the previous model the seller’s opportunity costs \( \omega \) can vary over time. For simplicity, it is assumed here that the realizations of \( \omega \) can only take two values, a low value \( \underline{\omega} \) and a high value \( \overline{\omega} \). The lower level opportunity costs \( \underline{\omega} \) is realized with probability \( \phi \), while the higher level \( \overline{\omega} \) occurs with the converse probability \( (1 - \phi) \). Clearly, if there is an incentive to breach, it will occur in the case of the high realization \( \overline{\omega} \). As in the previous model, the actual level of these \emph{ex post} opportunity costs will be revealed after the seller has incurred the costs \( c \) of generating the \( q \) certificates, such

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3 See section 4.4.2.
4 This concept is at the basis of models of regulation under incomplete enforcement, which borrowed it, in turn, from the economics of criminal law as developed by Becker (1968).
5 The model presented here can also formulated in a general neutral contract setting. Ohndorf et al. (2009) use a slightly altered version of this approach for an analysis of contract damages provided for within different legal systems.
that $\omega$ can also be interpreted as a third-party offer. These production costs are publicly known and constant for any specified amount $q$. Hence, again, it is assumed that there is certainty on the level of production costs.

In order to represent incomplete enforcement, contract enforcement is assumed to be stochastic. Hence, in case of a high realization of the ex post opportunity costs, i.e. $\overline{\omega}$, the seller has an incentive to breach the contract. If breach occurs, the contract will be enforced with probability $\theta$, while it is not enforced with converse probability $(1 - \theta)$. The level of $\theta$ depends on the reliability of the judicial system within the host country. In case the contract is breached, the seller receives, in addition to the upfront payment $\alpha k q$, the value of her outside option $\overline{\omega}$. If the contract is enforced she has to pay damages $d$, which is not the case if the contract remains unenforced. In the latter case, the buyer is not compensated for losing his start-up investment $\alpha k q$. There exists, hence, a potential 'ex post moral hazard' situation, where the seller could take the upfront payment and give nothing in return. It is assumed that the buyer is aware of this problem and reacts by stipulating damages exceeding their full enforcement level. Hence, the contract damages $d$ satisfy $d > \overline{\omega} - \beta k q$. As the the amount of certificates $q$ is fixed at the conclusion of the contract and cannot vary over time it is, for convenience, normalized to one. Figure (6.2) represents the timing of the contract situation laid out above.

![Figure 6.2: Timing of contract with changing opportunity costs under incomplete enforcement](image)

Given the above-depicted setup, a contract can be defined as being a combination of contract price $k$, the share of upfront payment $\alpha$, and contract damages $d$ which is offered by the buyer at the time of contracting, $t=0$. If the contract is to be concluded the seller must expect to be as least as well-off within as without the contract. Hence, the following participation constraint needs to be fulfilled:

$$
\phi \cdot u(k - c) + (1 - \phi)\theta \cdot u(\overline{\omega} + \alpha k - d) + (1 - \phi)(1 - \theta) \cdot u(\overline{\omega} + \alpha k) \geq u_0
$$

(6.12)
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The left hand side of the inequality represents the expected utility of the buyer from agreeing to the contract. The addends represent the utilities from the three possible states of nature, i.e. contract performance, contract breach with enforcement, and breach with non-enforcement, each weighted with the respective probabilities. The right-hand side of the inequality, that is $u_0$, is the ex ante reservation utility, just as in the previous model. For simplicity, this reservation utility is again normalized to zero.

It is further assumed that the buyer is interested in a contract that effectively offsets the problem of opportunistic contract breach. The contract is hence to be ‘enforcement-proof’, which implies that the seller’s incentive to breach in case of a realization of high opportunity costs is to be effectively reduced. Formally, this assumption can be expressed by requiring that the following enforcement proofness constraint has to be fulfilled:

$$u(k - c) \geq \theta \cdot u(\omega - d - c) + (1 - \theta) \cdot u(\omega - c)$$  (6.13)

The intuition for this constraint is the following. In case a high level of opportunity costs $\omega$ is realized, the seller’s utility from contract performance—the left hand side of the inequality—must be larger or equal to the seller’s expected utility from breaching, i.e. the right hand side of the inequality. In the case where both sides are equal, it is assumed that the seller chooses not to breach the contract. This might be interpreted as a preference for being ‘righteous’ at the margin. A similar constraint needs to be satisfied for situations where the lower level opportunity costs, i.e. $\omega$, is realized. It is, however, straightforward that this constraint will be non-binding if (6.13) holds.

6.2.2. An enforcement-proof Contract without constrained Damages

We first present a contract for which the choice of contract damages $d$ is unconstrained from above. The optimal risk-sharing contract can, hence, be found in a similar way as within the previous model where punitive damages are allowed. Again, it is assumed for the sake of simplicity that the buyer holds all the bargaining power. In this case the optimal contract can be found by solving the following program, $(P_2)$:

$$\max_{\alpha, k, d} \phi \cdot (y - k) + (1 - \phi)\theta \cdot (d - \alpha k) - (1 - \phi)(1 - \theta) \cdot \alpha k$$

subject to: (6.11), (6.12), and (6.13)  $(P_2)$

It is, however, not obvious that program $P_2$ is concave, for which the Kuhn-Tucker method would yield the optimum. This is due to the fact that the concave function $u(\cdot)$ appears on both sides of the Enforcement Proofness Constraint (6.13). This problem can be overcome by introducing a set of new variables that express the levels of the seller’s ex post utility for all three states of nature. We first define $h(\cdot) = u^{-1}(\cdot)$ as the inverse function of $u(\cdot)$, with $h' > 0$ and $h'' > 0$. The relevant utility levels for contract
6. Optimal Contract Damages under the Resale Paradigm with Risk Sharing

$q$ : agreed quantity, fixed in advance and normalized to 1

$y$ : buyer’s gross benefit if contract is completed, e.g. reduction in abatement cost, $y \in Y \subset \mathbb{N}$

$k$ : contract price for the amount $q$, with $k \in Y$, and $k \leq y$

$\alpha$ : share of contract price paid in advance

$\beta$ : share of contract price paid on delivery, with $\alpha + \beta = 1$

$d$ : damages payable in case of breach

$\omega$ : monetary value of opportunity costs, $\omega \in \Omega$, where $\Omega = [\omega_1; \omega_2] \subset \mathbb{N}$, with $\omega_1 < y < \omega_2$

$c$ : seller’s cost to produce $q$

$u(\cdot)$ : seller’s utility function ($u' > 0, u'' \leq 0, u(0) = 0$)

$\Phi$ : probability of occurrence of $\omega$, with $(1 - \Phi)$ being the probability for $\overline{\omega}$

$\theta$ : probability of contract enforcement, with $(1 - \theta)$ being the probability of non-enforcement

$u_P$ : buyer’s utility level in case of contract performance

$u_E$ : buyer’s utility level in case of breach and contract enforcement

$u_N$ : buyer’s utility level in case of breach and non-enforcement

Table 6.2.: Parameters and Variables of the incomplete enforcement-model

<table>
<thead>
<tr>
<th>Performance $u_P$, breach and enforcement $u_E$, and breach and non-enforcement $u_N$ are then defined as follows:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$u_P \equiv u(k - c)$, with $h(u_P) = k - c$ \hspace{1cm} (6.14)</td>
</tr>
<tr>
<td>$u_E \equiv u(\omega + \alpha k - d - c)$, with $h(u_E) = \omega + \alpha k - d - c$ \hspace{1cm} (6.15)</td>
</tr>
<tr>
<td>$u_N \equiv u(\omega + \alpha k - c)$, with $h(u_N) = \omega + \alpha k - c$ \hspace{1cm} (6.16)</td>
</tr>
</tbody>
</table>

For the reader’s convenience the parameters and variables used within this model are listed in table 6.2.

Using these new definitions, the three constraints of $P_2$ can be linearized as follows.

The constraint on the upfront payment (6.11) can be rewritten as:

$u_N \geq u_g = u(g + \omega - c)$ \hspace{1cm} (6.17)

The participation constraint (6.12) is transformed to:

$\phi \cdot u_P + (1 - \phi) \theta \cdot u_E + (1 - \phi)(1 - \theta) \cdot u_N \geq u_0 = 0$ \hspace{1cm} (6.18)

Finally, the enforcement proofness constraint (6.13) rewrites as:

$u_P - (\theta u_E + (1 - \theta)u_N) \geq 0$ \hspace{1cm} (6.19)
Taking into account (6.14) to (6.16), the objective function of the buyer is transformed into:

\[ \phi(y - h(u_P)) + (1 - \phi)\theta(\omega - h(u_E)) + (1 - \phi)(1 - \theta)(\omega - h(u_N)) - c \quad (6.20) \]

The transformed optimization program \((P'_2)\) is hence:

\[ \max_{u_P, u_E, u_N} (6.20) \text{ subject to: (6.17), (6.18), and (6.19)} \quad (P'_2) \]

Note that the buyer’s objective function in \((P'_2)\) is concave, as \(h(\cdot)\) is convex in \(u\). Hence, the Kuhn-Tucker method can be used to solve program \((P'_2)\). With \(\psi, \lambda, \text{ and } \mu\) being the non-negative Lagrange-multipliers for the program’s constraints, the associated Lagrangian is:

\[
\mathcal{L} = \phi(y - h(u_P)) + (1 - \phi)\theta(\omega - h(u_E)) + (1 - \phi)(1 - \theta)(\omega - h(u_N)) - c \\
+ \psi[u_N - u_g] \\
+ \lambda[\phi u_P + (1 - \phi)u_E + (1 - \phi)(1 - \theta)u_N] \\
+ \mu[u_P - (\phi u_E + (1 - \theta)u_N)]
\]

Partially differentiating with respect to \(u_P, u_E, \text{ and } u_N\) yields the following first-order conditions:

\[
\frac{\partial \mathcal{L}}{\partial u_P} = -\phi(h'(u_P)) + \phi \lambda + \mu = 0 \quad (6.21)
\]
\[
\frac{\partial \mathcal{L}}{\partial u_E} = -(1 - \phi)h'(u_E) + \lambda(1 - \phi) - \mu = 0 \quad (6.22)
\]
\[
\frac{\partial \mathcal{L}}{\partial u_N} = -(1 - \phi)h'(u_N) + (1 - \phi) \lambda - \mu + \psi \frac{1}{(1 - \theta)} = 0 \quad (6.23)
\]

Solving for the Lagrange multipliers yields the following results:

\[
\psi = (1 - \phi)(1 - \theta)(1 - \frac{u_N}{u_E}) \quad (6.24)
\]

\[
\lambda = \frac{\phi}{u_P} + \frac{1 - \phi}{u_E} \quad (6.25)
\]

\[
\mu = \phi(1 - \phi)(\frac{1}{u_P} - \frac{1}{u_E}) \quad (6.26)
\]

Note that under the given assumptions all three Lagrange multipliers will be positive. For \(\lambda\) as given by (6.25) this is obvious. To determine the sign for the other two Lagrange
multipliers recall definitions (6.14) to (6.16). Note that with punitive damages and \( u(\cdot) \) being concave, the order of utility levels is \( u_N > u_P > u_E \), which implies \( u'_N < u'_P < u'_E \). Hence, the last quotient in 6.24 will be smaller than one, and \( \psi \) is positive. Furthermore, as contract damages \( d \) are larger than in the full enforcement case, the last term in (6.26) is also unambiguously positive. Hence \( \mu \) is also larger than zero.

6.2.3. Model Results

As all constraints are binding, the optimal contract is determined by (6.17) to (6.19), each holding with equality. These equations can be transformed back into (6.11) to (6.13), again holding with equality. As a consequence, the buyer’s choice on the upfront payment \( \alpha_k \) directly follows from (6.11) and (6.17):

\[
u^*_N = u_g, \quad \text{and} \quad \alpha^* k^* = g
\]  

(6.27)

Hence, the upfront payment corresponds to the minimum value that is necessary to start-up the project. This is hardly surprising. Note that within the contract setup considered here, the upfront payment is not productive and that there exists no uncertainty on the production costs. As a consequence, the buyer does not have any incentive to raise the upfront payment above the level \( g \).

More interesting are the results on the contractual damages. Unfortunately, the exact level of \( d \) can only be specified if a specific functional form for the utility function is assumed. This would, however, significantly reduce the general applicability of the model. As a consequence, we rather chose to interpret the seller’s utility levels induced by the optimal contract, which is standard in contract models including risk-averse actors.

From (6.18) and (6.19) it follows that:

\[
u^*_P = u_0 = 0
\]  

(6.28)

Hence, the seller’s utility from performing the contract is set to the same level as the reservation utility from the ex ante outside option which, for convenience, was normalized to zero. Hence, again, the contract fully ensures the seller insofar as it guarantees her initial reservation utility in case of performance. As discussed within 6.1.2, a change in the sharing rule should alter the contract price \( k \), but not the general effects of contract damages on the seller’s relevant utility levels. As to these effects, further interesting insights can be gained. Using (6.18) and (6.19), we can derive the following relationship between the seller’s utility levels given breach with and without enforcement:

\[
\frac{u^*_E}{u^*_N} = \frac{1 - \theta}{\theta} = 1 - \frac{1}{\theta}
\]  

(6.29)

This equation establishes the dependence of the punitive element in optimal damages on the enforcement probability. As the arguments of the utility function for \( u_E \) and \( u_N \)
only differ in the contract damages payable, i.e. \( d \), the optimal level of contract damages can be easily derived from equation (6.29) if the functional form of the utility function is specified. Note that with incomplete enforcement, the value resulting from this equation is always negative, as \( u_E \) is smaller than zero—i.e. the reservation utility—if damages are assumed to be punitive. Hence, in case of breach and enforcement, the seller is always worse-off than in case of performance, except if the enforcement probability is one. In the latter case, the level of damages would correspond to the full-insurance damages derived within the full enforcement model. If, however, enforcement is not perfect, the contract’s enforcement-proofness requires an additional punitive element in damages which increases asymptotically with decreasing enforcement probability. Given the constrained optimal contract derived above, the contract damages \( d^* \) induce a disutility from enforcement which is smaller than the utility from non-enforcement as long as the enforcement probability is larger than 0.5. Conversely, for lower enforcement probabilities the disutility from enforcement will have to surpass the utility from non-enforcement of the contract if the contract is to remain enforcement-proof.

6.3. Limited Enforcement and constrained Damages

In real-world contracts it is unlikely that damages could take the high punitive levels which would be required with low enforcement probabilities. It is more likely that there exist some boundaries for the level of disutility that can be imposed on the seller in case of breach. First, there are surely limits with respect to the assets that can be seized from the seller. Hence, a first constraint on contract damages is imposed by limited liability rules. Second, there might exist institutional boundaries as to the punitive element of contract damages, like the ‘penalty doctrine’ in case law countries which entirely prohibits punitive damages. Third, damages might be deliberately set at lower levels due to equity concerns, as discussed above. There are hence a multitude of reasons for assuming that contract damages cannot be freely negotiated, but are constrained from above.

Formally, such a constraint is introduced through the following condition:

\[
u_E \geq u_d \tag{6.30}\]

Hence, it is assumed that the seller’s utility level in case of enforcement is cannot be lower than some value \( u_d \). Note that \( u_d \) might or might not be negative, depending on the underlying rationale to the constraint. For example, a boundary based on the seller’s limited liability might also include negative values, as \( u_d \) then depends on the amount of assets the seller can potentially bring in as collateral. Within the penalty doctrine, however, the contract damages are not to exceed the contract value \( y \). Consequently, \( u_d \) would be restricted to \( u(\omega + \alpha k - y) \), which—in most interpretations—would have a positive value. In the following, \( u_d = 0 \) is assumed, because this best reflects the equity
6. Optimal Contract Damages under the Resale Paradigm with Risk Sharing

concerns that were raised in the discussion on the level of damages to be stipulated within ERPAs. Under this assumption, in case of breach with contract enforcement, the seller’s utility is at the same level as if the contract had not been concluded.

