Managing Investment Revenues and Costs in the Transportation Climate Initiative Region

Issue Brief 20-05 by **Dallas Burtraw**, **Maya Domeshek**, and **Derek Wietelman** — April 2020

Twelve northeast and mid-Atlantic states and the District of Columbia are participating in the **Transportation Climate Initiative (TCI)**, a regional transportation effort to coordinate investment in cleaner transportation and infrastructure.[1] One expected element of the program is a price on carbon emissions from transportation to be implemented through emissions cap and trade. Emissions allowances would be distributed initially through an auction and subsequently could be traded in a secondary carbon market to ensure emissions reductions are achieved at the least possible cost. [2] The auction could yield billions of dollars for investment to modernize transportation infrastructure.

The investments of auction revenue to improve transportation infrastructure are expected to contribute importantly to achieving the goal of reducing emissions in the transportation sector by expanding opportunities for low carbon transportation as well as improving transportation access and community amenities. However, long-lived infrastructure investments and annual program operations require projections of carbon revenues. Variability in gasoline prices, economic activity, vehicle miles traveled, regulation at other levels of government and technological change could make allowance auction prices and associated investment revenue in a transportation cap-and-trade program vary from expected levels, and generally difficult to predict. Variability in allowance prices also implies that costs could differ from expectations. This issue brief examines approaches to manage the variability in allowance prices, auction revenues and costs that could occur in the program. We illustrate how potential variability could affect program revenues. We identify several elements of program design that can reduce revenue variability. From among these, we focus on the combination of an emissions and cost containment reserves in the allowance auction, which is a feature that appears in some other allowance markets including the Regional Greenhouse Gas Initiative (RGGI). This feature tethers the supply of emissions allowances to the price in the allowance auction, so that greater reductions are made when it is cheap to make them, and fewer reductions are made when it is expensive to make them. The responsiveness of the supply of a commodity to its price is a characteristic that describes commodity markets in general but is a recent innovation in environmental markets.

Our conclusions are:

- Several elements of market design could mitigate potential allowance price and revenue variability in TCI and generally help constrain allowance prices. These options include emissions allowance banking, expanding the market geographically, linking with other markets, and allowing for the use of offsets.
- One of the most important design features for limiting allowance prices is the cap-and-invest approach to emissions trading. By using revenues from the allowance auctions to make program related investments that accelerate the modernization of transportation infrastructure,

1 The participating states include Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland and Virginia, along with the District of Columbia.

2 State fuel suppliers are the regulated entities.

the states enable the region to reduce emissions more quickly. These investments have a counter-cyclical effect on allowance prices and program revenues; for example, if prices tend high then auction revenues increase, leading to an increase in investment revenue, which helps reduce the allowance price.

- Emissions and cost containment reserves provide the most direct mechanisms to govern allowance price and auction revenue variability. Previous allowance trading programs have introduced just one or a few price steps that make a quantity of allowances available in the auction only when bids are at or above those prices. A price staircase with quantities of allowances made available at many different price steps may be advantageous. We address considerations of other design features including average slope of the allowance supply schedule.

Price volatility and price levels in carbon markets

The traditional approach to cap and trade fixes an acceptable emissions level and enables firms to buy and sell the right to pollute, subject to the rule that total emissions do not exceed the emissions cap. The trading market identifies the price of tradable emissions allowances and provides an economic incentive to reduce emissions, while the price level varies and is uncertain ex ante.

Price volatility in TCI could be precipitated by many external factors. For example, changes in oil prices or in economic activity are expected to affect vehicle miles traveled. Variability in the fundamental characteristics of demand and supply for transportation fuels can be amplified in the allowance market. Generally, in commodity markets one observes price volatility that exceeds what one would anticipate based on market fundamentals because prices are influenced not only by current period behavior but also by expectations about future trends and public policy. [3]

Modest price volatility is useful in directing resources in the economy. A high level of price volatility is a concern, though, because it creates uncertainty for firms and their customers that tends to undermine investment and constrain economic activity, and also tends to undermine confidence in the market. Further anxiety surrounds the possibility that variable prices could result in high prices that harm business.

