Kyoto University,
Graduate School of Economics
Discussion Paper Series

Developing the North American Carbon Market:

Prospects for Sustainable Linking

Sven Rudolph, Achim Lerch, and Takeshi Kawakatsu

Discussion Paper No. E-16-009

Graduate School of Economics
Kyoto University
Yoshida-Hommachi, Sakyo-ku
Kyoto City, 606-8501, Japan

November, 2016

DEVELOPING THE NORTH AMERICAN CARBON MARKET

PROSPECTS FOR SUSTAINABLE LINKING[1]

Sven Rudolph, Achim Lerch, Takeshi Kawakatsu[2]

1 Introduction

The Paris Agreement is certainly a diplomatic success and it blazes the trail for future global climate action. However, in order to achieve its target of keeping the global temperature increase significantly below 2°C, the Agreement has to be substantiated by more ambitious reduction targets and policies (UNFCCC 2016). Regional interlinked carbon markets provide a promising option to do so (Lerch 2016).

Carbon markets, despite of some criticism, are still a valuable policy instrument. They minimize compliance costs and achieve pre-set targets accurately (Tietenberg 2006). They can be designed to fulfill ambitious criteria of sustainable development like environmental effectiveness, economic efficiency, and social justice (Rudolph et al. 2012). And the benefits of linking domestic carbon markets certainly dominate the concerns (Flachsland et al 2009, Ranson/Stavins 2015, Tuerk et al 2009). Not least, carbon markets have been spreading internationally across all governance levels (ICAP 2016).

Sub-national policies are an important supplement to global and national measures. The New Environmental Federalism (Oates 2004, Rudolph/Morotomi 2016) objects to earlier warnings of a "race to the bottom" and underscores the value of sub-national regimes as policy laboratories;

---

[1] Discussion paper presented at the 17th Global Conference on Environmental Taxation – Smart Instrument Mixes in a Greening Economy (GCET17), September 22-23, 2016, University of Groningen, Netherlands.

[2] Dr. Sven Rudolph, Associate Professor, Graduate School of Economics, Kyoto University, Japan; Dr. Achim Lerch, Professor, Hessian University of Cooperative Education (Hessische Berufsakademie), Germany; Takeshi Kawakatsu, PhD, Associate Professor, Faculty of Public Policy, Kyoto Prefectural University, Japan. Contact: rudolph@econ.kyoto-u.ac.jp.

in addition, on the local and regional level policy measures can be tailored to residents' preferences and to the particular infrastructural needs in order to increase economic welfare.

In practice, Canada and the US, both global Top 10 emitters of per capita carbon dioxide (CO_2) and total greenhouse gases (GHG), are obvious examples for, on the one hand, the political failure of national carbon pricing and, on the other hand, the success of regional schemes. The US Northeast, California, and Québec have already been using carbon markets for some years, Ontario and Manitoba have scheduled their schemes for the near future, and Washington State is also sincerely considering cap-and-trade. Not least, the US Clean Power Plan (CPP) might produce new dynamics, because the Environmental Protection Agency (EPA) offers a Cap-and-Trade Model Rule to US states, the implementation of which would almost automatically guarantee state compliance with federal CO_2 standards (EPA 2015).

As research on the sustainability of regional carbon market linkages in North America is virtually non-existent, in this chapter we ask if and how these linkages can foster efficient, effective, and fair climate policy in the US and Canada. We do so by, first, reviewing the arguments on efficient and effective carbon market design and linking and then adding a social justice component. Second, we give an overview of established and upcoming carbon markets in Canada and the US and identify the chances and barriers of linking. Third we evaluate the programs based on sustainability criteria and analyze the prospects for linking. We show that North America has a new historic chance to act as a role model for sustainable climate policy developed from the bottom-up by linking sub-national carbon markets.

2 Sustainable Carbon Markets and the Gains from Linking

2.1 Sustainability Requirements for Carbon Markets

Economists have long outlined the positive economic and environmental effects of cap-and-trade such as the accuracy in reaching an environmental target, static cost efficiency, innovation incentives (dynamic efficiency), the implementation of the polluter-pays-principle (PPP), the reduction of administrative and transaction costs, the reduction of competitive distortions, the definition of distinct property rights, as well as the separation of scale, distribution, and allocation decisions (Bromley 1991, Daly 1996, Endres 2011).

However, in climate policy practice, obviously much of the promised positive effects of carbon markets depends on the actual design of GHG cap-and-trade programs (Weishaar 2014). Yet, as we showed in an earlier paper (Rudolph et al. 2012), carbon markets can be made sustainable, so that they not only fulfill ambitious criteria of environmental effectiveness and economics efficiency but also contribute to social justice. Building on environmental economics' and climate justice theory, we derived a set of design recommendations for sustainable domestic carbon market, which did not exhibit major contradictions between environmental, economic, and social requirements but rather pointed in the same direction (Tab. 1): a mandatory cap-and-trade scheme with comprehensive coverage, an ambitious volume-based cap, and full auctioning of emission allowance combined with a reasonable re-distribution of auctioning proceeds.