Simply adding this additional constraint to Program \((P_2')\) would, however, lead to unspecified solutions, because the system of equations from the three first-order conditions, would not be sufficient to solve for four Lagrange multipliers. We will circumvent this problem by solving the following Program \((P_3)\), and then show that the solutions fulfill the seller’s participations constraint \((6.18)\).

\[
\max_{u_P,u_E,u_N} (6.20), \text{ subject to } (6.17), (6.19), \text{ and } (6.30) \quad (P_3)
\]

Denoting the Lagrange Multipliers for the constraints \((6.17)\), \((6.19)\) and \((6.30)\) with \(\psi, \mu, \text{ and } \eta\), the first order conditions for Program \(P_3\) result in the following values:

\[
\mu = \frac{\phi}{u_P'} \quad (6.31)
\]

\[
\psi = (1 - \theta) \left[ \frac{1 - \phi}{u_N'} + \frac{\phi}{u_P'} \right] \quad (6.32)
\]

\[
\eta = \theta \left[ \frac{1 - \phi}{u_E'} + \frac{\phi}{u_P'} \right] \quad (6.33)
\]

Hence, all three constraints are binding, which means that \((6.17)\), \((6.19)\) and \((6.30)\) all hold with equality and determine the solutions to program \((P_3)\).

From \((6.17)\) follows:

\[
u_N^{**} = u_g \quad (6.34)
\]

Thus, just as in the case with unconstrained damages, the chosen level of the upfront payment corresponds to the minimum required to start-up the project, i.e. \(\alpha^{**}k^{**} = g\). As already discussed, the intuition for this result is quite obvious.

Furthermore, from \((6.30)\) follows:

\[
u_E^{**} = u_d \quad (6.35)
\]

Consequently, the contract damages will be set to the maximum possible level. As these are assumed to induce the same utility as the ex ante outside option, i.e. \(u_0\), the value of \(u_E^{**}\) is zero, due to the normalization made above.

Finally, substituting \((6.34)\) and \((6.35)\) into \((6.19)\) holding with equality yields:

\[
u_P^{**} = (1 - \theta)u_g + \theta u_d \quad (6.36)
\]
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Hence, under the given assumptions this utility level is strictly larger than zero. It follows that in the case of constrained damages the contract price is larger than in the case where damages can be chosen freely. The reason for this surprising result lies in the fact that the contract presented here is assumed to be enforcement-proof. With constrained damages, the only possibility to effectively deter opportunistic contract breach, is to increase the seller’s gains from performance compared to both cases of breach. If the upfront payment is also constrained from below, as is the case here, the only instrument for deterring opportunistic contract breach is to increase the amount payable on delivery of the certificates, i.e. $\beta k$. This increase accounts for a positive difference $\Delta u_P = u_P^* - u_P^\ast$. 

It remains to check if the solutions to $P_3$ the seller’s participation constraint, which is, in fact, straightforward. Given the chosen contract fulfills (6.34) to (6.36), the buyer’s participation constraint holds with inequality if and only if

$$\theta u_d > -(1 - \theta) u_g, \iff \frac{u_d}{u_g} > -\frac{1 - \theta}{\theta}. \quad (6.37)$$

Hence, with $u_d$ being equal to zero, the participation constraint is necessarily non-binding. Hence, while the solutions (6.34) to (6.36) optimize the contract under constrained damages, risk-sharing within this contract does no longer correspond to the first-best. In fact, the risk-averse seller receives the non-productive rent $\Delta u_P$ simply because damages are constrained. As a consequence, the seller is, in fact, ‘over-insured’ compared to the full enforcement case. The risk-neutral buyer, taking over the part of the insurer, will agree to such a contract only if his expected gain from contract performance, that is $\phi (y - k^\ast)$, remains larger than the expected costs from the breach case. This becomes—ceteris paribus—more unlikely the smaller the enforcement probability of the contract $\theta$ is. Consequently, constraining damages will decrease the set of possible contracts under the Resale Paradigm, at least if opportunistic contract breach is to be effectively excluded ex ante.

6.4. Discussion of the Incomplete Enforcement Case

It is quite obvious that contract damages decrease the seller’s incentive to disappropriate the buyer from his upfront payment. The power of the corresponding disincentive can be measured by comparing the possible utility levels in case of breach, i.e. the levels with in case of enforcement $u_E$, and without enforcement $u_N$. The ratio $\frac{u_E}{u_N}$, derived in section 6.2.3, represents a measure for the intensity of the ‘punitive spread’ to be induced by the chosen contract damages if opportunistic breach is to be effectively prevented. Obviously, the punitive spread is to increase in absolute terms if the probability of contract enforcement decreases.
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The functional relationship between the punitive spread and enforcement probability $\theta$ for the case of unconstrained damages has been established within equation (6.29). The curve in figure 6.3 represents a graphic representation of this relationship. Note that the range of the functional relationship between the optimal punitive ratio and the enforcement probability is within $R_0^-$, as $u_E < u_0 = 0$. If contract damages are allowed to take values that would imply a punitive ratio situated below this curve, the respective constraint on damages is non-binding and the buyer would choose the optimal insurance contract $(k^*, \alpha^*, d^*)$. Over-insurance will only occur if the constraint on damages (6.30) restricts the punitive ratio to values lying above the optimal insurance curve. The set of these combinations is depicted as the shaded area in figure 6.3. Within this area the contract price $k^{**}$ is high enough for the seller’s participation constraint to be non-binding. This results in the over-insurance phenomenon, derived above. Clearly, the likelihood for this phenomenon to occur, increases with a decreasing enforcement probability.

![Figure 6.3: The punishment ratio dependent on the enforcement probability](image)

As already mentioned, there might be several reasons why liquidated damages stipulated in a contract are constrained from above. First and foremost, under standard limited liability provisions the damages are limited by the amount of the seller’s seizable assets. This is often taken into account in complete contract models through the inclusion of a ‘limited liability constraint’. As mentioned before, institutional barriers on enforcement—like the Anglosaxon ‘penalty doctrine’—are likely to increase the distortion of the contract’s risk sharing. This is due to the fact that in most legal interpreta-
tions damages are considered to be ‘punitive’ if they exceed the level of full compensation of the buyer. However, if damages are restricted to the level of the valuation of the contract $y$ the corresponding utility level under enforcement $u_d$ will be positive. In this case, even for enforcement probabilities very close to one, the agreement will feature an over-insuring contract price.

The same problem arises if damages are constrained through self-imposed restrictions by the buyer. If liquidated damages are restricted because of equity concerns, as assumed within the model presented in section 6.3, the contract will feature an inefficient sharing of risks. In fact, within the Resale Paradigm, asymmetries in risk preferences do not justify to restrict damages below a punitive level, but rather the opposite. While this is true for the full enforcement case, limited enforcement strengthens the case for punitive damages in order to achieve optimal risk sharing. Hence, if equity concerns are to be included, efficiency would require to take these into account within the stipulation of the contract price, but not the structure of contract damages.

It is important that the increase in contract price due to constrained damages leads, in tendency, to a reduction of implemented CDM projects, and can explain at least partly the buyer’s restraint to provide upfront financing. Evidently, a primary market-buyer of CDM certificates will only consider to invest in a project if the net gain from the project is positive. Hence, if contract prices include a non-productive mark-up, the set of profitable projects featuring upfront financing is, ceteris paribus, necessarily reduced. It might be argued that this ceteris paribus argument does not apply here. As explained in section 6.1.1, the buyer’s valuation varies with the market price of certificates on the carbon market. Consequently, if a reduction in CDM projects leads to an increase in certificate prices the buyer’s valuation would also increase. However, the market volume of the CDM is still small compared to the overall carbon market\(^6\). Hence, the increase in the buyer’s valuation due to the above-described effect is likely to be lower than the mark-up in contract prices due to over-insurance.

It is to be emphasized that the optimal level of damages identified here, only apply to the situations corresponding to the Resale Paradigm. Clearly, if breach is due to an unexpected increase in production costs or a situation that renders the generation of certificates impossible, the seller’s risk aversion would require damages that are non-punitive. Optimal levels of damages are, hence, dependent on the reason for breach, on which they should be made contingent. An interesting extension of the models here would be, hence, the introduction of information asymmetries on the actual cause of the non-performance of the contract. As the buyer and the court are likely to have less information on the actual reason for the seller’s breach, this would be an important area for future research, for contracts in general as well as CDM ERPAs in specific.

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6. Optimal Contract Damages under the Resale Paradigm with Risk Sharing

6.5. Conclusion

In this chapter, the level of optimal risk-sharing damages for contracts featuring a risk-neutral buyer and a risk-averse seller were derived for situations corresponding to the Resale Paradigm. Interestingly, even in the case of full enforcement, optimal risk-sharing damages might exceed the buyer’s value to the contract. Furthermore, it was shown that even under incomplete enforcement, a contract guaranteeing specific upfront payment could yield efficient risk-sharing. This is no longer possible, if damages are restricted to levels that are generally recognized as being ‘non-punitive’. In fact, the seller’s incentive to ‘take the money and run’ can only be offset by stipulating high enough damages. Constraining damages within the Resale Paradigm does result in over-insurance of the risk-averse seller and cannot be justified by asymmetries in the level of risk-aversion.

While the general results can be applied to any purchase contract that corresponds to the assumed set-up, they are of particular importance to CDM ERPAs. As the general guidelines for contracting within this Mechanism are still to in the process of being developed, the findings presented here might give useful insights into how the liquidated damages within ERPAs should be structured. The level for contractual damages should be made contingent on the reason for breach and be punitive in those cases where the extended Resale Paradigm applies. The a priori exclusion of punitive damages as featured within ERPAs of the World Bank’s Prototype Carbon Fund presented in section 5.6.1, are hence likely to lead to inefficient risk sharing. This is particularly interesting as the exclusion of higher levels of damages was, in fact, motivated by the risk-aversion of the seller. Furthermore, excluding punitive damages clearly decreases the levels of contract featuring upfront payments. This, in turn, is likely to result in a reduction of the overall GHG reduction potential achievable through the CDM, which is clearly in conflict with the primary objective of the Clean Development Mechanism.
7. ERPAs with Adverse Selection and Moral Hazard – A combined Model

Breaches of contract in the context of the CDM might not always occur due to the mere exploitation of incomplete enforcement. Another scenario of breach that needs to be considered is reflected by the Loss Paradigm presented in section 5.1. This legal paradigm applies to situations where the seller’s production costs increase up to a level where performance of the contract would be no longer profitable to her. A special case for such situations is the realization of a contingency which renders the generation of certificates impossible. Clearly, the discussion on contract damages within such scenarios also raise the question of efficient risk-sharing within the contract.

In such situations, however, another problem of opportunism might arise, which is associated with potential asymmetric information between buyer and seller. As discussed in chapters 4 and 5, a contract that fully insures the seller against such contingencies is prone to moral hazard. Given that the seller is implementing the project, she has often better control over the risks than the buyer. Consequently, full insurance would disincentivize precaution measures to be undertaken by the seller. In principle, this moral hazard can be reduced by attributing some of the risk back to the seller. As this is in conflict with risk-sharing, an optimal contract would have to seek a trade-off between incentives and insurance.

Yet, in addition to the moral hazard on precaution, another problem of asymmetric information might arise. The susceptibility to different risks necessarily varies over the range of different projects that are proposed to the buyer. For example, wind energy projects are generally considered to be less risk-prone than the application of other technologies. Such differences in susceptibility to risk are also likely to occur within the category of projects implementing the same technology. In this context it is likely that the seller has better information on the risk exposure of her project than the buyer. Hence, there might also exist problems of asymmetric information before the signing of the contract. If this is not taken into account within the contract such 'pre-contractual' information asymmetries could lead to adverse selection. Thus, if the difference in risk exposure between different projects is large enough, an optimal contract would also have to aim for a truthful revelation of risk-types.

Within this chapter we present a model on optimal contract damages under the Loss Paradigm which takes both of the above-described incentive problems into account, i.e. moral hazard and adverse selection. In order to reduce the complexity of real-world
7. ERP As with Adverse Selection and Moral Hazard – A combined Model

setups, the different influences on contingencies are treated as being binary. While this represents a considerable simplification of reality, it permits to present the basic arguments that can be derived with respect to optimal levels of damages within an intuitively comprehensible framework.

The chapter is structured as follows. Section 7.1 describes the contractual setup. Here, the different constraints to the contract are introduced that result from the problems of asymmetric information and the insurance function. In section 7.2 an optimal contract is derived for the case where contract damages are unconstrained. Under the given assumptions this contract is primarily driven by the moral hazard, while the adverse selection does not influence the choice of contract price and damages. This changes if damages are constrained, a case which is presented in section 7.3. The effects of such constrained damages on contracts featuring upfront payments are discussed in 7.4. As it turns out, an a priori exclusion of higher levels of damages will again result in an unproductive ex ante rent conceded to the buyer, which decreases the set of feasible contracts. Section 7.5 concludes.

7.1. Contractual Setup

We consider the following CDM contract setup. A risk-neutral buyer offers a contract to a risk-averse project developer implementing a CDM project with the potential to generate a specific amount of certificates. The project requires a start-up investment to be successfully implemented. Just as in the preceding chapter, it is assumed that the seller’s access to the credit market is restricted, such that the upfront financing has to be provided within the contract. Hence again the contract features a frontloaded payment by the buyer to cover the project’s start-up costs. It is assumed that the project generates the agreed amount of certificates with probability $\pi$. With the converse probability $(1 - \pi)$ the project defaults and fails to deliver any certificates. The default risk is subject to the two different problems of asymmetric information depicted in the introduction to this chapter.

First, it is assumed that there exists an adverse selection problem on the project-specific level of risk. The probability of default is hence dependent on a project-specific parameter $\tau$, which is known to the project developer but not the buyer of the certificates. For the sake of simplicity, the parameter can take only two values, $\underline{\tau}$ implying a lower inherent risk, and $\overline{\tau}$ representing a higher project-specific risk. Hence, $\pi(\underline{\tau}) - \pi(\overline{\tau}) > 0$. The actual risk type of the project is the private information of the seller. For many real-world cases this is a plausible assumption as the project developer is likely to be able to assess the default risk more accurately than the buyer. In this case, the buyer can only observe the failure rates of similar projects. It is hence assumed that the buyer knows the relative frequency of low-risk project types, which is denoted by $\nu$. The
converse frequency \((1 - \nu)\) represents, hence, the probability that a specific seller is of the high-risk type.

The second problem of asymmetric information taken into account here is a standard moral hazard. It is assumed that the seller can make an investment in precaution which reduces the probability of a project failure. Hence, the probability of success is also dependent on the level of the seller’s precaution level \(e\), i.e. \(\pi(\tau, e)\). Again, for simplicity, the choice of the precautionary measure \(e\) is binary: The seller can chose to either incur the precautionary costs by choosing \(e = 1\), or she can decide to ”shirk”, in which case \(e = 0\). The provision of precaution is assumed to be costly. The seller, hence, incurs cost of precaution \(c(e)\), with \(c(0) = 0\) and \(c(1) = c\). The precaution level chosen by the seller is unobservable, neither by the buyer, nor the court. The resulting non-contractibility of the precaution effort level entails that the contract is prone to a problem of hidden action, as exposed in sections 4.4 and 5.4. As emphasis is laid exclusively on the effects of asymmetric information, we assume throughout this chapter that all other specifics of the agreement are fully enforceable.

