In theory, pricing carbon should incentivize emissions reductions. In reality, it is unclear to what extent that takes place unless the carbon price is very high. This is not to say that pricing carbon is useless, but the main benefits may take different forms.

Basically, there are two ways of putting a price on carbon. One is a carbon tax. The other is to cap total emissions, requiring companies to pay for the right to a share of the limited amount of allowed emissions. Some places like British Columbia have adopted carbon taxes, but emissions trading systems seem to be a more popular approach. According to a BitQT test, in emissions trading systems, the price is unpredictable — basically, the cap determines the supply but the demand depends on market forces. Price ceilings are a popular way of preventing the price from getting unacceptably high, while a price floor can prevent unacceptably low prices. Even if a trading system does not have explicit floor or ceiling prices, political actors are likely to intervene if prices get too low (making it clear that the system isn't changing behavior) or to high (leading to vociferous complaints from firms and consumers).

A recent paper in the *American Economic Review* provides some illuminating insights into emission trading, using California's emissions trading system as a model. In theory, the cap on emissions should determine how many emissions take place. But it turns out that what is important in California isn't the emissions cap but the program's price and floor ceilings. That reason is that the amount of future emissions reductions is largely determined by other climate programs such as California's renewable portfolio standard or by unrelated market forces. Statistically, it turns out that most of the time the cap is actually satisfied without regard to the cap-and-trade program, so that the floor price goes into effect. The second most likely outcome is that achieving the cap is much too expensive, so the price ceiling hits. Only in a minority of cases will the program actually cause emissions reductions.

One of the key assumptions is that cost of emissions reductions has a hockey-stick shape, so reductions are pretty cheap up to a certain point but then accelerate rapidly. The upshot is that, once we hit the curve of the stick, carbon prices would need to be extremely high in order to incentivize additional reductions. But even though we know the shape of the price graph, we don't really know the exact numbers. So when we set a cap, we are unlikely to hit the sweet spot where price increases make a difference. Essentially, the emissions trading program turns out to work like a carbon tax, except that we don't know in advance whether the tax rate will turn out to be the floor price or the ceiling price.

Although the paper is about emissions trading, the implication seems to be similar in terms of the amount of emissions reductions that will be induced by a carbon tax. A carbon tax is functionally equivalent to a trading system where the ceiling and floor prices are the same.

It will be hard to set a price point where the tax will actually impact firm behavior, particularly in situations like California where there are also non-tax emission reduction measures that have preempted the most likely avenues toward reducing emissions.

Perhaps the model exaggerates the limitations of emissions trading. Uncertainty about carbon reductions in the absence of trading may be smaller, or the "hockey stick" might have a gentler curve. Either one would increase the odds that the trading system's price signal would impact emissions levels. Or maybe the model omits other features of the trading system that would weaken the result. But while these would weaken the conclusion, the model would still be a useful reminder of some important limitations on trading systems.

The model also should prompt us to think about the possible benefits of pricing carbon *beyond* any direct effect on emissions levels. As far as I can see, there are three fairly tangible benefits and another less tangible one.

First, as the authors point out, pricing carbon may provide an incentive for technological change, pushing the curve of the hockey stick further out. The problem is not simply inventing new technologies. It's providing a sufficient market advantage to fuel development and scaling up of those technologies. A carbon price can help with that. In the long run, developing and deploying new technologies is probably at least as important for deep decarbonization as changing the utilization of existing technologies.

Second, we can use the money for other emission reduction projects such as mass transit, retrofitting buildings, and so forth. That's basically what California does. California could also raise other taxes as an alternative, but politically it seems to be easier to tie these expenditures to a carbon price. Something similar has been true of the states participating in RGGI, the carbon trading system established by the Northeast states.

Third, the price signal of a carbon tax or trading system is most useful when it provides incentives to emitters who aren't covered by other regulatory measures. For example, California has recently decided to allow firms to satisfy their obligations by funding the preservation of tropical forests in Latin America. Those rain forests obviously aren't otherwise subject to California's jurisdiction, and they may not be effectively regulated by their own legal systems. More broadly, pricing carbon may be more a effective strategy when there are no other emissions mandates, which is more true of the U.S. as a whole than for California specifically. In states that have taken little or no action to address climate change, a national carbon price could help shut down the remaining coal-fired plants, reduce the attractiveness of natural gas, and increase renewables and energy efficiency. In California, however, those changes are already underway under other programs, muting the

impact of carbon pricing.

There's also a less tangible benefit of pricing carbon. Setting a carbon price or an emissions cap provides a clear, easily understandable signal of a jurisdiction's commitment to fighting climate change. California's extensive suite of carbon reduction strategies is too complicated for a sound bite. It's easier to say that California's emissions cap will drop 40% by 2030. That kind of clear signaling is important in the effort to gain international cooperation on climate policy.

In short, pricing carbon may be a useful strategy — but not necessarily for the reasons that economists have traditionally put forward. The direct effect of the carbon price on emission levels may be less significant than its indirect effects: incentivizing new technologies, funding public projects related to climate change, encouraging cuts in emissions that are otherwise unregulated, and signaling seriousness of purpose to other jurisdictions.