Several market design options reduce allowance price and revenue variability in emission markets and generally help constrain allowance prices. One option is emissions allowance banking, which provides flexibility for firms in response to inter-annual fluctuations in allowance demand that might stem from changes in weather or economic conditions. In the absence of banking, at the end of a compliance period emissions will either exceed or be less than the available emissions allowances. These results have undesirable effects in the allowance market, causing prices to spike or fall to zero, respectively. Another market design option is expanding the market geographically or linking with other markets to accommodate regional differences in fluctuations in weather or economic activity, or differences across sectors. Banking and linking are mechanisms to spread compliance responsibility over time and space and therefore directly reduce price volatility. These mechanisms also reduce costs by enabling the pooling of risk associated with the uncertainty affecting the short-run demand for permits. [4]

A third market design option intended primarily to limit costs but that also mitigates price volatility is the use of out-of-market compliance instruments, known as offsets. Many observers find there are substantial low-cost opportunities to achieve emissions reductions at unregulated sources and offsets provide a way for regulated parties to capture these low-cost emissions reduction opportunities.

While price volatility is a concern, special attention is always given to the possibility that prices turn out to be greater than expected. If this occurs, firms and

3 For example, see Newell, Papps and Sanchirico (2007) for an investigation of present-value asset pricing in an environmental market for fishing quotas. "Asset Pricing in Created Markets," Amer. J. Agr. Econ. 89(2): 259-272.

4 Doda, Quemin and Taschini, 2019. Linking permit markets multilaterally. J Env Econ Management. **https://doi.org/10.1016/j.jeem.2019.102259.**

consumers may experience sticker shock that would undermine the political sustainability of the program. Often these concerns are magnified when these firms do not have previous experience with emissions trading, and this concern is understandable because firms could be disadvantaged compared to competing firms in other jurisdictions if prices were to rise to unanticipated levels. Policy makers now have over thirty years of experience with emissions trading, however, and in fact, the reality in trading programs for several different pollutants across North America and Europe has been the opposite — prices have been lower than anticipated in every market and have often fallen over time in real terms.[5] Several factors contribute to this outcome including a generous initial allocation of allowances, the introduction of overlapping policies at various levels of government that encourage emissions reductions at the same sources, and changes in institutions and public attitudes that also encourage emissions reductions. Technological innovation prompted by incentives introduced by emissions pricing is another key factor, working just the way these programs are intended to work.

Another key feature of most allowance trading programs has been the direction of program revenues to achieve program-related goals. For example, in RGGI, auction proceeds have been directed toward investments in energy efficiency that help reduce emissions from the electricity sector. The use of program revenues is also valuable for mitigating allowance price volatility because spending within the capped sector has a counter-cyclical effect on allowance prices. For example, in RGGI when allowance prices tend high, auction revenues increase, and states can increase their spending on energy efficiency. This in turn helps lower electricity demand and thus allowance prices. In TCI, the use of auction proceeds to accelerate emissions reductions will be a key part of overall program design; however, allowance price volatility could affect the revenues that are collected and undermine planning for the type of investments needed to induce long-term reduction in the demand for allowances.

Emissions and cost containment in carbon markets

While banking, linking, offsets, and program-related use of auction revenue can all help reduce carbon market volatility and reduce costs, the most direct mechanism for governing allowance price and revenue volatility is to tether emissions allowance supply to allowance prices. In general, the supply of commodities or other goods and services are related in this way. Environmental markets like TCI would likely benefit from building this feature into their design.