The buyer’s valuation of the contracted certificates is assumed to be known and denoted by \(y\). As laid out in the previous chapter, \(y\) can be interpreted as the number of contracted certificates times the expected price for Kyoto certificates on the secondary market. The contracted transfer is divided into the upfront payment \(\alpha\) and a fraction \(\beta\) paid upon delivery of the certificates. It is assumed that the upfront payment exactly covers the start-up costs of the project which, for convenience, are assumed to be the same for both project risk types. The frontloaded payment is hence a necessity for the conclusion of the contract, but has no influence on the seller’s ex post utility level. In case the project is implemented successfully and generates the expected certificates, the seller receives a backloaded payment \(\beta\), which can be interpreted as a contracted per-unit payment times the contracted amount of certificates \(q\). If the project fails to produce the certificates the net transfer to the seller is denoted by \(d\). The values of the variable \(d\) can either be smaller than, equal to, or larger than zero. This is to take into account that, a priori, it cannot be ruled out that the seller demands a positive transfer even in case of a project failure. In case the seller’s (opportunity) costs are larger than zero, a risk-averse seller might insist on receiving a positive payoff even if no certificates are generated. In real-world contracts this is often dealt with by augmenting the upfront-payment by a utility-relevant amount while still choosing a negative level of damages. For the sake of a comprehensible argumentation, we will refer to the transfer \(d\) as 'contract damages'.

It is further assumed that it is rational for the buyer to always induce a positive level of precaution, which will be the case if \(y\) is large enough. In addition, we assume that the buyer is interested in truthful self-revelation of the seller’s risk type. The formal assumptions for ensuring both, positive effort and truth-telling will be discussed below. In order to create a revelation mechanism, the buyer must discriminate among the two risk types within both determinants of the seller’s ex post utilities, i.e. the backloaded payment \(\beta\) and the damages payable in case of non-performance \(d\). The respective
transfers will be denoted as \((\beta, d)\) for a seller identifying herself as low-risk, and \((\bar{\beta}, \bar{d})\) for a self-proclaimed high-risk seller.

Given truth-telling and positive effort levels, the objective function of the risk-neutral, payoff-maximizing buyer in this binary setup is as follows:

\[
V(\beta, \bar{\beta}, d, \bar{d}) = \nu \left[ \pi(\tau, 1)(y - \beta) + (1 - \pi(\tau, 1)) \cdot (-\bar{d}) \right] \\
+ (1 - \nu) \left[ \pi(\tau, 1)(y - \bar{\beta}) + (1 - \pi(\tau, 1)) \cdot (-d) \right] - \alpha
\]

(7.1)

Hence, for both risk types the buyer is to pay or receive the respective ex post transfer depending on the realized state of nature. If the project is implemented successfully, which is associated with the ex ante probability \(\pi\), the seller pays the respective backloaded payment \(\beta\). If the complementary event realizes, i.e. the project fails to generate certificates, the buyer receives the pre-agreed contract damages \((-d)\) from the seller.\(^1\)

Both types of sellers are assumed to only differ with respect to the exposure to risk of their project, but not with respect to their utility functions. Hence, all sellers are assumed to be identical with respect to their risk preferences. Furthermore, the sellers’ utility is assumed to be additively separable in money and effort. Given truth-telling and a positive effort level, the expected utility from the contract of the high-risk seller is:

\[
U(\beta, \bar{d}) = \left( \pi(\tau, 1) \cdot u(\beta) + (1 - \pi(\tau, 1) \cdot u(\bar{d}) \right) - c
\]

(7.2)

Similarly, under the same assumptions, the low-risk seller’s expected utility is:

\[
U(\beta, d) = \left( \pi(\tau, 1) \cdot u(\beta) + (1 - \pi(\tau, 1) \cdot u(d) \right) - c
\]

(7.3)

A priori, neither separation of types nor the provision of effort by the seller is guaranteed. As both of these variables are subject to asymmetric information, the buyer needs to set the correct incentives within the contract in order to ensure truthful revelation of information. Hence, in order to select the optimal contract, the buyer’s optimization is subject to several constraints, which will be presented in the following section.

7.1.1. Constraints to the Optimization

Clearly, the different sellers’ expected utility will only correspond to (7.2) and (7.3) if both types of sellers are induced to take the precautionary measures, while incurring the respective cost of precaution \(c\). Hence, in order to achieve an expected utility as

\(^1\)Note that in its standard interpretation as contract damages, \(d\) is negative. If \(d\) takes a positive value, (7.1) implies that the seller receives a payment in the bad state of nature.
described by (7.1), the buyer needs to ensure that the following incentive constraints are fulfilled. The *moral hazard incentive constraint* for the *high-risk seller* is:

\[
U(\beta, d) \geq \pi(\tau, 0) \cdot u(\beta) + (1 - \pi(\tau, 0)) \cdot u(d)
\]  

(7.4)

Analogously the *moral hazard incentive constraint* for the *low-risk seller* is:

\[
U(\beta, d) \geq \pi(\tau, 0) \cdot u(\beta) + (1 - \pi(\tau, 0)) \cdot u(d)
\]  

(7.5)

In words, these two constraints ensure that—*given truthful revelation of types*—for both types of sellers the expected utility from taking precautionary measures is larger than from “shirking”. Hence, given truthful reporting is induced, the seller will always decide to provide a positive level of precaution. However, even if it is optimal for the buyer to induce a positive effort under the assumption of truth-telling, it is not necessarily optimal to do so if the seller lies about her risk type. This lack of structure is typical to models featuring both, adverse selection and moral hazard. The standard strategy to reduce the complexity of the problem, laid out in detail in Laffont and Martimort (2002), is to make an assumption with respect to the relative influence of effort \(e\) on the differences in the probability of default \(\pi(\tau, e)\) as defined as follows:

**Definition 7.1**

\[
\Delta \pi(\tau) \equiv \pi(\tau, 1) - \pi(\tau, 0)
\]

Using this definition the following assumption can be made.

**Assumption 7.1** *The provision of precaution effort has a larger impact on the probability of success of the high-risk type than of the low-risk type, that is:*

\[
\Delta \pi(\tau) < \Delta \pi(\tau)
\]

This assumption implies that the moral hazard incentive constraint for the high-risk type (7.4) is easier to satisfy than the one for the low-risk type, i.e. (7.5). Hence, if the difference in utilities in the different states of the world is large enough for the low-risk seller to take precaution measures, it is also rational to do so for a high-risk seller pretending to be of the low-risk type. It is to note that this assumption is quite plausible. Additional precautionary measures often have a larger effect on projects that are intrinsically more risk-prone than on low-risk projects. As laid out in Laffont and Martimort (2002), this assumption significantly simplifies the analysis by adding structure to the decision problem. As a consequence, the adverse selection incentive constraint—which is to guarantee that the high-risk seller prefers to reveal his type truthfully—can be formulated in a form where the choice of a positive precaution level is given. The *high-risk seller’s adverse selection incentive constraint* is hence:
Note that a similar constraint can be constructed to guarantee that the low-risk seller does not imitate a high risk seller. In a setup considering exclusively adverse selection, such a constraint would be always slack at the optimum. This is, a priori, not the case in the mixed environment considered here, which also includes a problem of moral hazard. In such a mixed setup there exists the possibility that a low-risk seller claims to be of the high-risk type while not providing any precaution effort. However, allowing for such a two-sided adverse selection increases the complexity of the decision problem, which would impede the straightforward argumentational flow that is attempted here. We hence simplify the analysis by restricting the adverse selection to be only one-sided by making the following assumption:

**Assumption 7.2** Only the high-risk seller is capable to be untruthful about her type.

This assumption implies that the buyer observes a signal which represents a necessary but not sufficient condition for the seller to be of the low-risk type. Note that for many conceivable types of CDM projects such an assumption is plausible. For example, the probability of a successful delivery of reduction credits is directly dependent on the production capacity of the technology used within the project. It can, hence, be rightfully assumed that a project which is larger than a specific critical size would always qualify as being of the low-risk type. As this information is included within the Project Design Document, the observability of signals with respect to project size is guaranteed. There might, however, exist additional characteristics—hidden to the buyer—which reduce the probability of project success. This is for example the case in the context of fuel-switch projects, where the seller has a better notion of the uncertainties associated with the security of supply of the new combustible than the buyer. A truthful revelation of a high-risk type would then imply that the buyer provides verifiable information on these uncertainties. Analogously, a high-risk seller lying about her type would simply not reveal additional information at the contracting stage. A low-risk seller, however, is not able to fake information on such additional project characteristics and is hence not able to untruthfully state her type. As a consequence, the adverse selection problem exists only with respect to a high-risk seller potentially claiming to be of the low-risk type, but not vice versa. Having established the basic structure of the contract, the different steps in the timing of the contract are now established. These are depicted in figure 7.1.

Under the given assumptions, truth-telling and a positive effort level is guaranteed through the constraints (7.4) to (7.6). Hence, if these constraints are satisfied the seller’s expected utilities are indeed given by (7.2) and (7.3). In addition to the incentive constraints, the buyer must also ensure that both types of sellers are interested in signing the contract in the first place, by fulfilling the seller-specific participation constraints.
7. ERP As with Adverse Selection and Moral Hazard – A combined Model

Buyer offers contract \{(\beta_0, \beta_1, \beta_2, \beta_3, \beta_4)\}

Seller accepts contract and reveals her risk type \(\tau\)

Buyer provides start-up investment \(\alpha\)

Seller chooses effort level \(e\) and incurs \(c(e)\)

\(\pi(\tau, e)\) is realized

Seller receives \(\beta_0\), given \(\tau\)

Buyer receives certificates

Seller pays \(d\), given \(\tau\)

Buyer receives \(-d\), given \(\tau\)

Buyer provides start-up investment \(\alpha\)

Seller performs

Buyer receives \(\beta_0\), given \(\tau\)

Figure 7.1.: Timing of contract with moral hazard and adverse selection

For simplicity, we assume that the seller’s outside option is independent of the project risk type and would generate the reservation utility of \(u_0\). Just as in the preceding chapter, we will normalize this reservation utility to zero. The participation constraint for the low-risk seller is hence:

\[
U(\beta, d) \geq u_0 = 0 \tag{7.7}
\]

Similarly, the participation constraint for the high-risk type is:

\[
U(\beta, d) \geq u_0 = 0 \tag{7.8}
\]

After having structured the problem accordingly, finding the optimal contract menu, i.e. \((\beta, d)\) and \(\beta, d\), would involve the optimization of the buyer’s objective function, subject to the constraints (7.4) to (7.8). However, just as in Problem \((P_2)\) presented in section 6.2.2, the concavity of the respective program would not be obvious. This is due to the fact that the choice variables appear within the concave transformation of the seller’s utility function on both sides of the moral hazard incentive constraints (7.4) and (7.5). Hence, while the objective function is linear in the choice variables, the moral hazard incentive constraints might, at first sight, be convex. As this precludes the validity of the Kuhn-Tucker approach, it is to be shown that the optimization program is concave. However, for the sake of generality we refrain from specifying a functional form for the utility function. Hence, a direct proof of the program’s concavity is not possible. Instead, we will adopt the same strategy as in the preceding chapter and transform the choice variables from payoffs into utility levels.

7.1.2. Transformation of Choice Variables

Analogous to the strategy adopted in section 6.2.2, the contractual transfers can be expressed as utility levels of the seller. As will be shown below, such a transformation yields a program where the objective function is concave and the constraints are linear in the choice variables, guaranteeing hence the validity of the Kuhn-Tucker approach. For


\[ y : \] Seller’s valuation of contracted certificates
\[ \tau : \] Seller’s risk parameter, where \( \tau \) represents low risk and \( \bar{\tau} \) refers to high risk
\[ e : \] Effort level chosen by the seller, with \( e \in \{0, 1\} \)
\[ c(e) : \] Seller’s cost from effort \( e \), with \( c(0) = 0 \) and \( c(1) = c \)
\[ \pi(\tau, e) : \] Probability of project success
\[ \nu : \] Probability of a seller being of low-risk
\[ \alpha : \] Start-up investment provided by the buyer
\[ \beta, (\bar{\beta}) : \] Contract price for low-risk seller (high-risk seller)
\[ d, (\bar{d}) : \] Level of contract damages for low-risk seller (high-risk seller)
\[ u(\cdot) : \] Seller’s utility function (\( u' > 0, u'' \leq 0, u(0) = 0 \))
\[ h(\cdot) : \] Inverse of Seller’s utility function \( h(\cdot) = u^{-1}(\cdot) \)
\[ u_p : \] Low-risk seller’s utility in case of contract performance
\[ u_d : \] Low-risk seller’s utility in case of non-performance
\[ u_{p'} : \] High-risk seller’s utility in case of contract performance
\[ u_{d'} : \] High-risk seller’s utility in case of non-performance

<table>
<thead>
<tr>
<th>Table 7.1.: Parameters and variables of the mixed environment model</th>
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problems of binary nature like the one depicted here, this approach is widely used within contract theory. The transformation of the transfers into utility levels is as follows:

\[
\begin{align*}
\pi_p &= u(\beta) \\
\pi_d &= u(\bar{d}) \\
u_p &= u_p \\
u_d &= u_d
\end{align*}
\]  

(7.9) 
(7.10) 
(7.11) 
(7.12)

Given these transformations the level of monetary transfers can be derived by re-transforming the respective utility levels with the inverse function of the seller’s utility, which in the following is denoted as \( h(\cdot) = u^{-1}(\cdot) \). Note that the inverse of a concave utility function is increasing and convex. For the readers convenience the parameters and variables used in the following are summarized in table 7.1.

The major advantage of reformulating the problem in terms of the seller’s utility levels is the fact that all constraints become linear in the choice variables. The \textit{high risk seller’s adverse selection incentive constraint} is transformed to:

\[
\pi(\tau, 1) \cdot \pi_p + (1 - \pi(\tau, 1)) \cdot \pi_d \geq \pi(\tau, 1) \cdot \pi_p + (1 - \pi(\tau, 1)) \cdot \pi_d 
\]  

(7.13)

Again, as an untruthful revelation of a low-risk type is excluded by assumption, the contract would not have to satisfy the corresponding constraint for the low-risk seller.

Reformulating (7.4) with respect to the new variables, and using definition 7.1, the new \textit{moral hazard incentive constraint} for the high-risk type can be expressed as:
This altered representation of the moral hazard incentive constraint has an important advantage: The relationship between the influence of \( e \) on the probabilities, i.e. \( \Delta \pi \), and the wedge in utility levels required to induce precaution \( (u_p - u_d) \) is explicitly stated. For this reason, this representation is often used by Laffont (2000) and Laffont and Martinot (2002). The moral hazard incentive constraint for the low-risk type is expressed analogously as:

\[
\pi(\tau, 1)u_p + (1 - \pi(\tau, 1))u_d - c \geq u_0 = 0
\]

The transformation of the participation constraints is straightforward. Keeping in mind that the reservation utility of both risk-types is normalized to zero, the reformulated participation constraints are as follows.

