Evolution of the international regulatory regime and “ecosystem” of international carbon market mechanisms since the late 1990s

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Abstract

A structured review of the existing literature on changes in international market mechanisms for greenhouse gas (GHG) emissions reductions and related regulatory systems is undertaken, including over 300 peer-reviewed articles and 40 articles from “grey literature” coming from highly-reputed sources. The key objective is to distil the key lessons for the design of the market mechanisms under the Paris Agreement. A key aspect of the review is the identification of distinct periods with specific challenges faced by markets and regulatory systems. The first period from 1997 until 2005 is characterized by the introduction of market mechanisms as a climate change mitigation tool. The operationalization of market mechanisms required the establishment of officially approved baseline and monitoring methodologies and piloting activities in different sectors. The nascent carbon market was characterized by the lack of demand from the private sector making the initial participation of the public sector crucial. Between 2005 and 2011, the carbon markets entered a phase characterized by great expansion. This period saw significant changes in markets and regulatory frameworks as the EU ETS became operational and was linked to the Kyoto mechanisms. This link created a large source of demand for carbon credits from the private sector adding to the demand from governments, e.g. in Japan. During this “gold rush” period criticism emerged with regards to the uneven distribution of projects and limited participation of poorer countries, as well as issues related to baselines and additionality that affected environmental integrity. The next period is characterized by a sudden fall in carbon prices between 2011 and 2013 and the resulting decline in the development of new carbon projects. This market crisis is due to changes in both domestic and international regulatory regimes. At the domestic level, the issuance of carbon credits started reaching the quantitative limits on the use of offsets in the EU ETS effectively eliminating the largest source of demand. At the international level, the failure of the Copenhagen conference and uncertainty surrounding the second Kyoto Commitment Period resulted in a drying up of demand from governments. The post-Paris period is characterized by significant changes in the international climate regime. Unlike the Kyoto Protocol the Paris Agreement adopted in 2015 involves global participation in mitigation, which will increase complexity. New market mechanisms will therefore face both old challenges – supply-demand balance, environmental integrity, transaction costs – and new ones – interactions with other policies and national targets, sectoral and policy baselines, enhancing the sustainable development contribution, etc.

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1. Introduction

1.1. Objective

The overarching objective of this article is to conduct a structured literature review of the existing research and the evidence on changes in international market mechanisms and related regulatory systems for climate change mitigation. The assessment period from 1997 to 2016 starts with the signing of the Kyoto Protocol and ends with the entry into force of the Paris Agreement. In order to ensure high quality of the results, the literature review follows approaches normally used by the IPCC. Peer-reviewed literature therefore is the backbone while non-peer-reviewed sources have only been used if they are published by an institution that has credible internal quality control process.

1.2. Search methodology

Academic literature search was conducted using the HEC Paris Library[1] search engine that covers an array of databases, including among others (databases with more than 100 initial search results are listed here):

- Academic OneFile
- Academic Search Index
- BASE
- Business Insights: Essentials
- Business Source Complete
- Complementary Index
- Expanded Academic ASAP
- General OneFile
- General Reference Center Gold
- GreenFILE
- InfoTrac Newsstand
- Regional Business News
- ScienceDirect

The following search terms were applied:

("carbon price" OR CDM OR "market mechanism" OR "carbon finance" OR "carbon credit" OR "Carbon Fund" OR "Clean Development Mechanism" OR "Joint Implementation" OR "regulatory regime" OR "Article 6" OR "Kyoto Mechanism" OR "baseline methodology" OR "additionality" OR "compliance market" OR "voluntary market" OR "Paris Agreement") AND ("carbon")

The following additional criteria were applied:

- Year of publication: 1997-2018
- Source type: academic journals

[1] http://www.hec.edu/Library/

- Publication type: peer-reviewed
- Language: English

1.3. Search results

The initial search yielded 5353 results. After removing duplicates, we have screened the titles of publications and removed those that were deemed irrelevant to the topic of the review. Out of the remaining 1148 papers we then excluded theoretical papers on emissions trading further narrowing the number of peer-reviewed papers to 792. Journals with more than 5 articles that were retained are listed in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Since grey literature was excluded from the initial search, a number of key seminal papers and review articles were identified by recognized experts in the field after the general literature search. This was particularly important for literature on market mechanisms under the Paris Agreement due to the relatively recent emergence of the topic and lack of relevant academic literature that has passed the lengthy peer review process. The list of 19 seminal papers that were added using expert judgement is presented in **Fehler! Verweisquelle konnte nicht gefunden werden.**. The total number of articles thus increased to 811.

1.4. Synthesizing of results

As a next step, we scanned through the abstracts of the retained papers and extracted key messages. Using expert review of the abstracts, a total of about 300 peer reviewed articles were retained in addition to about 40 papers from “grey literature”. The remainder of the article presents the findings using a synthetic narrative along the four stages in the evolution of carbon markets: emergence, “gold rush”, fragmentation and post-Paris perspectives. Specifically, for each of the four stages we discuss main features of the period and key market and regulatory challenges. The article then concludes with recommendations for future international carbon market mechanisms.

2. The emergence of carbon markets: pre-2005

2.1. Main features of the period: conception and emergence of carbon markets

2.1.1. At the origins: the UNFCCC and the Kyoto Protocol

The practical concept of carbon markets emerged in the 1990s. The starting point was Article 4.2 of the UN Framework Convention on Climate Change (UNFCCC) with its rule on “Joint Implementation” (JI) for greenhouse gas mitigation by several countries. This was seen as window to develop market mechanisms by several European and North American countries. An early assessment of the US Initiative on JI (IJI), for instance, elaborated on the experience with 31 pilot projects in South-East Asia (e.g. carbon sequestration in Indonesia through reduced impact logging, and rural electrification in Sri Lanka). and derived recommendations for market mechanisms (Dixon, 1998). Given opposing views between developing and industrialized countries on whether such mechanisms made sense COP 1 in 1995 decided to start a pilot phase of the “Activities Implemented Jointly” (AIJ) lasting until 2000 without generation of emission credits. This allowed countries to test different market mechanism design options (see Dutschke and Michaelowa, (2003) for Costa Rica, which was a pioneering host country, and Springer (2003) for the Swedish approach to invest in the Baltic states). Costa Rica was the first developing country to implement AIJ in several sectors including conservation, reforestation and renewable energy (wind and hydro). An assessment of 11 AIJ projects from the Swedish pilot program (energy efficiency and renewable energy in the Baltic countries) showed that project implementation costs were higher than projected, while GHG emission reductions were lower than ex-ante estimations. It was also suggested that such project risks can be mitigated by carbon funds through aggregation of demand (Springer, 2003).

While the economic rationale for industrialized countries to invest in activities in developing countries due to lower mitigation costs was not challenged, Zhang (1997) and Swisher (1997) identified various benefits and risks for developing countries. Presaging debates that fully erupted in the 2010s, some authors (Michaelowa and Schmidt, 1997) supported carbon crediting [2]for JI to ensure efficient mitigation in the short term and mobilize technology transfer but proposed to progressively reduce the crediting in the long term to ensure innovation and research and development on low-carbon technologies/measures through increasing domestic carbon prices.

The Kyoto Protocol (KP), adopted in 1997, set GHG emissions reduction targets for 38 industrialized countries and economies in transition (EIT) – Annex B Parties to the Protocol. These mitigation targets were defined through emissions allowances – assigned amount units (AAUs) – allocated to countries. In order to maximize the economic efficiency of achieving their emission targets, Annex B Parties were allowed to use three flexible mechanisms. They could exchange AAUs through international emissions trading (IET) and use carbon credits resulting from emissions reduction projects – Joint Implementation (JI) in Annex B countries (generating ERUs) and the Clean Development Mechanism (CDM) in non-Annex B countries (generating CERs) (Shishlov et al., 2016)[3]. The CDM arose from the Brazilian Proposal's Clean Development Fund, and the concept was developed jointly by Brazil and the United States in the weeks preceding the Kyoto Conference of Parties in 1997. G-77 countries and China pushed the Annex 1 countries to comply with their mitigation goal, and accepted the CDM as an alternative mean of compliance (Cole, 2012).

[2] A *carbon credit* is a generic tradable certificate or permit for GHG emissions reduced or removed from the atmosphere (e.g. tons of CO_2e) from generating mitigation activity. It is hence an instrument that represents ownership of a standardized unit of GHG emission reductions that can be traded, sold, retired or transferred. Crediting here refers to the issuance of a carbon credit (a tCO_2) for an equivalent reduction of GHG emissions. Offsetting refers to the use of carbon credits within different schemes, e.g., CERs could be used as offsets under ETS or domestic carbon pricing but can also be cancelled and hence contribute to net mitigation.

[3] So, the connotation of the term JI changed from the earlier terminology used in the UNFCCC. While initially the term JI indicated all activities tested during the initial introduction and test period of the market mechanisms, it later indicated only the activities that can be implemented in Annex B countries.

2.1.2. **Expected benefits and challenges to international carbon markets**

In the late 1990s and early 2000s, many researchers foresaw significant benefits of the flexible mechanisms of the Kyoto Protocol. Jepma and van Der Gaast (2003) stressed the potential of the three flexible mechanisms (IET, JI and the CDM) to achieve considerable mitigation cost savings and foster a multi-billion-dollar market for carbon credits, depending on content of the COP decisions; possibility to carry over AAUs, CERs and ERUs beyond 2012; and participation of the USA in the carbon market (Chen, 2003)[4]. The size of the carbon market would be driven by Annex B demand, on the one hand, and institutional barriers in host countries, on the other (Michaelowa and Jotzo, 2005). The CDM was seen as a cost-effective tool to achieve mitigation, effectively support dissemination of renewable energy (RE) technologies in developing countries (Duic et al., 2003), provided that carbon leakage[5] is avoided (Bollen et al., 1999). Dutschke and Michaelowa (2003) emphasized the need for sufficient economic incentives for investors from developed countries investing in CDM projects in developing countries, since the carbon credit price has a strong impact on the economics of different CDM projects (Shrestha and Shrestha, 2004). For example, an early assessment of the power sector in Sri Lanka, Thailand, and Vietnam, Shrestha (2004) concluded that CER prices of USD 4-5 per tCO_2e would support fuel switch from coal to gas and oil, but were insufficient to mobilize renewable energy (RE).

There are benefits from the CDM participation for both Annex I and non-Annex I countries. However, in order to maximize benefits, the non-Annex I countries should participate more actively in the rule design process for the flexible mechanisms (Painuly, 2001). With regards to compliance costs, a combination of different carbon pricing mechanisms, based on the case of Germany, was explored. JI combined with an environmental tax reform could reduce overall costs as compared to the tax reform alone, as JI would reduce the level of tax needed to reach mitigation targets domestically (Böhringer et al., 2003). Other researchers highlighted capacity building and technology transfer benefits of the mechanisms, as well as co-benefits for biodiversity protection (Fehse, 2003).

In terms of the geographical potential, China emerged as potential frontrunner due to the high carbon intensity of the power sector and large potential for improving energy efficiency (EE) (Vrolijk and Liu, 2005). An improved institutional set up and increasing awareness could help to increase further attractiveness of Chinese CDM activities (Zeng and Yan, 2005). This highlights the importance of factors that are not only related to investment costs or potential for mitigation, but that affect attractiveness of CDM activities.

2.2. **Key market and regulatory challenges in this period**

In the phase of emergence of the mechanisms, concerns were raised regarding low demand and low credit prices (Jotzo and Michaelowa, 2002). Specific challenges of the CDM and JI

[4] The US, even though supporting the introduction of the flexible mechanisms, did not ratify the Kyoto Protocol and hence never participated directly in use of the credits generated by these mechanisms.

[5] Carbon leakage occurs when economic activities that generate GHG emissions migrate from a jurisdiction with a strict policy on emissions to another jurisdiction with lax emission regulations.

identified by the early literature include the need to generate sustainable development (SD) benefits, and also the need for capacity building and data collection (Begg et al., 2001). Carbon leakage and the need for monitoring, reporting and verification (MRV) were also identified as relevant issues, regardless of the specific sector of implementation, to be explored in detail (Chomitz, 2002; Geres and Michaelowa, 2002). The risk that "hot air"[6], i.e. surpluses of the domestic emissions budget could be "laundered" through JI was raised early on (Bollen et al., 1999; Jotzo and Michaelowa, 2002). For the CDM, multinational corporations could artificially argue that baseline investments would be highly carbon-intensive in order to maximize credits (Schreuder and Sherry, 2001). A solution for that problem would be clear rules for baseline determination to ensure environmental integrity (Dutschke and Michaelowa, 2003). These topics are further discussed below.