For example, when demand for a commodity like corn or natural gas goes down, causing its price to go down, less of that commodity is brought to the market. In response to low prices, farmers will substitute their planting away from corn, and fewer natural gas wells will be drilled, or uneconomic ones will be taken out of service. The reduction in supply of these commodities tends to offset the effect on the commodity price due to the reduction in demand. An increase in the demand for a commodity has the opposite effect by causing the market price to rise, which attracts an expansion in the supply of the product that tends to offset the increase in the price. This is the natural process of achieving equilibrium between demand and supply in markets that smooths the changes that occur because of unanticipated events.

In the emissions market, the supply of emissions allowances is the result of government policies and regulatory targets, not individual decisions. The outcome of interest in TCI is the decarbonization of the transportation sector, but the path of annual emissions targets that best helps the region achieve its long run decarbonization goals is not foreordained. The path will be chosen through a regulatory negotiation that balances costs and benefits. That path is important not just for carbon reductions in TCI, but also as a signal of commitment to other jurisdictions looking to reduce their emissions. In this context, if policy makers learned that the costs of achieving the desired outcome were

5 Burtraw and Keyes, 2018. Recognizing gravity as the strong force in atmosphere emissions markets. RFF Working Paper 18-16. **https://www.rff.org/publications/working-papers/recognizing-gravity-as-the-strong-force-in-atmosphere-emissions-markets/**

less than anticipated, they should want to accelerate their progress and achieve more emissions reductions in the short run. Vice versa, if costs were greater than anticipated, policy makers would likely choose more modest annual targets.

Adjustments in response to new information about the cost of emissions reductions can be implemented through ongoing program review and regulatory negotiations, but experience tells us that this approach is time consuming and difficult. Moreover, the firms that are affected by outcomes in the allowance markets face an additional element of uncertainty in the face of repeated adjustments to the program. Although program review and administrative adjustment always remains an option for policy makers, a different approach is to build instructions for allowance supply into the market design that reflects the balancing of costs and benefits, that can be automatically implemented, and that are predictable for market participants.

RGGI implemented an early and simple approach to automatically adjusting allowance supply with the introduction of a price floor, which defined a minimum price at which allowances would be sold in the auction. If market conditions were to result in a price that was below the price floor, the supply in the market would contract, thereby boosting the market price. This approach was subsequently adopted in the Western Climate Initiative and is evident in the California and Quebec emissions auctions.

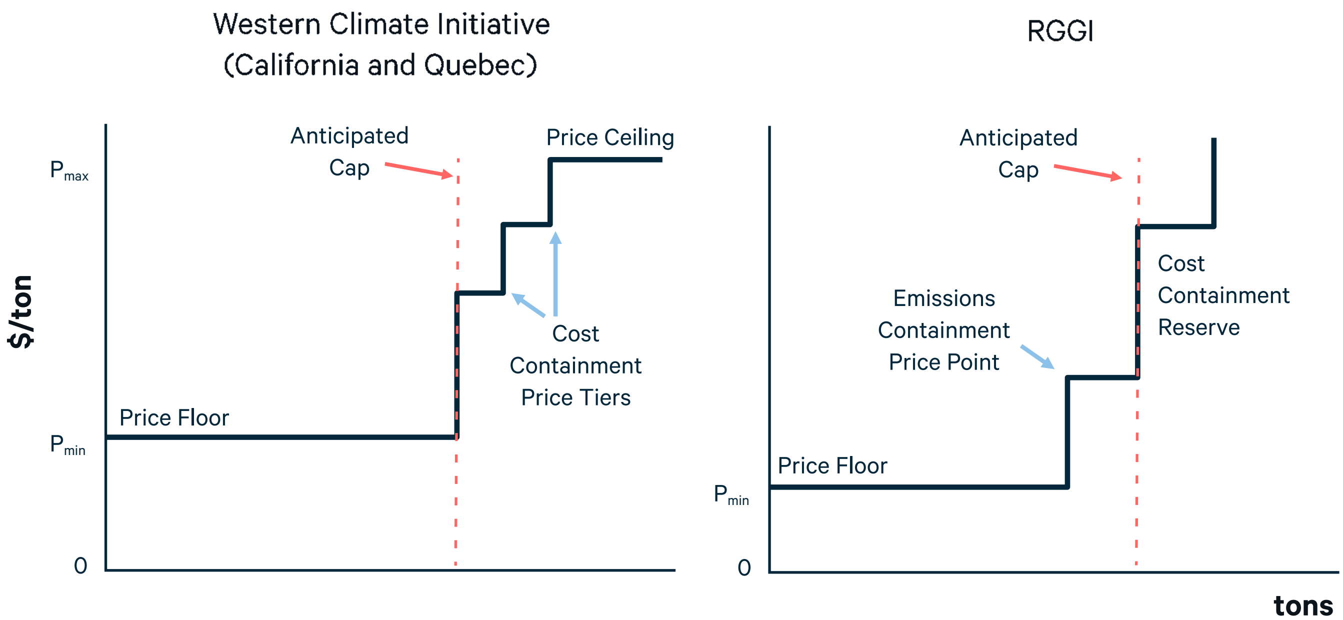
The price floor was balanced by a feature called a cost containment reserve that would make an additional quantity of allowances available if the price rose to a specific trigger point. In RGGI, additional allowances were drawn from a single cost containment reserve with a single price trigger. In the WCI this feature was implemented with three cost containment reserves with separate price triggers. In 2021, that design will evolve further with the introduction of a price ceiling at which an unlimited quantity of allowances becomes available.