**Low-risk seller’s participation constraint:**
\[
\pi(\tau, 1)u_p + (1 - \pi(\tau, 1))u_d - c \geq u_0 = 0
\]

**High-risk seller’s participation constraint:**
\[
\pi(\tau, 1)u_p + (1 - \pi(\tau, 1))u_d - c \geq u_0 = 0
\]

While after this transformation the constraints are now all linear in the choice variables, the same will no longer be true for the buyer’s objective function. As the initial form of the latter, i.e. equation (7.1), is expressed in terms of the contractual transfers, a reformulation necessarily involves the above-defined inverse of the seller’s utility function \( h(\cdot) \). More specifically, the buyer’s expected profit is transformed to:

\[
V(u_p, u_d, \pi_p, \pi_d) = -\alpha + \nu \cdot \left[ \pi(\tau, 1) \cdot (y - h(u_p)) + (1 - \pi(\tau, 1)) \cdot (-h(u_d)) \right] + (1 - \nu) \cdot \left[ \pi(\tau, 1) \cdot (y - h(u_p)) + (1 - \pi(\tau, 1)) \cdot (-h(u_d)) \right]
\]

Note that this new objective function is strictly concave in its arguments, as the inverse of the utility function \( h(\cdot) \) is always convex. As a consequence, the validity of the Kuhn-Tucker approach for the transformed problem is guaranteed. Given these specifications to the contractual setup, we can now proceed to derive the optimal contract. In the following section we will solve for the optimal second-best contract given unconstrained contract damages, which is to serve as a baseline for comparison. The actual contract featuring a constraint on contract damages will be presented in section 7.3.
7. ERP As with Adverse Selection and Moral Hazard – A combined Model

7.2. A Model without constrained Contract Damages

While the specifications made in the preceding section lead to a well-structured decision problem, the amount of constraints involved suggests—at least at first glance—that the underlying system of equations is overconstrained. When facing such a setup, a common strategy within economic contract theory is to reduce the amount of constraints while deriving the first-order conditions and check the non-considered constraints ex post for slackness at the second-best optimum. In the following, we will adopt the same approach by optimizing the objective function subject to the two moral hazard incentive constraints and the two participation constraints. The adverse selection incentive constraint will be checked ex post. Following this strategy, the optimal contract can be found by solving the program $(P'_1)$:

$$\max_{(u_p, u_d); (\bar{u}_p, \bar{u}_d)} (7.18), \text{ subject to: (7.14), (7.15), (7.16), and (7.17)} \quad (P'_1)$$

Denoting with $\mathcal{L}$ the Lagrangian, and with $\mu$, $\psi$, $\phi$, and $\lambda$, the Lagrange multipliers for the constraints (7.14), (7.15), (7.16), and (7.17), the following first-order conditions can be derived:

$$\frac{d\mathcal{L}}{du_p} = -\nu \cdot \pi(\bar{\tau}, 1) \cdot h'(\bar{u}_p) + \psi \cdot \pi(\bar{\tau}, 1) = 0$$

$$\frac{d\mathcal{L}}{du_d} = -\nu \cdot (1 - \pi(\bar{\tau}, 1)) \cdot h'(\bar{u}_d) - \psi \cdot (1 - \pi(\bar{\tau}, 1)) = 0$$

$$\frac{d\mathcal{L}}{d\bar{u}_p} = -(1 - \nu) \cdot \pi(\bar{\tau}, 1) \cdot h'(\bar{u}_p) + \mu + \lambda \cdot \pi(\bar{\tau}, 1) = 0$$

$$\frac{d\mathcal{L}}{d\bar{u}_d} = -(1 - \nu) \cdot (1 - \pi(\bar{\tau}, 1)) \cdot h'(\bar{u}_d) - \mu + \lambda \cdot (1 - \pi(\bar{\tau}, 1)) = 0$$

Solving this system of equations for the Lagrange multipliers yields the following:

$$\psi = \nu \cdot \pi(\bar{\tau}, 1) \cdot (1 - \pi(\bar{\tau}, 1)) \cdot \left(h'(\bar{u}_p) - h'(\bar{u}_d)\right) \quad (7.19)$$

$$\phi = \nu \cdot \left[(1 - \pi(\bar{\tau}, 1)) \cdot h'(\bar{u}_d) + \pi(\bar{\tau}, 1) \cdot h'(\bar{u}_p)\right] \quad (7.20)$$

$$\mu = (1 - \nu) \cdot \pi(\bar{\tau}, 1) \cdot (1 - \pi(\bar{\tau}, 1)) \cdot (h'(\bar{u}_p) - h'(\bar{u}_d)) \quad (7.21)$$

$$\lambda = (1 - \nu) \cdot [(1 - \pi(\bar{\tau}, 1)) \cdot h'(\bar{u}_d) + \pi(\bar{\tau}, 1) \cdot h'(\bar{u}_p)] \quad (7.22)$$

As $h'(\cdot)$ is strictly positive for all possible realizations of $u(\cdot)$, it is obvious that $\lambda$ and $\phi$ are always positive. Moreover, given the curvature of $h(\cdot)$, $\mu$ and $\psi$ must be always positive as well. As the inverse function of a concave utility function is convex, the statement $(h'(\bar{u}_p) - h'(\bar{u}_d)) > 0$ is always true for $\bar{u}_p > \bar{u}_d$. As a consequence, all four
The optimal contract is hence completely determined by (7.14) to (7.17) holding with equality.

### 7.2.1. Second-Best Optima with unconstrained Contract Damages

Calculating the optimal contract—expressed as the different sellers’ utility levels being induced by the contractual transfers—is now straightforward. As the constraints (7.14) to (7.17) hold with equality, the optimal utility levels are:

\[
\begin{align*}
\bar{u}^{ss}_{p} &= c + \frac{1 - \pi(\tau, 1)}{\Delta \pi(\tau)} \cdot c \\
\bar{u}^{ss}_{d} &= c - \frac{\pi(\tau, 1)}{\Delta \pi(\tau)} \cdot c \\
\bar{u}^{ss}_{p} &= c + \frac{1 - \pi(\tau, 1)}{\Delta \pi(\tau)} \cdot c \\
\bar{u}^{ss}_{d} &= c - \frac{\pi(\tau, 1)}{\Delta \pi(\tau)} \cdot c
\end{align*}
\]  

(7.23)\(\text{to}\) (7.26)

It remains to check whether the high-risk seller’s adverse selection incentive constraint is slack at these utility levels. This is the case if (7.13) holds with inequality at the above-derived second-best optimum. Hence, substituting (7.23) to (7.26) into (7.13) holding with inequality yields after simplification:

\[
\pi(\tau, 1) - \pi(\tau, 1) \cdot c > 0
\]  

(7.27)

This inequality always holds, as by construction the probability of success for low-risk seller \(\pi(\tau, 1)\) is always higher than for the high-risk seller \(\pi(\tau, 1)\). Hence the second-best optimal contract is entirely defined by the second-best utility levels defined by equations (7.23) to (7.26).

Note that these results are significantly different from the ones derived in Laffont and Martimort (2002). This can be attributed to the fact that these authors seem to implicitly assume that the seller has an imperfect capacity of anticipation. In this case the high-risk seller’s participation constraint might be reduced to a version that does not take into account a positive level of precaution costs. As such an altered participation constraint is slack at the optimum, the optimal contract necessarily differs from the one depicted above. However, in the model derived here, we assume that the seller does not make any mistakes in anticipating whether she is going to provide a positive precaution effort. In this case, fulfilling the high-risk agent’s moral hazard incentive constraint implies that the corresponding participation constraint is necessarily of the form as specified in (7.17). The buyer hence needs to ensure the high-risk seller’s participation given the fact that she would want to provide a positive precaution effort.
7. ERP As with Adverse Selection and Moral Hazard – A combined Model

7.2.2. Characteristics of the second-best Contract

One of the most interesting features of the above-derived contracts is surely the fact that the high-risk seller's adverse selection incentive constraint holds with inequality. Thus, the optimal contract represents in fact the solution of the two separate moral hazard problems, i.e. inducing precaution for both risk types while ensuring—independently—their participation.\footnote{As solving the two moral hazard problems also solves the adverse selection problem, the latter does not require an additional information rent to guarantee truthful revelation of types. The above-depicted contract hence represents a case where adding the one-sided adverse selection problem does not increase the inefficiencies that result from the two moral hazard problems \textit{per se}.}

Still, the moral hazard is sufficient to distort the contract away from the first-best optimum. Clearly, under symmetric information optimal risk-sharing would require that the risk-neutral buyer fully ensures the risk-averse seller. Consequently, under perfect observability of precaution effort and risk-type, the buyer would simply compensate the seller for the incurred costs. In the above-depicted setup, the first-best transfer would hence always be equal to the costs of precaution $c$, irrespective of the realized state of nature. Given the assumed moral hazard problem, such perfect risk-sharing is no longer possible. In the second-best solution presented above, some of the risk is to be borne by the seller in order to create an incentive to take measures of precaution. The corresponding wedge between utilities is, for each risk-type, determined by the two different moral hazard incentive constraints.

However, while the difference in utilities within the same risk-type is unambiguously determined, a relative ranking over all the different contractual payoffs—or the associated utility levels—is not possible without further assumptions. This is summarized in the following proposition.

\textbf{Proposition 7.1} \textit{Given the second-best optimal contract $\{u_{d}^{**}; \pi^{***}; u_{p}^{**}; \pi^{**}\}$ the relative size of the contractual payoffs is characterized as follows:}

\begin{itemize}
  \item[a)] \textit{The low-risk type's payoff in the case of non-delivery is strictly smaller than for the high risk seller, i.e. $u_{d}^{**} < u_{d}^{*}$.}
  \item[b)] \textit{The relationship of payoffs in case of delivery depends on the relative strength of the two considered problems of asymmetric information.}
\end{itemize}

More specifically, $u_{p}^{**} \lesssim u_{p}^{***}$ iff

\[
\frac{1 - \pi(\tau, 1)}{1 - \pi(\tau, 1)} - \frac{\Delta \pi(\tau)}{\Delta \pi(\tau)} \approx 0,
\]

(7.28)

\footnote{Clearly, this result will only hold under the above-made assumption that the buyer's valuation of certificates is high enough to render the inducement of precaution for both risk-types profitable.}
Proof: See Mathematical Appendix

Note that under the given assumptions, both minuend and subtrahend in (7.28) are strictly smaller than 1, while the sign of the difference is undetermined. Hence, under the given assumptions, it is not clear if the payoff in case of project success will be larger for the low-risk or the high-risk type. At first glance, it might strike as odd that the payoff to the high-risk type can be larger than for the low-risk type. It is, however, to be recognized that this is only the case if the effect of providing effort on the probability of success is quite similar for both types, while the difference in probabilities of failure is rather large. The latter would imply that the probability of success is significantly lower for the high-risk type than for the low-risk type. As a consequence, the high-risk seller’s participation constraint can only be fulfilled by increasing her payoff in the good state. Given \( u_{d}^{**} < u_{d}^{*} \) and if both \( \Delta \pi(\tau) \) are similar, such a constellation would imply that a high-risk seller would only sign the contract if her remuneration on delivery is larger than for the low-risk type.

Furthermore, the indeterminacy in (7.28) hints to the fact that the above-derived contract would not necessarily lead to a separation of types if the low-risk seller were able to mimic a high-risk seller and chose to provide no precaution effort. Indeed, in this case separation of types would be only guaranteed if the following (modified) adverse selection constraint were fulfilled:

\[
\pi(\tau, 1) \cdot u_{p} + (1 - \pi(\tau, 1)) \cdot u_{d} \geq \pi(\tau, 0) \cdot u_{p} + (1 - \pi(\tau, 1)) \cdot u_{d} \quad (7.29)
\]

It is easy to check that the solutions specified in (7.23) to (7.26) do not fulfill this constraint. Hence, the above-derived contract will not be optimal if assumption 7.2 is relaxed.

In the context of the Clean Development Mechanism as an instrument to provide foreign direct investment, it is important to analyze how the investment appraisal of the buyer is affected by the second-best contract. These effects are intuitively more accessible through reformulating the buyer’s expected utility as follows.

\[
V(u_{p}, u_{d}, \bar{u}_{p}, \bar{u}_{d}) = [\nu \cdot \pi(\tau, 1) + (1 - \nu) \cdot \pi(\tau, 0)] \cdot y - \alpha - \kappa(u_{p}, u_{d}, \bar{u}_{p}, \bar{u}_{d}) \quad (7.30)
\]

where \( \kappa \) are the buyer’s expected costs from the contract. As already mentioned, in the absence of information asymmetries, efficient risk-sharing would require full insurance of the seller. Hence, the first-best result would be \( \kappa^* = h(c) \), i.e. the seller is compensated for her costs of precaution. Comparing the first-best contract costs with the expected costs from the above-derived second-best solution, denoted as \( \kappa^{**} = \kappa(u_{p}^{**}, u_{d}^{**}, \bar{u}_{p}^{**}, \bar{u}_{d}^{**}) \), yields the following proposition.
Proposition 7.2 The buyer’s second-best expected costs from the contract \( \{ u_p^{**}, u_d^{**}, \bar{w}_p^{**}, \bar{w}_d^{**} \} \) are strictly larger than for the first-best, i.e. \( \kappa^{**} > \kappa^* \).

Proof:
Taking (7.23) to (7.26) into account, the buyer’s second-best expected costs from the contract are:

\[
\kappa^{**} = \nu \cdot \left[ \pi(\tau, 1) \cdot h(c + \frac{1 - \pi(\tau)}{\Delta \pi(\tau)} \cdot c) + (1 - \pi(\tau, 1)) \cdot h(c - \frac{\pi(\tau)}{\Delta \pi(\tau)} \cdot c) \right] \\
+ (1 - \nu) \cdot \left[ \pi(\overline{\tau}, 1) \cdot h(c + \frac{1 - \pi(\overline{\tau})}{\Delta \pi(\overline{\tau})} \cdot c) + (1 - \pi(\overline{\tau}, 1)) \cdot h(c - \frac{\pi(\overline{\tau})}{\Delta \pi(\overline{\tau})} \cdot c) \right]
\]

Given the concavity of the sellers’ utility function, Jensen’s inequality holds in its strict sense, hence for both risk-types the following is necessarily true:

\[
U(p, d) = \pi(\tau, e) \cdot h(u_p^{**}) + (1 - \pi(\tau, e)) \cdot h(u_d^{**}) > \pi(\tau, e) \cdot u_p^{**} + (1 - \pi(\tau, e)) \cdot u_d^{**} \quad (7.31)
\]

As both participation constraints are binding, the right hand side of inequality (7.31) equals to \( h(c) \), i.e. \( \kappa^* \). The expected value for any given \( \nu \) then yields \( \kappa^{**} > \kappa^* \). \( \square \)

Proposition 7.2 has important implications. Clearly, a rational buyer will only propose the above-derived second-best contract if the expected net gain from investing in the project is larger than the expected costs from the contract \( \kappa = \kappa^{**} \):

\[
[\nu \cdot \pi(\overline{\tau}, 1) + (1 - \nu) \cdot \pi(\tau, 1)] \cdot y - \alpha > \kappa \quad (7.32)
\]

Hence, proposition 7.2 implies that the existence of information asymmetries reduces the set of feasible contracts that induce a positive level of precaution. For higher values of the upfront investment \( \alpha \), investing in the project under the above-derived contract will not be profitable. As a consequence, the observed reluctance to make larger ex ante investments in CDM projects, which was addressed in section 4.4, might indeed be partly explained by information asymmetries.

In this context it is interesting to analyze the effects of limitations in contract damages. It is likely that constraining contract damages will not only have an influence on the enforceability of the contract, but also on the incentives with respect to precaution and the truthful revelation of risk exposure. In the following section we present a model with constrained contract damages, to which the above-derived second-best contract will be compared.
7. ERP As with Adverse Selection and Moral Hazard – A combined Model

7.3. A Model with constrained Contract Damages

The reason for which contract damages might be constrained have already been laid out in the preceding chapter.\(^3\) Clearly, contract damages are limited by the value of the seller’s seizable assets. In the economic theory of complete contracts, this provides the rationale for including the often-used ‘limited liability constraint’. There are, however, reasons for which the contract damages might even be restricted further, like the already-mentioned ‘penalty doctrine’ in case law countries or the equity considerations outlined in section 5.6.3. In the contractual framework presented in this chapter, such limitations on contract damages become relevant if they are strict enough to have an impact on the seller’s expected payoff. For example, if the restrictions on contract damages lead to a situation, where implementing the utility level \(u_p\) is no longer feasible, the theory of the second-best suggests that all other elements of the contract \(\{u^{**}_p, u^{**}_d\}\) might no longer be optimal either. Indeed, it will be shown below that—in the context of the information asymmetries considered here—constraining damages will distort all contractual transfers upwards.