Table 1: Sustainable Carbon Market Design

	Sustainable Carbon Market Design
Coverage	mandatory all GHG (applying CO_2e) all polluters
Cap	absolute volume scarce based on 2°C target (e.g. 25-40% by 2020, base 1990)
Allocation	unit of 1 t of CO_2e/a 100% auctioning for all polluters frequent, non-discriminatory auctions equally accessible market
Revenue Use	100% revenue recycling in a sensible combination of measures for climate protection, tax system efficiency enhancement or budget deficit reductions, and immediate cost compensation for low-income households with a clear focus on the latter
Flexibility Mechanisms	unlimited banking no borrowing offsets limited to high-quality projects (sustainability criteria)
Price Management	price floor no price ceiling
Compliance	short control periods (longer trading periods possible) continuous emissions monitoring; emission and allowance tracking and registration deterring fines on non-compliance; ex post compensation of excess emissions

Source: Rudolph et al. 2012

However, even perfectly designed, sustainable, domestic carbon markets can gain from inter-market linking in terms of economic efficiency, environmental effectiveness, and social justice.

2.2 Sustainability Gains from Linking

Linking – and we focus on multilateral direct linking here – previously separated schemes obviously enhances the economic and environmental performance of carbon markets

(Flachsland et al 2009, Ranson/Stavins 2015, Tuerk et al 2009): First and foremost, linking reduces the total costs of achieving a pre-determined emission reduction target. In general, cap-and-trade achieves cost efficiency by equalizing marginal abatement costs (MAC) across all polluters, pollutants, and time periods via a unique price signal. The bigger the differences in MAC are ex ante, the greater the efficiency gains from using cap-and-trade (e.g. compared to command-and-control) are. Separate markets with their own unique price are internally efficient; but overall efficiency of reaching the two systems' added total target can be increased by linking and by generating one price signal for all polluters. The linked system then covers more polluters (and maybe even pollutants) with probably bigger differences in MAC, which leads to efficiency gains not only compared to other instruments but also compared separate markets. In addition, market liquidity might increase and price volatility decrease.

However, innovation incentives might be weakened by linking two cap-and-trade schemes with differing ambitions and MAC. Innovation incentives for polluters are determined by internal MAC and the allowance price. While in the short-run MAC are immutable for each individual polluter, linking changes the price. Compared to the ex ante situation the unique average price in the linked system raises the price in the scheme with higher MAC and/or a more stringent cap and lowers the price in the scheme with lower MAC and/or a more lenient cap. Hence, the innovation incentives for emitters in the ex ante high price scheme decrease, while those in the low price scheme increase; the result would thus only be a shift or re-allocation of innovation incentives. However, assuming the usual downward sloping shape of the MAC curve, regions with high MAC already dispose of modern abatement technologies, while polluters in low-MAC regions might buy modern technologies from high-MAC regions without engaging in additional research and development. Hence, linking might reduce innovation incentives in high-price regions without increasing them in low-price regions.

Administrative costs are a considerable cost component in public policy, but linking might lower these costs. Administrative costs are usually determined by the complexity and the number of government agency's tasks, e.g. in the case of the initial distribution of allowances or the verification of compliance. If linking prevents the duplication of administrative tasks by bundling, e.g. by using uniform initial distribution rules across the linked system, by using one auctioning platform, or by sharing one registration systems, respective costs could be reduced.

Transaction costs, being costs of property right transfers between private agents, can also be reduced. Using one stock exchange as the major base of secondary market transactions in the newly linked system could e.g. reduce search costs for interested parties.

Linking can also reduce competitive distortions and leakage. Competitive distortions might result from differences in environmental prices between jurisdictions. With respect to carbon markets, leakage in terms of production capacities, jobs, and emissions from one jurisdiction with high carbon prices to others with low or no prices has hence been an issue intensively discussed in the literature (Copeland/Taylor 2005). Without doubt, at least in the long run, decreasing prices resulting from overall efficiency gains by linking would lower the danger of leakage. Still, in the short run, linking might increase the danger of leakage in the ex ante low-price regions and reduce it in the ex ante high-price regions, with the net-effect being difficult to predict and depending on the concrete competitive situation of the respective polluters. However, linking could at least eliminate the danger of leakage amongst the two previously unlinked schemes with an ex ante price differential. Not least, linking transform two small markets into a bigger one, which might also reduce the probability of competitive distortions from monopolization.

Different from economic and environmental effects of carbon market linkages, however, the social justice implications are neither immediately obvious nor have they been sufficiently studied yet. One reason for this is the fact that, while social justice in climate policy is a “key enabler of ambition”, the concept itself remains “elusive” (Klinsky/Winkler 2013: 6, 1). However, as has been shown in another paper (Lerch/Rudolph 2016), differentiating sub-concepts such as procedural justice vs. the result of distributive justice, justice in transfer/acquisition vs. justice within allocation vs. redistributive justice, desert-based justice and welfare-based justice, egalitarianism vs. non-egalitarianism, inter- and intra-generational justice, and national and international justice offers a clearer view on the variety of social justice implications of carbon markets and allows for designing more socially just schemes.