Market design evolved further as an outcome of the 2016 RGGI program review when RGGI decided to introduce in 2021 another price step, above the price floor, that will provide a minimum price for the sale of about ten percent of the allowances available in the auction. If this measure is triggered, fewer allowances enter the market. This feature is called the emissions containment reserve because it captures emissions reduction benefits when prices (costs) turn out to be lower than expected.

These innovations in the RGGI and WCI programs illustrate a price-responsive supply schedule of emissions allowances in place of a fixed emissions cap that is typically described in textbooks. Figure 1 illustrates these supply schedules, and the way that the introduction of allowances into the market adjusts to the market clearing price in the auction. For instance, in RGGI, if the price is below the Emissions Containment Price Point, a portion of the anticipated cap will not be sold. In WCI allowances equal to the entire anticipated cap allocation are sold at prices above the price floor. If the price rises to the cost containment price tiers, additional allowances enter the program.

Implementation of these features is administratively simple in auction software. Two important considerations though are the origin of additional allowances added to the market and the destination of allowances removed from the market. In RGGI, allowances in the cost containment reserve are additional to the cap, so when the reserve is triggered the region winds up on a higher emissions pathway. In contrast, WCI determined the maximum emissions they considered acceptable, before setting aside some of them from future years for their cost containment reserve, so those allowances come from underneath their multi-year cap. In RGGI, allowances not sold under the price floor are not automatically retired, but all past program reviews have decided to retire them. Starting with the next program implementation in RGGI, allowances not sold under the emissions containment reserve will be automatically retired. In contrast, in WCI allowances that are not sold at the price floor are placed in a cost containment reserve and may re-enter the market in the future.

Figure 1. Supply of Emissions Allowances in North American Carbon Trading Programs in 2021