In the following, we extend the above-presented contract framework by introducing two *constraints on the contractual damages*, such that the buyer needs to respect the following conditions:

\[
\bar{d} \geq l \text{ or } u_l \geq u(l) = u_l, \tag{7.33}
\]

and

\[
\bar{d} \geq l \text{ or } \bar{u}_d \geq u(l) = u_l, \tag{7.34}
\]

Hence, for both types of sellers, payoff and utility level cannot be lower than a specific value denoted with \(l\) and \(u_l\) respectively. In the following we assume \(u_l\) to be high enough that both participation constraints are no longer binding. In particular we make the following assumption.

**Assumption 7.3**

\[
u_l > c - \frac{\pi(\tau, 1)}{\Delta \pi(\tau)} \cdot c
\]

Hence, under these altered conditions, the optimal contract would have to fulfill the constraints (7.13) to (7.17) and (7.33) to (7.34). As before, we proceed by optimizing the objective function subject to a reduced amount of these constraints and check the others for slackness ex post. In particular we only take into account the adverse selection incentive constraint, both moral hazard incentive constraints, and the constraint on contract damages of the low-risk seller. This yields the following program \(P_2'\):

\(^3\)See section 6.3.
\[
\max \limits_{(u^p, u^d): (\pi_p, \pi_d)} (7.18), \text{subject to: (7.13), (7.14), (7.15), and (7.33)} \quad (P'_2)
\]

Denoting the Lagrangian with \( L \) and the multipliers of (7.13), (7.14), (7.15), and (7.33), with \( \lambda, \mu, \psi, \) and \( \xi \) respectively, the first-order conditions are:

\[
\begin{align*}
\frac{dL}{du^p} &= -\nu \cdot \frac{\pi(\tau, 1)}{u'(\underline{u}_p)} - \lambda \cdot \pi(\tau, 1) + \psi = 0 \\
\frac{dL}{du^d} &= -\nu \cdot \frac{1 - \pi(\tau, 1)}{u'(\underline{u}_d)} - \lambda \cdot (1 - \pi(\tau, 1)) - \psi + \xi = 0 \\
\frac{dL}{d\pi_p} &= -(1 - \nu) \cdot \frac{\pi(\tau, 1)}{u'(\underline{\pi}_p)} + \lambda \cdot \pi(\tau, 1) + \mu = 0 \\
\frac{dL}{d\pi_d} &= -(1 - \nu) \cdot \frac{1 - \pi(\tau, 1)}{u'(\underline{\pi}_d)} + \lambda \cdot (1 - \pi(\tau, 1)) - \mu = 0
\end{align*}
\]

Solving the first-order conditions for the Lagrange Multipliers yields the following:

\[
\begin{align*}
\mu &= (1 - \nu) \cdot \pi(\tau, 1) \cdot (1 - \pi(\tau, 1)) \cdot (h'(\pi_p) - h'(\pi_d)) \\
\lambda &= (1 - \nu) \cdot [(1 - \pi(\tau, 1)) \cdot h'(\pi_d) + \pi(\tau, 1) \cdot h'(\pi_p)] \\
\psi &= (1 - \nu) \cdot \pi(\tau, 1) \cdot [(\pi(\tau, 1) \cdot h'(\pi_p) + (1 - \pi(\tau, 1)) \cdot h'(\underline{u}_p)] + \nu \cdot \pi(\tau, 1) \cdot h'(\pi_p) \\
\xi &= (1 - \nu) \cdot [\pi(\tau, 1) \cdot h'(\underline{u}_p) + (1 - \pi(\tau, 1)) \cdot h'(\underline{u}_p)] \\
&\quad + \nu \cdot [(1 - \pi(\tau, 1)) \cdot h'(\underline{\pi}_d) + \pi(\tau, 1) \cdot h'(\pi_p)]
\end{align*}
\]

It is obvious that the Lagrange-multipliers \( \lambda, \psi, \) and \( \xi \) are positive. The corresponding constraints are hence binding. Furthermore, as \( h(\cdot) \) is increasing and convex, the multiplier \( \mu \) is also always larger than zero. Hence, as all constraints are binding the solution to the optimization program \( P'_2 \) is entirely determined by (7.13), (7.14), (7.15), and (7.33), each holding with equality. Given these equations the following utility levels can be derived.
As shown in the mathematical appendix, the constraints not considered within program $P_2'$ are all slack at this optimum. Hence, the optimal contract under constrained damages expressed in utility levels is indeed \( \{u^{***}_p, u^{***}_d, u^{***}_p, u^{***}_d\} \).

### 7.4. The Effects of Constraining Contract Damages

An analysis of the above-derived optimal contract allows for some very important insights. First of all, note that the binding adverse selection constraint fixes the relationship of transfers between the two risk types. Hence, contrary to the case with unlimited contract damages, the relative size of the contract payoffs is now unambiguously defined. If assumption 7.1 holds, the transfers within the contract are structured according to the following ascending order of utility levels:

\[
\begin{align*}

u^{***}_d &< u^{***}_p < u^{***}_d < u^{***}_p \\

\end{align*}
\]

Clearly, this structured order of payoffs is a consequence of the assumed necessity to separate risk-types. Just as in a standard screening contract, the amount of risk borne by the low-risk agent needs to be larger than for the high-risk type.

Furthermore, it is important to note that the contract defined by (7.39) to (7.42) could also be optimal if the adverse selection were assumed to be two-sided. In order to identify the situations for which this would be the case, it needs to be checked under which assumptions the low-risk seller’s adverse selection constraint is slack for \( \{u^{***}_p, u^{***}_d, u^{***}_p, u^{***}_d\} \). Substituting (7.39) to (7.42) in (7.29) yields after some simplification:

\[
\frac{\pi(\tau, 1) - \pi(\tau, 0)}{\Delta \pi(\tau)} \geq 0
\]

While the left-hand addend in this inequality is strictly larger than zero, the sign of the right-hand addend is ambiguous under the given assumptions. It is however obvious that a sufficient condition for (7.43) to hold with inequality is \( \pi(\tau, 1) - \pi(\tau, 0) \geq 0 \). Clearly, this is the case if the influence of precaution effort on the probability of project success is larger than the effect of difference in types. Hence, for those contractual setups where the moral hazard is the predominant problem, the contract derived in the previous section would remain second-best efficient even if the adverse selection were two-sided. In a
variety of potential CDM settings this might indeed be the case. For a CDM Forestry project, for example, it is plausible to assume that the precaution measures against forest fires have a larger influence on the project success than unobservable attributes of the seller. Thus, the contract determined by (7.39) to (7.42) would remain optimal even if assumption 7.2 is relaxed.

Further important insights can be gained from comparing the optimal contract under constrained damages with the contract derived in section 7.2. First, we examine the difference in utility levels for each type of seller induced by the two different contracts. Defining this wedge generally as \( \Delta u = u_p - u_d \), a comparison between contracts yields the following:

\[
\Delta u^{***} = \Delta u^{**} = \frac{c}{\Delta \pi(\tau)}, \quad \text{and} \quad \Delta u^{***} = \Delta u^{**} = \frac{c}{\Delta \pi(\tau)}
\] (7.44)

In other words, if contract damages are assumed to be constrained the relative risk borne by both risk-types remains unchanged. This comes to no surprise as in both situations the wedge between payoffs and the induced utility levels is determined by the two binding moral hazard incentive constraints. However, introducing limitations on contract damages leads to an increase in absolute levels of induced utility. This can be easily seen by comparing the utility levels defined by (7.39) to (7.42) with those defined by (7.23) to (7.26). Given assumption 7.3, it is straightforward that constraining contract damages unambiguously increases all induced utility levels in absolute terms.

As already mentioned, the contract under unconstrained damages does not provide full insurance, as the seller’s payoff in the bad state of the world is negative. The risk-sharing is hence not first-best optimal. This is due to the fact, that part of the risk must be attributed to the seller in order to incentivize a positive effort level. This contract, hence, represents the trade-off between incentives and risk-sharing as discussed in chapters 4 and 5. In principle, the same is true for the the contract under constrained damages. However, if the constraint on damages is strict enough, i.e. \( u_l \geq c \), then the seller’s utility will—in all states of the world—be strictly larger than her reservation utility. Hence, in this case the constraint on damages will entail that the ex post rent conceded to the seller will be positive even in the case of contract default. This is not unlikely to be the case under the provisions of the World Bank PCF contracts, as exposed in section 5.6.1. In those contracts, the seller does not have to pay contract damages in case a contingency realizes. Hence, if the upfront payment exceeds the project costs that were incurred till the occurrence of this eventuality, the seller’s payoff is positive.

Certainly, shifting all induced utility levels upwards implies also an increase in the expected utility of both types of sellers. Hence both participation constraints, which were binding under unconstrained damages, become slack if contract damages are constrained. As a consequence, in the latter case both seller types receive a positive non-productive
rent. The level of this *ex ante rent* \( r \) can be directly derived from the slackness conditions of the participation constraints.\(^4\) This ex ante rent \( r \) is for a low-risk seller:

\[
\mathcal{L} = u_l + \pi(\mathcal{L}, 1) \cdot \frac{c}{\Delta \pi(\mathcal{L})} - c = u_l - c + \pi(\mathcal{L}, 1) \cdot \Delta w^{***} \tag{7.45}
\]

For a high-risk seller the *ex ante rent* is:

\[
\mathcal{R} = u_l + \pi(\mathcal{R}, 1) \cdot \frac{c}{\Delta \pi(\mathcal{R})} - c = u_l - c + \pi(\mathcal{R}, 1) \cdot \Delta w^{***} \tag{7.46}
\]

It is obvious that under assumption 7.3, the *ex ante rents* for both sellers are positive. As these positive net expected utility levels result from the buyer’s need to overcome both problems of asymmetric information, they represent, in fact, *information rents* in the narrowest sense. Under assumption 7.1 the low-risk type’s rent is larger than the high-risk type’s, as a stronger incentive is required to ensure the provision of precaution measures by the former.

Note that a change in the permitted level of contract damages does not only have an impact on the payoff in case of project failure, but also influences the seller’s utility if the project succeeds. Consequently, the functional relationship between the rent \( r \) of both risk-types and \( u_l \) is linear with slope one. For the low-risk type’s rent \( \mathcal{L} \) the explanation of this one-to-one relationship is straightforward. On the one hand, the lowest possible utility level that can be induced in the case of non-delivery of certificates is fixed at \( u_l \). On the other hand, the wedge in utilities \( \Delta w^{***} \) for the low-risk seller is determined by the binding moral hazard incentive constraint. Changing \( u_l \) hence entails a shift by the same magnitude in \( w^{***} \). This is intuitively plausible. As the relative risk borne by the seller must remain the same in order to induce a positive effort level, the low-risk seller’s *ex ante rent* increases or decreases by exactly the same amount as the permitted contract damages. The information rent for the high-risk seller, is hence quite similar to the one under a simple moral hazard associated with limited liability of the agent.\(^5\)

The information rent for the high-risk type \( \mathcal{R} \) is, however, not exclusively determined by the moral hazard problem. While the wedge in the high-risk seller’s utility levels is the same as without constrained damages, the last addend in equation (7.46) does not depend on high-risk type’s relative risk \( \Delta \pi^{***} \). Instead, \( \mathcal{R} \) depends on the larger, corresponding wedge of the low-risk type, i.e. \( \Delta w^{***} \). There is hence an increase in information rent compared to a standard moral hazard case. This is due to the fact that the high-risk seller also needs to be incentivized to reveal her type truthfully. As a consequence, due to the buyer’s need to overcome adverse selection, the high-risk seller’s payoff in case of project failure, defined in equation (7.42), is distorted upwards. This, in turn, leads to a larger information rent for the high-risk type than under moral hazard alone.

\(^4\)See mathematical appendix.

\(^5\)See, for example, Laffont and Martimort (2002), p. 155ff.
Given that both types receive positive ex ante rents, which is not the case with unconstrained contract damages, the following proposition is straightforward.

**Proposition 7.3** With constrained contract damages, the buyer’s expected costs from the contract are strictly larger than with unbounded damages, or

\[
\kappa^{***} = \kappa(u_p^{***}, u_d^{***}, u_p^{***}, u_d^{***}) > \kappa^{**}
\]

Taking propositions 7.2 and 7.3 into account, we can now derive the most important result of this chapter. Obviously, the range of upfront payments \(\alpha\) for which condition (7.32) is satisfied is larger for \(\kappa^{**}\) than for \(\kappa^{***}\). Hence, given that the costs from the contract increase with the introduction of a constraint on damages, the set of contracts which provide startup financing and induce effort decreases. As a consequence, projects prone to large but manageable contingencies will be underprovided.

The above-derived result might help to explain the limited amount of commercial contracts within the CDM that provide upfront investments. It is not unlikely that in many cases already the lowest possible constraint on contract damages, which is the amount of the seller’s seizable assets, will lead to the above-described upward shift in contractual payoffs. Evidently, if the seller’s access to the market for capital is restricted this is often due to a low level of potential collaterals. As the average buyer would have to make the same considerations on investment risks as other financing institutions, he might shy away from a large amount of potentially profitable contracts. Yet, it is to emphasize that any restriction on contract damages which is stricter than a limited liability constraint, will further reduce the set of feasible contracts. Hence, if it can be anticipated that courts will not enforce higher levels of contract damages, ERPAs providing upfront finance under the CDM will remain rare. The same effect can be expected if commercial buyers are obliged to restrict contract damages due to fairness considerations.

### 7.5. Conclusions from the formal contract analyses

With the above-presented results we can conclude our formal considerations on CDM contracts. As it turns out, the intuition expressed in chapters 4 and 5 was confirmed through our formal analyses. Contract damages should optimally be chosen to account for incentives as well as risk-sharing. This is the case for both classes of incentive problems considered here: The problem of opportunistic breach, analyzed in the preceding chapter, as well as the combined moral hazard and adverse selection problem which was considered over the last few pages. As was argued in the first part of this thesis, primary market transactions within the CDM are particularly prone to these problems, because all incentive issues arising on the upper institutional levels are devolved to the individual contract.
The application of economic contract theory as provided here represents a novelty for the analysis of CDM contracts. Yet, the method itself does not need further justification, as contract theory has long found its way into introductory texts to microeconomics. It is however to be emphasized that microeconomic models on the level of generality as the ones presented here have their strengths as well as their limitations. The main advantage of this approach clearly lies in the analytical rigor in identifying and separating different countervailing effects that determine the second-best optimum achievable within a contractual relationship. Consequently, the optimal response to a situation that is adequately described by the model assumptions will in principle correspond to the model results. This feature of contract theoretic analyses renders these approaches particularly useful to make propositions on the general lines of an optimal policy. The level of generality preferred in these analyses does however have its drawbacks. Given that such contract models will typically identify qualitative relationships, a direct application to specific real-world situations is difficult. The main problem is that a calibration of these models would require quite a detailed set of available data. It is however in the very nature of asymmetric information that the relevant data are not disclosed. Furthermore, it is to recognize that real-world contracts often reach a level of complexity which is not adequately reflected by even the most sophisticated models. As a consequence, the results of economic contract theory should be mainly interpreted with respect to the relative strength of the identified effects, not their exact level.

