GLOBAL ECONOMY & DEVELOPMENT
WORKING PAPER 63 | DECEMBER 2013

Global Economy and Development at BROOKINGS

TRADING UP
THE CASE FOR AN INTERNATIONAL CARBON MARKET RESERVE TO REDUCE VOLATILITY AT THE LIMITS IN 2020 AND BEYOND

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Acknowledgments:
The authors would like to thank Joshua Meltzer of the Brookings Institution, Wendy Hughes and Vikram Widge of the World Bank Group, as well as Anthony Mansell of the International Emissions Trading Association for their thoughtful and constructive comments. We also thank Jay Mariyappan, Gareth Phillips and Assaad Razzouk of Sindicatum Sustainable Resources for their time and expertise. Finally, we wish to thank our colleague, Michael Wolosin, who provided valuable contributions to our modeling exercise. All errors and omissions are the authors' own.

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EXECUTIVE SUMMARY

Climate policymakers face major challenges when designing future global carbon markets—those involving carbon transactions between "buyers" (predominantly developed countries to date) and "sellers" (mainly developing countries, particularly least developed nations). On one hand, domestic carbon markets are currently spreading and linking rapidly around the world. By 2015, based on already announced policies, carbon markets will cover almost 3 billion people and the lion's share of the world's economy.[1] Because carbon markets, and carbon pricing instruments in general, present the most flexible mechanism to create low-carbon economies, carbon markets are likely to play a major role in future efforts to confront climate change—perhaps on the order of shouldering 50 percent of the solution.

Yet today's global carbon market, on the other hand, is somewhat dysfunctional and highly volatile—characterized by dramatic changes in supply, demand, price, and public confidence. Prices today under the Clean Development Mechanism (CDM), the world's largest global carbon market, are just 7 percent of market value in 2011, leaving policymakers, companies, and investors wondering what should be done to make the future global carbon market more viable.

Absent new policy solutions, global carbon markets of the future—including the new global mechanisms nations are constructing in ongoing international climate talks for 2020 and beyond—are likely to face similar uncertainty, volatility and crises in confidence. Most economic models project that global carbon market prices are likely to remain depressed through 2020 with supply greatly exceeding demand. In the longer run, high prices, low prices and price spikes all seem plausible. Demand for carbon market securities, or Certified Emissions Reductions (CERs), depends mainly on three things—rates of economic growth, the speed of innovation, and the stringency and scope of climate policy—each of which change constantly, sometimes quite unpredictably, and rapidly. For its part, Point Carbon estimates that by 2030 carbon prices in the European Union will hover around €70 per ton, suggesting that prices in the international carbon market might be roughly €45 per ton.[2]

Reducing extreme volatility in global carbon markets would have numerous benefits, including providing a steady stream of foreign direct investment for low-carbon development in least developed countries (LDCs), minimizing the costly disruptions of price spikes and crashes and empowering the world to pursue ambitious climate goals. Beginning immediately, nations need to design post-2020 global carbon markets with policy features that reduce extreme volatility and that reflect, at least to some degree, the real value to the world of reducing emissions.

In this paper we make the case for one useful, albeit partial, solution: a new international carbon market reserve with the authority and mandate to adjust the supply of global carbon market securities when prices rise or fall to extremes. An international carbon market reserve could help nations temper likely swings in global carbon markets by increasing the supply of carbon credits when demand exceeds supply, and potentially reduce supply by purchasing credits when prices fall. Furthermore, were the reserve to forgo a price floor function, it would generate new financing—perhaps billions of dollars—to build resilience to the adverse effects of climate change in developing countries.

Carbon market reserves are already part of several regional and national carbon markets, but are absent from global markets. Our modeling suggests that an international carbon market reserve of 600 million tons of carbon securities could eliminate global carbon price spikes in the early years of the post-2020 period and reduce price spikes by as much as 40 percent under a number of likely scenarios between 2020 and 2030.

Among existing global international organizations, the most logical candidates for housing a carbon market reserve are the International Monetary Fund (IMF), the World Bank and United Nations. Each institution has its strengths. While the IMF's mission is most closely aligned with the goals of a global carbon market reserve, the organization has the least carbon market experience today. In contrast, the World Bank has been an innovator in carbon markets, while its mission to promote economic development fits well with the defining feature of the global carbon market—namely, carbon transactions involving developing nations. For its part, the United Nations offers tremendous legitimacy and has regulated the vast majority of the global carbon market for the past decade. While all three institutions might usefully contribute to the management of a global carbon market reserve once established, we urge the World Bank to take the lead in developing the idea now and to present a proposal for a carbon market reserve to the international community. Ideally, such a proposal would be released well before the 2015 session of global climate talks when nations have agreed to conclude a new climate agreement.

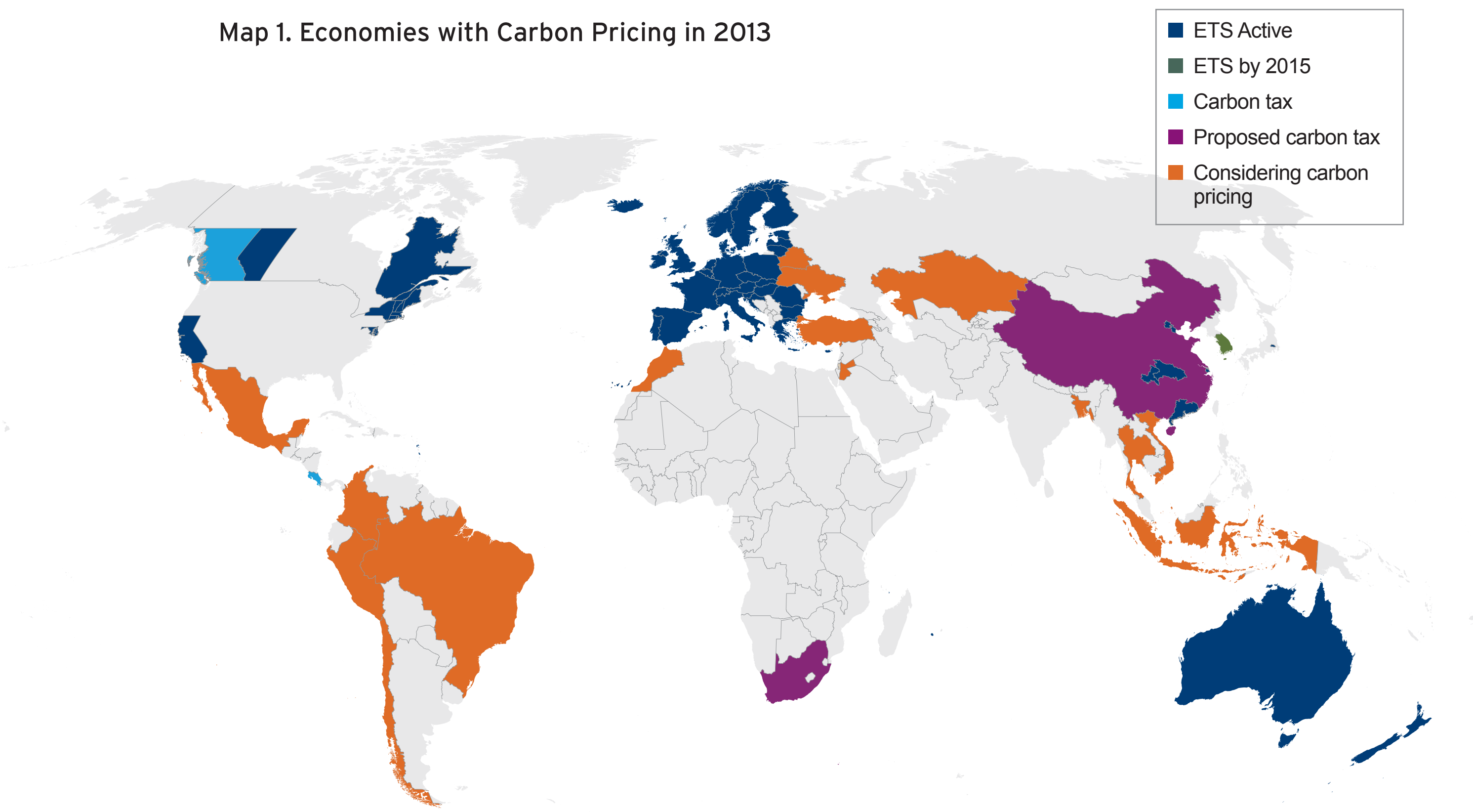
Beginning to capitalize an international carbon market reserve now makes sense for a number of reasons. First, today's depressed carbon prices offer the world an exceptionally rare opportunity to begin capitalizing an international carbon market reserve at extremely low cost. In today's market, stockpiling 600 million tons of CDM credits would cost the international community at most $600 million and would represent a substantial head start toward capitalizing an international carbon market reserve. In fact, our estimates suggest that by 2030, a reserve of this size would be worth about $14 billion in today's dollars, counting both cash and the value of remaining CERs.[3] Second, acting now could reduce the cost of a reserve by roughly 90 percent compared to 2020. Even if the international community cannot mobilize $600 million immediately, marshaling $100 million over the next two years could save the world roughly $1 billion relative to the 2020 tab.[4] Third, increasing demand for international carbon credits today would help restore confidence and maintain capacity and knowhow in today's international carbon market. While not the primary reason for intervening, restoring confidence (if not robust prices) to today's carbon markets might encourage countries, companies and investors to accelerate the global transition to the low-carbon economy.