2.2.1. **Generic project risks**

CDM investments in developing countries aim at cheap emission reductions, but in many cases, they have to face a difficult business climate, i.e. functioning of the institutions, regulatory systems and political stability (Fankhauser and Lavric, 2003). Methodological issues regarding the rules of the CDM/JI increased risks for investors in carbon projects, and diversification tools were therefore suggested to manage these risks. In some views (Springer, 2003) reduction of project risks, i.e. technical, political and economic, was to be achieved through diversification and thus carbon funds could be effective in reducing private company risks. More sophisticated financial products, such as call options for buyers and sellers of carbon credits, were suggested (Tucker, 2001) as another option. Initial uncertainty and lack of precedents on carbon transactions also led to concerns that legal disputes could become frequent (Brown, 2003).

2.2.2. **Contribution to sustainable development (SD)**

While the CDM can be an effective tool to lower emission reduction costs, it does not necessarily lead to the maximization of social and environmental development benefits in host countries (da Motta, 2003). Projects would need to strike a balance between aspiration to deliver SD benefits and their economic rationale (Fichtner et al., 2002; Kim, 2004). Contribution to SD of the CDM thus became one of the main challenges to the mechanism from the outset.

2.2.3. **Additionality and baselines**

Two of the key regulatory elements of the Kyoto Mechanisms discussed in the literature are baseline and additionality determination (Gustavsson et al., 2000; de Coninck and van der Linden, 2003). In the context of project-based mechanisms, the baseline is the reference scenario that is identified as the most likely in absence of the proposed project, and against which emission reduction can be claimed. Additionality indicates that the project would not have occurred anyway in absence of the revenue from sale of the emission credits. This

[6] "Hot air" indicates the large surplus of AAUs in some of the emerging economies following the reduction of GHG emissions due to the collapse of the socialist economies.

concept become one of the most contested issues for CDM activities starting from this initial period.

Case studies from the power sector in non-Annex 1 countries in 2001 highlighted the high risk for crediting activities that would be implemented anyway, also in the absence of the CDM, i.e. non-additional projects, which called for the definition of strong rules on additionality to ensure environmental integrity (Bernow et al. ,2001). An assessment of 37 early CDM and 12 JI projects raised concerns on consistency and additionality (de Coninck and van der Linden, 2003).

Another issue that emerged relates to the perverse incentives leading to overestimation of baselines to maximize emission reductions potential, leading to difficulties in identifying credible baselines (Anagnostopoulos et al., 2003). Illum and Meyer (2004) stressed that project-based activities could only be seen as additional if the baseline was referring to the national energy system where the project is implemented, capturing the real impacts of other projects implemented in the same energy system. Thus, a broader sectoral baseline was proposed. Inappropriate baseline settings ultimately lead to either missing “good” emission reductions opportunities that meet additionality requirements or to compromising the environmental integrity (Zhang et al., 2005).

2.2.4. Transaction costs

Developing the project documentation, especially regarding additionality determination and baseline setting as well as third-party validation and verification were seen to generate transaction costs that could limit the scope of the CDM (Jotzo and Michaelowa, 2002). Small-scale projects were found to have disproportionally higher transaction costs, and special rules for such projects were therefore suggested as a potential solution (Spalding-Fecher et al., 2002; Michaelowa et al., 2003). Simplified rules and procedures were subsequently introduced from COP7 in Montreal, 2005 onwards (UNFCCC, 2006).

2.2.5. The inclusion of forestry activities

Many researchers supported the inclusion of forestry under the CDM and JI, to unlock the mitigation potential in this sector, especially through reduced logging and deforestation (Olschewski and Benitez, 2005; Osborne and Kiker, 2005). The following main benefits were identified: high mitigation potential in terms of delivering large volumes of emission reductions (Pearson and Bloomfield, 2000; Bernoux et al., 2002; Pelley, 2003), high cost effectiveness and additionality (Subak, 2000), support for local communities, rural development and forest conservation (Klooster and Masera, 2000; Hardner et al., 2000), especially if a high share of the carbon revenues reaches local people and if local communities can manage the land rights (Gundimeda, 2004). A case study of Panama (Dale et al., 2003) found that reduced deforestation is a more efficient way to reduce emissions than afforestation. The former however is not eligible under the CDM. Concerns however emerged on the inclusion of forestry projects in the first commitment period (2008-2012) of the Kyoto Protocol: it was expected that it would deliver only limited impacts, with major benefits for Annex B countries, LAC and Africa, while China would be negatively affected (Jung ,2005). The study was based on the development and assessment of marginal carbon sequestration cost curves, resulting in the forecast of a limited role for forestry in the first commitment period.

A number of potential issues were identified including baselines, carbon accounting, and use of the wood products (LeBlanc, 1999). Land use change models were proposed to identify the baseline. Complexity of the flexible mechanisms under negotiations regarding carbon sinks was also raised as a factor of inefficiency and potential discrimination for developing countries (Bettelheim and d'Origny, 2002). Significant concerns arose especially regarding the contribution to SD in the forestry sector, partly because of the lack of sufficient supporting available data (Cullet and Kameri-Mbote, 1998), regarding potential negative impacts on the local communities and biodiversity conservation (Lindegaard and Segura, 2001; Nelson and de Jong, 2003; Peter et al., 2005). Improving local communities' participation and integrating socio-economic concerns was suggested as a solution (Peter et al., 2005). Subak (2002) suggested stringent criteria (e.g. those of the Forest Stewardship Council) to ensure sustainable forest management and avoid leakage to minimize these risks. Case studies on rehabilitation of degraded forests in Czech Republic and Uganda demonstrated that additionality and sustainable development contribution can be ensured in the forestry sector if clear rules are defined (Verweij and Emmer 1998). Finally, leakage of timber extraction towards developing countries could occur if carbon market activities implemented in Annex I countries (JI) are credited under the Kyoto Protocol (Niesten et al., 2002).

A key strand of literature discussed the issue of permanent vs. temporary sequestration of carbon in forestry (Marland et al., 2001). The concept of temporary CERs was adopted in 2005 (UNFCCC, 2005). The use of temporary credits, coupled with insurance or reserves could maintain the incentive for long-term sequestration and also guarantee a multi-year obligation (Subak, 2003; Vöhringer, 2004). Another option to ensure environmental integrity would be the introduction of stringent MRV procedures. This option however would result in higher MRV costs that can negatively affect the viability of forestry projects (Stuart et al., 2000; Robertson et al., 2004).

3. The "gold rush" period of 2006-2011

The period 2006-2011 saw a strong growth of the international carbon markets, triggered by the 2004 decision of the EU on the "linking directive" allowing the use of credits from CDM and JI for compliance under the EU ETS. Under these circumstances, the flexible mechanisms gained sudden popularity and carbon markets grew much more than originally expected. However, the "gold rush" also exposed problems that were discussed intensely in the research literature.

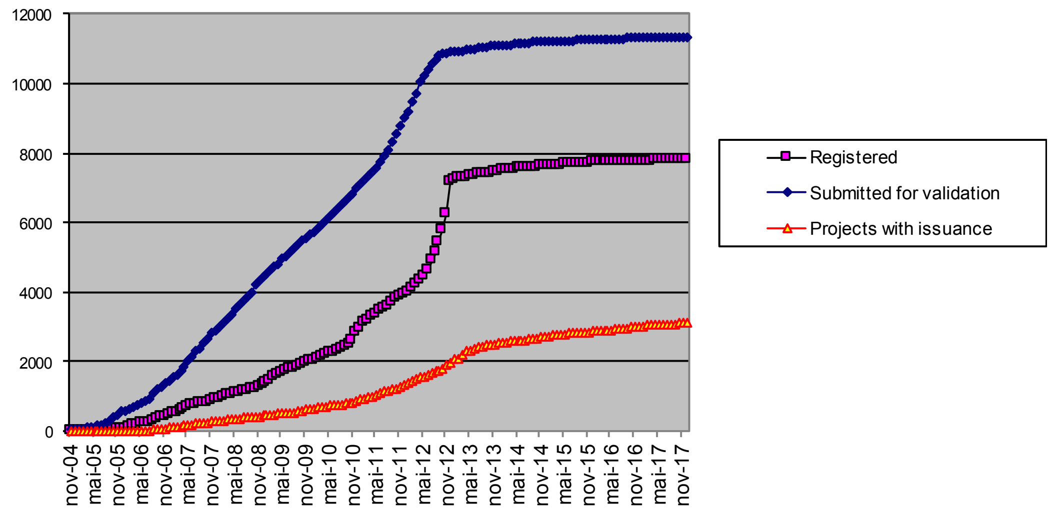
3.1. Main features of the period: growth and expansion of carbon markets

3.1.1. Supply and demand for carbon credits

The CDM was initially seen as a mechanism for countries that could support governments significantly reduce the cost of compliance with the KP (Bréchet and Lussis, 2006). But in practice both supply and demand for CERs was largely privatized and the CDM capacity to attract large private capital on an annual basis was an unprecedented and non-anticipated feature of the mechanism (Shishlov, 2012). On the demand side, this privatization was largely achieved thanks to the EU ETS which provided a large and reliable source of demand for CERs (Shishlov, 2012).

While the initial use of offsets in the EU 2008-2009 was rather limited (Trotignon, 2012), market actors from 2004 realized the cost-saving potential through the use of credits thanks to the difference between EUA and CER prices (Vasa, 2012) and the demand from the EU ETS grew in leaps and bounds leading to a “gold rush” period of the CDM. The following graph shows the trend in the pipeline of CDM projects submitted for validation, registered and those that issued CERs (Figure 1).

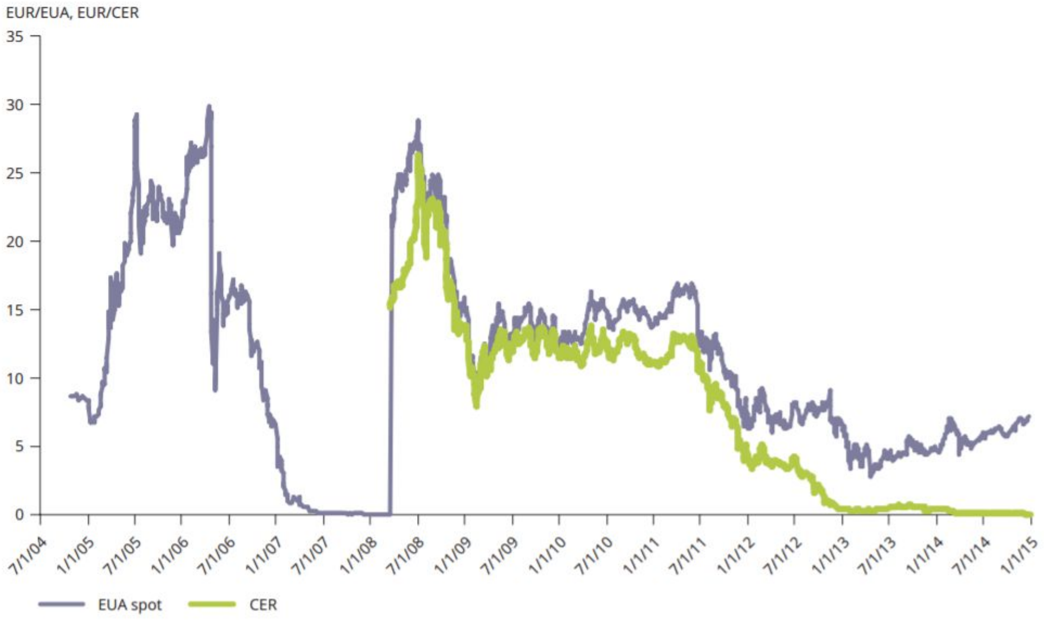
Figure 1. Accumulated number of CDM projects.



Source: UNEP DTU (2017a)

The reduction of GHG mitigation compliance costs for firms in the EU and Japan was estimated at least around USD 2.3 billion for the period 2008 - 2012 based on the difference between CER and EUA prices (Spalding-Fecher, 2012). Additionally, for the same period (2008-2012) it was estimated that for the public sector, the use of CERs by Annex I governments to meet their Kyoto commitments yielded an additional USD 1.3 billion in savings (ibid.). Figure 2 demonstrates the evolution of EUA and CER prices from the beginning of the EU ETS in 2005. The CER prices refer to “secondary” prices quoted on exchanges; actually, over the counter trades directly from project developers happened since 2005.