Taking these reflections into account, the results derived above are of particular interest for the ongoing discussion on how CDM contracts should be designed in general. As it is unlikely that the devolution of incentive problems to the contract level will be corrected for in the near future, optimal responses to these problems within the contract will remain a major concern for the project parties. As laid out above, setting incentives is in fact particularly problematic if sellers are risk-averse, which can be plausibly assumed for the larger part of the market. As follows from our analysis made in chapter 6, optimal sharing of risks under incomplete contract enforcement is only possible when ‘punitive’ contract damages are allowed for the Resale Paradigm. For potential contract breaches under the Loss Paradigm we have shown in the current chapter that the existence of information asymmetries resulted in a reduction in insurance compared to the first-best case. In order to induce a positive level of precaution, some of the default risk is to be attributed to the seller. This, in turn, leads to the effect that even without constraining damages, the existence of information asymmetries leads to a reduction in feasible incentive-compatible CDM purchase agreements. For both of the considered paradigms of breach, a constraint on contract damages results in the concession of an unproductive ex ante rent to the seller, which further reduces the set of incentive-compatible contracts that provide project upfront financing.

These considerations lead to the—a priori counterintuitive—conclusion that a higher degree of the seller’s risk aversion should not be used as a reason for restricting contract damages. Our results hence provide a valuable contribution to the debate on the level
of damages within commercial Emission Reduction Purchase Agreements as presented in section 5.6, which does not take incentive effects explicitly into account. It is to note that this discourse is primarily lead by lawyers on the grounds of justice considerations. The results presented here emphasize that such contract provisions will also have an impact on economic efficiency. This is true for the level of the individual contract as well as the Clean Development Mechanism as a whole. If the current underprovision of upfront finance within the CDM is to be overcome, the stipulation of higher levels of contract damages should not be a priori excluded.
Conclusions and Outlook

Within the current international climate policy regime the Clean Development Mechanism represents the only instrument incentivizing greenhouse gas emission reductions in developing countries. In this respect the CDM remains, regardless of all its potential shortcomings, the 'only game in town'. A call for economic analyses of the Mechanism’s mode of operation, as the ones attempted here, is hence necessarily justified. We argued that the CDM is, just as any market-based environmental policy instrument, an artifact entirely created through regulation. The challenge in ensuring the smooth operation of such instruments lies in the definition and enforcement of property rights for greenhouse gas emissions and emission reductions. In particular, the certificates traded on the marketplace need to correspond to the underlying actual emission reductions in the physical world. The set of possible regulatory approaches for the CDM to ensure this is restricted through the superordinate climate policy institutions. As was argued in the first part of this thesis, the operationalization of the Mechanism is to a large extent determined by the Kyoto approach, which exempts developing countries from mandatory emission reduction targets. As the most stringent sanctions within the Kyoto regimes are dependent on the existence of such targets, the potential to effectively deter opportunistic behavior within individual CDM projects is at the inter-country level quite limited. As a consequence, the resulting incentive problems are to be dealt with at the lower institutional levels.

Within this thesis we have analyzed two classes of incentive problems that are devolved downwards within the institutional cascade. First, we have analyzed the problem of incomplete enforcement on truthful reporting of emission reductions. This problem is a result from the specificities of the Kyoto architecture, which require that baseline and actual emissions need to be determined solely on the level of the individual project. As neither the project parties nor the host country are a priori interested in truthful reporting, the CDM is associated with a complex admission and verification procedure. Yet, the established system of third-party verification has some potential for collusion. As a consequence, the CDM Executive Board needs to conduct spot-checks in order to reduce the incentive to overreport. The model presented in chapter 3 is to provide some intuition on how to optimally allocate the monitoring intensity over a range of CDM projects. We will discuss these results in light of some general considerations on the CDM verification cycle in the following section.

A second class of incentive problems was addressed in the second part of this thesis, which is dedicated to problems at the level of the individual contract. Again, we
argued that these problems are devolved from the upper institutional levels due to the implicit attribution of liability for the certificates to the primary market-buyer. The corresponding purchase agreements are hence subject to problems of incomplete contract enforcement as well as asymmetric information between seller and buyer. The results from our contractual considerations are further discussed in the last part of this conclusion.

The Effects of Control on the Market

One of the most important drawbacks of the current CDM framework is that the complex CDM control cycle, presented in section 2.3, engenders comparatively large transaction costs. First, the necessary procedures are associated with directly observable monetary costs to the project parties, like the share of proceeds for administration and the adaptation fund, or the fees paid to the verifiers. Second, the preparations for the different steps in this cycle and the associated time lags engender administrative costs and could bind a non-negligible part of corporate resources. An estimate in monetary terms of the overall transaction costs arising from the CDM-specific provisions is difficult. While several developers claimed that the observed scrutiny in the approval process led to a depreciation of their portfolios, actual estimates of these costs have not been published. Krey (2005) presents evidence for seven different projects implemented in the early stages of the CDM. The estimates for transaction costs for these projects range from 0.07 to 0.47 USD per tonne CO₂. Michaelowa and Jotzo (2005) report modeling results for overall transaction costs of the CDM, including trade. Their estimates range from 0.33 to 2.23 Euro per tonne CO₂. Both studies emphasize the role of economies of scale in terms of total amount of CERs generated over the crediting period. Correspondingly, larger projects are likely to incur a lower amount of transaction costs per tonne CO₂ offset.

The fact that smaller-scale projects are associated with higher transaction costs might, however, be undesirable given the secondary objective of the CDM. Small-scale projects—like decentralized electrification of rural areas based on solar energy—are likely to have lower negative impacts on the sustainable development of a region than large-scale projects involving heavy industry. Consequently, the Kyoto rules provide for simplified procedures for small-scale projects. Due to this relief in regulatory burden, small-scale projects play a significant role within the current project mix. According to Fenmann (2008b), 44 percent of all current CDM projects are small-scale. Recently, the CDM Executive Board has also approved procedures that allow the pooling of single activities.

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7 See UNFCCC (2005a), Decision 4, Annex II. The special case of small-scale afforestation and reforestation projects is subject to UNFCCC (2005d), Decision 6.
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under a ‘Programme of Activities (PoA)’, which is likely to lead to a further reduction in transaction costs for small-scale offsets.\footnote{See UNFCCC (2007d).}

The Need for Regulatory Rigor

Despite the above-mentioned efforts, transaction costs for CDM are likely to remain higher than those associated with the use of the other Flexible Mechanisms, i.e. Joint Implementation and Kyoto Emissions Trading.\footnote{Michaelowa and Jotzo (2005) use estimates of 0.20 to 0.75 Euro per tonne CO2 for Joint implementation and 0.10 Euro/t CO2e for Kyoto Emissions Trading.} This is an interesting insight, as it emphasizes that the transaction costs—i.e. the "costs of using the price mechanism" as Coase (1937) puts it—are asymmetrically distributed among the different Kyoto carbon markets. At first sight, this difference in costs might appear as an oddity, as the commodity traded on all three markets, i.e. carbon offsets, is supposed to be more or less homogeneous. However, the apparent paradox vanishes when taking into account that the Clean Development Mechanism is more vulnerable to opportunistic behavior, which is according to Williamson (1985) one of the most common reasons for the existence of transaction costs.

It is the Mechanism’s cycle of recurring controls—from project design up to the actual issuance of credits—that particularly burdens the CDM with transaction costs. The corresponding procedures are time-consuming and require a significant amount of resources on the part of the project participants, as well as the verifiers. As of June 2009, CERs have been issued for 511 projects. Additional 3906 projects are still in the earlier stages of the project cycle. A total of 1141 of these projects are successfully registered within the CDM, while further 211 projects are currently in the process of registration.\footnote{UNEP/Risoe (2009)} Hence, the largest part of the projects in the pipeline are still at the validation stage. Consequently, the timing and stringency of the different control processes within the project cycle have a significant influence on the supply of certificates on the CDM market. The current development indicates that the controlling institutions are likely to represent the most important bottleneck, restricting the CDM’s potential for cost-effective mitigation of climate change. As Fenham (2008a) reports, the number of newly submitted CDM projects has sharply increased from mid-2007 on, while the number of projects being registered each month remained stable. Consequently, the queue of projects currently under review and hence the time lag until registration has increased. Observers attribute this increase in processing time to a shortage in capacities within both major controlling institutions, the Designated Operational Entities, as well as the Executive Board.\footnote{See, for example, Fenham (2008a) and PointCarbon (2008).}

In the future, the average processing time of projects within the CDM cycle is likely to decrease. As the CDM market was only set up recently, the controlling bodies are
still in a ‘learning phase’. With the market becoming more mature, the Designated Operational Entities and the control panels of the Executive Board will develop further routine. For example, with a growing number of accepted baseline methodologies, the validation of projects based on similar preconditions will be less time consuming, as all actors become more experienced with respect to the assessment of the baseline. In the simplest case, a project could use an already existing baseline, which would considerably shorten its accreditation time. On the other hand, the number of projects will most probably increase further over the coming years. Yet, the regulatory institutions are likely to adapt their capacity to the increased demand for their services.\textsuperscript{12}

Yet, the need to reduce transaction costs should not result in a decrease in the level of regulatory control. As the Mechanism is particularly prone to opportunistic misreporting of reductions, controls by DOEs and the CDM Executive Board would rather have to increase in scrutiny not decrease. This is particularly important if the Clean Development Mechanism is to remain a politically accepted instrument to incentivize developing country reductions. This is particularly important in light of the fact that several project types accepted in the early years of the CDM have been severely criticized with respect to their actual additionality.

One example for an obvious problem of control is the manipulation of baselines for projects designed to reduce hydrofluorcarbons (HFCs) in China. As mentioned in section 2.1, this class of projects was one of the preferred categories in the early implementation stage of the Mechanism. As Wara (2008) reports, the gains from reductions within such projects were in fact higher than the gains from the actual production processes within which such emissions occurred. As a consequence, the implementation of such projects was extraordinarily lucrative. The baseline for these projects was calculated with respect to the respective plant’s HFC emissions in the years prior to the project implementation. This created the perverse incentive to expand HFC emissions in order to manipulate the baseline. As was argued within this thesis this represents a strategy for opportunistic overreporting. The CDM Executive Board reacted to this problem by banning HFC reductions projects involving new capacities or plants from the CDM.\textsuperscript{13}

Another example where the additionality of early-stage CDM projects can be reasonably doubted, are hydropower projects in China. As Haya (2007) reports, the submitted baselines for several of these projects would imply that the rate of increase in hydropower capacity would have suddenly dropped by 65 percent. This is not justifiable in the context of general assessments of the Chinese Electricity market.\textsuperscript{14} Furthermore, most of the respective hydropower plants were already under construction before the Project Design Document was submitted. This strongly hints to the fact that these plants would

\textsuperscript{12}PointCarbon (2008), for example, point out that the UNFCCC secretariat received greater resources to support the EB in 2007.
\textsuperscript{13}See CDM Executive Board (2005b).
\textsuperscript{14}See for example Sheng Zhou and Liu (2009).
also have been installed without the additional cash flow from CDM credit sales. Consequently, it is likely that the project developers simply wanted to exploit windfall gains through projects that are, in principle, not additional.

These examples from the early implementation stage of the Mechanism showcase the susceptibility of the CDM to opportunistic overreporting of emission offsets. As a reaction to the above-addressed issues, the CDM Executive Board has become more inclined to reject submitted projects in recent years. In case of such a rejection, all investments into the initial CDM registration procedure represent, in principle, sunk cost. An increase in the probability of rejection hence decreases the incentive to submit projects which are de facto non-additional. In this context it is to be asked whether these disincentives are sufficient to reduce the potential for overstating project baselines. This requires a systematic analysis of the different countervailing incentives. The model we presented in chapter 3 is meant as a first attempt to shed some light on the different effects that can be expected. In the following we shortly discuss the qualitative results of this model in the context of the above-depicted regulatory reality.

Interpretation of theoretical Considerations in Context of Regulatory Reality

The model presented in chapter 3 represents the first model we know of analyzing the optimal monitoring intensity in credit-based emissions trading schemes. Several interesting learnings can be drawn from the analytical results provided in this chapter. First, a complete deterrence of cheating in such schemes seems to be impossible, in particular if it is taken into account that the regulator’s monitoring budget is constrained. In the latter case, it is inefficient to monitor projects with the lowest degree of verifiability, at least if a large range of projects are admitted within such mechanisms. The specific monitoring strategy to be applied depends on the relationship between the penalty and the abatement costs of the different projects. In tendency, the monitoring intensity should be increasing in all segments of the verifiability continuum if the increase in the expected marginal penalty is stricter than in the marginal abatement costs. If the opposite is the case monitoring intensity should first increase with decreasing project verifiability, then decrease.

It is particularly interesting to discuss the model results in the context of the real-world implementation of the Clean Development Mechanism. For cases where overreporting is due to an overstatement of the baseline, like in the above-described examples, the penalty for the project developers will only consist of the sunk cost stemming from a failed project admission process. However, as the example of the Chinese HFC projects shows, the associated marginal abatement costs can, in principle, also be almost constant. In such a

\[15\] For an elaboration of this argument see Haya (2007).
\[16\] See, for example, PointCarbon (2008) and UNEP/Risoe (2009).
\[17\] It is, however, to note that the results stated in proposition 3.5 imply that the monitoring function is not necessarily continuous in this continuum.
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situation, our model results provides at least a rule of thumb with respect to applicable intensity in the regulator’s scrutiny for baseline admission: If the truthfulness of the baseline is more difficult to assess more resources should be allocated to its assessment. As our model results show, this strategy would not be optimal in the case of steep abatements costs. In this case and if project verifiability is low enough, the regulator’s resources would be better used for increasing scrutiny in projects that are easier to verify.

Yet, in light of the fact that the CDM was rightfully criticized with respect to the non-additionality of early-stage projects, our model results suggest the use of another instrument. In addition to monitoring through spot-checks, the CDM Executive Board should adjust the standards for project admission in order to prevent opportunistic behavior. As discussed in section 3.4.2, it would be wise to extend these standards by including minimum criteria with respect to the verifiability of baseline and project emissions. This would be of particular importance if the credibility of the CDM as an instrument for mitigation is at stake. A consequent application of this strategy would imply a general refusal of projects which are subject to severe information asymmetries with respect to their baseline methodology. It can be resonably argued that such a strategy would have effectively reduced the rate of admission for projects that have turned out to be non-additional. The same argument will hold if overreporting is due to an ex post understatement of actual project emissions. In this case it is likely that the most severe penalty applied is the exclusion of the project from the Mechanism. The penalty is hence capped by the expected future gains from the project. Again, the most effective strategy to deter overreporting would be to exclude project types for which cheating is unlikely to be discovered. The predominant policy implication of our theoretical considerations would hence be to include such criteria within the project admission guidelines.

Based on this recommendation, further insights can be gained by considering the role of the Designated Operational Entities, or DOEs. These companies act as third-party verifiers within the CDM control process. Given that these verifiers are being remunerated by the project parties, they were not explicitely modeled within chapter 3, as there is considerable potential for shirking and collusion. Yet, the level of verifiability of a project by the regulator crucially depends on the DOE’s effort when specifying the project’s validation and verification plan. Moreover, it is quite evident that a thorough audit also increases the probability of discovering potential overreporting. A reduction in the verifier’s incentive to shirk or collude would hence quite naturally increase the environmental effectiveness of the CDM. Recent developments on the market provided first anecdotal evidence with respect to the power of such disincentives. At the end of November 2008, the CDM Executive Board suspended the DOE accreditation of Det Norske Veritas (DNV), one of the market’s most active auditors. The cited official reasons included deficient internal audits, not assigning staff with the required compe-
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tences to evaluate projects, and a lack of transparency in auditing decisions.\textsuperscript{18} Due to the suspension, projects audited by DNV could no longer be submitted for registration. Furthermore, DNV was not allowed to monitor or verify project emissions. PointCarbon (2009) reported that the expected loss for projects supervised by DNV amounted to up to 7 Million CERs per month of suspension. Consequently, the loss in DNV’s cash flow could have been potentially quite severe. However, after having exercised several spot-checks on DNV-supervised projects, the Executive Board reinstated DNV as a DOE after little more than 2 months. Thus, as the company was allowed to informally continue the assessment of ongoing projects, the number of projects which experienced a delay was quite limited.\textsuperscript{19}

In an interpretation of the above-described events several conclusions can be drawn. As DNV’s shortfall in earnings due to the suspension can be expected to be rather small, the CDM Executive Board’s decision rather represents a ‘warning shot’ to the Mechanism’s verifiers than an actual punishment for opportunism. By this act, the regulator signalled that opportunistic behavior on the part of the DOE’s will not be tolerated in the future. In this context it is to note that the actual allegations against DNV implied a rather mild form of shirking, not the more severe intentional collusion. Hence, the Executive Board has send a signal to the market emphasizing that it will not hesitate to use its leverage over the DOE’s to enforce a certain minimum level of scrutiny in project auditing. It further turned out that this leverage is quite considerable, as a long-lasting or permanent exclusion from the verification market would entail considerable costs to the verifier in terms of earnings foregone. If these costs are perceived to be large enough the EB’s warning is likely to increase the verifiability of CDM projects in general. In the context of our formal considerations on project monitoring this would reduce the necessary spot-check intensity for the projects, as the verifiers are more likely to assume their assigned role as an information provider.\textsuperscript{20} Departing from these considerations a natural step for future research would be to include the actions of the verifier explicitly within the model. Furthermore, as most actual penalties are dependent on future income streams, the development of a dynamic model is to be considered which should also take differences in project abatement costs into account.