Since the world has not seriously considered whether to create a global carbon market reserve, it would be premature to conclude that the concept is either politically feasible or infeasible. To be sure, some would oppose what they might unfairly demonize as a new global central bank. Yet others are likely to see how a global reserve could complement national and regional mechanisms to maintain domestic price stability, while limiting excessive volatility across the rapidly evolving global carbon market. Since both developed and developing nations would benefit from the reserve—the former from predictable and reasonably priced carbon securities in developing nations, the latter from strong and stable demand for carbon credits from developed nations—creating consensus about the desirability of a reserve may prove manageable in the years ahead.

INTRODUCTION

Carbon markets are spreading globally and becoming an ever more important policy tool in the fight against climate change. A fresh group of developed and developing economies—from China and South Korea to California and Quebec—are implementing new emission trading systems, adding to the mature carbon markets in the European Union, New England, New Zealand and elsewhere (see map 1). China, for instance, is in the process of constructing municipal and provincial emissions trading schemes that will precede a planned national carbon market from 2015 onwards.[5] California, meanwhile, launched a statewide emissions-trading system in 2012. Increasingly, these markets are linking to each other—from California and Quebec planning to link in 2014 to Australia seeking to fast-track linkage to the European carbon market (though Australia's recent elections may mean that these plans will be put on hold). Nations are also negotiating in global climate talks a variety of new global market mechanisms for 2020 and beyond, building on experiences with the Clean Development Mechanism (CDM) and Joint Implementation, the global carbon market created under the 1997 Kyoto Protocol. In short, policymakers are increasingly looking to carbon markets to steer their economies along greener, more sustainable pathways.

Map 1. Economies with Carbon Pricing in 2013



Source: Adapted from International Emissions Trading Association and Environmental Defense Fund, The World's Carbon Markets: A Case Study Guide to Emissions Trading (2013), Ecofys, "Mapping Carbon Pricing Initiatives: Developments and Prospects," World Bank (2013), and M. Grubb, "Emissions trading: Cap and trade finds new energy," Nature 491 (2012): 666-667.

Policymakers are looking to carbon markets more and more because they have a fundamental role to play in meeting the climate challenge. The fifth assessment report of the United Nation's Intergovernmental Panel on Climate Change (IPCC) warns that the challenge is growing, with temperatures on course to far surpass the 2 degree Celsius threshold of warming that would avoid the worst social, economic, health and environmental impacts of climate change.[6] Carbon markets and carbon pricing more broadly, in contrast to standards and regulations and fossil fuel subsidies, present the most efficient, flexible mechanism for economies to transition to low-carbon alternatives. Carbon market players suggest that they may even comprise up to 50 percent of the climate solution.[7] Furthermore, they offer important opportunities for supporting new technologies and leveraging private investment in nations outside their respective market. In fact, the UN secretary-general's High-Level Advisory Group on Climate Change Financing estimated that carbon markets could generate roughly $40 billion annually for emissions mitigation by 2020, and therefore recommended that carbon markets be further strengthened and developed.[8]

To date, the global carbon market, which has long been nearly synonymous with the CDM (comprising approximately 90 percent of the market for carbon securities from developing nations), has accelerated greenhouse gas mitigation while helping to drive foreign direct investment into developing countries.[9] The CDM has spread clean technology and channeled billion of dollars into developing countries,[10] while making emissions reductions much more affordable for developed nations, saving them at least $3.6 billion since 2008. The cost of reducing emissions from CDM was $1.30 to $6.50 less than alternative emission reduction opportunities in the EU Emissions Trading System (ETS)—the carbon market that caps emissions for most of Europe—from 2008 to 2011.[11] European companies saved at least $1.5 billion over the same period by purchasing these credits rather than reducing their own emissions. Similarly, Japanese companies, which also purchased CDM credits to offset their emissions, saved at least $2.1 billion. And importantly, these cost savings have enabled nations to pursue far more ambitious emission-reduction policies than would have occurred otherwise. Furthermore, evidence suggests that participation in the global carbon market has also led to the proliferation of national and local carbon markets in developing countries.[12] In short, the global carbon market may have successfully made the case that all countries and communities can benefit from fighting climate change and that pricing carbon makes economic sense.

In the process, however, the international carbon market has failed in serious ways, including through major price swings over the market's short existence and questionable emissions crediting incidents. In recent years, CDM credit prices fell from $20 at the end of 2008 to less than $5 at the end of 2012 and down to 80 cents today[13]—likely a function of stagnated demand and an explosion of supply.[14] The international carbon market may have also given credits for questionable emission reductions, which undermined the system's credibility further. For instance, renewable-energy projects often derive only a small portion of their revenue from CDM credits, which suggests that a portion of them would have been built without the support of the CDM. Perhaps the most bruising scandal came from the perverse incentives the market provided for destroying stockpiles of certain climate-damaging air conditioning coolants and other industrial gases.[15] The CDM gave a large number of credits—47 percent of credits issued to date[16]—for these projects because of the gases' outsized impacts on global warming and the projects' abilities to meet CDM eligibility criteria (in that they produced no revenue beyond the sale of the CDM credit). Knowing this, a number of coolant manufacturing plants may have increased production of the gas only to receive payments from carbon markets for destroying the unnecessary stockpiles that they made. Taken together, these failures have led to an erosion of confidence in the global carbon market's ability to generate real, additional reductions.

Given the current crisis in confidence in the global carbon market, policymakers should consider ways to ensure the future does not repeat the past. We recommend, therefore, a helpful, albeit partial, solution to address supply and demand imbalances at the extremes: that policymakers establish a global carbon market reserve to guard against extreme price volatility and engender confidence in the market of 2020. We also urge the international community to begin to capitalize the reserve by buying high quality and highly affordable credits flooding the global market now, ideally from renewable energy and other environmentally strong projects in least developed nations (our proposal does not directly address the challenge of environmentally questionable CERs, however we recommend that the international community buy high-quality securities today and/or retire a given portion immediately so as not to import problematic CERs into the post-2020 era). We conclude by discussing the politics of establishing a reserve and argue that while it is no substitute for ambitious mitigation efforts, it could help ensure that tomorrow's carbon market is stronger and less volatile than today's. Two assumptions underlie these recommendations: that countries will eventually increase the ambition of their national emissions targets as adverse climate impacts mount, and that decision-makers in "buyer" markets allow a proportion of international carbon securities into their domestic markets to meet emissions targets. A carbon market reserve would do little on its own to stabilize global carbon markets in the absence of meaningful demand for international carbon credits.

THE PERILS OF EXCESS MARKET VOLATILITY

High levels of volatility in global carbon markets are damaging to climate change mitigation efforts and sustainable development finance across the globe. For mitigation policy, dramatic price swings have a chilling effect as policymakers have little sense of how much climate action will cost their economy—often adding to their reluctance to act. For climate finance, volatility reduces the value of climate change assistance as price swings can adversely affect the level and composition of investment. Price volatility also dampens clean energy innovation by undermining investor confidence and creating uncertainty among clean energy developers that prefer stable markets. Like carbon market incentives, volatile government financing for wind energy in the United States restrains the industry from achieving its full potential. If incentives were predictable across years, wind energy could triple by 2030 as opposed to the lackluster growth projected today.[17] Ultimately, volatility at the extremes has helped compound uncertainty in the global market, and is driving out private sector knowhow and capacity and eroding the very infrastructure of today's market as project developers leave, given the low returns and high costs of participation. To be sure, some degrees of volatility may be positive. In some cases, volatility itself may act as an incentive to invest in low-carbon alternatives as a way to reduce an entity's vulnerability to carbon price volatility.[18] In general, however, reducing excess volatility in global carbon markets could make climate action less financially risky and thereby encourage more ambitious global mitigation policies.

THE AGE OF OVERSUPPLY (2005-2020)

The global carbon market of today has suffered from extreme price volatility and a general disequilibrium between supply and demand that has completely eroded the value of CDM credits (see figure 1); as a consequence, international climate investment flows into clean energy have significantly slowed to developing countries. Meager mitigation ambition on the part of purchasing nations (to date only developed nations) and attendant policy uncertainty is largely to blame. Major questions have loomed large over the past few years: would the European Union look to cut emissions by 20 or 30 percent by 2020? Would the United States pass an economy-wide carbon cap that creates demand for international carbon market credits? Furthermore, major disturbances in the macro economy have meant sustained downturns for the CDM market. As nations' emissions fall with reduced economic output, fewer CDM credits are needed to cost-effectively meet domestic caps. For instance, following the global recession of 2008, European greenhouse gas emissions fell by 3 percent in a single year as industrial output declined significantly.[19] Combined with the protracted eurozone crisis, the economic downturn contracted the CDM market by 12 percent in 2008, 59 percent in 2009 and 46 percent in 2010.[20] Europe has been the largest buyer of CDM credits by far, and this decline in demand decimated global CDM prices.