Figure 2. EUA and secondary CER price evolution.



Source: European Environment Agency (2015)

In 2005 it became also clear that the so called "unilateral CDM"[7] approach could be used, where stakeholders from developing countries are investing in a mitigation project in anticipation of potential carbon credit buyers and sell emission credits as a commodity. Unilateral CDM had the potential to attract investment in a more efficient manner compared to "bilateral" activities in specific circumstances, for instance through a reduction of transaction costs and low need of technology transfer (Michaelowa, 2007; Bayer et al., 2013a). Potential for unilateral CDM varied from country to country, depending on the domestic context and with African countries still depending on international support to a much higher degree than other developing countries in Latin America and Asia (Michaelowa, 2007).

While the regulatory uncertainty about the CDM did not allow CER and EUA prices to fully converge (Mizrach, 2012), a clear correlation was observed (Sadefo Kamdem et al., 2016). It was demonstrated how price volatility was exacerbated by the decisions of the European Parliament and suggested the need for policymakers to improve communication of long-term strategies for the EU ETS (Deeney et al., 2016). Moreover, concerns about price volatility in the primary market due to imperfect information were also raised (Zavodov, 2012).

3.1.2. Carbon finance: learning by doing through expansion of the market

Being the first-of-a-kind climate change mitigation instrument, the CDM followed a "learning by doing" pattern, whereby the transparency of the mechanism allowed for scrutiny by

[7] Unilateral CDM are those project activities that are implemented by developing countries and the CERs generated by these activities are sold without any participation from Annex I countries.

researchers and NGOs leading to numerous reforms (Shishlov, 2012). The CDM, as well as voluntary offset schemes, helped developing countries in building technical capacity regarding structuring of emissions reduction projects and carbon accounting (Mehling and Mielke, 2012). Indeed, a common view among stakeholder inputs to the CDM Policy Dialogue was that capacity-building for the low-carbon transition in developing countries was one of the most important impacts of the CDM (Spalding-Fecher, 2012). Especially in large emerging economies like India, China and Brazil very rapidly an “ecosystem” of CDM consultants emerged that quickly made the role of the World Bank superfluous (Michaelowa and Michaelowa, 2011). Michaelowa and Michaelowa (2011) have argued that the World Bank did not leave the market as initially promised once it picked up but started to compete with private sector market players.

In this phase, private financial institutions were actively participating in the carbon markets as intermediaries, enhancing liquidity of the market (Weber and Darbellay, 2011), especially in large countries like China (Fan et al., 2011). But they did not contribute actively to rule setting for CDM regulatory mechanisms (Haigh, 2011) while carbon funds can play a fundamental role in pooling demand for credits. Then number of carbon funds should however slow down, given the regulatory uncertainties with the post-2012 period (de Dominicis, 2006). Carbon funds are one of the main drivers that enable DFIs to support CDM dissemination especially in low income countries in Africa (Karani and Gantsho, 2007).

3.1.3. Carbon finance and domestic climate policies

The CDM and international carbon finance were also assessed against domestic mitigation policies. In the context of the Sub-Saharan agricultural sector, the use of a carbon payment system can be a reasonable alternative to subsidies aimed at improving soil fertility (Marenya et al., 2012). In China, based on the successful CDM experience, a domestic “inter-provincial CDM” was suggested (Jacques et al., 2013). Strand (2011) identified a perverse incentive of the CDM to weaken domestic energy and environmental policies to leave sufficient potential for emission credits sales through the CDM. Such considerations led to the definition of the so-called E+ and E- policies to be taken into account when identifying the baseline. According to the UNFCCC (2005), E+ policies are “national and/or sectoral policies or regulations that give comparative advantages to more emissions-intensive technologies or fuels over less emissions-intensive technologies or fuels”, while the E- policies are “national and/or sectoral policies or regulations that give comparative advantages to less emissions-intensive technologies over more emissions-intensive technologies (e.g. public subsidies to promote the diffusion of renewable energy or to finance energy efficiency programs)”. The E- rule stated that mitigation policy instruments introduced after the Marrakech Accords do not need to be taken into account in assessing additionality of CDM projects.

3.1.4. Carbon Capture and Storage (CCS)

One new topic that emerged during this period was the introduction of Carbon Capture and Storage (CCS) as an eligible project activity under the CDM at COP 17 in Durban, 2011. However, at the time of writing, no baseline and monitoring methodology for CCS has been approved and hence no activity has been registered. In some views there was the need to explore potential tradeoffs between mitigation through CCS and negative local impacts at storage sites (Ebeling and Yasué, 2008). Other authors stressed the need to review the existing CDM framework to introduce new concepts to address long term liability and CER cancellation (Lotz and Brent, 2008). Opposite views on this topic have been raised by a number of authors (see, arguing that concerns with this technology could be addressed with available methodologies (Boute, 2008 for a typical assessment). Pollak and Wilson (2009) and Kalkbrenner (2010) stressed that long term responsibility, local environment protection and safety are posing a serious obstacle for the inclusion of CCS in the CDM. Other concerns were discussed regarding potential impact of large volume of credits generated by CCS projects under the CDM and repercussions on credit prices (Zakkour et al., 2011).

3.2. Key market and regulatory challenges in this period

Economic efficiency, environmental integrity and contribution to sustainable development are among the key challenges faced by the international carbon market in this period (Shishlov, 2012; Lewis, 2009). CDM has been depicted as an ineffective instrument with limited results in reducing global GHG emission (Wara, 2007) while Michaelowa (2011) found that more effective instruments, e.g. carbon taxes, are available.

Other main concerns refer to possible "low-hanging fruits" project types, project risks, contribution to SD in host countries, uneven geographical distribution, challenges for forestry projects, additionality and baselines, , technology transfer, and capacity building needs, and governance. These issues are presented in the following sections.

3.2.1. Mobilizing "low-hanging fruit"

One of the challenges raised with regards to the CDM was the problem of "low-hanging fruits" being captured by the market, potentially precluding countries from taking on more ambitious targets (Akita et al., 2012; Peter and Bumpus, 2012). Quantitative assessment, however, demonstrated that a project-based mechanism like the CDM could only capture a small share of cheap abatement opportunities, with a notable exception of China, where it captured almost a third of theoretical low-cost abatement potential (Castro, 2012). Difficulties in the equalization of marginal abatement costs across sectors were identified by Millard-Ball and Ortolano, 2010).

Some sectors have benefitted more than others: industrial gases, renewables including large hydro (Whittington, 2007), fuel switch projects were leading, while energy efficiency and transport were lagging. In order to reorient investments towards projects in the latter sectors with a strong SD component, governments could do upfront CER purchase or pool activities in order to limit market distortions (Lof, 2009). Research focused on reasons to explain the problems of the energy efficiency sector. Improvement of the institutional capacity at UNFCCC level and setup of a working group to develop baseline and monitoring methodologies were suggested (Niederberger and Spalding-Fecher, 2006). The financial support from CDM was identified (Ren et al., 2011) as an incentive for the dissemination of distributed energy resources through energy service companies (ESCOs) in Chinese urban areas (Ren et al., 2011).

Concerns were raised on the effect of inclusion of unrestricted trading of carbon credits from reducing emissions from deforestation and forest degradation (REDD) projects as it could significantly depress carbon prices. However, it was also argued that the inclusion of such cheap abatement options in the international carbon market can help encourage governments to adopt tighter emissions reduction targets (Anger et al., 2012).

3.2.2. Going beyond projects

One significant evolution of the CDM beyond single projects is the introduction of the concept of Program of Activities (PoA) in 2005. This option allows the registration of multiple activities of the same type without any limit of the number over a period of 28 years. PoAs reduce transaction costs (Matschoss, 2007), which was confirmed by empirical studies, such as in the case of a PoA for CFL dissemination in Chile (Karakosta and Askounis, 2010).

The project focus of CDM was increasingly seen as outdated. Various authors proposed sectoral crediting mechanisms and explained their design using the case of utilization of associated gas (Suykens, 2010; Duan, 2011).

3.2.3. Performance risks and delivery risk

The CDM performance risk associated with the discrepancy between estimated and issued carbon credits was identified as one of the key challenges to development of projects. One study on 227 renewable energy projects, including hydro and wind of different scales and in different countries found large variations in terms of project performance risks, with projects generally not generating the level of emissions estimated in the PDDs. On average, hydro and wind projects performed in a similar manner (Balatbat et al., 2012). An attempt to differentiate the risks incurred by CDM projects in terms of expected CERs that will never be issued found 29% due to failure of projects (negative validation, project withdrawn, etc.), 12% due to delays during the approval process (validation and registration), 27% due to delays at issuance, and only 1% due to underperformance of projects in terms of CER delivered per day. Only around 30% of the CERs was issued according to PDD forecasts. This results in only 576 million CERs issued by April 1, 2011 against an expected volume of 1.8 billion CERs (Cormier and Bellassen, 2013). Technology (project type) was identified as a key driver for all these risks: some technologies are less risky than others. Securitization of the CDM investments and a CDM guarantee trust were proposed to address delivery risk (especially for remote areas and new promising technologies) (Rajan, 2009). The International Finance Corporation established a Carbon Delivery Guarantee to reduce delivery risks and increase returns from carbon credits. Under the Carbon Delivery Guarantee, IFC signed three deals for a cumulated volume of around 2.2 million CERs, from three projects located in India, South Africa (WBG 2010).

3.2.4. Ensuring sustainable development contributions

The CDM was designed to address the need for cost-effective greenhouse gas mitigation and promote sustainable development (SD) benefits in host countries at the same time (Cole, 2012). Overall, the system of sustainability assessment under the CDM placed the principle of national sovereignty on top, as the CDM is part of the development strategy of host countries.

Therefore, there have been no standardized criteria and monitoring methods for measuring the impacts and contributions to sustainable development. The structure of the CDM, and the possibility for host parties to define the SD priorities at the national level creates an incentive for a “race to the bottom” regarding the requirements related to SD for CDM projects (Rindefjall et al., 2011). Van Asselt and Gupta (2009) and Nguyen et al. (2010) find that the CDM gives little consideration to sustainable development and called for reform of the CDM. This is mainly due to the fact that there is a perverse incentive for developing countries to allow also projects with limited or without SD benefits to attract investments: investors from developed countries select projects based on the cost of the carbon credits, with little or no consideration for the implications on the SD in the host country. In addition, there is a perverse incentive for host countries to delay implementation of more stringent environmental and climate policies to avoid reducing the potential for generating CERs from CDM activities and therefore losing potential investments.

The case of Chile is used to identify a deliberate strategy to attract foreign investments and “export” emission reductions marginalizing the SD component. There is a general trade-off between the GHG emissions reduction and contribution to sustainable development in the CDM (Wittman and Caron, 2009; Bakker et al., 2010; Macdonald, 2010b). This is supported by an analysis based on taxonomy for sustainability assessment of text analysis of 744 PDDs submitted until May 2006 (Olsen and Fenhann, 2008), as well as another assessment of40 projects from India (Alexeew et al., 2010). Similar conclusions have been identified through a small sample of ten projects (Boyd et al., 2009) and by a literature review up to 2007 (Olsen, 2007). Contribution to SD in host countries is mixed and largely depends on national context and can result in trade-offs between GHG emission reductions and SD contributions (Shishlov, 2012). An assessment of a small sample of 16 registered projects rating their performance on SD and on the likelihood of delivering real and measurable emission reductions, found that while around 72% of the projects can deliver real emission reductions, only 1% is capable of delivering SD benefits and none of the currently registered CDM activities actually does so This is mainly due to the existence of projects delivering large volumes of CERs, which scored poorly when assessed against SD criteria (Sutter and Parreño, 2007). Issues with large scale dams and indigenous people’s rights have been raised (Finley-Brook and Thomas, 2010) and in general hydro projects are questioned for their negative impacts on SD at local level (Shishlov, 2012). The SD benefits of the CDM are limited to economic benefits with little environmental benefits beyond cleaner production (Thomas et al., 2011). In other views, renewable energy projects can benefit from support of the CDM in delivering SD benefits and in their inclusion in the priorities of developing countries (Doukas et al., 2009). China was seen as giving preference to CDM projects in poorer and less developed provinces and provinces that lack foreign direct investments (FDI) in order to maximize economic co-benefits (Bayer et al., 2013b; Hong et al., 2013). However, an assessment of selected hydropower projects in Yunnan province argued while the CDM might have contributed to boosting hydropower development, their benefits were often not channelled to local communities (Rousseau, 2017). Energy-related CDM activities in China were seen to deliver substantial health benefits effects and monetary savings (Vennemo et al., 2006). While the CDM did not explicitly focus on co-benefits, “add-on” standards, such as, for example, the Climate, Community and Biodiversity (CCB) or Gold Standard used by certain projects have delivered over-proportional co-benefits for poor populations (Crowe, 2013). Nussbaumer (2009) finds that labelled activities tend to have better performance regarding contribution to local SD, even if this is not the case for all projects.