Yet, if the possibility of being excluded from the market provides the strongest incentive to the DOE’s to audit and report scrutinously the effectiveness of project supervision crucially depends on the future perspectives of the CDM. Obviously, the loss of future earnings to the verifiers will only be large if the project-based mechanisms can be expected to remain in place after the end of the first commitment period in 2012. Hence,

\textsuperscript{19}See DNV (2009).
\textsuperscript{20}As to project validation, there exists already some evidence hinting to the fact that DOE’s are willing to take over this regulatory function. At the time of writing, 29 projects were withdrawn due to unfavorable DOE reports. 437 projects were rejected by Designated Operational Entities. (See UNEP/Risoe (2009).)
the problem of incomplete enforcement provides another argument for fixing a longer time frame for the Clean Development Mechanism, which was a recurring theme in this thesis. However, contrary to the problem of reducing uncertainty in longer-term investments, the incomplete enforcement problem could be reduced through rather simple changes in the regulatory framework. The verifier’s incentive for colluding with the project parties could be easily dealt with by reorganizing the remuneration of the verifier. Instead of being paid by the project parties, the DOE’s should be remunerated by the regulator. The required additional finance could be provided by levying a fee at issuance of the CERs. We can hence conclude our considerations on project supervision with the—quite obvious—general statement that verifiers should be paid by the regulator not the regulated.

**Considerations on Upfront Financing and Contract Damages**

The considerations on the contract level presented in the second part of this thesis were primarily motivated by the observation that most CDM contracts fail to provide upfront financing. The predominant type of agreement on the primary CDM market is the purchase contract, whereas agreements on more integrated technological and organizational cooperation within the project are rare. In most cases, the entire contracted payment is only paid on delivery of the certificates. Under this contracting practice, however, it is unlikely that the full potential of the Mechanism to foster abatement and sustainable development in developing countries can be tapped. Without contractual upfront payments, the group of potential sellers with restricted access to the credit market will lack the necessary start-up financing to successfully implement a CDM project. It is also unlikely that sellers with a higher degree of risk-aversion will participate in the market, as the CDM does not only feature standard project-risks but is also associated with additional regulatory and political risks. As a consequence, small- and medium-scale actors within developing countries are likely to remain completely locked out of the CDM market. This might be especially problematic for the achievement of the secondary goal of the Clean Development Mechanism, which is fostering sustainable development.

As was shown within our formal considerations in chapters 6 and 7, one reason for the lack of upfront financing in contracts is the presence of problems of opportunistic behavior on the part of the seller. We argued that such situations are likely to occur within CDM contracts, due to the devolution of incentive problems from the upper institutional levels. In particular the limited contract enforcement in developing countries and the existence of information asymmetries render such Emission Reduction Purchase Agreements (ERPAs) particularly prone to an undesired expropriation of the buyer’s upfront investments. These problems can, in principle, be overcome by stipulating contract damages at levels high enough to incentivize contract performance and investments in precaution on the part of the seller. Yet, as the Law and Economics literature shows,
contract damages cannot be set such that ex post and ex ante efficiency is achieved at the same time. In our formal considerations, we hence focused on the trade-off between incentives and risk sharing.

This trade-off lies at the heart of an ongoing dispute on the levels of contract damages to be stipulated within CDM purchase contracts presented in section 5.6. Within this dispute opponents of higher levels of contract damages argue that the latter might be considered as being ‘unfair’ by small, risk averse sellers. Yet, our results show that a second-best efficient contract providing efficient risk sharing and incentives still requires high levels of contract damages. Furthermore, to prevent opportunistic breach the levels of contract damages would even have to be ‘punitive’ if overinsurance of the seller is to be avoided. In all cases, constraining damages leads to a reduction in contracts that provide upfront finance. This provides a plausible explanation for the observed buyer’s reluctance to concede frontloaded payments within such contracts, as contract damages are de facto capped by the seller’s collaterals. For the sake of the argumentation, the models we presented were kept simple. For future research, an extension to multiple periods and continuous choice parameters would be a natural step.

As to the institutional level, the learnings from our contractual considerations are straightforward. Just as with any other type of foreign direct investment, CDM investors will remain reluctant to provide upfront finance if contract enforcement in CDM host countries remains weak. Evidently, in this context, the general statement often expressed within development economics that ‘institutions matter’ is just as true. Our results obviously hint to the fact that CDM investments could be raised by increasing the probability of contract enforcement, e.g. through a reform in the judicial court system. Yet, further improvements can be achieved if the level of contract damages allowed within the host country’s contract law is rather large. Hence, a ‘penalty doctrine’ that a priori bans higher levels of contract damages is likely to constrain the amount of investments achievable within the CDM, while the efficiency of existing contracts might be considerably lowered.

Further Considerations on CDM Contracts

It is unlikely that contract parties would turn to a text on institutional economics, such as this thesis, for advice on how to set up a contract for a CDM project. In principle, this reflects that these people form their expectations quite rationally. Yet, some of our considerations might still be useful on sensible provisions within such contracts. Generally, parties of existing ERPAs are reluctant to reveal more detailed information on contract clauses. However, some organizations, like the International Emissions Trading Association in Geneva, have compiled standard contracts which can be used for reference when designing an ERPA.\textsuperscript{21} Furthermore, some public sector buyers have revealed

\textsuperscript{21}See IETA (2005).
features of their purchase agreements, like the World Bank’s Carbon Finance Unit or the Dutch government. We have presented some of these features in section 5.6.

However, it is unlikely that provisions from public sector contracts will be adopted within the private sector without modification. For example, the above-presented World Bank’s contracts feature a large amount of performance excuses which attribute de facto almost all project-related and regulatory risks to the buyer. This is a result from the World Bank’s mandate to foster the development of the host country as well as reducing market barriers within the carbon market. It is unlikely that private sector parties are willing to contribute as generously to these public goods. The risk sharing within the ERPAs of the Dutch ERUPT/CERUPT scheme seems to be more in line with private sector interests, because performance excuses are apparently restricted to events that are not controlled by the seller. In case of under- or non-performance the different ERUPT/CERUPT contracts include a contract penalty which—in line with our findings—might help to reduce problems of opportunism. Interestingly, the penalties do not lead to inefficient breach or inefficiently high precaution as the seller has the option to provide alternative credits. The overcompensation within these contracts is hence optional. Such a provision might be interesting for private sector contracts as well. In order to reduce the risk of opportunistic contract breach, the ERP could provide for overcompensating contract damages, at least those for those situations which come under the Resale Paradigm.

For breach under the Loss Paradigm, contract damages and price would have to be chosen in a combination which takes the trade-off between incentives and risk-sharing into account. This is particularly important in light of the fact that within the CDM, the seller can be reasonably assumed to reflect a higher degree of risk-aversion. A first heuristic to take this trade-off into account could be based on the principle of the superior risk bearer, proposed by Posner and Rosenfield (1977). While this principle has been formulated in the context of tort law, it can also be adapted to contract situations. A contract design according to this principle requires to attribute a specific risk to the contract party which incurs lower cost to either control or mitigate this risk. An application of this principle within real-world contracting would involve, in a first step, the identification of those contingencies that cannot be influenced by the seller. For these contingencies the buyer can provide higher levels of insurance, without risking problems associated with information asymmetries. If the difference in risk preferences is large enough, the least-cost contract would include clauses specifying performance excuses in case these contingencies realize. In a second step, a provision would have to be added to the contract for all other contingencies, i.e. those risks which can be influenced by the seller. As for these risks the contract is prone to moral hazard, contract damages need to be specified. The exact level of these contract damages would be subject to
individual negotiations.\footnote{For a detailed description of this procedural approach to the principle of the cheapest cost avoider in tort law, see Schäfer and Ott (2000).} If the situation is close enough to our model assumptions, the result of these negotiations would then reflect—but only in principle—the second-best optimum presented in chapter 7. Hence, just as with any microeconomic model, the formal considerations presented in this thesis are not meant to be a one-to-one reflection of reality, but are to identify the general effects that will occur in one form or the other in situations for which the model assumptions hold.

### Final Remarks–On the Future of the CDM

The Clean Development Mechanism, just as the Kyoto approach as a whole, is by far not flawless and probably quite far away from being theoretically first-best optimal. As a consequence, the CDM came justifiably under criticism. A first point at issue is the above-described obvious non-additionality of first-mover projects.\footnote{See for example Wara (2007) for an overview on these issues.} This apparent regulatory failure gave rise for calls to abolish the CDM as a whole. In light of our considerations on incomplete enforcement, it is quite evident that the CDM’s effectiveness crucially depends on its capacity to induce actual emission reductions in developing countries. Indeed, if CDM certificates generally failed to reflect real-world reductions the underlying carbon-offset-approach would have to be declared a failure and should be abandoned. There is however no indication that this is currently the case. Given the increased scrutiny in project admission, it seems that the respective regulative bodies have adjusted their approach in dealing with large scale opportunistic behavior. The analytical considerations presented in this thesis are meant to assist the reader to systematically understand the forces at work within the additionality issue, which represents in fact a problem of incomplete enforcement. Yet, incomplete enforcement is not equivalent to a complete absence of enforcement. While the latter would indeed result in bogus certificates, the former will always guarantee a certain level of actual emission reductions if the regulations are stringent enough. The average ‘quality’ of CDM certificates—i.e. to what extent CERs represent actual offsets—is hence dependent on the chosen trade-off between regulatory control and corresponding transaction costs for the carbon market. For the sake of the CDM’s environmental effectiveness as well as its political acceptability, it is probably desirable to have a high level of control, even if this entails larger costs to the market and hence lower incentives to invest in such projects.

A second point at issue is the fact that Annex I-countries can purchase lower cost CDM certificates instead of implementing more stringent domestic, but more expensive, policies. As a consequence, it is often argued that the CDM prevents the Annex I-countries from setting more stringent incentives for the development of low-carbon tech-
While this argument is appealing at first sight, it fails when tested for logical stringency. In fact, the only reason for which the negotiators opted for the inclusion of the Flexible Mechanisms in the first place was that market-based instruments allow for a more cost-effective mitigation of climate change. To the economist, an increase in cost-effectiveness is particularly appealing, as this implies that the respective policy is closer to the \textit{static} social optimum. Yet, the above-presented criticism is formulated in terms of incentives to develop low-carbon technologies being employed in the \textit{future}. The argument seems hence to use a \textit{dynamic} optimum as a point of reference. This implies that the argument, in its sense as a criticism against the use of CDM certificates, is not valid. To see this, note that the current Kyoto approach could, in principle, be adjusted quite easily to achieve \textit{any} level of investment incentives. Given that within an emissions trading scheme the incentive to invest in abatement is determined by the carbon price, an appropriate increase in the scarcity of certificates will necessarily lead to the desired level in investment. Hence, if a higher level in low-carbon investments is striven for it suffices to set stricter targets for Annex I-countries. If instead the Flexible Mechanisms are abolished, the same level of investment incentives might be achieved, but static efficiency would be lower, i.e. one would achieve the same result at higher cost.

The above-made considerations also give support to the view that a complete abandonment of the carbon offset approach, featured in the project-based Kyoto Mechanisms, is rather unlikely. An abolishment of these Mechanisms would mean that the Annex I-countries’ costs from the agreement would increase. For example, Switzerland’s decision to extensively use this approach for meeting its current target can be interpreted as a result of considerations on cost effectiveness.\footnote{See SAEFL (2005).} It can hence be reasonably assumed that the political acceptability of the current Annex I-country targets was fostered by the inclusion of the Flexible Mechanisms. In this view, the existing climate policy framework represents the result of a political inter-country compromise, of which the CDM is an integral part. In a reverse conclusion, any measure that increases the parties’ cost would lead to a lower level of politically feasible reduction commitments. An abolishment of the carbon offset approach would hence lead, at least in tendency, to lower reduction commitments in the future. This, in turn, is surely not intended by the proponents of such an abandonment.

Given the current level of publicly available information, any prognosis on the exact design of a post-2012 regime is within the realm of pure speculation. Clearly, stringent reduction commitments by the industrialized countries and the inclusion of large emerging economies in general, and China in particular, would be preferable. In this context, an extension of the CDM to the sectoral and programmatic scale might represent an intermediate step if more stringent solutions turn out to be politically unfeasible. Yet, it is

\footnote{For an elaboration of this argument see for example WWF (2007).}
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to be clearly stated that given the large information asymmetries associated with project by project assessment, mandatory targets at a global scale are by far more preferrable. However, the author of these lines does not consider himself qualified to give any further prediction of the future climate policy framework. Yet, from the considerations presented with this thesis, two important points can be stated. First, the implementation of the current climate policy regime took more than 10 years until the framework was fully operational. This needs to be kept in mind when calling for a completely different approach, as the time lags for finding an international consensus are apparently considerable. Second, investment incentives as well as enforcement of current regulations crucially depend on the continuation of the approach chosen at present. This holds for the Kyoto framework in general as well as the Clean Development Mechanism in specific. Hence, considerations on future climate policy should always take into account the rules which are already in place and consider all effects of institutional changes. Within this thesis we hence opted to analyse the incentive effects of institutions which are already in place. While this approach admittedly lacks in ambition it has the advantage to reflect reality quite closely.
A. Mathematical Appendix

A.1. Appendix to Chapter 3

Sufficient conditions for (3.4) and (3.5) denoting a minimum:

\[
\frac{\partial^2 C}{\partial e^2} = c''(e) + \alpha \beta \theta''(z - e) > 0 \\
\frac{\partial^2 C}{\partial z^2} = \alpha \beta \theta''(z - e) > 0 \\
\frac{\partial^2 C}{\partial e^2} \frac{\partial^2 C}{\partial z^2} - \left(\frac{\partial^2 C}{\partial e \partial z}\right)^2 = \alpha \beta c''(e)\theta''(z - e) \geq 0
\]

\[\Rightarrow \text{Solution for the first order conditions (3.4) and (3.5) denote a minimum.}\]

Proof of Proposition 3.1:

Note that \( e^0 \) is, by definition, strictly positive. For \( \alpha \beta = 0 \), Equation (3.3) becomes \( c(e) - pz \) which is evidently minimized by \( e^0 = \bar{e} \) and \( z^0 = \bar{z} \), that is we are in region (a).

For the rest of this proof it is supposed that \( \alpha \beta > 0 \). From equation (3.5) follows that the report \( z^0 \) only represents an interior solution if and only if \( \alpha \beta \theta'(0) < p(1 - \alpha \beta) < \alpha \beta \theta'(\bar{e} - e^0) \).