Linking domestic schemes can even generate additional positive effects, especially referring to the result of distributive justice as well as justice within allocation and redistributive justice: First, expanding the market promises efficiency gains and lower costs, which has several positive effects on the social justice of carbon markets: It relieves current generations from unnecessarily high cost-burdens of achieving a pre-given target and hence serves intergenerational justice. Additional cost savings also offer a bigger margin for re-distributional measures such as supporting developing countries in climate adaptation and by that fostering intra-generational international justice or compensating for the regressive effect of carbon pricing and by that serving intra-generational national justice. Not least, lower total compliance costs and hence carbon prices in a linked system can also reduce carbon leakage to regions with no or a low carbon price, which in turn strengthens climate protection and serves intergenerational justice.

Second, linking aligns differing carbon prices from ex ante separated markets and hence reduces competitive distortions between polluters regulated under a previously more stringent scheme and those faced with a less stringent cap; this undoubtedly serves the equality criteria of socially justice. In addition, this price alignment between jurisdiction with ex ante low and high allowance prices also serves the polluter-pays-principle and intra-generational justice, because the new average price in the linked system additionally burdens the laggards and disburdens the pioneers.

However, linking could also lead to more intra-generational national injustice, because a carbon price increase in the ex ante low-price jurisdiction can put a higher relative burden on poor households or disadvantaged communities due to the regressive effect of energy price increases. Yet, the eventual energy cost effect largely depends on how the efficiency gains of linking are re-distributed in the respective jurisdictions; overall even the low-price region benefits from cap-and-trade. And, auction revenues can be used for compensating poor households or disadvantaged communities.

Overall, even sustainable domestic carbon markets can gain from linking in terms of environmental effectiveness, economic efficiency, and social justice. A sustainable market-based climate policy from the bottom-up as a supplement to national or global regimes thus seems reasonable.

Yet, while design prerequisites for linking have been intensively studied from the environmental economics perspective, research on requirements from the social justice perspective is still in its infancy (Lenz et al. 2014). However, while some differences in design elements such as price corridors or cap stringency cause major disturbances when linking happens, most differences do not constitute insurmountable barriers. Apparently, yet, the more similar domestic programs are, the easier inter-market linkages can be achieved and the smaller market disturbances are.

Hence, with some design alignments already achieved by supra-regional model rules such as the Western Climate Initiative (WCI 2008) and more on the horizon stimulated e.g. by the Clean Power Plan Model Trading Rule (EPA 2015), North America now has a historic chance to prove the sustainability of sub-national carbon market linking. Both the US and Canada have experienced the failure of ambitious national-level carbon pricing schemes, while on the other hand more and more sub-national schemes have been surfacing and already existing programs have been reformed and significantly improved.

3 Regional Carbon Markets in Canada and the US

3.1 The Regional Greenhouse Gas Initiative

The Regional Greenhouse Gas Initiative (RGGI) was the first large-scale, multi-state carbon market in the US. It went into operation in 2009, with a major revision in 2014. While intended to be a multi-state program from the beginning, it now comprises legally independent carbon markets of nine North Eastern US states (RGGI 2013).

RGGI is mandatory for all fossil-fuel-based power generation units of at least 25MW and covered 163 entities in 2016. RGGI caps CO_2 emissions alone, so that the total coverage is only 20% of all RGGI region's GHG emissions.

While the absolute volume cap was initially set at a generous constant 188 million US tons of CO_2 per year from 2009 to 2014 (4% above average 2002-2004 emissions) and a reduction path of 2.5% per year in Phase II, the tremendous oversupply led to a cap reduction by more than 50%

in 2014. For 2014 the cap was set at 91 million US tons and it then entered the yearly reduction dynamics of 2.5%. In 2020 this results in a total emission reduction of around 50% compared to 1990 levels (approx. 155 m t).

RGGI rules oblige participating states to auction off at least 25% of all allowances, each worth 1 US ton (= 1.10231 metric tons) of CO_2 emissions in one year; in fact, however, more than 90% are being auctioned. New entrants have to buy all their allowances, and there are no specific rules for returning unused allowances in the case of facility shut-downs. Allowances can be bought from non-discriminator state auctions held quarterly (March, June, September, December). The allowance market is open to all covered entities and interested parties. Allowances can also be obtained from several secondary markets such as the Chicago Climate Futures Exchange (CCFE).

For revenue use, the auctioning rules oblige participating states to invest all revenues from the 25% mandatory auctioning share in consumer benefit programs (energy efficiency, renewable energy, direct energy bill assistance, other greenhouse gas reduction programs). However, the real auction share of approx. 90% leaves a lot of leeway to participating states, so that in fact two thirds of all revenues are used for climate and energy programs, 15% go to the support of disadvantaged communities, and 15% to budget consolidation.

In order to allow flexibility and banking is unrestricted; however, Phase II caps were adjusted for Phase I banked allowances in the 2014 reform. Borrowing is prohibited. Offset use is limited to 3.3% of entities' liabilities and to additional and sustainable CH_4, SF_6, and CO_2 project credits from agriculture, forestry, waste treatment, and end-use energy efficiency measures within the US. While the early program allowed the use of Kyoto credits if allowance prices exceed 10 US$, since the 2014 reform no such credits are accepted.