Some authors proposed the development of sophisticated tools to prioritize activities from a SD contribution standpoint that could also be used as a verification protocol for DOEs for MRV on SD impacts (Lenzen et al., 2007; Olsen and Fenhann, 2008). The CDM adopted the SD tool, which is used on a voluntary basis by project participants to assess the SD contribution of their CDM activities. An attempt to develop a tool to define models for SD contribution that can support both government planning and private company participation was carried out in Chile (Karakosta et al., 2009) and also in Viet Nam (Huge et al., 2010).

3.2.5. Uneven geographical distribution

One of the main criticisms of CDM and JI is the uneven distribution of projects across host countries (Hultman et al., 2009). Host country attractiveness under the CDM at the height of the "gold rush" and found India, China, Mexico, Brazil and Chile at the top, while under JI New Zealand, Denmark and Sweden were seen as leaders (Oleschak and Springer, 2007). When assessing bilateral CDM projects, it was found that the familiarity factors (colonial history; bilateral trade; and bilateral aid) strongly influence CDM location decisions (Dolšak and Crandall, 2013). Evidence of the CDM projects following closely the traditional FDI patterns was identified (von Unger and Streck, 2009). Availability of human capital, mitigation potential, which is indicated by the carbon intensity, existence of profitable markets for CDM co-products (e.g. electricity) increases the chances of hosting CDM activities (Winkelman and Moore, 2011). A comparative analysis of the CDM experience in China and South Africa demonstrated that a strong industrial and energy policy in the host country plays a crucial role in the development of CDM (Fay et al., 2012). Policies fostering a low-carbon development pathway encourage the CDM uptake, rather than CDM driving a low-emission development pathway. In addition, the active engagement by key government and private sector stakeholders and the presence of a friendly business environment are crucial. Lack of capacity of local actors, aggravated by limited access to financing, was identified as key barrier for entrepreneurship in in the CDM in South Africa (Dolles et al., 2013).

In some views, PoAs can support a more balanced distribution of CDM activities (van der Gaast and Begg, 2009). The successful use of PoAs is contingent on establishing an appropriate institutional framework, building local capacity, increasing institutional learning around project development, and harmonizing evolving carbon finance mechanism (Schomer and van Asselt, 2012). These activities are also proposed for underrepresented countries (Hwang and Kim, 2011). Combining financial instruments, e.g. carbon crediting and micro-finance, can help scale household programs, such as for example in the case of the diffusion of solar lanterns through micro-loans (Hogarth, 2012) and thus open new opportunities also for underrepresented countries.

3.2.6. Challenges for forestry and land-use projects in the CDM and outside (REDD+)

The debate on forestry projects continued in similar strands as in the preceding period. CDM can lead to forest protection but also to negative impacts on forests and local and indigenous communities and four key elements were identified as relevant for the delivery of real local SD development: ownership, price, transaction costs, and use rights. Land-use based mitigation activities are legitimate in the long term if they also provide biodiversity protection (Kerr et al., 2006). Concerns were raised on potential conflicts that could emerge with production of bioenergy and increased use of wood products (Dutschke, 2007). Potential solutions are also available, such as to consider existing rural development strategies, enhance local stakeholder participation and design projects in a flexible manner (Boyd et al., 2007). However, other authors saw the chance to harness combined mitigation and adaptation benefits and to maximize the revenues for small landowners (Bryan et al., 2010).

Concerns remained important. While recognizing the potential to generate a large volume of emission reductions, interactions of forestry projects under the CDM and other land uses, such as agriculture, were highlighted by several researchers as crucial for delivering SD benefits for local and indigenous communities (Groen et al., 2006; Dulal et al., 2011; Zomer et al., 2008). Murthy et al. (2006) stressed the importance of proper boundary identification, while Corbera and Friedli (2012) criticized the frequent use of inaccurate carbon accounting methods. Introduction of remote sensing monitoring can help overcome information asymmetries according to Brandt and Svendsen (2013). Cacho et al. (2013) stress high transaction costs as an important barrier. In the case of Cameroon, it was found that data availability was a major barrier to forestry projects (Minang et al., 2008). Building on a case study in Vietnam, a closer involvement of local communities in the design of afforestation projects would help address the risks of non-permanence of emissions and leakage, due to the limited availability land for tradition uses (Yamanoshita and Amano, 2012). The assessment of two Payment for Environmental Services (PES) projects in Ecuador found positive results through focus on targeted environmental services and high level of concessionality (Wunder and Albán, 2008).

The debate on permanence continued intensively. In some views, temporary credits are seen as a good solution to balance environmental integrity and financial attractiveness allowing their inclusion under the CDM, even if additional rules are suggested to strengthen the concept (Marechal and Hecq, 2006). Other observers (Galinato and Uchida, 2010) criticized the approach due to the fact that impacts of carbon release due to timber harvest are not internalized by the project owner. Moreover, overcrediting occurs as accumulated carbon is counted instead of marginally sequestered carbon.

To reduce emissions in the forestry sector, the concept of Reducing Emissions from Deforestation and land Degradation (REDD) was introduced in the UNFCCC in 2005 but not into the CDM. The final definition of REDD+, adopted in 2010, includes the concept of sustainable management of forests and enhancement of carbon stocks. During the assessed period the debate increased whether REDD+ should be integrated into the CDM. Ensuring additionality was seen as key, as non-additional REDD+ could generate a very large amount of “bogus” emission reductions (Pirard and Karsenty, 2009). Given the non-eligibility of deforestation activities under the CDM, and the uncertainty on whether its inclusion would create a real incentive for investors, a Conservation Carbon Mechanism as part of the CDM was proposed as a potential solution to overcome the lack of a system that gives a value to standing forests. The mechanism introduces a stock-based accounting approach and trading mechanism with the goal of rewarding also SD benefits delivered to local communities. (O'Sullivan and Streck, 2008). Other researchers have shown that REDD+ can have positive impacts, but it is necessary to balance the interests of financiers and those of the local communities. For example, REDD+ can benefit from existing positive experiences from both CDM activities and voluntary projects in the forestry sector (such as in Uganda) to support the structure of these activities and of direct payments between buyers and local communities (Peskett et al., 2011).

An assessment of 34 quantification methods for REDD under the CDM and other voluntary schemes, found that the Voluntary Carbon Standard has been identified as the only carbon accounting standard to fulfil all leakage quantification requirements (Henders and Ostwald, 2012). To address indirectly technical and administrative challenges related with leakage, permanence and additionality, a project-specific “iREDD” insurance is proposed, to be negotiated upfront based on the evaluation of risk depending on governance quality, the integrity of management plans, liquidity, monitoring and evaluation frameworks, and political acceptability. A certain share of the price of CERs is set aside as insurance premium and whose volume depends on the risk assessment of the project (van Oosterzee et al., 2012). It was suggested that REDD+ mechanisms should provide local authorities with enough flexibility to address the local development trade-offs and ensure that local demand for goods and services related with the forestry sector is taken into account (Dyer et al., 2012). (Newton et al. (2012) argued that a differentiated payment scheme for avoided primary forest conversion rather than a uniform carbon credit payment could be more effective in reducing deforestation, while Cairns and Lasserre (2006) proposed an accounting method based on observable data.

REDD+ governance can become a major barrier (Bhullar, 2013) due to the poor level of governance in many of the countries with the highest REDD+ potential. Success of reduced deforestation projects seems to depend on supporting incentives for government, local communities and business sector (Ebeling and Yasué, 2008; Corbera and Brown, 2008). Boyd (2009) called for effective institutions at local and national level, enhanced communications between stakeholders, and better integration of local relationships. Sathaye et al. (2011) called for capacity building as precondition to harness the substantial mitigation potential of REDD+.

3.2.7. **Additionality**

The additionality of CDM projects was also severely criticized during the CDM “gold rush” (Streck and Thiago, 2007; Streck, 2011; Koo, 2017b). An assessment of projects in India and Brazil finds that due to the uncertainty of CDM revenues, project developers preferred projects viable without CDM credits (Hultman et al., 2012). Doubts were raised on the additionality of small hydro projects in China (Wu and Chen, 2011) and for wind projects (He and Morse, 2013) (*in general for China*: Lewis, 2010). An assessment of bagasse power CDM projects in Brazil, India and Thailand (Amatayakul and Berndes, 2012) found that power purchase agreements rather than carbon credit sales were decisive for project implementation. Both articles ignore the E- rule due to which revenues from feed-in tariffs are not accounted for under the CDM. Fearnside (2013) argues large hydro projects in

Amazonia would have likely been implemented without the CDM. For small hydro, Martins et al. (2013) found that, among the 431 projects which became active in Brazil since 2001, 339 were not CDM projects and thus the role of CDM revenue as an incentive was uncertain. Looking at renewable energy projects, Gilau et al. (2007) suggested that CDM should move away from a purely "market- oriented" perspective towards barrier removal.

It is acknowledged that in practice, it is virtually impossible to ensure additionality in 100% of the cases (Shishlov, 2012). The natural contradiction between strict additionality and not impeding new environmental policies at the national level partly explains this. The higher transaction costs which come together with a stringent case-by-case scrutiny are another explanation. More stringent baselines and performance benchmarks can help ensure net emissions reductions that could compensate for non-additional projects that manage to slip through. Ultimately, the additionality test becomes a matter of finding the right balance between: "false positives and false negatives" (Carmichael et al., 2016). Relaxing the additionality demonstration on a project basis, but at the same time strengthening additionality on a technology level is one potential option to address the additionality issue (Chung 2007; Castro and Michaelowa, 2010). The CDM would have to move away from a pure offset mechanism through discounting the volume of CERs generated (i.e. allowing crediting for only a certain share of total CERs generated, thus rendering not tradable the remaining share) in order to deliver net mitigation benefits for the world as a whole and ensure additionality at an aggregated level (Schneider, 2009).

3.2.8. **Baselines**

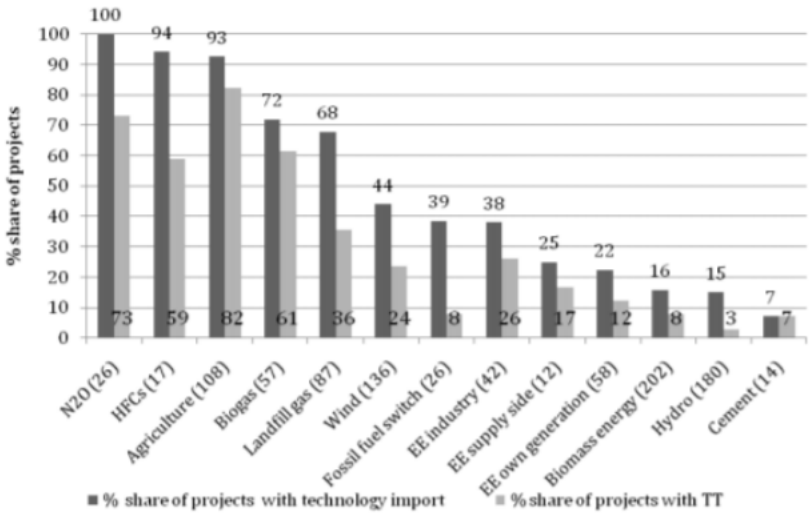
Like additionality, baseline determination continued to be controversial during this phase. (Leakage would have to be taken into account to prevent an increase in global GHG emissions (Rosendahl and Strand, 2011). Other authors argued that the asymmetry of information between the regulator (the CDM Executive Board) and the companies participating in the CDM may result in higher emissions baselines due to the potential to manipulate data and hence increase overall emissions (Strand and Rosendahl, 2012). A similar result was identified also for the voluntary carbon market looking at energy efficiency for buildings in the US (Liu and Cui, 2017). Conservative baselines depending on uncertainty of baseline setting and credit price levels have been proposed as a possible solution (Bento et al., 2016). Other options such as standardization of baselines has been suggested to address these issues (Murtishaw et al., 2006; Zhang et al., 2006). Standardized baselines were calculated for the South African Power Pool (Spalding-Fecher, 2011). This was taken up by the regulators in the post-2010 period

There were cases of specific sectors, i.e. coal bed or coal mine methane recovery and landfill gas (LFG) recovery where approved baselines methodologies are using inconsistent assumptions on the global warming impact of the CO_2 emission from oxidization of methane. In the case of LFG it leads to overestimations of the mitigation impact (Moellersten and Grönkvist, 2007).