Emissions and cost containment reserves in TCI

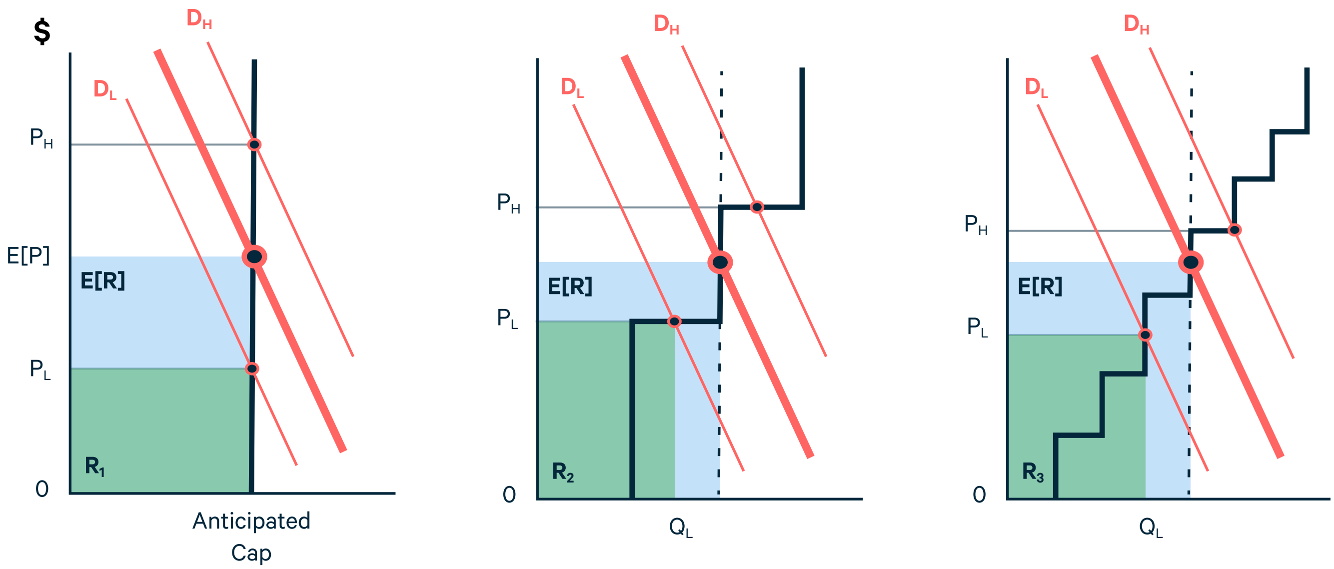
The TCI draft memorandum of understanding released in December 2019[6] anticipates the inclusion of emissions and cost containment reserves as part of the program, although the design is not specified. These provisions will help to stabilize prices and revenues in the program. The key questions to be addressed is how many price steps to include and what should be their size and shape.

The number of price steps

Figure 2 illustrates three allowance supply schedules with the horizontal axis representing the quantity of emissions allowances and the vertical axis representing their price. The first panel illustrates a traditional emission cap without emissions or cost containment reserves, with three possible downward sloping demand curves for emissions allowances. The bold line demand curve in the center is the expected allowance demand curve ex ante and where it crosses the allowance supply schedule identifies the expected price of allowances (E[P]). The expected revenue (E[R]) that results is shaded area, the product of the quantity of allowances and the price. Potential low demand (D_L) and high demand (D_H) are also illustrated. With allowance supply fixed at a specified quantity, the revenue from the sale of allowances is directly proportional to the allowance price. For example, at the low allowance price (P_L) the revenue collected is R_1.

6 The full text of the draft memorandum can be found here: **https://www.transportationandclimate.org/sites/default/files/FINAL%20TCI_draft-MOU_20191217.pdf.** The language discussing the potential inclusion of emissions containment reserve and cost containment reserve mechanisms can be found on pages 6-7.

Figure 2. Variability of allowance prices and revenue under three allowance supply schedules



One might pause to ask what it means to describe multiple demand curves in Figure 2. This illustration represents possible future outcomes that would be affected by exogenous factors such as changes in transportation demand as mentioned at the outset, or technological change, etc. While each individual curve describes how allowance demand changes in response to allowance price, the family of curves reflects alternative outcomes that shift demand over time.