Market imbalances are also to blame. To date, developed countries have failed to make full use of the existing global carbon market. Only Europe and Japan have purchased significant quantities of international carbon securities and even they are retrenching.[21] As

Figure 1. Historical CDM credit prices (€/CER)

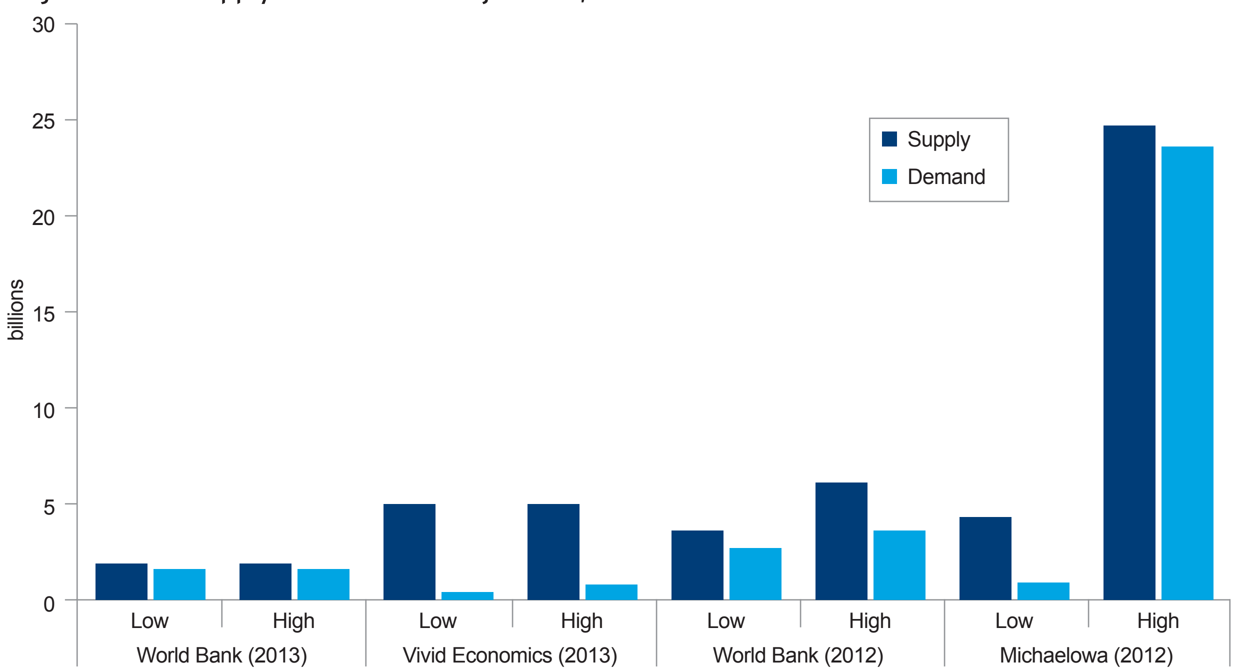
Source: Bloomberg

*EUA refers to European Union Allowances; climate credits used in the European Union Emissions Trading Scheme (EU ETS) of 2013, the European Union no longer accepts credits from projects to eliminate certain greenhouse gases, such as the aforementioned refrigerants, nor from projects in middle-income countries (including China) where the projects were registered with the CDM after 2012.[22] Japan, for its part, is moving away from global carbon markets (the CDM specifically) and moving toward purchasing credits through bilateral carbon markets it intends to create with regional allies.[23]

Estimates suggest that today's low carbon market prices are likely to persist in the near-term as well, primarily due to continued, dramatic market imbalances (see figure 2). Between 2013 and 2020, most projections regarding the likely demand for global carbon market securities range from less than 1 billion to about 4 billion CERs. Most supply estimates vary between 2 billion and 6 billion CERs over the next 8 years; the large range reflects uncertainty about the number of carbon market developers that are likely to leave the market due to the low marginal return on participation in the CDM. (If the costs involved in receiving credits outweigh the potential profits from selling them, project developers are likely to exit the market and the supply and demand imbalance may not be as acute as these figures imply.)[24] Still, these projected imbalances suggest a continuation of the highly dysfunctional market we have seen over the next several years, with continued price volatility at the tails as policy conditions change.

In short, this first age of the global carbon market—from 2005 to 2020—is likely to be remembered as the age of oversupply with high degrees of policy uncertainty, price volatility, and a general crisis of confidence.

Figure 2. CER Supply and Demand Projections, 2013-2020



Source: Based on data from World Bank (2013), Vived Economics (2013), World Bank (2012) and Michaelowa (2012).

THE ROAD AHEAD (2021 AND BEYOND)

Will the global carbon market of tomorrow suffer the same fate? Prognosticating about the future of the international carbon market presents many challenges. However, in this section we offer two reasonable and quite different scenarios for 2021 and beyond. Both scenarios, however, point to continued market uncertainty and the need for smarter carbon market policy.

Scenario One: An Age of Over-demand

The global carbon market post-2020 could be radically different than today. The oversupply problem of the previous era could give way to over-demand as countries ramp up mitigation ambition and look to the global market to contain costs. Point Carbon analysis suggests that by 2030 prices could reach €66 per ton in the EU ETS—or €48 per ton in constant 2013 euros—and average about €30 per ton over the period, implying that international CERs would likely hover around €45 per ton by 2030 and average €20 per ton.[25] Price spikes could replace price collapse, which has threatened the viability of the market to date. All told, the post-2020 period could be an era plagued by problems we have yet to see.

How might this scenario unfold? Imagine a world in which many more nations have established carbon-pricing schemes to increase their mitigation ambition through 2050 to avoid the 4 degrees Celsius of warming by the end of the century that scientists expect to occur absent much stronger climate policies. Climate change on that scale would exacerbate inequality within the global community and trigger human suffering on an unprecedented scale.[26] To avoid these adverse impacts and steer businesses and consumers toward low-emissions alternatives, nations may adopt carbon prices stringent enough that market participants look to international carbon markets—including project-based credits or sector-based credits potentially through Nationally Appropriate Mitigation Actions (NAMAs), offsets through the CDM, or whatever other international carbon securities emerge—at least in part to meet domestic obligations. Many developed nations might restrict purchases of carbon securities to least developed countries as Europe has already done through the CDM, which would severely limit supply.[27] Demand in international carbon markets might therefore far outstrip supply in the early years after 2020. In turn, prices could spike erratically as projects get up and running, compromising a number of critical benefits of the international carbon market—including cost containment for buyers of carbon securities and predictable flows of foreign direct investment for developing countries.

Scenario Two: An Age of Volatility on Overdrive

Likewise it is entirely possible that the global carbon market post-2020 might look much like it does today—with volatile and unexpected price rises and falls above and below reasonable thresholds. Dramatic price swings over short time periods could continue and worsen, as domestic climate action might remain highly polarized and unpredictable, with the pace of innovation and technology diffusion varying unexpectedly, and national economies experiencing exacerbated swings in the economic cycle. While the structure of the global carbon market may look different as a result of decisions in the international climate change negotiations, supply challenges may remain that would exacerbate excessive market volatility. All told, it could be an era plagued by known problems that we have yet to fully reconcile.

The world may continue to experience sporadic periods of intense debate about whether to strengthen climate policy. These periods could create policy "bubbles" that artificially inflate carbon prices and then lead to severe price collapse when policymakers fail to meet market expectations. For instance, nations may commit to establish carbon-pricing schemes across the world to increase their mitigation ambition beginning in 2020. However, inertia could rule the day and nations may fail to enact those policies along pledged timelines through 2030. An American president could, for example, commit toward the end of the decade to enact significantly larger emissions reductions beginning in 2020, leading initially to far higher prices in global carbon markets. Yet in 2020, Congress might fail to pass required legislation, thus triggering a price collapse in the global carbon market. More broadly, prices might swing as buyers and sellers in the international market respond to climate policy bubbles.

Furthermore, like today, it is entirely possible that nations could experience periods of slow economic growth or faster than anticipated innovation that leaves domestic carbon prices well under historic averages. Such conditions would make international carbon securities unattractive and unneeded, potentially driving down their price to the historic lows that reigned in the pre-2020 period.

In addition, new global climate policy may lead to unexpected and dramatic changes in the supply of global carbon market securities. In the first instance, new global carbon markets may experience bumpy and unpredictable starts, akin to the CDM. In addition to the current market, nations could also begin using two new entities being developed in global climate negotiations: the Framework for Various Approaches and the New Market Mechanism. The first, with the somewhat odd name of Framework for Various Approaches, is expected to specify minimum standards for local, national, and regional carbon markets and other climate policies, as well as enable countries to compare the impact of different policies. The second market entity, the New Market Mechanism, or NMM, is expected to certify emission-reduction credits from developing nations for use by other countries. It would likely be a sectoral-crediting system, setting baselines for national economic sectors such as electricity generation, cement manufacturing, or forestry, and would provide credits if the country beats the given baseline—enabling countries to receive credits for various degrees of domestic climate policies. Like the CDM before them, there may be difficulties getting these markets up and running that would create additional degrees of uncertainty in the post-2020 period. In the second instance, the NMM could have outsized impacts on the supply and prices of global carbon securities. With middle-income countries excluded from the CDM, they could continue to provide credits to the international market through the NMM in potentially large quantities—depending on set national baselines. This could ensure that even a choked supply of credits from LDCs could be more than made whole through carbon securities generated in middle-income countries.[28]

Taken together, the second age of the global carbon market could be marked by continued, unpredictable price volatility at the extremes, potentially even with price collapse. General uncertainty could rule the day. Over time, dramatic price swings would damage the credibility of the global carbon market and lead more countries and businesses to forgo allowing, purchasing or developing the credits.