3.2.9. Technology transfer

Unlike the contribution to sustainable development, technology transfer is not an explicit objective of the CDM, but it represents an important co-benefit for host countries and has been widely researched (Schmid, 2012; Cox, 2010; Youngman et al., 2007). In contrast to other co-benefits, the existing evidence which started emerging during this phase is particularly inconsistent. While in some views (Schneider et al., 2008) CDM is seen as effective in supporting technology transfer, lowering existing barriers and enhancing the quality of the transfer, other assessments (Youngman et al., 2007) concluded that that around 50% of CDM projects and 62% of JI involved hardware from outside the host country by 2007. However, other researchers (Doranova et al., 2010) came to an opposite conclusion with a majority of CDM activities using domestically produced technologies. Heterogeneous technology transfer results have been identified across CDM project types with different degrees of reliance on imported technology (Karakosta et al., 2012). Others (Das, 2011) reported that technology transfer impacts depend largely on the project type/technology, as shown in Figure 3.

Figure 3. Technology import and technology transfer by project type



Source: based on an assessment of 1000 CDM projects by Das (2011).

An empirical assessment of the barriers that may slow down technology transfer through carbon markets identified high tariffs on environmental goods and services as well as burdensome administrative procedures to launch new businesses as key factors. Other findings indicated that technology transfer is driven by minimization of the abatement cost rather than actual alignment with host country priorities and needs (van der Gaast et al., 2009).

A case study of wind power CDM projects in China and India (Lema and Lema, 2013) demonstrates that while technology transfer does occur, it is based on mechanisms available prior to and independent of CDM projects. This means that CDM projects tend to use technology transfer mechanisms and options already available in the country and independent of the CDM component not the other way around. In China the proportion of total income generated by CERs is high and the domestic availability of the technology is low, drives the choice of project owners to use foreign technologies (Wang, 2010). On the other hand, only limited incentives are identified for technology transfer in the Chinese renewables sector (Wang and Chen, 2010).

3.2.10. **Governance**

During the gold rush period, governance issues became highly relevant, especially under the CDM with a strong participation of private companies. Governance is relevant both on the international and national level. Regarding the former, CDM project developers highlight the issue of lack of transparency on the Executive Board (EB) decision on projects, lack of a mechanism to review or appeal EB decisions, and limited possibility for interaction along the process. This is a consequence of the unique nature of the CDM, where the UN directly interacts with the private sector. An econometric assessment of 250 CDM methodologies and around 1000 registered projects shows that EB’s final decisions are determined by both formal quality criteria and also on political-economic variables (Flues et al., 2010). Likewise, business and industry NGOs influenced decision-making on CCS under the CDM (Vormedal, 2008). Developed countries and emissions-intensive companies are effectively influencing the negotiation and the actual implementation of the flexible mechanisms (Vlachou and Konstantinidis, 2010). In contrast, some authors see a very limited NGO influence on the CDM and other carbon markets (Lederer, 2012).

The governance structures of CDM and voluntary markets carbon offsets are often criticized as subject to capital-accumulation strategies without public oversight (Bumpus and Liverman, 2008; Lövbrand et al., 2009). The CDM criticism is reflecting the effectiveness and legitimacy of the environmental governance at international level (Jacur, 2009). Other authors expressed fears regarding the fact that in the context of oppressive societies market mechanisms can lead to harmful effects for the indigenous communities and it is thus necessary to introduce a mechanism for protecting their rights under the CDM (Finley-Brook and Thomas, 2011). The case of hydropower development in Yunnan Province in China shows that CDM did not contribute to delivering SD benefits but it rather consolidated existing power structures (Rousseau, 2017). However, there is room for improving interactions between the various stakeholders and regulators and increase participation (Millar and Wilder, 2009; von Unger and Streck, 2009). Governance reforms could allow the CDM a more effective and credible international instrument (Purdy, 2009). Several proposals were brought forward, such as professionalization of the EB and appropriate administrative rule with an appeal process to increase transparency (Lin and Streck, 2009; Streck and Lin, 2008). While an appeal process was not introduced to date, several improvements such as granting the possibility of discussing directly through a phone call with the UNFCCC Secretariat the outcome of PDD evaluation to clarify issues, were introduced. An assessment of the commercial activities of the participants to UNEP Risoe's CDM Bazaar shows that different regulatory designs have strong implications on value chain creation, for example influencing the role of specialized CDM consultancies (Schneider et al., 2010).

When assessing the differences among host country domestic CDM governance structures, links can be identified to the specific governance structure in each country (Newell, 2009). A combination of CDM and carbon tax for developing countries (where emission reductions achieved under the carbon tax can be exported) was proposed by Timilsina (2009) to increase host country welfare; actually a number of countries are now combining carbon taxes with the CDM. On the side of buying countries, the initial no-cap option under the EU Linking Directive was pushed by EU Member states but the EU commission prevailed (Flåm, 2009).

3.2.11. Voluntary markets Capacity building

Regarding capacity building, the CDM and the carbon markets delivered limited results. In the case of Africa and LDCs, donor agencies provided USD 45 million for CDM related capacity building until 2009, equivalent to 8% of the total carbon revenues from these countries. Training activities, for instance support in establishment of the Designated National Authorities, were more successful than activities targeting project mobilization. Efficiency of assistance was higher when the full CDM process and cycle is supported rather than parts of it (Okubo and Michaelowa, 2010).

3.2.12. Auditing and conflict of interest

Another regulatory issue which became clear during this phase was the issue of auditing GHG emission reduction through the CDM framework. The auditing functions under the CDM scheme are performed by third parties accredited by the CDM EB, the so called Designated Operational Entities (DOEs). These entities are hired by the project owners for performing the validation and, except in the case of small-scale projects, the DOE validating projects cannot verify the emission reductions generated by the projects. DOEs need to check the conformity of proposed activities against the set of requirements and rules defined by the EB. Researchers emphasized the inherent flaws of delegating authority under the CDM to private actors (Hickmann, 2013) while others pointed to the fact that the risk of losing accreditation outweighs the potential benefits of gaming the system (Shishlov, 2012). Third party auditors also faced challenges in safeguarding environmental integrity, due to lack of clear guidelines on how to interpret existing rules and requirements for CDM activities, hiring of DOEs by the project owners and resulting in pressures on projects registration, time and ability of the DOEs in developing sufficient internal expertise (Dyck, 2011). Researchers pointed out that interactions between buyers and verifiers, including disputes, should be regulated in a stable legal framework (Simonetti, 2010). Introduction of a materiality threshold for verification at UNFCCC level might reduce transaction costs and increase DOEs' objectivity in validations and verifications, reducing inconsistencies (Cole, 2011).

4. Fragmentation of carbon markets in 2012-2015

4.1. Main features of the period: volatility and decline of carbon markets

4.1.1. Falling demand for carbon credits

The main source of demand for CDM and JI credits - the EU ETS - started to fade in 2011-2012 as the issuance of CERs and ERUs started reaching the quantitative limits on the use of offsets.

This limit was set in order to ensure that at least half of the emissions reductions necessary under the KP would be achieved domestically. This is often referred to as "supplementarity principle" (Michaelowa, 2014). The total demand for international carbon credits from the EU ETS was thus estimated at around 1.6 billion tCO_2e until 2020 (Bellassen et al., 2012).

Another important source of demand for carbon credits came from governments of countries – most notably Japan – that required them for compliance under the KP. Indeed, the analysis of the final data for national GHG emissions and exchanges in carbon units during the first KP Commitment Period demonstrated that overall, the Annex B parties to the KP surpassed their aggregate commitment and that all individual countries were in compliance, with 9 of 36 countries – Austria, Denmark, Iceland, Japan, Lichtenstein, Luxembourg, Norway, Spain and Switzerland – achieving it only thanks to the use of flexibility mechanisms (Shishlov et al., 2016). This source of demand was estimated to be around 300 million tCO_2e between 2008 and 2015 (Bellassen et al., 2012).

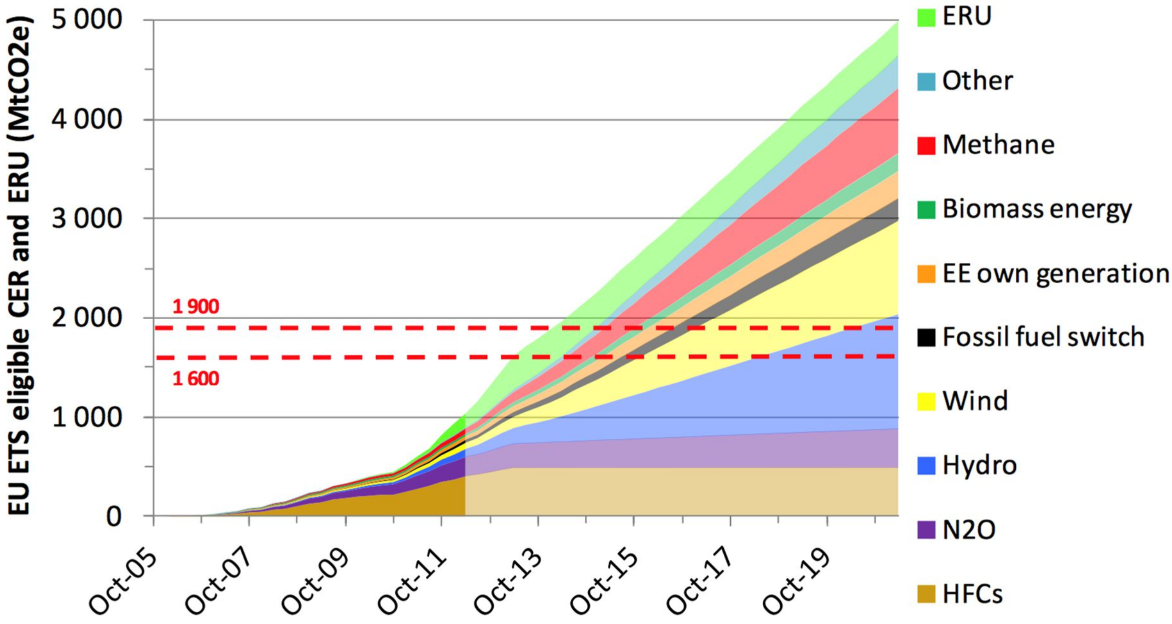
Heindl and Voigt (2012) estimated that should the OECD countries fulfil the "Copenhagen Pledges" and seek cost containment, the potential demand for carbon offsets would be 627-667 $MtCO_2e$ per year. However, the "Copenhagen pledges" were never translated into binding emissions reduction targets, e.g. under the second Kyoto Commitment period. Moreover, the Doha Amendment that prolongs the Kyoto Protocol into its second Commitment Period (2013-2020) never entered into force, since it was not ratified by a sufficient number of countries.

4.1.2. Increasing supply of carbon credits

On the supply side, the CDM was stably delivering CERs. The supply of offsets is also weakly sensitive to prices: once the initial investments in a project are undertaken, it makes sense to issue CERs as long as carbon revenues exceed marginal operational and transaction costs (Shishlov, 2012). It was demonstrated that transaction costs for CDM projects range from less than USD 0.1/tCO_2e for large industrial gas projects to USD 1.5/tCO_2e and above for small-scale projects (Shishlov and Bellassen, 2016). Towards the end of the first Commitment Period there was a large increase of issuance of carbon credits from JI projects in Russia and Ukraine, which is usually explained by the rush to sell credits before the demand fades. This "flood" of JI credits further contributed to the oversupply of the market although this was forecasted ex-ante (Korppoo and Gassan-Zade, 2014).