For price control, RGGI implemented a floor price of US$ 1.89, which has increased annually by 2.5%. In addition, the 2014 reform implemented a Cost Containment Reserve (CCR) populated with 10 million allowances taken from the overall budget and refilled only if necessary. CCR allowances are auctioned if the carbon price exceeds US$ 4 US$ (2014), 6 US$ (2015), 8 US$ (2016), or 10 US$ (2017); after 2017 trigger prices increase by 2.5% per year.

Control periods are three years, after which 100% of emissions have to be covered by allowances; but in addition, after the first two years of each control period 50% of needed allowances must be held in stock, providing extra safety in terms of compliance. Emissions data is continuously provided by the US Environmental Protection Agency (EPA) based on 1995 Clean Air Act (CAA) rules. Allowances, emissions, and transfers are recorded in the CO_2 Allowance Tracking System (COATS), which is even open to the public. In the case of non-compliance, fines of up to US$ 25,000 apply in addition to a 3-for-1 excess emissions coverage requirement.

Linking with other jurisdictions, however, has so far not ranked high on RGGI's agenda.

3.2 The California-Québec Cap-and-Trade Program

California now runs the second biggest carbon market in the world (CARB 2013, CARB 2015). The program was put into operation in 2013, with a major expansion in 2015. Since 2014, under the umbrella of the WCI, the California Cap-and-Trade Program has been linked to Québec's carbon market, which itself started in 2013 (GdQ 2014).

Participation is mandatory for all eligible entities in both California and Québec. Both schemes include all Kyoto gases (CO_2, CH_4, N_2O, SF_6, HFCs, PFCs) plus NF_3 and have been covering large industrial facilities, power generation, and electricity imports downstream since 2013, but expanded coverage in 2015 to also include emissions from liquid and gaseous fossil fuel use in smaller facilities, buildings and the transport sector upstream. The size threshold for participation in both programs is emissions of at least 25,000 t CO_2e per year; thus, in 2016 California covered 450 entities and Québec 80. In total, the programs cap 85% of both regions' GHG emissions.

California' carbon market had an absolute volume cap of 163 million tons of CO_2e in 2013, which was 2% below the level forecasted for 2012; in 2014, the cap again was reduced by 2%. In 2015, due to broadened coverage, the cap increased to 395 m t and will reach 334 m t in 2020 by an annual reduction of 3%. Total reductions for the covered sectors thus sum up to about 15% below 1990 levels. Québec's cap was 23 m t annually in the first compliance period. The broadened coverage raised the cap to 65 m t in 2015 and it will be reduced by 1-2% annually to a final of 55 m t in 2020, which is about 25% below 1990 emissions of the covered sectors.

California and Québec both hand out allowances each worth one metric ton of CO_2e emissions in a given year. In California, electrical distribution utilities receive 90% of average emissions free of charge, but the economic value of these has to be almost entirely redistributed to ratepayers. Around two thirds of these allowances go to investor-owned utilities (IOU), while only one third goes to public-owned utilities (POU). POU can directly use allowances for compliance, but IOU have to consign their allowances to auctions and buy back the amount needed for compliance. Natural gas utilities‘ allocation is based on 2011 supply to non-covered entities, while transport fuel distributors do not receive free allowances. Industry also receives 90% of average emissions for free; the individual allocation depending on a product benchmark, the cap decline factor, and a carbon leakage assistance factor. However, the share of auctioning to industry is supposed to increase in the future. In Québec 100% of allowances needed for compliance have to be obtained at auctions or the secondary market by non-industry sectors such as utilities and fuel distributors. However, industries subject to international competition receive a major share of their allowances for free. Based on historical emissions, production level, and intensity targets, in the first compliance period facilities with combustion-based emissions receive 80% for free, while all others receive 100% for free. The share of free allocation, however, diminishes by 1-2% per year. In addition, in the second compliance phase, only 75% of allocated allowances are handed out at the beginning of each year, while the other 25% are only offered in September of the following year after emissions reports have been verified. In both jurisdictions, new entrants are served from an allowance reserve, which is endowed with an increasing share of allowances (1% in 2013-14, 4% in 2015-17, 7% in 2018-20) originating from the cap. If facilities are shut down allowances have to be returned. While in the first compliance phase California and Québec had separate auctions, both regions' environmental ministries have held joint non-discriminatory allowance sales quarterly in February, May, August, and November since 2015. The market is open to all covered facilities and interested parties. Allowances can be traded on secondary markets such as the Intercontinental Exchange.

Revenues are mainly used for climate protection in both California and Québec, but California explicitly redistributes some of the value to disadvantaged communities (Burtraw et al. 2012). As power and gas utilities receive allowances on behalf of their clients in California, at least 85% of the allowance value has to benefit rate payers and achieve GHG reductions. In the case of IOU the Public Utility Commission (PUC) decides about the concrete spending of the auction revenues, while in the case of POU the utilities themselves can distribute the allowance value. The revenue from auctions to industry is transferred to the Greenhouse Gas Reduction Account in the Air Pollution Control Fund. By law 25% of California's climate investments have to benefit disadvantaged communities and 10% even have to be allocated to projects within these communities. In Québec, however, all auction revenues go to the Québec Green Fund and are dedicated to climate protection projects, particularly related to the 2013-2020 Climate Change Action Plan. Yet, while there is no legal obligation, there is also on option for using revenues for mitigating negative social impacts of emissions reduction efforts.