Dramatic Volatility: A Common Thread

Regardless of the scenario that comes to pass, high degrees of uncertainty are likely. Whether plagued by systemic over-demand where prices unexpectedly spike or by misaligned expectations and actions where prices bounce around, the second age of the global carbon market—from 2021 through 2030 and beyond—could have excessive price volatility. This volatility at the extremes would create costly, albeit differentiated, disruptions for both "buying" and "selling" countries alike with price spikes and crashes. For carbon security "buyers," predominantly developed countries, price spikes could undermine the pursuit of ambitious climate goals; policymakers, businesses and consumers in capped economies may lose their resolve for action if the price were considered unreasonably large (see subsequent sections). Price collapse, on the other hand, would make mitigation incredibly affordable, assuming the supply of carbon securities were unable to adjust to new market conditions. For carbon security "sellers," mainly developing countries, price spikes would augment climate finance in any given month or year. Conversely, price collapse could undermine a reliable source of climate finance (also see subsequent sections). Beginning immediately, therefore, nations need to design post-2020 global carbon markets with policy features that reduce excessive volatility and that reflect, at least to some degree, the real value to the world of reducing emissions.

A GLOBAL CARBON MARKET RESERVE

In view of these predictable shortcomings, policy-makers should consider what could be done now to minimize the risk of extreme volatility in the post-2020 carbon market. We argue that a global carbon market reserve, if properly designed, could help fortify the market against the ills of either an age of over-demand (price spikes) or continued policy risk (extreme price uncertainty and even price collapse). More importantly, however, a global carbon market reserve could help ensure that some benefits of climate action accrue to developing countries that have yet to cap their own emissions. The following section makes the case that a global carbon market reserve (in practice, a repository of carbon securities) would help instill greater confidence in the market by smoothing prices within a reasonable band.

The Case for a Reserve

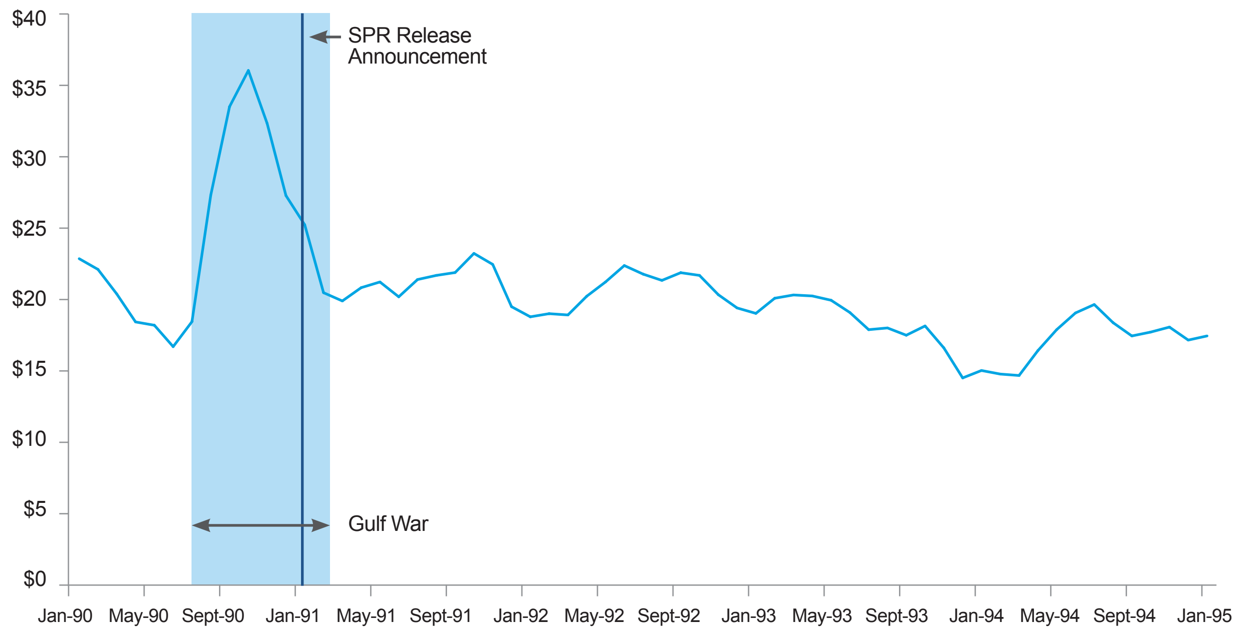
Reserves are accounts set aside to meet any unexpected fluctuations in supply and demand of a given asset. Reserves can be filled with assets at regular intervals, or all at one time. Once filled, they make additional assets available for purchase on the market when prices reach a certain level or when decision-makers otherwise decree. Some reserves also purchase assets when prices fall as a way to keep prices from declining too far. Reserves can thus be used to control price in a given market by releasing or holding the asset (while they do not eliminate price volatility at the margin, they can be useful in preventing spikes above or below a given band). For instance, the U.S. Strategic Petroleum Reserve, a stockpile of nearly 700 million barrels of crude oil, ensures that the United States has an emergency energy supply should political unrest or other forces disrupt its oil imports and drive prices up.[29] In several rare cases, the U.S. president has released oil from the reserve to ease dramatic energy price spikes for American consumers (and the world since the petroleum market is global). During the Persian Gulf War in 1990-91, in tandem with other members of the International Energy Agency that also maintain oil reserves, the United States coordinated a major release to bolster global oil supply and stabilize prices (see figure 4).

A reserve has several key benefits in any market where general price stability and predictable prices are helpful, including international carbon markets whatever their form (i.e. project-based, sector-based, or policy-based crediting). First, a reserve could smooth price volatility by holding a significant amount of carbon securities and releasing them into the international market if credits reach a given price. For example, if prices rise above a given ceiling, CERs would be put into the market to effectively increase supply and drive prices down. Similarly if prices were to fall below a given floor, a reserve with proper authorities could buy up credits to effectively restrict supply and drive prices up.

Second, it would preserve the cost-containment function of the global carbon market for participating national and regional carbon markets—assuming the price ceiling is below domestic market ceilings. For instance, if the price ceiling in the international market were below that of domestic allowances in the EU ETS when prices spike, covered European entities would know they could rely on credits from the global market to meet their obligations.

Third, a reserve could set expectations within the market. Expectations are powerful predictors and influencers of market outcomes. The price of a carbon credit in the international market, for example, depends on how many projects are developed for the market, which in

Figure 3. Global Crude Oil Prices ($/barrel), 1990–1994



Source: Based on data from the U.S. Energy Information Administration, "Spot Prices: Crude Oil in Dollars per Barrel."

turn depends on the returns project developers expect to realize when they produce and sell their credits. As another example, the value of a currency and its rate of depreciation depend partly on what people expect that rate of depreciation to be. As people rush to offload a currency that they expect to lose value, they contribute to its devaluation by affecting expectations.

Fourth, a reserve could serve as a bridge and help perpetuate the market. Reserves may be filled with credits unsold from previous years, or they may take a percentage of credits from the market each year. These credits could then be accessible at certain times and at certain prices, creating a more stable market in the long run.

Finally, a global reserve to manage volatility at the extremes in the international market would make national and regional carbon market linking clearer for decision makers. When markets look to link and already connect to the international market, policymakers would have a sense at the outset about how much a ton of carbon is worth in each respective market as reflected in price. This information on the value of a ton could itself expedite bilateral linking as it provides de facto exchange rates.

A carbon market reserve at the global level, in particular, could offer a number of additional benefits by virtue of instilling greater confidence in the long-term viability of international carbon markets. These benefits are discrete and potentially quite significant for both climate mitigation and finance in support of sustainable development.

For the climate, enhanced market confidence about predictable, affordable carbon securities would help support greater emissions reductions by driving down the cost of action, catalyzing innovation and mobilizing investment in low-carbon technology worldwide. In the past, the cost savings provided by the prospects of a stable international carbon market have enabled nations to pursue far more ambitious emission-reduction policies than would have occurred otherwise. The 1997 Kyoto conference offers a case in point. In exchange for including the CDM in the Kyoto Protocol, most developed nations agreed to more ambitious emission-reduction targets. Japan, for example, stated publicly that the CDM allowed it to commit to stronger emission-reduction goals. The lead U.S. climate negotiator at the time, Stu Eizenstat, testified to Congress that the United States would not have agreed to any emission reductions at Kyoto without the CDM.[30] In truth, a global reserve is not going to make weak national targets stringent. However, it might make each nation's target more stringent at the margin, which, when taken together, could generate additional ambition.

For sustainable development, enhanced market confidence would perpetuate a pipeline of low-carbon investment that has thus far generated billions of dollars in revenues for businesses in developing countries and $356 billion in supporting investments.[31] These investments have sparked even more in local economic activity by providing jobs and wages that benefit local businesses. Moreover, many carbon market-supported clean energy projects have successfully diffused clean technologies and knowhow across the developing world, effectively encouraging the development of domestic industries and displacing other dirtier sources of electricity. For instance, an Irish company provided the technology to recover waste gases from landfills, dairy farms, and cattle ranches across Brazil and Mexico. And Spanish and Danish companies initially provided many of the wind turbines used to generate clean energy in China.[32] A global carbon market reserve might help ensure that these benefits accrue to LDCs and other uncapped economies in the developing world in 2020 and beyond, as the reserve could impart greater price certainty in the global carbon market spurring new and scaled-up investment and technology development. Whatever the form global carbon markets take, global carbon securities have the potential to channel millions of dollars in clean energy investments into economies across the developing world that have yet to place their own domestic price on carbon.