Steadily increasing supply of carbon credits was thus rapidly saturating the aggregate demand – from the EU ETS and national governments – which was estimated at between 1.6 and 1.9 billion tCO_2e until 2015 (Figure 4). Based on this supply-demand disequilibrium Bellassen et al. (2012) forecasted that CER and ERU prices would collapse, which proved prophetic.

Figure 4. Issuance and forecasted issuance of EU ETS-eligible Kyoto offsets.

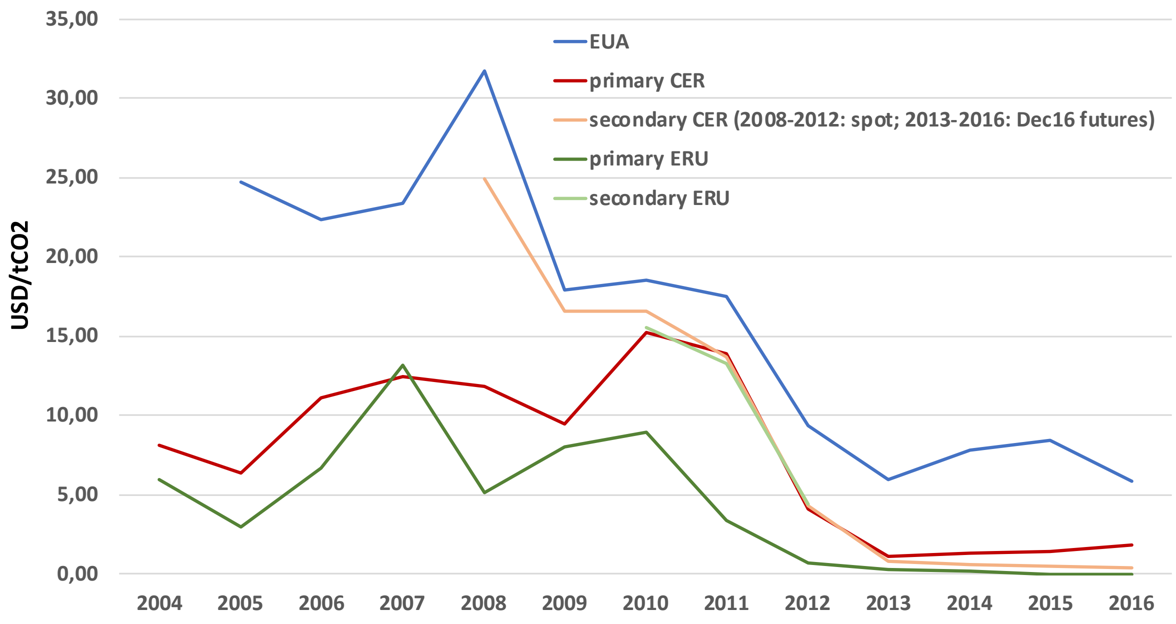


Source: Bellassen et al. (2012)

4.1.3. Falling carbon credit prices

CER prices were largely correlated with the EUA prices until late-2011 (see figure below). EUA prices have been following an overall downward trend following the economic recession, emissions reductions due to other policies (e.g. renewable energy), as well as the inflow of international offsets (Koch et al., 2014). As the CER import limit was filling up, starting in late-2011 an increasing decorrelation between EUA and CDM credit prices could be observed culminating in CER prices collapsing below EUR 1/tCO_2e.

Figure 5: Annual average CER, ERU and EU allowance prices 2004 - 2016



Data sources: Point Carbon (EUAs), Bluenext/EEX (secondary CERs/ERUs), World Bank reports on the state of the carbon markets

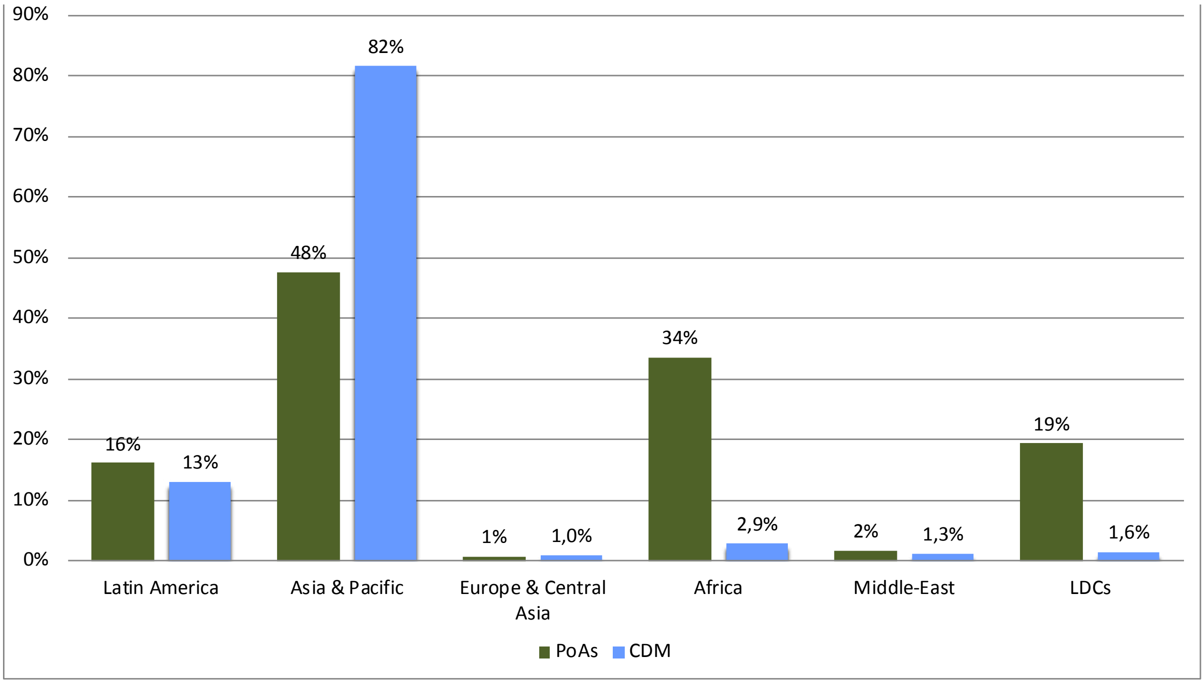
4.2. Key market and regulatory challenges in this period

4.2.1. Lack of demand for credits to sustain projects

While the CER prices were falling, the costs of mitigation actions under the CDM were going up with time as project developers started to exhaust the cheap options (Rahman et al., 2015). The fall in carbon prices combined with regulatory uncertainty on the future of the CDM in the post-2012 climate regime resulted in a drastic decrease in the number of new CDM project registrations.

The fall in carbon credit prices was particularly painful for LDCs where Programmes of Activities (PoAs) had finally started to foster many new projects and where past capacity building had started to bear fruit (Kreibich et al., 2017). Indeed, Africa represents 34% of PoAs compared to only 3% of regular CDM projects, while LDCs account for 19% of PoAs compared to only 1.6% of regular CDM projects (Figure 6). The declining market, however, threatened the gradual loss of this accumulating capacity of low-income countries to develop low-carbon projects.

Figure 6. Geographical distribution of PoAs and CDM projects until 2017.



Source: UNEP DTU (2017b)

4.2.2. Uptake of household-level technologies in developing countries

The accumulating experience with PoAs focused on household appliances in developing countries demonstrated that the uptake of new technologies might be much lower than expected. This was confirmed by case studies of projects focused on improved cookstoves in India (Aung et al., 2016) and Kenya (Freeman and Zerriffi, 2014) and water filters in Kenya (Pickering et al., 2017) raising issues about ex-post monitoring of emissions reductions and other co-benefits. It was suggested that more rigorous research was needed for underlying assumptions and monitoring approaches for household water treatment projects (Summers et al., 2015) and cookstoves (Lee et al., 2014). For cookstoves, it was additionally suggested that not enough effort has been directed to assessing the improved air quality (Balakrishnan et al., 2015).

However, these results are not unequivocal, as at the same time, a case study of improved cookstoves and water filters in Rwanda demonstrated very high uptake rates. It was suggested that continued engagement with households contributed to high adoption rates (Barstow et al., 2016).

An important challenge in using carbon finance for low-income households is that the current consumption may not reflect the real need for basic services. The CDM rules have evolved to include the consideration of this "suppressed demand" in baselines, but challenges remained to balance simplification with maintaining environmental integrity (Randall, 2015). The PoA structure also supported the dissemination of such household technologies more efficiently than project-based activities.

4.2.3. Accelerating CDM reform

At its 63rd meeting in September 2011, the CDM EB decided to establish a High-Level Panel to conduct a policy dialogue involving the civil society, policymakers and market participants. The intent was to review past CDM experience and prepare the mechanism for the post- 2012 period. The Panel was composed of 11 leaders of companies, NGOs and governmental bodies not directly involved in the CDM. The policy dialogue consisted of 58 public input submissions, 18 consultations with stakeholders and 17 informal meetings. In September 2012 at the 69th meeting of the CDM EB, the Panel published the final report consisting of 51 recommendations that address not only the CDM EB, but also other stakeholders including national governments, the UNFCCC and project participants (UNFCCC, 2012).

Key issues addressed in the CDM Policy Dialogue were: (i) streamlining the project cycle; (ii) changing the methods for determining additionality; (iii) modifying the role of the secretariat; (iv) improving the validation and verification model; (v) professionalization of the EB; (vi) implementation of an appeals mechanism; and (vii) strengthening the current stakeholder consultation system (Classen, 2012).

As discussed earlier, during the CDM's initial "gold rush" period, many non-additional projects were registered because project developers could claim additionality using an ill-defined "barrier test". As a reaction, regulators replaced the barrier test by an investment test, which immediately resulted in the share of non-additional projects falling substantially (Michaelowa and Butzengeiger, 2017).

5. Carbon markets and regulatory frameworks post-Paris

5.1. Main features of the period: post-Paris revival of carbon markets

5.1.1. Evolving international climate policy regime

The 21st Conference of Parties (COP21) held in Paris in December 2015 marked an historical turning point regarding fighting climate change: the Paris Agreement (PA) established ambitious global mitigation targets, with the goal of limiting temperature increase well below 2°C, with efforts to contain the temperature increase within 1.5°C (Art. 2). Moreover, a balance of emissions by sources and removal by sinks is to be reached by the second half of the century (Art 4.1). A global stocktaking (Art. 14.1 and 2) will be undertaken every 5 years, starting in 2023.

Unlike the KP that only covered developed countries the PA adopted in 2015 involves global participation, which comes, however, at the cost of increasing complexity. Instead of a uniform formula, the PA allows Parties to voluntarily define their Nationally Determined Contributions (NDCs) indicating the mitigation and adaptation targets for each Party under the PA and can also identify the instruments and measures to achieve them. This new regime, however, resulted in a significant level of heterogeneity complicating mitigation accounting (Kreibich and Obergassel, 2016). The international climate regime has thus changed its character from a top-down approach based on mandatory emissions commitments to a bottom-up system of voluntary government pledges. Generally, the transition toward a bottom-up regime risks a reduction of transparency and increases in the transaction costs of mitigation (Michaelowa, 2015).

5.1.2. Market mechanisms under the Paris Agreement

The fate of international carbon markets post-Kyoto remained uncertain for a number of years. The negotiations under the UNFCCC on the New Market Mechanisms (NMM) and the Framework for Various Approaches (FVA), which covers both market-based and non-market-based approaches, have been ongoing since COP13 in Bali in 2007. Limited progress has been achieved by 2012 and a number of important design elements remained outstanding in the negotiations concerning the NMM and its modalities and procedures (Kulovesi, 2012). These negotiations advanced slowly towards COP21 and the inclusion of cooperative mechanisms into the PA was one of the last-minute surprises (Dransfeld et al. 2016).