Banking is allowed without limits in both California and Québec, while borrowing is prohibited. Also in both jurisdictions, offsets are allowed for coverage of up to 8% of individual entity's compliance obligations. Reductions have to be additional, durable, and verifiable, and offsets will be verified by independents agents. In California project types are limited to forestry, urban forestry, dairy digesters, rice cultivation, mine methane and the destruction of ozone-depleting substances in the US (while there exists a framework for international expansion). In Québec, province-based projects of ozone-depleting substance destruction, manure storage methane destruction, and landfill site gas capture are eligible.

For cost containment both California and Québec have established a price collar following similar rules: Acting as a price ceiling, from the above mentioned allowance reserve, allowances are sold in three equal price tiers at 40, 45 and 50 US$/CA$ (2013); but only entities registered in the respective jurisdictions are eligible. Representing the price floor a minimum auction price of 10 US$/CA$ was set (2013); in joint auctions Québec applies the higher price of the two. Both upper and lower price limits increase 5% over inflation.

Compliance periods in both California and Québec are 2013-2014, 2015-2017 and 2018-2020. In California, however, each year allowances worth 30% of the previous year's emissions have to be surrendered; the rest must be submitted at the end of each compliance period. Facilities in both California and Québec have to report their GHG emissions annually and get independent emission report verification. Both jurisdictions' emissions as well as allowances are registered in the joint Compliance Instrument Tracking System Service (CITSS). In the case of non-compliance, in California four allowances must be provided for every ton of emissions not covered in time and penalties of up to several thousand US dollars per day apply. In Québec penalties may amount to several million CA$ per case, imprisonment, and the suspension from any new allowance allocations are possible. In addition, three allowances have to be surrendered for each non-covered ton of emissions.

The California-Québec-link is a result of the co-operation under the WCI. From its beginning, the WCI, has considered domestic regional-level program linkages a major objective. Concrete program and linkage guidelines were provided as early as 2008 to WCI members including California, Manitoba, Ontario, and Québec (WCI 2008).

3.3 Ontario, Manitoba, and Washington State Cap-and-Trade Proposals

The Canadian provinces of Manitoba and Ontario as well as Washington State in the US also signed a memorandum of understanding that stated their intention to link their carbon markets under the WCI. While the design proposals for Manitoba and Washington State have not yet been announced in detail, the Government of Ontario published its draft legislation in February 2016 (GoO 2016). Ontario's carbon markets is supposed to start in 2017 after receiving final legislative approval and largely follows the California-Québec example.

The scheme covers CO_2 and non-CO_2 GHG emissions; however, so far, the legislation fails to include a comprehensive list of non-CO_2 GHG to be covered. In 2017, about 150 emitters are subject to the carbon market on a mandatory basis: electricity generation (including imports), stationary industrial production, and institutional or commercial activities with emissions of at least 25,000 t CO_2e per year. While stationary sources are covered at the facility level (downstream), transport fuels and natural gas are covered at the distributor level (upstream). New facilities have a grace period until their third year of operations before being covered by the program. Total coverage is expected to sum up to about 82% of Ontario's GHG emissions.

The cap is set on an absolute volume basis at roughly 142 m t of CO_2e. In 2017, the total number of allowances released into the system will be roughly equal to expected emissions for that year. The cap will then decline each year by around 4.4% starting from 2018 in order to achieve a total reduction of 15% below 1990 levels by 2020.

Electricity generators, electricity importers, and natural gas and transport fuel distributors are not eligible for free allocation. However, in the first compliance period, large industrial, institutional, and commercial emitters receive 100% of their allowances for free, applying an allocation method that still has to be decided by the Ontario government. This transition assistance factor will be reassessed prior to the beginning of the second compliance period. Auctions will be held four times a year and allowances are also available at secondary markets.

The province expects the cap and trade regime to generate about C$1.9 billion (US$1.5 billion) annually, with all of these proceeds being reinvested in initiatives that will reduce Ontario’s GHG emissions and support the transition to a low carbon economy.

Following California and Québec banking is unlimited, borrowing prohibited, and offsets are allowed for covering up to 8 of entities obligations.

As part of the WCI, Ontario intends to align its price collar with California and Québec, using a market stability reserve and an auction reserve price.

The first compliance period of the Ontario carbon market runs from 2017 to 2020, with successive three years compliance periods after that. Participants with excess emissions will be subject to a three-to-one compliance and penalties equal to Québec.

The Ontario government plans to link its proposed scheme with California and Québec as early as 2018.