Furthermore, a global carbon market reserve would also provide some degree of insulation within "seller" markets—those countries seeking to entice low-carbon investments—that are completely exposed to both the price and policy volatility (including caps on the proportion of external carbon securities allowed into domestic markets) within "buying" markets at present. Unlike fluctuations in capped economies where mechanisms may exist to manage extreme volatility (see subsequent section), seller markets have no domestic options available. A global carbon market reserve might serve as a critical mechanism in bridging periods of low prices, and therefore, preserve offset markets in least developed countries.

Carbon Reserves are Widely In-Use

Carbon market reserves are not a new idea, but have yet to be implemented at a global scale. Several emissions trading systems around the world, in fact, already use reserve stabilization funds or other ways to address low demand in their individual markets—including the U.S. Regional Greenhouse Gas Initiative (RGGI), California and Quebec (see Annex I for comprehensive details and background information on additional approaches).

RGGI, a carbon market covering several northeastern U.S. states, is introducing a "cost-containment reserve" in 2014 that will function as a reserve under the region's carbon cap. The reserve will hold a fixed quantity of allowances that will become available at a designated price.

Elsewhere in the United States, the California carbon market has in place a price stabilization mechanism. California created an Allowance Price Containment Reserve, or APCR, that collects a percentage of emissions allowances and releases them into the market if carbon security prices reach $40 or more. The percent of allowances withheld from auction to fill the APCR begins at 1 percent and increases over time.[33]

The Quebec carbon market has designed an allowance reserve account very similar to California's, with the same percent of allowances held over equivalent periods of time and triggered at equivalent prices (in Canadian dollars). Despite similar mechanics, the Quebec and California markets' allowance reserves are not accessible to each other, although the markets will link in 2014. The credits held in the Quebec allowance reserve account can also be adjusted by the Minister of Sustainable Development, Environment, Wildlife and Parks, giving policymakers additional flexibility.[34]

For its part, the European Union is reportedly considering establishing a regional reserve to avoid future price collapse as part of structural reforms for 2020 onwards.[35] In the meantime, EU policymakers are pursuing a new approach to stabilize current prices in the EU ETS by "back loading" credits, or postponing their auction until demand increases in the future. Back loading will delay the auction of up to 900 million allowances until 2019, which could reduce price volatility (assuming economic growth eventually rebounds) without reducing the number of allowances auctioned overall through 2020.[36]

National and regional reserves operate independently with their own trigger price and allocations. Yet none operate in a vacuum and many feed back into the international market (assuming, of course, they allow global carbon securities into their domestic systems). A global carbon reserve would complement national cost-containment instruments and serve as a backstop against price volatility for the domestic market's "swing supply" of carbon securities. A global reserve could also provide new assurances for markets without domestic reserves for at least some of the credits traded in those markets. Finally, it could help ensure that the aforementioned benefits of sustaining the global carbon market (namely cost containment and foreign direct investment) are realized for both buyers and sellers alike by serving as a bridge between periods of climate policy action and inertia.

Optimal Reserve Size

Size is critical when it comes to an effective reserve. Too small and it would do little to affect price, much as a drop of water in the ocean does little to affect sea level overall. Releasing a trivial number of carbon securities into the global market would do little to affect supply and dampen price or shift expectations. Too big and it would become untenable for the international community. Given the slow global economic recovery and ongoing disputes about climate finance, it would be inconceivable to propose mobilizing billions of dollars in support of the global carbon market. From a practical standpoint, if a reserve were too large it would also undermine market liquidity by withholding too many securities from general use in the market, adding to the extreme price volatility the reserve seeks to reduce.

Therefore, to be both large enough to be effective and small enough to be politically possible, we estimate that between 2020 and 2030, a global carbon market reserve would need to command about 1 percent of the international offset market over that decade. On average, this could amount to at least 60 million CERs per year. This estimate is based on the projected size of the CDM market in 2020 as estimates of the broader international carbon market are unavailable, with an assumed annual growth rate of 5 percent. We took one percent of the market based on a literature review of current market approaches to populating a carbon market reserve (see Annex II) and on consultation with market experts.

Admittedly, this estimate is highly speculative for a number of reasons. First, the size of the global carbon market between 2020 and 2030 is unknown because developed nations that will purchase global credits have yet to set their own targets. Second, those nations have also yet to determine to what degree they will allow polluters to satisfy emission reduction goals using international carbon credits. Third, as the market is currently structured, there would be no limit on the number of credits that suppliers could generate for the global market. Fourth, the global carbon market is a subsidiary or dependent market. When prices fall in the European Union, for example, prices in the global market also decline in complex ways with unpredictable feedback loops. Fifth, this figure accounts solely for the number of projected CDM credits in the market—not the totality of potential international securities under other instruments, as these are unknown today. Finally, carbon market reserves being put into place in domestic and regional markets today are likely to partially insulate the global carbon market from adverse shocks, but the extent to which this is true remains hard to predict. In the absence of greater certainty, nonetheless, the estimate provides a useful basis for discussion about the design of the post-2020 global carbon market and the expected cost of implementing a global carbon market reserve.

Governance

Size is not the only thing that would influence the efficacy of a global carbon market reserve. The rules governing how and when such a reserve would kick into action would also matter a great deal. The reserve would need a clear mandate. That mandate might be expressed as an instruction to keep the price of global carbon market securities within a pre-agreed price range, which might escalate gradually over time to reflect rising carbon prices. The reserve would have authority to buy carbon credits when prices fall below a certain level and authority to sell carbon credits when prices rise above an agreed level. The reserve would also need a predictable and respected decision-making process. The most common approach taken so far in national and regional carbon reserves has been to empanel a technical body or executive board to manage each reserve. Ideally, the executive board for the global carbon reserve would enjoy the same independence as central banks to contain inappropriate political influence.

Box 1: Not A Centralized Global Carbon Bank

An international carbon market reserve is fairly narrow in scope and should not be confused with a potential world carbon bank, which would integrate with domestic carbon markets across the world to a far greater degree than a reserve of the scope we envision. Our proposal is strictly focused on reducing price volatility outside of a targeted range for international carbon securities exclusively. The design of an international carbon bank would be far more complex and would require political considerations beyond the scope of this proposal (see table 1, page 18).

Table 1. Differences between a Global Carbon Central Bank and a Global Carbon Market Reserve

	Global carbon bank	Global carbon market reserve
Scope	All carbon markets worldwide	International carbon markets (e.g., CDM, NMM, etc.)
Size	> 10 billion tons carbon dioxide[37]	~600 million tons carbon dioxide
Cost	> $25 billion[38]	~$600 million
Authorities	• Pooling a fraction of all national carbon credits • Facilitating linkages between carbon markets • Assessing and mitigating risks to global carbon markets • Providing assistance to developing countries seeking to establish carbon markets	• Pooling a fraction of carbon credits in international markets • Releasing credits when certain trigger prices are reached

Finally, a global carbon reserve would need an organizational identity or institutional home. Experience shows that nations usually prefer to house new financial mechanisms within existing multilateral institutions rather than proliferating new ones. Setting up new institutions takes time and can be expensive compared to building new capacities within existing institutions. Among existing global international organizations, the most logical candidates for housing a carbon market reserve are the IMF, the World Bank and the United Nations. Each institution has its strengths. The mission of the IMF (maintaining economic stability) is perhaps most closely aligned with the goals of a global carbon market reserve. Yet, of the three institutions, the IMF has the least carbon market experience and expertise today. The World Bank has been an innovator in carbon markets and its mission (promoting economic development in poor nations) fits well with the defining feature of the global carbon market: carbon transactions involving developing nations. The United Nations offers tremendous legitimacy and is the home of formal global climate negotiations. The United Nations, in addition, has regulated the vast majority of the global carbon market for the past decade (through the CDM).

While all three institutions might usefully contribute to the management of a global carbon market reserve once established, the World Bank should take the lead in developing the idea. First, the World Bank has been the laboratory where nations have tested new carbon market instruments. For instance, the World Bank created the first carbon fund, the Prototype Fund, even before the CDM was up and running. Furthermore, the World Bank is already experimenting with the types of programmatic and sector-wide approaches (such as those for reducing emissions from deforestation) that nations may eventually adopt in global negotiations for the period after 2020. Second, the World Bank has the technical and economic expertise to design a carbon market reserve. Third, a degree of separation from global climate negotiations could help avoid unnecessary political and ideological setbacks (the World Bank, of course, is governed by nations so it would not be operating free of political input). Finally, the World Bank has a proven track record of capitalizing innovative carbon market mechanisms—more than $3 billion worth to date. The World Bank should be encouraged to present a proposal for a carbon market reserve to the international community, ideally well before the 2015 session of global climate talks when nations have agreed to conclude a new international climate agreement.

Composition

While today the global carbon market is dominated by the CDM, the future is likely to look very different (as described above). Global carbon market securities may include CERs generated through the CDM, but also those created through the NMM and NAMAs that value sector-based and/or policy-based emissions reductions. A global carbon market reserve should accommodate all of these types of securities in the post-2020 period and not be constrained by the world as it looks today.