The second panel illustrates an allowance supply schedule with two steps, below and above the expected allowance price, that represent an emissions containment reserve and a cost containment reserve analogous to the RGGI program.[7] The expected allowance price and expected revenue are the same as in the first panel. However, in this case the low allowance demand curve results in a higher price and lower quantity of allowances. In principle the revenue collected (R_2) in the low demand case could be greater or less than in the first panel, but in practical terms the revenue is likely to be greater ($R_2>R_1$) although still less than anticipated initially ($R_2<E[R]$). Revenue is greater than in the first panel because demand for transportation services is considered fairly inelastic (insensitive) to a change in the price; in this case revenue is maximized by reducing the quantity and maintaining a higher price. Conversely, if the allowance demand curve were greater than expected, the revenues that resulted would be less than in the first panel because the realized price would be less, but revenues would still be greater than anticipated initially. In summary, the two step emissions and cost containment reserves yield less variability in allowance prices and revenue than would be observed under a fixed supply at the allowance cap.

The third panel describes a price staircase. The change in revenue under different demand curves (signified by the shaded area R_3 for the low allowance demand curve) in this example is ambiguous compared to the second panel with two price steps. However, if the supply schedule is designed to have the same average slope over a range of outcomes then the price staircase will yield less price and revenue variability.[8] In other words,

7 RGGI also has a price floor that is not illustrated in this example.

8 We assume the distribution of potential realizations of demand is single-peaked and more likely to be in the neighborhood of the expected demand curve than far away from it.

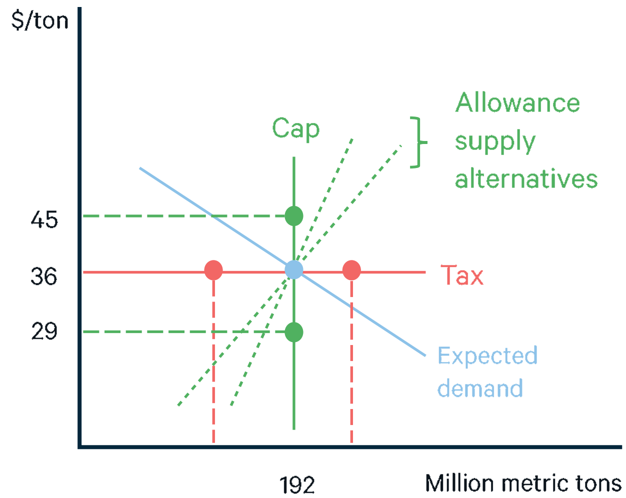
more price trigger points along a similar supply schedule in TCI will enhance the predictability of prices for market participants and revenues for state agencies that make long-term budgeting decisions.

The size and shape of the price steps

A second key element of the allowance supply schedule involves the level of the price points and the quantity of allowances made available at each price point. One can imagine this as the average slope of the price schedule. In general, given that transportation demand and consequently demand for emissions allowances in TCI is inelastic, revenue will be closer to expected revenue if alternative realizations of uncertain future demand result in relatively greater changes in the quantity of emissions and smaller changes in the price. This argues for a supply schedule that has a relatively flat slope. In the extreme, of course, this supply schedule might resemble a tax, but revenue reliability is not the primary consideration in the design of the program. The primary outcome of interest is the change in emissions, and variations in emissions outcomes under a tax could undermine this goal and fail to deliver timely environmental benefits to communities in the region. [9] Consequently, a tradeoff exists between revenue and emissions predictability because both contribute to the success of TCI.