4 Program Evaluation and the Prospects for Inter-Regional Linking

Overall, evaluating existing carbon markets and those in planning on the basis of compliance with sustainability criteria (see Tab. 1), certainly the WCI jurisdictions of California, Ontario, and Québec do best in terms of the sustainability requirement of comprehensive coverage, while RGGI only partly complies. The US Northeast, however, succeeds in terms of the criterion of a sufficiently ambitious cap in line with climate protection necessities, while the WCI jurisdictions lack ambition. In all programs, utilities and in the WCI regions also major parts of fuel distributors fully pay for their emission rights, while industries are largely exempted from auctioning in the WCI jurisdictions; hence the WCI programs only partly comply with the sustainability requirement of full auctioning. Revenues in all programs are mainly used for climate protection. Yet while RGGI states also allocate a minor share to social purposes and this also seems to be possible in Quèbec, California has the most explicit rules and the biggest share of revenue use for compensating low-income households; social justice as a major component of sustainable market-based climate policy is hence most strongly taken into account in California. Banking and borrowing rules follow sustainability requirements in all programs. Offsets are allowed in all programs, but they are limited in quality and quantity and RGGI is the least generous in terms of acceptance. All programs establish price collars with lower and upper price limits, using cost containment reserves and reserve prices; this only partly complies with sustainability criteria as price floors are reasonable while price ceilings are not, and hence, comparing the programs, the WCI regions with higher price floors and ceilings comply with sustainability criteria to a larger extent than RGGI. Compliance in all programs is verified in 3-years control periods, a reasonably short period, and RGGI and California even combine this with extra holding requirements for specific years of the control periods. Monitoring schemes and penalties combined with compensation requirements for excess emissions fully comply with sustainability requirements in all programs. In sum, WCI programs and RGGI partially comply with ambitious criteria for sustainable carbon markets. While RGGI mainly suffers from limited coverage, especially California and Ontario lack ambition in terms of the cap size.

Comparing program design, it is most obvious that programs under the umbrella of the WCI exhibit the greatest similarities. Coverage is almost identical, the rules for allocation and revenue use are quite similar, flexibility mechanisms and price management are largely aligned and so is the compliance system. The only design element that differs strongly between Quèbec and the other two WCI programs is the reduction target, with Quèbec being significantly more ambitious than California and Ontario. However, this does not act as a major barrier to linking. Linking WCI jurisdictions is hence easily achievable, which is certainly a result of ex ante negotiations on the WCI Model Rule and the early intention to link regional programs.

RGGI, however, differs a lot from the WCI programs in terms of coverage, ambition, and price management. Although technically possible, linking the WCI jurisdictions with RGGI would result in major price effects.

Still, the benefits of linking North American regional carbon markets are obvious: MAC differences between polluters in California, Ontario, Quèbec, and the Northeastern US states are certainly bigger than within the regions, so that linking promises significant efficiency gains. Administrative costs can be expected to decrease if, as in the case of using COATS and joint auctions within the WCID jurisdictions, emission and allowance tracking as well as the initial allocation are harmonized especially between the WCI and RGGI. While competitive distortions between WCI participants are certainly reduced already, those between WCI and RGGI polluters can only be reduced to a limited extent, because the sectors faced with inter-region or even international competition such as the industry and fuel sectors are not covered in RGGI and, without a change in program design, would still not be after linking. Hence, in the RGGI region, those sectors would still not have to pay a carbon price and would remain privileged. Yet, lower overall compliance costs reduce competitive distortions for covered sectors and lower the risk of leakage to non-covered jurisdictions outside of the RGGI-WCI carbon market. Again, however, this mainly applies to WCI jurisdictions as the threat of carbon leakage is significantly smaller for utilities covered in RGGI. Still, this would not only serve the environmental effectiveness especially of the WCI programs, but would also foster inter-generational justice. In addition, lower compliance costs would relieve current generations in the respective North American regions of unnecessary burdens and increase the margin for re-distributional measures, thus serving inter- and intra-generational justice. Not least, the alignment of previously differing carbon prices in the WCI and the RGGI region would serve the equality criteria of socially justice as well as the polluter pays principle. And while linking would certainly lead to a price increase in the RGGI region with probably unwanted regressive effects, RGGI states could use a bigger share of the auction proceeds for alleviating these effects.

5 Conclusions

Developing and linking sub-national carbon markets is a promising strategy for substantiating the Paris Agreement. Sub-national schemes can be tailored to local circumstances and peoples' preferences, and they can act as policy laboratories for the national and international level especially in jurisdictions where macro-level carbon pricing has failed so far, such as in Canada and the US.

Carbon markets can be designed in a sustainable way, so that they fulfil ambitious criteria of economic efficiency, environmental effectiveness, and social justice. Recommendations from the three perspectives all point to the same carbon market design: a comprehensive coverage of emitters and pollutants, stringent caps, full auctioning, and at least a partial use of revenues for the compensation of the regressive effects of energy price hikes. But even sustainable domestic carbon markets gain in efficiency, effectiveness, and justice, if interlinked.

Already 11 North American states and provinces have implemented and even partly linked their domestic carbon markets; and three more are about to implement and link their schemes. The design of these schemes already partially fulfill stringent sustainability criteria. Linking these schemes would lead to an even more effective, efficient, and just market-based climate policy from the bottom up. Model rules such as those developed under the WCI and the US CPP significantly facilitate a trans-national North American carbon market.

However, for advancing sustainable sub-national carbon market linking in North America more detailed research is certainly needed on

(1) the detailed social justice implications of linking carbon markets with differing design elements and a set of minimum design alignment requirements for fair linking;
(2) the design of (upcoming) North American carbon markets and their compliance with the requirements in (1); and
(3) the US Clean Power Plan Model Trading Rule's capacity to foster sustainable sub-national carbon market linkages in the US and beyond.