Similarly, while today's markets of "buyers" and "sellers" generally cleave along developed and developing country lines, the future is likely to look very different as well. In the first instance, developing countries could increasingly implement domestic carbon markets as we are already seeing today. Carbon securities available to the international market are then a direct function of the level of domestic ambition in "seller" markets. If ambition were high, securities would likely be absorbed within the domestic market to meet emissions caps. Conversely, if ambition were low, carbon securities could be readily available for the international market. In the second instance, global greenhouse gas emissions could continue to grow the fastest in major emerging economies,[39] and consequently, there may be little appetite for rewarding nations perceived to be free riders—even potentially among lower middle-income nations. As a result, carbon market securities would be judged both by the stringency of domestic climate action and the integrity of the security itself. A global carbon market reserve should accommodate this complexity by integrating modalities to compare the climate change mitigation value of different kinds of offset assets (including CDM-generated CERs from different countries, NAMAs, etc.) while at the same time seeking to accommodate them.

The Reserve in Action in the Global Market: Modeling Results

This analysis employed a simple Monte Carlo simulation of 100,000 future monthly average international carbon market security prices between 2020 and 2030 with and without a reserve, which is described in greater detail in Annex III. The model generated random price pathways that matched the observed average annual volatility of 2012 CERs between August 2008 and November 2012, and that used a set starting price of roughly $10 in 2020 and averaged an assumed end price of $45 in 2030.[40] We then imposed a price ceiling ($30 in 2020) and floor ($3.30 in 2020) on these pathways to observe the effect of a 600 million CER reserve. We assumed that the strategic reserve held 600 million tons of CERs at the start of 2020 and that no funds were available in 2020 for purchases to maintain the floor price, but that proceeds from CER sales could be held and used later for such purchases.

Our analysis found that the reserve policy completely eliminated price spikes in about 40 percent of our simulated international carbon price pathways over the course of 10 years. Furthermore, we found that the reserve was able to provide on average sixteen months of smooth prices—or about a year and a half before the first price spike. This time would allow policymakers to put in place the corrections and interventions needed to restore confidence to the carbon market. Importantly, we found that the average total ending value of a reserve of this size, counting both cash and the value of remaining CERs, was $14 billion, far more than the $600 million cost of capitalizing the reserve (and a pretty impressive return on investment). These resources could be used for climate change and sustainable development outcomes in developing nations and/or to strengthen the reserve for the future, including by making it possible to maintain a price floor through a long downturn in global carbon markets. For the 25 percent of the time when the reserve sold tons, total proceeds were frequently within a range as high as $25 billion to $50 billion (the 50th and 90th percentile of the distribution of total proceeds in the reserve at the end of the time period for the set of simulations in which the reserve sold tons, respectively). Less than 10 percent of the time the value of the reserve was below the initial investment cost.

IMMENSE OPPORTUNITY FOR ACTION TODAY

Given the vast oversupply of carbon securities in the market today, the world has a unique opportunity to begin to capitalize a post-2020 carbon market reserve now at low cost.[41] Making inroads toward capitalizing a post-2020 reserve would place the world on a path toward stronger carbon markets tomorrow while, as a secondary benefit, also helping to shore up today's carbon markets by reducing excess supply.

Capitalizing the reserve today would be a bargain relative to acting in 2020. Independent analysis by Vivid Economics suggests that there are roughly 500 million CERs in the market today worth less than $1, or 1 billion CERs worth less than $1 through 2014.[42] This would imply that today one could capitalize a carbon market reserve for 2020 to 2030 for at most $600 million through a reverse auction,[43] while still leaving plenty of cheap CERs in the market for use through 2020. Were the world to decide to wait, however, and capitalize the reserve in 2020, one would have to pay 2020 CER prices that will likely be significantly higher than today's market clearing rate of less than $1. Policymakers in Europe, for example, assume that carbon market prices in 2020 are likely to be around €16 in the ETS.[44] Creating a reserve under those circumstances then would cost roughly 10 times more than doing so today.[45]

Even if the international community cannot mobilize $600 million, gathering $100 million over the next two years could go a long way toward populating the reserve. In fact, if the world were to marshal $100 million, the international community would save roughly $1 billion compared to projected costs in 2020. Of course this is not the full sum required, but the savings would be large enough to warrant even incremental action now. Much like buying a home, committing to a down payment upfront—even if it is only a small percentage of the overall amount—saves in the long run relative to funding the whole venture via a mortgage.

Beyond being a cost-effective way to begin capitalizing the reserve, acting now would have the added benefit of helping to solve the current problems facing the global carbon market. Buying up even a fraction of the 600 million CERs now would go some way towards rebalancing supply and demand. In fact, the Norwegian government has announced its intention to help do just that by buying up to 30 million vulnerable carbon securities from stranded CDM projects at above market prices as a way to help perpetuate the market.[46] While estimates suggest that augmenting near-term demand at these levels would likely do little to affect the CDM price today, such interventions could help to retain capacities that are essential for a functioning global market. Such capacities include monitoring, reporting, and verification knowhow at each project site, all of which will likely be lost if current market conditions prevail.[47] If project developers continue to leave the market with their vast institutional knowledge and experience, policymakers will be left with no other option but to reinvent the wheel down the road.

Given concerns about the environmental integrity of some carbon securities issued to date, purchases for the post-2020 global reserve could focus on certain sectors and projects so as to ensure that questionable CERs in the market today are not introduced into the post-2020 era. The reserve, for example, could buy only CERs from renewable energy projects in least developed nations. Alternatively, it could immediately retire 20 percent of the credits it purchases to safeguard against prior over-crediting by the CDM. Either approach would help ensure that only high-quality credits carry over from today's market into the post-2020 period. Restricting purchases or retiring extra credits would likely drive up the cost of capitalizing a reserve today, but total costs would still remain many times cheaper than capitalizing the reserve later at 2020 prices.

BOX 2: Not a Bailout for Big Banks

Creating a global carbon market reserve would not be an unpopular bailout for Wall Street banks and global financial institutions, which invoked international ire at the beginning of the recent economic recession.

First, the primary purpose of a global carbon market reserve would be to strengthen climate action—not to rescue investors in a floundering market. While Wall Street knowingly created toxic assets and encouraged excessive risk-taking, carbon market investors and project developers are investing in and creating assets the world needs if it is to transition to a low-carbon future. The Wall Street bailout of 2008 and 2009 used U.S. taxpayer money to rescue investors and institutions whose failure would have had global repercussions. A global carbon market reserve, on the other hand, would aim to strengthen the market in order to spur increased climate ambition, with none of its design oriented towards a bailout.

In addition, the global financial market and the global carbon market are floundering for fundamentally different reasons. Much of the financial woes in the United States are due to out-of-touch investors who took excessive risks. Those responsible for carbon market failure, on the other hand, are primarily policymakers and voters who have failed to demand action commensurate with the projected scale of global warming. With policymakers unwilling to lead on such a cost-effective climate opportunity, carbon markets were crunched by low-ambition domestic policies and resulting uncertainties in demand. Were mitigation ambition worldwide to increase as the science demands, the global carbon market would presumably thrive. The market conditions are also fundamentally different. The “too big to fail” narrative that overshadowed the big bank bailout is simply not applicable to carbon markets, which are not large or interconnected enough to bring down the global economy with their failure. Instead, they can only help—by facilitating climate change mitigation and enhanced investment in clean energy in developing economies.

Paying for the Reserve

Since the world has not seriously considered whether to create a global carbon market reserve, it would be premature to conclude that the concept is either politically feasible or infeasible. To be sure, some would oppose what they might unfairly demonize as a new global central bank. Yet others are likely to see how a global reserve would complement national and regional mechanisms to maintain order and limit excessive volatility across rapidly evolving carbon markets. Since both developed and developing nations would benefit from the reserve—the former from predictable and reasonably priced carbon securities in seller nations, the latter from strong and stable demand for carbon credits from buyer nations—creating consensus about the desirability of a reserve may prove manageable in the years ahead.

While nations may ultimately agree on the benefits of a reserve in the abstract, they may not agree easily on who should pay to capitalize it. But even here there are at least three reasons for optimism. First, as the modeling results presented above demonstrate, a well-designed reserve would capitalize itself over time by buying credits when prices fall and selling credits when prices spike. A few such buy-low-sell-high cycles could turn even a relatively thinly capitalized mechanism into an effective instrument with the depth of resources needed to smooth out significant price peaks and troughs. The reserve might even make enough money to pay back loans made by initial investors. In our model runs, the reserve was valued more than the initial $600 million outlay in 90 percent of our simulations. In fact, by the end of the period, the reserve was valued at about $14 billion in real terms in the median scenario.

Second, nations have rallied to capitalize innovative carbon instruments in the past. The World Bank, for example, has no fewer than fifteen carbon funds with a combined capitalization in excess of $3 billion. Most if not all of these were capitalized through voluntary contributions from nations, companies and nongovernmental organizations that viewed the experience gained through these carbon instruments as worthy of substantial investments despite the potential risks in an untested market. Most of these carbon funds provided compliance credits toward the Kyoto Protocol, and thus nations and companies had strong financial incentives to invest. However, the Partnership for Market Readiness has also attracted more than $100 million despite not providing any regulatory or compliance credit. This history suggests that nations might well band together to raise the $100 million or so needed to get a carbon market reserve off the ground and the $600 million needed to get it to minimum scale.