In order to encourage international collaboration and improve the cost-effectiveness of the achievement of NDCs, the Article 6 of the PA provides an array of market and non-market mechanisms:

- **Article 6.2** defines Cooperative Approaches (CA) which can be used to transfer "internationally transferred mitigation outcomes" (ITMOs) to fulfil a country's NDC targets. CAs are generally understood to be a mean through which parties can trade ITMOs bilaterally or in groups for instance through GHG crediting mechanisms, linking of emission trading schemes or direct government-to-government transfers. The mechanism is subject to UNFCCC guidance, but not direct international supervision. It can therefore be compared with International Emissions Trading and the JI Track 1 under the Kyoto Protocol.
- **Article 6.4** establishes a new market mechanism for generation of emissions credits – often called "Sustainable Development Mechanism" (SDM) – which is centrally governed by a UNFCCC body and is also meant to contribute to sustainable development in host countries. From the governance standpoint, the SDM can thus be compared with the CDM and JI Track 2.
- **Article 6.8**, in contrast to the SDM and CAs, "recognizes" the importance of non-market approaches to (a) Promote mitigation and adaptation ambition; (b) Enhance public and private sector participation; and (c) Enable opportunities for coordination across instruments and relevant institutional arrangements. At this point in time it is unclear how such approaches will function at the end. Article 6.8 might for example become a framework for public climate finance flows.

5.1.3. Emerging national and regional carbon pricing initiatives

While the global carbon market under the KP declined, there has been an increasing number of carbon pricing initiatives around the world in the past several years. According to the World Bank, as of 2017, 42 national and 25 subnational jurisdictions have implemented carbon pricing (ETS or carbon tax) covering about 8 Gt CO_2e or about 15% of global GHG emissions. According to the World Bank's "State and Trends of Carbon Pricing" Carbon prices vary drastically from less than USD 1 to over USD 140 with the total global annual value of over USD 20 billion (Zechter et al., 2017). Moreover, 81 of the 155 Parties that have submitted their NDCs have indicated the intention to use carbon pricing as a tool to meet their commitments (ibid.). Further growth of carbon pricing initiatives including emissions trading schemes around the world can therefore be expected in the coming years. The combination of existing, emerging, and potential carbon market-mechanisms can be regarded as an emerging pre-2020 fragmented global carbon market landscape based on differing bottom-up market-based approaches (Redmond and Convery, 2015). While it is expected that carbon prices will be applied in an increasing number of jurisdictions, some suggested that carbon price levels will remain relatively low, and their mitigation benefits will be more than outweighed by the growth of infrastructure and consumption (Michaelowa, 2015).

5.2. Key market and regulatory challenges in this period

5.2.1. Increasing the mitigation ambition

The purpose of international carbon markets has changed from increasing economic efficiency to raising mitigation ambition (Cames et al., 2016). For example, while the CDM could theoretically increase ambition and provide "net mitigation" when crediting periods are shorter than the project lifetime, additionality issues put this possibility into question (Erickson et al., 2014). Discounting carbon credits and using baselines below business-as-usual were put forward as potential solutions (Warnecke, 2014).

One of the suggestions to boost ambition, was the creation of a Club of Carbon Markets (CCM) that would establish common standards for market infrastructure, transparency and environmental integrity (Keohane et al., 2017). It was argued that such a club could foster increased participation in climate change mitigation in the same way as the General Agreement on Tariffs and Trade (GATT) helped broaden trade in products and services.

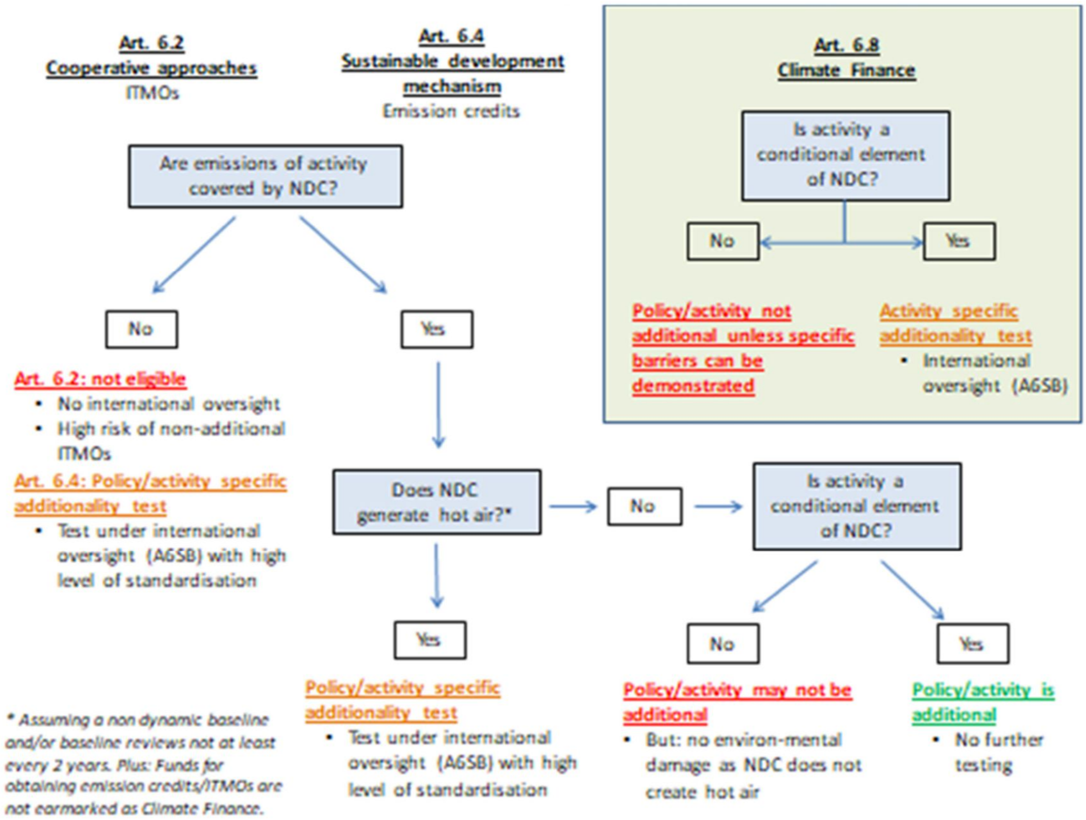
Linking different national and regional ETS was suggested to improve their economic efficiency and potentially help raise ambition. At the same time, there are some important risks related to linking, such as loss of control over domestic carbon policies (Ranson and Stavins 2016). "Exchange rates" were suggested to be used for linked systems in a similar way as currency exchange rates function (Pillay and Vinuales, 2016). Haites and Wang (2009) point out that linking different emission trading scheme does not in itself necessarily ensure higher environmental integrity of the linked systems. Moreover, actual difficulties should be considered and policy development and institutional cooperation are necessary to link different schemes. Tuerk et al. (2009) found that at that time only little advancement could be theoretically made to link different schemes, due to differences in policy priorities and needs for harmonization. Even if difficulties are present due to different domestic and international policies, it was argued that the EU and the USA would benefit from a linked carbon market (Sterk and Kruger, 2009). The issue of linking the fragmented carbon pricing initiatives therefore remains one of the open questions in the post-Paris international climate regime.

5.2.2. Baselines and additionality for mechanisms under Article 6

While the Article 6 mechanisms may provide governments with access to less costly mitigation options, they could also provide an important incentive to increase the ambition of NDCs over time. However, in order for this potential to be realized additionality must be defined carefully in the context of the Paris Agreement, especially if applied to policy instruments (Michaelowa, 2017).

Using the CDM experience, it was argued early on that new market mechanisms should be focused on ensuring a high level of environmental integrity (Newell 2012a) particularly through the determination of project additionality (Bento et al., 2015a; Michaelowa and Butzengeiger, 2017) and the emissions baseline used to calculate crediting volumes (Michaelowa, 2012; Bento et al., 2015b). Indeed, many NDCs have baselines that are above any credible business-as-usual path. It is thus highly likely that a significant number of NDCs would generate “hot air” if NDC baselines were to be used as a basis for crediting emission reductions or allocating emission allowances. The experience gained with JI leads to a clear recommendation for the Paris mechanisms – international oversight is crucial to prevent transfers of “hot air” (Michaelowa and Hoch, 2017). The issue of additionality under the Article 6 of the PA is further complicated by three factors (Spalding-Fecher et al., 2017). First, the nature of the conditionality of the NDC pledges is not clear. Secondly, there is a number of technical issues with translating the NDC pledges into metrics that are suitable for baselines and additionality assessment. Thirdly, using NDC pledges for crediting baselines assumes that these pledges are below business-as-usual emissions, which is not the case in practice (Michaelowa and Hoch, 2017). In the context of the Article 6 of the PA an additionality algorithm was suggested depending on whether a given activity is covered by an NDC, whether it is conditional or unconditional and whether an NDC is likely to generate “hot air” (Figure 7).

Figure 7. Suggested additionality test algorithm.



Source: Michaelowa and Butzengeiger (2017)

An important issue that was raised for renewable energy projects in developing countries was the fact that in in the context of widespread energy shortage, the extra electricity produced by the CDM projects is more likely to be used to provide extra electricity supply rather than substitute the Business-as-usual (BAU) electricity supply (Zhu and Tang, 2015). Appropriate baseline setting was found to be the best instrument for minimizing non-additional offsets compared to trade ratios and quantitative limits (Bento et al., 2015b).

It will also be important to make sure that the flexibility mechanisms do not deter setting ambitious emissions reduction targets and/or policies. Indeed, some researchers argued that the CDM is not neutral on the global level of carbon emissions as it entices countries to raise their emission caps (Brechet et al., 2016). It was therefore suggested that for future market mechanisms, a coordinated approach is needed to address potential trade-offs between global and national incentives at the sector-wide level (Liu, 2015).

5.2.3. Issues related to Monitoring, Reporting and Verification (MRV)

Monitoring, Reporting and Verification (MRV) is paramount in ensuring the environmental integrity of carbon markets and will therefore have to properly addressed in the rules for the implementation of the Article 6 of the Paris Agreement. MRV, however, comes at a cost that in the CDM ranged from several cents to EUR 1.20 and above per tCO_2e depending on the project type. Generally, there is a trade-off between the stringency and the cost of monitoring, which if not addressed properly may become a major barrier for the implementation of mitigation projects in some sectors, particularly in the context of currently low carbon prices (Shishlov and Bellassen, 2016). For example, monitoring rules under the CDM are often more stringent than those under the EU ETS, which could potentially put an unreasonable burden on project developers (Warnecke, 2014).

Double counting is another important carbon accounting issue that needs to be addressed under the PA. The key challenge is that double counting can occur in several different ways, such as double issuance and double claiming. While avoiding these problems is difficult it is technically possible through a coherent set of rules for accounting of units, design of mechanisms, and tracking and reporting of units (Schneider et al., 2015).

5.2.4. The future role of the CDM

The future role of the CDM remains uncertain and will depend upon the evolution of countries' NDCs and the development of the "Paris Rulebook" particularly for the Article 6. While the CDM is part of the KP, it could theoretically continue beyond 2020, for example, if recycled into the Sustainable Development Mechanism under Article 6.4 of the PA. In this respect, different scenarios for the CDM future – from expansion to phase-out – can be envisaged (Vivid Economics, 2012).

With regards to pre-2020 action, several recommendations were made, most notably (Cames, 2016):

- Limiting the purchase of CERs to either existing projects with discontinuation risk, such as landfill gas flaring, or to new projects that have a high likelihood of ensuring environmental integrity.
- Accompanying purchase of CERs with support for a transition of host countries to broader and more effective climate policies.
- Focusing international crediting mechanisms to address specific emission sources in countries that do not have the capacity to implement alternative climate policies.

In some instances, the CDM might be seen as a transition mechanism to other climate policies, once the abatement cost has been discovered by the market. This was the case, for example, with HFC emissions that were included in direct regulations under the Montreal Protocol after the initial experience under the CDM. In some countries – most notably China – the CDM is being transformed into a domestic offsetting mechanism under the newly piloted national carbon trading scheme with more than 2000 projects re-validated for this purpose (Lo and Cong, 2017).

5.2.5. Sustainable development benefits and avoiding harmful effects

As the Article 6.4 of the PA explicitly focuses on sustainable development benefits, the issue of alignment of climate and development agendas is gaining new momentum. Studies demonstrated that existing frameworks under the CDM, REDD+ and GCF do not sufficiently integrate the issue of sustainable development in their rules and processes, as host countries' governance entities maintain the decisive role in the approval process (Horstmann and Hein, 2017).

While the CDM did not provide explicit incentives for boosting SD-benefits, the voluntary carbon market might have partially achieved that objective. For example, Parnphumeesup and Kerr (2015) found that 56.4% of the buyers were willing to pay a price premium (on average EUR 1.12/tCO_2e) for carbon credits certified under the Gold Standard. Charity groups and governments are more likely to place a price premium on certified credit than private sector buyers. Torabi and Bekessy (2015) demonstrated on the example of carbon sequestration projects in Australia that corporate social responsibility (CSR) was the main driving force for business interest in the co-benefits of carbon projects.