When \( p(1 - \alpha \beta) \geq \alpha \beta \theta'(0) \) the corner solution is \( z^0 = e^0 \), the firm’s report is honest. Under these conditions, it follows from (3.4) that \( e^0 = e^* \). We are, thus in region (d).

When \( \alpha \beta \theta'(\bar{e} - e^0) \geq p(1 - \alpha \beta) \) the firm reports the maximum believable emissions reduction, i.e. \( z^0 = \bar{z} \). The firm thus chooses \( e^0 \) satisfying (3.4) for \( z^0 = \bar{z} \), i.e. \( e^0 \) satisfies (3.6). This pair, \( z^0 = \bar{z} \) and \( e^0 \) satisfying (3.6), is indeed a candidate for maximization if and only if \( \alpha \beta \theta'(\bar{e} - e^0) \geq p(1 - \alpha \beta) \) for the proposed \( e^0 \). Given (3.6) the previous inequality is equivalent to \( p \geq c'(\bar{e} - e^0) \), i.e. \( e^0 \geq e^* \). Thus, we are in region (b). When both, emission reductions and report are interior, then adding (3.4) and (3.5) this leads to \( p = c'(\bar{e} - e^0) \), i.e. \( e^0 = e^* \). The optimal report \( z^0 \) in this region is given by (3.5) for \( e^0 = e^* \), thus it is given by equation (3.7). \( \square \)

Proof of Proposition 3.3:

For \( \beta \to 0 \), \( \frac{d}{dx} \), given by equation (3.15), approaches 0 as well, as \( e'(\alpha \beta) \) is never infinitely large for \( e \in [\underline{e}, \bar{e}] \). Hence, according to condition (3.14), for \( \beta_1 < \beta_2 \) and \( \beta_1 \) small enough, a decrease in \( \alpha_1 \) is always efficient as long as \( \alpha_1 > 0 \). Furthermore, it is easy to check that for \( \alpha = 0 \) the function \( e'(\alpha) \) is increasing in \( \beta \). Hence, it follows from condition (3.14) that all projects with \( \beta > \beta_1(B) \) are monitored with positive probability. \( \square \)
A. Mathematical Appendix

Proof of Proposition 3.4

In order to prove proposition 3.4 we first state and prove the following two Lemmas.

Lemma A.1:

For any pair of projects with $\beta_1$ and $\beta_2$ for which the probability of discovery is $\alpha_i \beta_i \in [\frac{p}{p+\theta(x-e^*)}; \frac{p}{p+\theta(0)}]$, optimal monitoring requires:

$$\frac{\partial x_1}{\partial \alpha_1} = \frac{\partial x_2}{\partial \alpha_2}$$

(A.1)

Proof of Lemma A.1

Lemma A.1 follows directly from the efficiency condition (3.14). For any two firms with verifiability $\beta_1$ and $\beta_2$ monitored with $\alpha_1$ and $\alpha_2$, condition (3.14) requires that at the optimum a decrease in $\alpha_1$ in order to increase $\alpha_2$ would lead to

$$f(\beta_1)\delta \left[ -\frac{\partial x_1}{\partial \alpha_1} + \frac{\partial x_2}{\partial \alpha_2} \right] \leq 0,$$

where $x_i = z_i - e_i$ (A.2)

As for any pair of projects with $\alpha_i \beta_i \in [0; \frac{p}{p+\theta(0)}]$ the two projects can be alternatingly defined as project 1 and 2, condition (A.2) only holds if $\frac{\partial x_1}{\partial \alpha_1} = \frac{\partial x_2}{\partial \alpha_2}$. □

Next we show that Assumption 3.1 guarantees that $-z'(\alpha)$ and $e'(\alpha)$ are decreasing in $\alpha$. The curvature of function $z(\alpha)$ for any given $\beta$ is given by:

$$-z''(\alpha) = \frac{-2q_e(x)q'_e(x) + q''(x)q'_e^2}{\alpha^2q'_e(x)^2}$$

Hence, $-z''(\alpha) < 0$ iff:

$$q''(x) - 2 \cdot \frac{q'(x)^2}{q(x)} < 0, \text{ with } x \in [0, (\overline{\tau} - e^*)]$$

(A.3)

$$e''(\alpha) = \frac{-2q_e q'_e - \frac{q''(\alpha)(-\alpha q''(\alpha))}{q'(\alpha) + \alpha q''(\alpha)}}{\left(\frac{\alpha q''(\alpha)}{q'(\alpha)} + \alpha q''(\alpha) \right)^2}, \text{ with } x \in [0, (\overline{\tau} - e), (\overline{\tau} - e^*)]$$

Hence, $e''(\alpha) < 0$ iff:

$$q''(x) - 2 \cdot \frac{q'(x)^2}{q(x)} < 2\rho(x)e''(\overline{\tau} - x) + e''(\overline{\tau} - x)$$

(A.4)

Assumption 3.1 is, thus, a sufficient condition for $e'(\alpha)$ and $-z'(\alpha)$ to be decreasing in $\alpha$. Hence, the following Lemma A.2 is straightforward.
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Lemma A.2:

Under Assumption 3.1 the following holds for any \( \beta_0 \in ]0,1] \) monitored with probability \( \alpha_0 \in ]0,1] \)

\[
e'(\alpha_0) = \beta_0 \cdot e'(\alpha_0 \beta_0) < \beta_0 \cdot e'(0), \text{ for } \alpha \beta \in ]0, \frac{p}{p + \theta'(\bar{v} - e^*)} [ \quad (A.5)
\]

Based on Lemmas A.1 and A.2 we can now proceed with the proof of Proposition 3.4.

Proof of Proposition 3.4(i)

Consider a project 1 with \( \beta_1 = 1 \). In order to incentivize \( z < \bar{v} \) for this project, the regulator must set \( \alpha_1 > \hat{\alpha}(1) \). As, under assumption 3.1, \( -z'(\alpha) \) is strictly decreasing in \( \alpha \), the corresponding level of \( -z'(\alpha) \) for \( \beta_1 = 1 \) must fulfill

\[
-z'(\alpha_1) < -z'(\hat{\alpha}(1)) = \frac{(p + \theta'(\bar{v} - e^*))^2}{p\theta''(\bar{v} - e^*)} \quad (A.6)
\]

If the monitoring Budget is large enough, such that optimal monitoring requires \( \alpha_1 \) for \( \beta_1 = 1 \) then it follows from condition (3.14) and Lemma A.2, that \( -z'(\alpha_1) > \beta(B) \cdot e'(0) \).

Substituting this result into A.6 yields:

\[
\beta(B) \frac{p + \theta'(\bar{v} - e^*)}{e''(\bar{v})} < \frac{(p + \theta'(\bar{v} - e^*))^2}{p\theta''(\bar{v} - e^*)}
\]

This expression is equivalent to (3.17). Hence, if condition (3.17) holds, there exists at least one project, namely \( \beta = 1 \), for which \( z < \bar{v} \).

Furthermore, if (3.17) holds, it follows from Lemma A.1 and the fact that \( z'(\alpha) = \beta \cdot z'(\alpha \beta) \) is decreasing in \( \alpha \) and continuous in \( \alpha \beta \) that there exists a \( \beta_m(B) < \beta_1 \), such that

\[
-z'(\alpha_1) = \beta_m(B) \cdot z'(\alpha_m \beta_m) = \beta_m \cdot z'(\frac{p}{p + \theta'(\bar{v} - e^*)}) \quad (A.7)
\]

For any \( \beta_0 > \beta_m \), monitored with its optimal probability \( \alpha_0 \), the respective slope of the report function is \( z'(\alpha_0) = \beta_0 \cdot z'(\alpha_0 \beta_0) \). As \( \beta_0 > \beta_m \), Lemma A.1 implies that \( z'(\alpha_0 \beta_0) < z'(\alpha_m \beta_m) \) which is equivalent to:

\[
\frac{\alpha_0 \beta_0}{\alpha_m \beta_m} > \frac{p(\alpha_0 \beta_0) - e^*)}{p(\bar{v} - e^*)} \quad (A.8)
\]

Under Assumption 3.1 this condition only holds if \( \alpha_0 \beta_0 > \alpha_m \beta_m = \frac{p}{p + \theta'(\bar{v} - e^*)} \). Hence, all projects larger than \( \beta_m \) will be incentivized to a report \( z_0 \) which is strictly lower than \( \bar{v} \).
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An increase in $B$ is equivalent to an increase of the overall sum of available $\alpha$. As under Assumption 3.1 $\frac{\partial e}{\partial \alpha}$ and $-\frac{\partial z}{\partial \alpha}$ are strictly decreasing in $\alpha$, an increase in $B$ will equally decrease both sides of A.1 for any $\beta$ monitored with positive $\alpha$. If $\beta_m$ exists after the increase in $B$—which is proven below—the associated slope $-z'(\alpha)$ at $\beta_m$ is defined as the right hand side of (A.7). Hence, in order to fulfill (A.1), $\beta_m$ must decrease with an increase in $B$. It is straightforward that the same applies for $\beta_l$ for those cases where $\beta_m$ does not exist. □

Proof of Proposition 3.4(ii)

The proof is very similiar to the proof of proposition 3.4(i). For $\beta = 1$ $z = 0$ if $\alpha \geq \bar{\alpha}(1)$. Applying Lemmas A.1 and A.2 one can show that $\bar{\alpha}(1)$ is only chosen if:

$$\beta_l(B) \frac{p + \theta'(\bar{e} - e)}{c''(\bar{e})} < \frac{(p + \theta'(0))^2}{p\theta''(0)}$$

This expression is equivalent to (3.18). Hence, if condition (3.18) holds, there exists at least one project, namely $\beta = 1$, for which $z = e$. The rest of the proof is analogous to the proof of proposition 4.4 (i) and therefore omitted here. □

Proof of Proposition 3.4(iii)

For all changes where $\beta_l(B)$ weakly decreases with $B$, the proof is trivial as condition (3.17) (condition (3.18)) will necessarily be fulfilled. The only reason for which $\beta_l(B)$ decreases with $B$ is that the thusly available units of $\alpha$ can be used to increase auditing pressure in the interval $[\beta_m; 1]$, hence $\beta_m$ must exist. As $-\frac{dz}{d\alpha}$ is decreasing and continuous in $\alpha$, the same argument applies to $\beta_l$. □

Proof of Proposition 3.5(i)

The result is straightforward, as

$$\lim_{\beta_0 \to \beta_m} \beta_0 \frac{p + \theta'(\bar{e} - e(\alpha_0\beta_0))}{c''(e(\alpha_0\beta_0)) + \alpha_0\beta_0\theta''(\bar{e} - e(\alpha_0\beta_0))} = \beta_m \frac{p + \theta'(\bar{e} - e^*)}{c''(e^*) + \alpha_0\beta_m\theta''(\bar{e} - e^*)}$$

(A.9)

will only fulfill A.1 if $\alpha_0 < \alpha_m$. □

Proof of Proposition 3.5(ii)

Proposition 3.5(ii) is proven by contradiction. Assume that under condition (3.19) a project with $\beta_0 < \beta_m(B)$ is monitored with positive probability. Then Lemmas A.1 and A.2 require
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\[
\beta_m(B) \cdot \frac{(p + \theta'(\bar{e} - e^*))^2}{p\theta''(\bar{e} - e^*)} < \beta_0 \cdot \frac{p + \theta'(\bar{e} - e^*)}{\theta''(\bar{e})}
\]  
(A.10)

As \( \beta_0 < \beta_m(B) \), (A.10) would only be true, if (3.19) were false. □

Proof of Proposition 3.5(iii)

For any two projects with \( \beta_1 \) and \( \beta_2 \), with \( \beta_i \geq \beta_m(B) \), Lemma A.1 implies for \( \beta_1 < \beta_2 \):

\[
\frac{\alpha_2\beta_2}{\alpha_1\beta_1} > \frac{\rho(z(\alpha_2\beta_2) - e^*)}{\rho(z(\alpha_1\beta_1) - e^*)}
\]

Given Assumption 3.1, this inequation is only true if \( \alpha_1 > \alpha_2 \), which proves proposition 3.5(ii). □

Proof of Proposition 3.5(iv)

If \( \frac{\partial e}{\partial \alpha} \) strictly increases (strictly decreases) in \( \beta \) then it follows from Lemma A.1 and (3.15) that \( \alpha(\beta_1) \) is lower than (greater than) \( \alpha(\beta_2) \) for any \( \beta_1 < \beta_2 < \beta_m \).

Given (3.15) the following holds:

\[
\frac{d^2e(\alpha)}{d\alpha d\beta} = e'(\alpha \beta) + \alpha \beta \theta''(\alpha \beta) \leq 0
\]  
(A.11)

if

\[
e''(\alpha \beta)^2 - (\alpha \beta)^2 \cdot \theta''(\bar{e} - e(\alpha \beta))^2 \leq \alpha \beta(p + \theta' (\bar{e} - e(\alpha \beta))) \cdot (e''(\alpha \beta)) - \theta''(\bar{e} - e(\alpha \beta)))
\]  
(A.12)

If \( c(\cdot) \) and \( \theta(\cdot) \) are quadratic functions, the right hand side of (A.12) is zero. The rest of the proof for 3.5(iv)(a) is straightforward. It remains to prove 3.5(iv)(b). It follows from proposition 3.5(iii) that the largest \( \alpha(\beta) \) within the interval \([\beta_m; 1]\) is \( \alpha(\beta_m) \). From Lemma A.1 follows that for any monitored \( \beta_0 \) in the interval \([0; \beta_m]\) the following holds:

\[
\beta_m \cdot z\left(\frac{p}{p + \theta'(\bar{e} - e^*)}\right) = \beta_0 \cdot \frac{p + \theta'(\bar{e} - e(\alpha_0\beta_0))}{\theta''(e(\alpha_0\beta_0)) + \alpha_0\beta_0 \theta''(\bar{e} - e(\alpha_0\beta_0))}
\]  
(A.13)

For \( c''(e) \) close to zero and under Assumption 3.1 this equation will only hold if \( \alpha_0 > \alpha_m \). □
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A.2. Appendix to Chapter 7

Proof of Proposition 7.1 a)

From (7.24) and (7.26) follows:

\[ u^* < u^* \text{ if } \frac{\pi_1}{\pi_1} > \frac{\Delta(\pi)}{\Delta(\pi)} \iff \pi_1 \Delta(\pi) > \pi_1 \Delta(\pi) \] (A.14)

Under assumption 7.1, this condition is always true. □

Proof of Proposition 7.1 b)

From (7.23) and (7.25) follows:

\[ u^* \geq u^*, \text{ iff } (1 - \pi_1)\pi_0 - (1 - \pi_1)\pi_0 \geq \pi_1 - \pi_1 \] (A.15)

Rearranging of terms yields proposition 7.1 b). □

Check of constraint on damages for the high-risk seller for Program P₂'

The constraint is slack at the optimum, as the following is obviously always true:

\[ u_l < u^{***} = u_l + \pi(\tau,1) \cdot c \left( \frac{1}{\Delta\pi(\tau)} - \frac{1}{\Delta\pi(\tau)} \right) \] (A.16)

Check of Participation constraints for Program P₂'

Substitution of (7.41) and (7.42) into (7.17) yields after simplification

\[ u_l + \pi(\tau,1) \cdot c - c > 0 \] (A.17)

As under assumption 7.3 this is always true, the participation of the high-risk buyer is slack at the optimum.

Substitution of (7.39) and (7.40) into (7.16) yields after simplification

\[ u_l + \pi(\tau,1) \cdot c - c > 0 \] (A.18)

As under assumption 7.3 this is always true, the participation of the low-risk buyer is slack at the optimum.
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