Third, even if nations are unwilling to capitalize a reserve using cash prior to 2020 they could still fund the reserve solely using carbon securities from the new post-2020 climate regime. Nations might agree, for example, to lend less than one percent of their total carbon budgets for the period 2020 to 2030 to a global carbon market reserve. The reserve could convert these allocations into carbon credits that it could sell when prices spike. Assuming prices fluctuate normally, the reserve could repurchase credits when prices fall below an agreed price and thus return the borrowed carbon to the nations that lent them, thereby not increasing the stringency or cost of national climate action. This approach has several downsides: the need to time the market and the necessity of waiting until nations have agreed on their 2020-2030 emission targets. For these reasons, we prefer taking advantage of the low cost CDM credits available today. But the potential to capitalize the reserve with 2020-era carbon credits without needing to come up with cash either today or then, provides yet another reason to believe that cost should not stop nations from embracing a global carbon market reserve.

CONCLUSION

In summary, global carbon markets of the future are likely to face great uncertainty if current conditions persist. Policymakers should consider today what could be done to ensure that the markets of tomorrow work more efficiently and improve upon this first period of carbon market experimentation. One option that should warrant heavy consideration is establishing a global carbon market reserve. Such a reserve could help nations temper likely swings in international carbon markets by increasing the supply of carbon credits when demand exceeds supply, and potentially reducing supply by buying up credits when prices fall. Reducing excessive volatility in global carbon markets would help minimize the costly disruptions of price spikes and crashes, and empower the world to pursue ambitious climate goals with confidence that investments in low-carbon innovation will be valued in the market. Furthermore, timely action now could prove incredibly cost-effective. The international community would need at least 600 million tons of carbon securities in reserve to prevent major price spikes in the early years of the post-2020 period. In today's market, stockpiling 600 million tons of CDM credits would cost the international community at most $600 million, given today's depressed CDM prices. Such action would represent a substantial head start toward capitalizing an international carbon market reserve that would meaningfully channel foreign direct investment into developing economies and manage cost for leaders in climate action.

ANNEX I: CURRENT STABILIZATION FUND APPROACHES

Market	Size of the Market	Mechanics	Effectiveness	References
EU	The EU ETS regulates roughly 40% of the EU's greenhouse gas (GHG) emissions, or over two billion tons of CO2e per year.	The EU has amended the ETS Auctioning Regulation to allow 'back-loading', which will postpone the auctioning of 900 million allowances from the years 2013-2015 until 2019-2020, when demand is expected to be higher. Back-loading does not reduce the overall number of allowances to be auctioned, but rather shifts the timing of their auction.	The European Commission predicts that back-loading would rebalance supply and demand in the next phase of the ETS and reduce price volatility without any significant impacts on competitiveness.	European Commission (2012), "Memo: Commission outlines two-step process to reform the European carbon market," available at: http://europa.eu/rapid/press-release_MEMO-12-861_en.htm.
California	The annual allowance budget in 2013 was 162.8 million tons of CO2e.	California's ETS includes an Allowance Price Containment Reserve (APCR) which collects a portion of allowances from auctions each year and releases them if trigger prices are reached, with the portion of allowances increasing over time. The percent of allowances withheld from auction to fill the APCR is 1% for 2013-2014, 4% for 2015-2017, and 7% for 2018-2020. Allowances from the APCR are divided into three tiers, which are available at $40, $45 and $50. From 2013 onwards, the price of reserve allowances will increase by 5% each year.	The first reserve sale of California allowances was scheduled for March 8, 2013, with a subsequent session on June 27. However, no participants expressed interest in bidding for either of these sessions. This could mean either that the reserve is already working as a long-term price stabilization mechanism and there is no need to buy allowances at reserve prices yet, or that buyers expect that prices will not rise in the future. Corrective proposals include replenishing California's reserve with international offsets from other ETSs.	Glowacki, Michael (2013), "Reasons why the California reserve sale scheduled for March 8, 2013 was not successful," Glowacki Law Firm, available at: http://www.emissions-euets.com/component/content/article/909-california-cap-and-trade/355-why-the-california-reserve-sale-scheduled-for-march-8-2013-has-failed. 427 Climate Consulting (2013), "Price Containment in California's Carbon Market: a Difficult Arbitrage," available at: http://427mt.com/2013/07/price-containment-in-californias-carbon-market-a-difficult-arbitrage.
China	China's seven pilot ETS schemes could cover 700 million tons of CO2e by 2014.	The pilot ETS city governments are holding on to some of the permits to create a reserve that can be released to regulate price spikes. However, the exact size of this reserve is unknown.	NA	Davidson, Michael (2013), "Transforming China's Grid: Obstacles on the Path to National Carbon Trading System," Energy Collective, available at: http://fw.to/eJjCnMC.

Annex I: Current Stabilization Fund Approaches continued

Market	Size of the Market	Mechanics	Effectiveness	References
Australia	Australia's ETS will cover 60% of Australia's emissions, or around 400 million tons of CO2e.	Price stabilization in the Australian ETS will primarily be achieved through establishing three different phases of cost containment: the fixed, flexible, and floating phases. The fixed phase sets an AU$23 price for allowance purchase. The flexible phase sets a price ceiling that rises 5% each year. Finally, the floating phase refers to removal of the price ceiling in 2018. The Australian ETS also promotes linking to international markets for cost containment.	NA	Environmental Defense Fund and International Emissions Trading Association (2013), "Australia - The World's Carbon Markets: A Case Study Guide to Emissions Trading," available at: http://www.edf.org/sites/default/files/EDF_IETA_Australia_Case_Study_May_2013.pdf.
Norway	(NA – now part of the EU ETS; previously the Norwegian ETS was capped at 15 million tons CO2e)	Before the Norwegian ETS was incorporated into the EU ETS, allowances were distributed into two phases. During the second phase, which began in 2007, half of the allowances were auctioned, 40% were sold freely, and roughly 10% were held in a reserve.	Supply far exceeded demand for allowances in the pilot Norwegian ETS and prices collapsed rapidly.	Environmental Defense Fund and International Emissions Trading Association (2013), "Norway - The World's Carbon Markets: A Case Study Guide to Emissions Trading," available at: http://www.edf.org/sites/default/files/EDF_IETA_Norway_Case_Study_May_2013.pdf.
Tokyo	The Tokyo ETS would cover 13 million tons of CO2e per year.	The Tokyo Municipal Government aims to prevent price surges by increasing the amount of market-based mitigation measures, such as renewable energy offset programs. The Tokyo governor has the power to take other steps to contain prices, including setting up a reserve fund – but this has not happened yet.	NA	Environmental Defense Fund and International Emissions Trading Association (2013), "Tokyo - The World's Carbon Markets: A Case Study Guide to Emissions Trading," available at: http://www.edf.org/sites/default/files/EDF_IETA_Tokyo_Case_Study_September_2013.pdf.

Annex I: Current Stabilization Fund Approaches continued

Market	Size of the Market	Mechanics	Effectiveness	References
Quebec	The Quebec ETS will cover 23.2 million tons CO2e from 2013-2014. In 2015, this will increase to 65.3 million tons CO2e, then decrease from 54.74 million tons CO2e by 4% each year after 2020.	The Quebec reserve closely mirrors California's APCR. The Quebec allowance reserve account holds 1% of allowances under the cap for 2013 and 2014, 4% of allowances for 2015 to 2017, 7% of allowances under the cap set for 2018 to 2020; and 4% of allowances after 2021. If allowance prices reach trigger prices, they will be sold via a "sale by mutual agreement" coordinated by WCI Inc. Allowances are divided into three tiers, which are set at $40, $45 and $50. From 2013 onwards, the price of reserve allowances will increase by 5% each year. Alternatively, the minister may choose to use these reserve allowances to adjust the amount of free allowances allocated to emitters.	A note on similarities between California and Quebec's reserves: The rules for California's system are similar, but only Québec emitters can access Québec reserve allowances and only California emitters can access California reserve allowances. Specifically, the numeric values for the prices at which reserve allowances become available are the same in California, but are priced in USD rather than CAD, and account for U.S. inflation rather than Canadian inflation.	Environmental Defense Fund and International Emissions Trading Association (2013), "Quebec - The World's Carbon Markets: A Case Study Guide to Emissions Trading," available at: http://www.edf.org/sites/default/files/EDF_IETA_Quebec_Case_Study_May_2013.pdf.
RGGI	Under the new Model Rule which will go into effect on January 1, 2014, the RGGI cap will be 91 million tons of CO2e.	The Model Rule will create a new cost containment reserve (CCR) that would consist of a fixed quantity of fully fungible allowances in addition to the cap. The annual CCR withdrawal limit will be 5 million allowances in 2014, and 10 million allowances in each year after. The CCR would initially be populated in 2013, and in subsequent years replenished only as needed to maintain the withdrawal limit. If bids exceed the CCR price trigger at an auction, allowances are made immediately available at or above the CCR trigger price. CCR trigger prices are $4 in 2014, $6 in 2015, $8 in 2016, and $10 in 2017. Each year after 2017, the CCR trigger price will increase by 2.5%.	NA for the CCR; Previous mechanism: During the first and second commitment periods, RGGI has used a trigger price mechanism with flexibility provisions. If the average price of an allowance exceeds the trigger price for one year, the duration of the compliance period can be extended. The trigger price is $10, and if this price is reached RGGI can accept international offset units, including CERs. Each RGGI auction also has a reserve price floor. The updated Model Rule would set the rate that the reserve price increases to 2.5 percent each year.	Regional Greenhouse Gas Initiative (2013), "Summary of RGGI Model Rule Changes: February 2013," available at: http://www.rggi.org/docs/ProgramReview/_FinalProgramReview Materials/ Model_Rule_Summary.pdf. Environmental Defense Fund and International Emissions Trading Association (2013), "Regional Greenhouse Gas Initiative - The World's Carbon Markets: A Case Study Guide to Emissions Trading," available at: http://www.edf.org/sites/default/ files/EDF_IETA_RGGI_Case_Study_May_2013.pdf.