It remains to be hoped that Canada and the US fervently grab this new chance of being world leaders in developing a sustainable global carbon market form the bottom up.

References

Bromley, D.W. (1991), *Environment and economy – property rights and public policy*, Oxford/Cambridge (Blackwell)

CARB (2013), *California Cap on Greenhouse Gas Emissions and Market-based Compliance Mechanism to Allow for the Use of Compliance Instruments Issued by Linked Jurisdictions*, Sacramento

CARB (2015), *Overview of ARB Emissions Trading Program*, Sacramento

Copeland, B.R., Taylor, M.S. (2005), Free Trade and Global Warming – a Trade Theory View of the Kyoto Protocol, Journal of Environmental Economics and Management 49 (2), 205-234

Daly, H. (1996), *Beyond Growth – The Economics of Sustainable Development*, Boston (Beacon Press)

Endres, A. (2011), *Environmental Economics – Theory and Policy*, Cambridge (Cambridge University Press)

EPA (2015), Federal Plan Requirements for Greenhouse Gas Emissions From Electric Utility Generating Units Constructed on or Before January 8, 2014; Model Trading Rules, Amendments to Framework Regulations, Washington D.C. (EPA)

Flachsland, C. et al. (2009): To link or not to link – Benefits and Disandvantages of Linking Cap-and-Trade Systems, Climate Policy 9, 358-372

GdQ (2014), *Québec's Cap-and-Trade System for Greenhouse Gas Emission Allowances – Technical Overview*, Québec (Gouvernement du Québec)

GdQ (2016), *The Québec Cap-and-Trade System for Greenhouse Gas Emission Allowances – Frequently asked questions*, Québec (Gouvernement du Québec)

GoO (2016): *Proposed Climate Change Mitigation and Low-Carbon Society Act 2016 – The Cap and Trade Program (Consultation Draft)*, Toronto (Government of Ontario)

ICAP (2016), *Emissions Trading Worldwide – Status Report 2016,* Berlin (ICAP)

Lenz, C., et al. (2014), *Die Verknüpfung von Emissionshandelssystemen – sozial gerecht und ökologisch effektiv*, Kassel (Kassel University Press)

Lerch, A. (2016), Perspektiven der Klimapolitik nach Paris – Mehr Markt!, *Umweltwirtschaftsforum* DOI 10.1007/s00550-016-0398-3

Lerch, A., Rudolph, S. (2016) Just ETS? Social Justice and recent reforms in EU and US carbon markets. I: Stoianoff, N. et al. (Eds.): *Market Instruments and the Protection of Natural Resources*. Cheltenham/Northampton (Edward Elgar) (forthcoming)

Oates, W.E., (2004) *Environmental Policy and Fiscal Federalism*, Cheltenham/Northampton (Edward Elgar)

RGGI (2013), *Model Rule – Revised 2013*. New York

Ranson, M., Stavins, R.N. (2015), Linkage of greenhouse gas emissions trading systems, *Climate Policy* DOI: 10.1080/14693062.2014.997658.

Rudolph, S., et al. (2012), Towards sustainable carbon markets. In: Kreiser, L. et al. (Eds.): *Carbon Pricing, Growth and the Environment*. Cheltenham/Northampton (Edward Elgar), 167-183

Rudolph, S., Morotomi, T (2016), *Environmental federalism featuring sub-national carbon markets – Politico-economic arguments and the cases of the US Northeast, Tokyo, and California*, Discussion Paper presented at ISEE2016, Washington D.C., June 26

Tietenberg, T. (2006), *Emissions Trading*. Washington D.C. (Resources for the Future)

Tuerk et al. (2009), Linking Carbon Markets – Concepts, Case Studies, and Pathsways, *Climate Policy* 9, 341-357

UNFCCC (2016), Aggregated effect of the intended nationally determined contributions – an update, Bonn (UNFCC)

WCI (2008), *Design Recommendations for the WCI Regional Cap-and-Trade Program*, Sacramento (WCI)

Weishaar, S. (2014), *Emissions Trading Design – A Critical Overview*, Cheltenham/Northampton (Edward Elgar)