The size and shape of the price steps in the supply schedule—or in other words the average slope of the supply schedule—embody this tradeoff. This is illustrated in Figure 3 which displays allowance market outcomes modeled by TCI. The reference point emissions outcome from motor gasoline and on-road diesel based on the 25 percent cap reduction from

Figure 3. Emissions and Price Outcomes in TCI in 2032 under the 25 percent reduction target



projected 2022 emissions by 2032 in the TCI 2019 Cap-and-Invest Modeling Results is 192 million metric tons in 2032, and is associated with an allowance price of $36 per metric ton (2017$).[10] However, there are many uncertain factors underlying this outcome. For example, TCI's modeling relies on projections of oil prices and electric vehicle battery prices that may be higher or lower than those that ultimately occur. Similarly, estimates of gasoline own price elasticities in the literature vary by an order of magnitude,[11] and there is evidence they are increasing over time[12], so people's response to the increased gasoline prices will likely differ from what is assumed in the TCI model of consumer gasoline purchasing behavior. Perhaps most interestingly, the emissions and price outcomes could be strongly affected by the way the auction revenues are

9 Analogous to a price-responsive supply curve under cap and trade, there are several proposals that would automatically adjust taxes in response to emissions outcomes, sometimes called an emissions assurance mechanism. See the recent forum in the Review of Environmental Economics and Policy (2020), **https://academic.oup.com/reep/issue/14/1**.

10 Reported on December 17, 2019 (slide 28). See **https://www.transportationandclimate.org/sites/default/files/TCI%20Public%20Webinar%20Slides_20191217.pdf** .

11 Short-run fuel price elasticities fall in the "range of -0.02 to -0.22 (average around -0.15) with longer-run elasticities falling mostly in the range -0.06 to -0.60 (average around -0.3) for the most common trip purposes" (Dong, Davidson, Southworth and Reuscher, 2012. Analysis of Automobile Travel Demand Elasticities with Respect to Travel Cost. Oak Ridge National Laboratory, p.9).

12 Goetzke and Vance, 2018. Is Gasoline Price Elasticity in the United States Increasing? Evidence from the 2009 and 2017 National Household Travel Surveys. Ruhr Economic Papers, No. 765.

utilized. TCI modeling illustrates that under alternative portfolios of clean transportation investments the allowance prices to achieve the fixed 25 percent reduction in emissions represented by the cap could range from $29 to $45.

Figure 3 illustrates this range of allowance price outcomes that might result if the emissions outcome were implemented with an inflexible emissions cap set at 192 million metric tons. Conversely, if one were interested primarily in price stability, the figure illustrates that a range of emissions outcomes might result from an emissions tax of $36. The steeper the supply curve, the more like a cap and the more emissions certainty is achieved. The more horizontal the supply curve, the more like a tax and the more revenue certainty.

The tradeoff between revenue and emissions predictability is illustrated by these alternatives, but the choice is not one or the other. A supply schedule that adjusts to price changes offers a balance. Moreover, history suggests that different levels of demand for emissions allowances are not equally likely. A variety of behavioral, policy and technology changes could affect transportation demand in unexpected ways. In the long run, for TCI to achieve its goals it is necessary that the demand for emissions allowances be severed from the transportation demand and fall over time in the same way that emissions have been severed from consumption in the electricity sector. This outcome may be achieved through the proliferation of lower and non-emitting vehicles and hopefully other changes in behavior, land use, etc. If these changes occur, they will shift allowance demand downward. If allowance supply is set at a fixed quantity, it will not be positioned to automatically capture these advantageous changes in technology. A price responsive schedule of allowances would automatically do so.

In summary, clearly a reduction in the supply of allowances can be programmed into annual emissions budgets and revisited further in periodic program review. However, because outcomes are inherently uncertain and investments rely on program revenues, an allowance supply curve that automatically responds to changes in demand would reduce variability in revenue and prices in the short run and could enhance program success and accelerate emissions reductions in the long run.

Concluding Thoughts

Uncertainty in carbon markets is manageable through several elements of market design. One of the most useful and most direct approaches is a supply of emissions allowances that automatically adjusts to changes in allowance price. This approach can balance allowance price certainty that would be achieved under a tax with emissions certainty that would occur under a fixed emissions cap and can improve on the reliability of program revenues compared to an emissions cap. It also helps manage costs for the regulated industry. We show a price staircase with multiple price steps contributes to reliable program outcomes.

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