Annex I: Current Stabilization Fund Approaches continued

Market	Size of the Market	Mechanics	Effectiveness	References
South Korea	South Korea's cap will aim to cut emissions by 236 million tons CO_2e from 2015-2020.	The South Korean government can increase the supply of allowances if prices rise too high by holding early auctions for up to 25% of reserve permits. South Korea has asserted that it will build an allowance reserve, but the size has yet to be determined. In addition, to stabilize the market, the Ministry of Environment may also set emissions permit possession limits, limit banking and borrowing and offsets, and set price ceilings and floors. The reserve would be activated not at a specific price, but rather over pre-determined price fluctuations of a given percent over a certain time period.	NA	Environmental Defense Fund and International Emissions Trading Association (2013), "South Korea - The World's Carbon Markets: A Case Study Guide to Emissions Trading," available at: http://www.edf.org/sites/default/files/EDF_IETA_Korea_Case_Study_September_2013.pdf.
Japan (speculative)	NA	The Japanese government's initial outline of a country-wide ETS specifies a cost-containment reserve as a price volatility measure. The government has not yet selected the reserve scale or the requirements for use.	NA	Environmental Defense Fund and International Emissions Trading Association (2013), "Japan - The World's Carbon Markets: A Case Study Guide to Emissions Trading," available at: http://www.edf.org/sites/default/files/EDF_IETA_Japan_Case_Study_September_2013.pdf. Japanese Ministry of the Environment (2010), "Scheme Options for Japanese Emissions Trading Scheme Based on Cap and Trade System," available at: http://www.env.go.jp/en/earth/ets/mkt_mech/scheme-options100910.pdf.

ANNEX II: SUMMARY OF APPROACHES TO CARBON MARKET RESERVES FOR PRICE STABILIZATION

Reference	Key ideas
Center for Clean Air Policy – Europe (2013), "The New Deal – An Enlightened Industrial Policy for the EU through Structural EU ETS Reform," available at: http://ccap.org/assets/The-New-Deal-An-Enlightened-Industrial-Policy-for-the-EU-through-Structural-EU-ETS-Reform_CCAP-Europe_Feb-2013.pdf.	A new Quantitative Easing Reserve would be populated by 500 million EUAs in order to mitigate potential carbon price spikes, improve supply stability, and reduce risks for climate-related investments. The reserve would require an automated legal mechanism to activate auctions for the reserve, primarily by setting a price ceiling that increases over time, as well as establishing a price floor. Revenues from reserve auctions would be used to buy additional allowances to populate the reserve.
Bailey, E., Borenstein, S., Bushnell, J., Wolak, F., & Zaragoza-Watkins, M. (2013), "Forecasting Supply and Demand Balance in California's Greenhouse Gas Cap and Trade Market," California Air and Resources Board, available at: http://ei.haas.berkeley.edu/pdf/Forecasting%20CA%20Cap%20and%20Trade.pdf.	Modeling of projected supply and demand for allowances in the California emissions trading system and its APCR reveals that most allowances priced below the APCR price trigger will be available at general auction prices. Only a small amount of the allowances will be above the trigger price, indicating that prices should be roughly stable at prices near the auction reserve price. However, significant demand for allowances could emerge, indicating a continued necessity for price containment mechanisms.
Murray, B., Newell, R. & Pizer, W. (2008), "Balancing Cost and Emissions Certainty – An Allowance Reserve for Cap-and-Trade," Resources for the Future, available at: http://www.rff.org/RFF/Documents/RFF-DP-08-24.pdf.	In order to succeed, cap-and-trade systems require a degree of flexibility that allows borrowing and price adjustment without exceeding the limits of rational supply and demand. An annual allowance reserve limit of 10-20% of the cap could mitigate short-term uncertainty while maintaining flexibility for long-term projections to influence the current market. A flexible floor price with a rigid ceiling price—a trigger price for the reserve—could optimize flexibility for price stabilization in an emissions trading system.
Tatsutani, M. & Pizer, W. (2008), "Managing Costs in a U.S. Greenhouse Gas Trading Program – A Workshop Summary," Resources for the Future, available at: http://www.rff.org/RFF/Documents/RFF-DP-08-23.pdf.	A potential U.S. carbon market reserve could draw from future allowances in order to maintain ambitious emissions targets. This would effectively shift part of the burden of compliance from the present into the future when mitigation may be achievable. An effective reserve could be adequately populated by allotting roughly 10% or less of long-term caps from 2030-2050. The reserve could also include allowances priced below a price floor.
United States Congressional Budget Office (2010), "Managing Allowance Prices in a Cap-and-Trade Program", available at: http://www.cbo.gov/sites/default/files/cbofiles/ftpdocs/118xx/doc11872/11-04-2010-cap-and-trade.pdf.	A potential reserve would sell allowances once a trigger price was reached. This reserve could operate via two possible mechanisms, each with differing effects. First, a reserve could be populated with allowances supplemental to those under the cap, which would allow more flexible compliance under high price scenarios. This would tend to increase emissions and lower prices. Alternatively, the reserve could be created by withdrawing allowances from the cap, which could increase compliance costs and allowance prices, but would regulate emissions more tightly.
Stocking, A. (2010), "Unintended Consequences of Price Controls: An Application to Allowance Markets," Congressional Budget Office, available at: http://www.cbo.gov/sites/default/files/cbofiles/ftpdocs/118xx/doc11871/pricecontrolscaptrade.pdf.	A potential reserve should draw off a significant fraction (between 5 and 20%) of the annual cap relative to the economy's responsiveness to price fluctuations.
International Energy Agency (2012), ""Policy Options for Low-Carbon Power Generation in China – Designing an emissions trading system for China's electricity sector," available at: http://www.iea.org/publications/insights/Insight_PolicyOptions_LowCarbon_China.pdf.	A potential allowance reserve in China would face significant risk of market curtailment if the reserve of allowances is set too low. An insufficiently populated reserve could cause prohibitively steep compliance costs for the energy sector, potentially slowing the addition of new power generation in China – a politically unacceptable outcome. Conversely, an overly large reserve could easily be managed by retiring unsold allowances at the end of the auction period. Another reserve management option would be to set the quantity of allowances in the reserve to match actual GDP growth.

ANNEX III. MODELING METHODOLOGY

For the analysis described in the paper, we employ a simple model of the impact of an international carbon market reserve on the price of global carbon market securities from 2020 to 2030. We do this by running a Monte Carlo simulation of 100,000 future monthly average prices between 2020 and 2030 with and without a reserve. The simulation first generates random price pathways between 2020 and 2030 using Geometric Brownian Motion (GBM) that matches the observed average annual volatility of 2012 CERs between August 2008 and November 2012, and that uses a set starting price of roughly $10 in 2020 and averaged an assumed end price of $45 in 2030.[48]

To model the price pathway with a strategic reserve, we made several additional assumptions reflecting a particular design and capitalization of the reserve:

- We made the simplifying assumption that CER demand was constant, totaling 60 billion tons CO2e purchased over the 10-year period.
- We assumed that the strategic reserve holds 600 million tons of CERs at the start of 2020; that it has no funds available at the start of 2020 for purchases to maintain the floor price, but that proceeds from CER sales are held and can be used later for such purchases.
- We set a price ceiling of $30 in 2020 and a price floor starting at $3.30 per ton in 2020. For any given price over the period, the ceiling and floor remains 3 times higher and 0.33 times lower respectively.
- Finally, we also assumed that the market price for CER's could be lowered (raised) by selling (buying) CERs at the ceiling (floor) price, using an assumed constant elasticity of supply of 0.62 to calculate the quantity required for a given change in price.[49]

In order for the ensemble of GBM price paths to average the assumed 2030 end price while also mimicking historical price volatility, many more price pathways must by necessity drop below the price floor than rise above the ceiling: 33 percent of price paths dropped below the floor. There is far more room for extreme prices above the 2030 mean price than below, which is bounded at zero. Whether this quirk is a bug or a feature of the simulation really depends on one's assumptions about the future carbon market. Regardless, the reserve as designed has no funds at the start for purchasing credits to maintain the floor price, so it can only maintain the floor price if it has previously generated funds through CER sales by hitting the ceiling. The price was below the floor price for roughly a third of our simulated time steps, and the reserve was only able to purchase credits about 1 percent of these months.

We ran a number of sensitivity analyses with differing elasticities and price bands, and found our results to be robust. Listed below are a handful of runs and accompanying results:

Run	*	1	2	3	4	5	6
Assumptions							
Elasticity	0.62	0.5	0.5	0.5	1	1	1
Floor	0.33	0.5	0.33	0.25	0.5	0.33	0.25
Ceiling	3	2	3	4	2	3	4
Percent change in price paths above ceiling with policy in place	39%	39%	42%	44%	32%	34%	35%
Percent change in volatility (only paths that exceed the ceiling)	-0.2%	-3.2%	-2.6%	-2.3%	-2.3%	-1.9%	-1.7%
Average value of the reserve (in billions)	$13.8	$11.1	$13.8	$15.6	$11.3	$13.8	$15.6
Percent of time reserve is valued more than $600 million	91%	91%	91%	91%	91%	91%	91%

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ISSN: 1939-9383

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