Table 2: North American Carbon Markets in Comparison

	RGGI	California	Québec	Ontario
Coverage	mandatory CO_2 utilities > 25MW total coverage 20%	mandatory CO_2, CH_4, N_2O, H-FKW/HFC, FKW/PFC, SF_6, NF_3 utilities and electricity imports as well as stationary industrial sources since 2013 (downstream); heating and transport fuel distributors (upstream) since 2015; all ≥ 25,000 t CO_2e 450 entities (2016) total coverage 85%	mandatory CO_2, CH_4, N_2O, H-FKW/HFC, FKW/PFC, SF_6, NF_3 utilities and electricity imports as well as stationary industrial sources since 2013 (downstream); heating and transport fuel distributors (upstream) since 2015; all ≥ 25,000 t CO_2e 80 entities (2016) total coverage 85%	mandatory CO_2, non-CO_2 GHG utilities and electricity imports as well as stationary industrial, institutional, and commercial sources (downstream) natural gas and transportation fuel distributors (upstream); all since 2017 and ≥ 25,000 t CO_2e 150 entities (2017) total coverage 82%
Cap	absolute volume 188 m t CO_2 (2009-13) 91 m t (2014) – 2.5%/a (2015-2020) 78 m t (2020) – 50% (1990/2020)	absolute volume 163 m t CO_2e (2013) – 2% (2014) 395 m t CO_2e (2015) – 3%/a (2016-2020) 334 m t CO_2e (2020) – 15% (1990/2020)	absolute volume 23 m t (2013-2014) 65 m t (2015) – 1-2%/a (2016-2020) 55 m t (2020) – 25% (1990/2020)	absolute volume 142 m t CO_2e (2017) – 4.4%/a (2018-2020) – 15% (1990/2020)
Allocation	unit of 1 short US ton ≥ 25% for purchase for power utilities (in fact 90%)	unit of 1 metric ton 90% free-of-charge for power utilities; economic value of allowance is given back to rate payers	unit of 1 metric ton 100% for purchase for power utilities	unit of 1 metric ton 100% for purchase for power utilities

		90% free-of-charge for industry (product benchmarks, leakage assistance factor, cap decline factor), increasing auctioning	80% free-of-charge for industries with combustion-based emissions and subject to international competition (historical emissions, production level, intensity target) (–1-2%/a 2015-2017, 75% ex ante, 25% ex post) 100% free-of-charge allocation for other industries subject to international competition (historical emissions, production, intensity target) (–1-2%/a 2015-2017, 75% ex ante, 25% ex post)	100% free of charge for all industrial, institutional, and commercial facilities
		100% of 2011 supply free-of-charge for natural gas suppliers		100% auctioning for natural gas distributors
		100% auctioning for transport fuels	100% auctioning for transport fuels	100% auctioning for transport fuels
	full auctioning for new entrants	free-of-charge for new entrants from reserve	free-of-charge for new entrants from reserve	
	no rules for shut-downs	allowance return in the case of shut-downs	allowance return in the case of shut-downs	
	four auctions per year	four auctions per year	four auctions per year	four auctions per year
	secondary market	secondary market	secondary market	secondary market
Revenue Use	100% of auction share for energy efficiency, renewable energy	85% of economic allowance value has to benefit rate payers and achieve emission reductions industry auction revenues for GHG reductions	100% of revenue for GHG reductions	100% of revenue for GHG reductions and transition to low carbon economy

		25% of investments in disadvantaged communities		
Flexibility Mechanisms	banking unlimited borrowing prohibited offsets 3.3% of facility emissions from US projects of CO_2, CH_4, or SF_3 reduction in agriculture, forestry, waste, buildings; verifiability, durability, additionality criteria apply, independent verification	banking unlimited borrowing prohibited offsets up to 8% of entity compliance obligation from US projects in forestry, urban forestry, dairy digesters, ozone-depleting substance destruction, mine methane capture; verifiability, durability, additionality criteria apply, independent verification	banking unlimited borrowing prohibited offsets up to 8% of entity compliance obligation from projects in manure storage methane destruction, landfill site gas capture, ozone-depleting substance destruction, mine methane capture; verifiability, durability, additionality criteria apply, independent verification	banking unlimited borrowing prohibited offsets up to 8% of entity compliance obligation
Price Management	cost containment reserve populated with 10 allowances from the cap price floor 1.89 US$ (+2.5%/a over inflation) price ceiling via allowance auctions from reserve if prices exceed 4 US$ (2014), 6 US$ (2015), 8 US$ (2016) (+2.5%/a over inflation from 2017 on)	cost containment reserve populated with 1 to 7% increasing share of cap price floor 10 US$ (+5% over inflation/a) price ceiling via allowance sales from reserve in three equal tiers at 40, 45, 50 US$ (+5% over inflation/a); only California-registered entities eligible	cost containment reserve price floor following California since 2015 price ceiling via allowance sales from reserve following California design since 2015; only Québec-registered entities eligible	cost containment reserve populated with around 5% of total allowances price floor following California/Québec from 2017 price ceiling via allowance sales from reserve following California/Québec-design from 2017
Compliance	3 year control periods 100% emission coverage at control period end 50% emission coverage via stocked allowances after first 2 years emission data provided by	3 year control periods (except 2013-2014) 100% emission coverage at control period end 30% emission coverage via surrendered allowances annually annual emission reporting,	3 year control periods (except 2013-2014) 100% emission coverage at control period end annual emission reporting,	3 year control periods (except 2017-2020) 100% emission coverage at control period end annual emission reporting,

	US EPA annually emission, allowance, and transfer tracking via COATS fines up to 25,000 US$ per day 3-for-1 compensation of excess emissions	independent verification emission, allowance, and transfer tracking via CITSS fines up to 25,000 US$ per day 4-for-1 compensation of excess emissions	independent verification emission, allowance, and transfer tracking via CITSS fines up to 3,000,000 CA$ per case, imprisonment, allocation suspension 3-for-1 compensation of excess emissions	independent verification emission, allowance, and transfer tracking via CITSS fines up to 3,000,000 CA$ per case, imprisonment, allocation suspension 3-for-1 compensation of excess emissions