One issue related to sustainable development is making sure that carbon market mechanisms do not produce harmful environmental or social impacts, which was raised as an important issue in several sectors. For example, Leonard (2015) argued that carbon finance projects in the waste sector in South Africa stimulated waste accumulation in order to secure methane for carbon credits rather than fostering broader recycling, which has negative social and local environmental impacts. Gender issues related to improved cookstove projects in Africa were also raised (Wang and Corson, 2015).

5.2.6. Sector-specific considerations

While energy efficiency is deemed to be one of the most important options to mitigate GHG emissions, studies demonstrated that carbon pricing signals might not be sufficient to unlock large-scale investments. For example, a survey of 509 industrial and commercial firms in Ukraine showed that an array of economic, behavioural, and institutional barriers may impede the deployment of energy-efficient technologies. Complementary policies, such as information provision and energy audits might therefore be necessary (Hochman and Timilsina, 2017).

It was demonstrated that for many urban projects, such as in transportation, the value of co-benefits of low-carbon investments by far outweighs the carbon value (Rashidi et al., 2017). However, as the case study of the Delhi Metro CDM project demonstrates, the evaluation and attribution of reduced local pollution (N_2O and PM) might be challenging (Goel and Gupta, 2017). Overall, it was suggested that carbon finance in the form of the CDM might not be suitable for low-carbon infrastructure investments in African cities (Silver, 2015).

Cities might therefore require a more holistic approach through low carbon development (LCD) strategic planning. The World Bank together with DNV KEMA Energy and Sustainability successfully supported the development of the Low Carbon City Development (LCCD) Programme for Rio de Janeiro (Rescalvo et al., 2013).

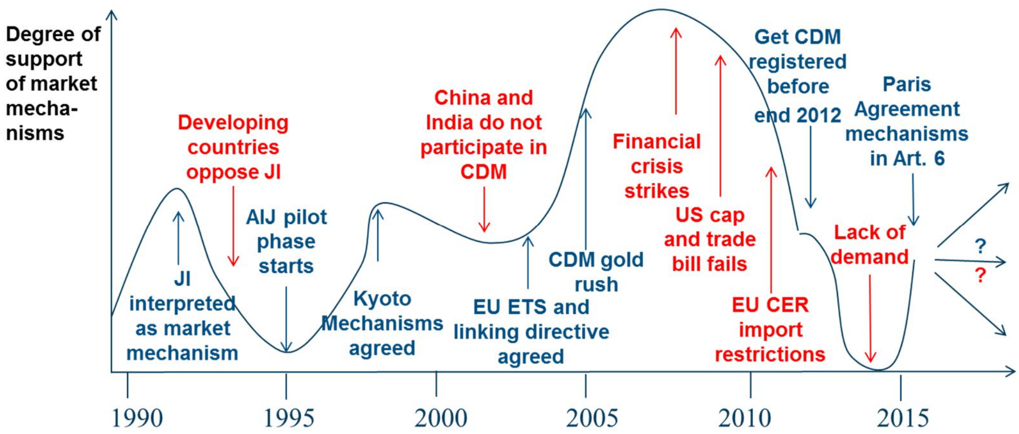
The objective of balancing GHG emissions and sinks under the PA puts an implicit emphasis on CCS technologies. CCS was officially included in the CDM in 2011 after several years of negotiations (Thorpe, 2012; Dixon et al., 2013). However, there was no uptake due to very high abatement costs of this project type. For example, it was estimated that a carbon price of above USD 50/tCO_2e is required to make CCS CDM projects feasible in India (Eto et al., 2013). The overall suitability of CCS as a mitigation solution was questioned from a political and climate governance standpoint, since it raises the question about the potential continuation of the use of fossil fuels (Krüger, 2017).

"Blue carbon" activities provide a large potential for carbon sequestration and several countries including Kenya, India, Vietnam, and Madagascar have been piloting these activities using carbon finance (Wylie et al., 2016). A case study of Philippines demonstrated that tapping into the "blue carbon" mitigation potential requires carbon prices of USD 5-12/tCO_2e (Thompson et al., 2014). The case study of Guinea-Bissau indicated the necessary carbon price in the range of USD 6.7-7.2/tCO_2e (Vasconcelos et al., 2015). The inclusion of "blue carbon" activities under the mechanisms of the PA remain uncertain (Herr et al., 2017).

6. Conclusions

The international carbon markets experienced widely varying fortunes since the 1990s. This is due to political and economic drivers that affect the development of the carbon markets. The following figure depicts the different phases and fortunes of market mechanisms, as well as their key drivers.

Figure 8. Differing fortunes of carbon market mechanisms over time.



Note: Blue colours denote positive influence on the markets, red ones negative influences

6.1. Emergence of carbon markets until 2005

This period is characterized by the introduction of market mechanisms as a climate change mitigation tool. Parties to the UNFCCC negotiated the definition of the flexible mechanisms that were included in the Kyoto Protocol (1997) and their operational rules and procedures that were included in the Marrakech Accords (2001). The operationalization of the CDM and JI required the establishment of officially approved baseline and monitoring methodologies and piloting activities in different sectors. The nascent carbon market was characterized by the lack of demand from the private sector making the initial participation of the public sector through various credit purchasing programs and carbon funds crucial.

6.2. "Gold rush" period from 2006 to 2011

After the initial testing period, the carbon markets entered a phase of great expansion. This period is characterized by significant changes in markets and regulatory frameworks as the EU ETS became operational and was linked to the CDM creating a large source of demand for carbon credits from the private sector adding to the demand from governments, e.g. in Japan.

Large developing countries, such as China, India, Brazil, Mexico and South Korea became the largest suppliers of carbon credits under the CDM. This raised concerns about the uneven distribution and limited participation of LDCs. The introduction of the PoA concept was aimed at addressing this issue. In terms of the sectoral breakdown, the supply of carbon credits was initially dominated by industrial gas projects that provided a cheap GHG abatement opportunity but raised criticism for creating perverse production incentives and not contributing to sustainable development. Additionality also emerged as a key issue particularly for large-scale renewable energy projects, such as large hydro. In the second part of the gold rush period, regulation regarding assessment of CDM project additionality and verification was strengthened significantly, with validators and verifiers becoming more careful following suspensions of accreditations by the regulators due to low quality work.

6.3. Fragmentation and decline of carbon markets in 2011-2015

This period is characterised by a sudden decline in carbon prices between 2011 and 2013 and the resulting decline in the development of new carbon projects. This is related to both domestic and international regulatory regimes. At the domestic level, the issuance of carbon credits started reaching the quantitative limits on the use of offsets in the EU ETS effectively eliminating the largest source of demand. The qualitative limits on the use of offsets that were introduced by the EU starting in 2013 therefore did not really matter. At the international level, the uncertainty surrounding the second Kyoto Commitment Period resulted in decreased demand from governments. The carbon market price collapse also led to multiple bankruptcies or scaling down of specialized consulting firms, in turn resulting in the gradual loss of expertise as specialists moved to other fields.

6.4. Post-Paris period of "relaunch" of market mechanisms

The post-Paris period is characterised by significant changes in the international climate regime that will affect the development of carbon markets in the future. Unlike the Kyoto Protocol that only covered developed countries, the Paris Agreement adopted in 2015 involves global participation, which comes, however, at the cost of increasing complexity. Instead of a uniform formula of "carbon budgets" translated in tonnes of CO_2eq, the Paris Agreement allows Parties to voluntarily define their Nationally Determined Contributions (NDCs) indicating the mitigation and adaptation targets for each Party. While the Paris Agreements includes provisions for market mechanisms through Articles 6.2 and 6.4, their modalities and procedures have not been adopted yet and the practical implementation remains uncertain. Principally, their scope could be upscaled to cover policy instruments or even entire sectors, which will inevitably raise issues how to guarantee additionality and set crediting baselines. While the international carbon market remains uncertain, an increasing number of domestic carbon pricing initiatives have been launched around the world in the past several years.

Table 1: Key features and challenges of the different carbon market periods

Time period	Main features of the period	Key challenges
Until 2005 (i.e. initial negotiations on flexible mechanisms and enter into force of the Kyoto Protocol)	- Parties negotiate for the definition of the flexible mechanisms and for the definition of their operational rules and procedures - After initial testing through AIJ, the CDM, JI and IET are agreed - Initial implementation of activities in different sectors - Carbon markets created and catalysed to demonstrate the potential for low cost emission reduction and compliance with Kyoto targets - Environmental integrity and economic efficiency of the mechanisms are studied in detail	- Evaluation of the cost effectiveness and associated risks for investors - Initial testing of different design models - Environmental integrity and contribution to Sustainable Development - Baseline setting and additionality concerns - Provision of incentives for technology transfer and innovation - Definition of eligible activities and associated issues for the forestry sector - Forestry projects are criticized for the negative impacts on SD at local level and for indigenous people
2006-2011 “Gold rush” of the carbon markets, with increasing numbers of mitigation projects implemented and credit prices rising	- After the initial testing period the carbon markets start a phase of great expansion. EU is the main source of demand for CDM credits while China and India dominate their supply - Improvements of the rules of the CDM, with operationalization of the PoA concept reducing transaction costs of small scale projects and contribute to a more balanced distribution - Governance and institutional set up, including capacity building needs, emerge as a key element for the carbon market functioning	- Additionality and baseline setting face significant issues affecting the environmental integrity of the CDM - Questionable contribution to SD and technology transfer - “Low hanging fruits” and uneven geographical distribution, penalizing Africa - Forest sector under close scrutiny also during this period, to avoid adverse impacts and ensure delivery of local SD benefits - Projects risks are assessed in more detail, through analysis of several years of operations
From 2012 until 2015	- After the “gold rush”, uncertainties on the future climate regime and lack of mitigation ambition of Annex I countries affect the carbon markets negatively - After failure of the Doha Amendment in December 2012 on ratification of the second commitment period of Kyoto (CP2), prices drop quickly reaching all-time low. Investors have less confidence on market mechanisms - Regarding the JI and CDM, only PoAs still show signs of life, with submission for registrations and issuances, although with limited numbers - CDM reforms in order to reduce transaction costs	- Carbon credit supply hits the EU’s demand ceiling - Supply-demand disequilibrium leads to carbon price collapse - Carbon prices are too low to sustain projects - Risk of project discontinuation and capacity loss
From 2015 to present	- Prices in the carbon markets are still very low. Limited activities in the international carbon markets - The PA brings positive developments regarding market instruments through Article 6. Detailed modalities and	- Need to increase mitigation ambition at global level - Transition of the CDM to the PA is contentious. Issues with baselines and additionality, and on MRV

Time period	Main features of the period	Key challenges
	procedures for the new mechanisms (i.e. the SDM and CAs) are still to be defined - An increasing number of developed and developing countries implements or plans to do so, carbon pricing initiatives, some of which allow use of credits	- Stronger emphasis on the importance of SD benefits and need to avoid negative impacts of market mechanisms

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8. Annexes

Annex 1. Journals with more than five papers retained

Journal	No. of papers retained
Energy Policy	67
Climate Policy (Earthscan)	39
Carbon & Climate Law Review	38
Ecological Economics	19
Climatic Change	17
Mitigation & Adaptation Strategies for Global Change	17
Mitigation and Adaptation Strategies for Global Change	15
Environmental Science and Policy	10
Journal of Cleaner Production	10
Global Environmental Change	10
Carbon Management	10
Journal of Environment & Development	10
Climate Policy	9
Energy Procedia	8
International Environmental Agreements: Politics, Law & Economics	8
Climate & Development	8
Renewable and Sustainable Energy Reviews	7
Energy & Environment	7
Waste Management	7
Global Environmental Politics	6
Journal of Sustainable Forestry	6
Energy for Sustainable Development	6
Total	334

Annex 2. List of seminal papers added using expert judgement

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- Spalding-Fecher, Randall; Achanta, Amrita; Erickson, Peter; Haites, Erik; Lazarus, Michael; Pahuja, Neha; Pandey, Nimisha; Seres, Stephen; Tewari, Ritika (2012): Assessing the impact of the Clean Development Mechanism. CDM Policy Dialogue, Bonn
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