Economic Models of AB 32: An Evaluation

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Assembly Bill 32 (AB 32), the Global Warming Solutions Act of 2006, requires California to reduce its greenhouse gas emissions to 1990 levels by 2020, representing roughly a 25% reduction compared to business as usual. In this note, I summarize and discuss the key assumptions of a number of economic models estimating the costs of AB 32. Despite ignoring many of key benefits of AB 32, the model suggests the costs of AB 32 are likely to be small.

Assembly Bill 32 (AB 32), the Global Warming Solutions Act of 2006, requires California to reduce its greenhouse gas emissions to 1990 levels by 2020, representing roughly a 25% reduction compared to business as usual. AB 32 is the most comprehensive climate change bill ever passed within the United States and is on par with the goals and actions of the European Union. AB 32 represents the first major piece of climate change legislation within the United States.

While the science is clear that greenhouse gas emissions are causing global temperatures to increase, regulating greenhouse gas emissions has an extra layer of complexity compared to regulating other pollutants such as nitrogen oxides (NOx) and carbon monoxide (CO). Unlike these other pollutants, greenhouse gases are a global pollutant; one ton of carbon dioxide (CO_2) emitted in California does the same amount of damage as one ton of CO_2 emitted elsewhere. This brings up a number of challenges to forming climate change public policy. Most importantly, it means that there is a significant free-rider problem since the benefits from any reductions in greenhouse gases are diffuse. That is, the ideal regulatory jurisdiction is at the global level. Any smaller scale than this will imply that jurisdictions may have an incentive to do nothing, relying instead on others to bear the cost burden of greenhouse gas reductions.

Despite this, a number of jurisdictions have passed climate change regulations at this smaller scale (e.g., Europe and Australia). At a national level, the United States has lagged the world on climate change policy.

Because the benefits of AB 32 accrue to both Californians and non-Californians, understanding the costs of AB 32 is perhaps more important. A number of cost estimates exist, often relying on highly technical and complicated models of economic activity. In this note, I discuss the basic structure of these models and the importance of several key assumptions. Several of the key models that exist largely agree on the bottom line of AB 32: ignoring many of the key benefits from the legislation, the cost of AB 32 is likely to be small.

Climate Change Policies: The Basic Economics

Climate change policies carry a number of costs. At the most basic level, you can categorize these costs into three groups. First, firms may change their product design or how they produce their products, relying on less greenhouse-gas-intensive technologies. For example, in the transportation sector, the policy may incentivize firms to produce more fuel-efficient vehicles by spending more on the technologies that go into those vehicles. Or, in the electricity side, firms may switch from burning coal to burning natural gas when generating electricity.

Second, consumer welfare may fall because the price of greenhouse-gas-intensive products rises. Under a command-and-control system, this may occur as a result of changing the product or how the product is produced. In a cap-and-trade or carbon-tax regime, this may occur because the firm must buy allowances or pay the carbon tax, or because the firm changes how the product is made. Finally, there may be macroeconomic costs associated with changes in the relative prices within the economy.

Climate change polices are also likely to carry benefits. Again, we can classify these into three groups. First, the policy may alleviate some of the negative consequences of climate change. These benefits will, of course, accrue to the entire world population and not just those within the jurisdiction of the policy, if that policy is more local.

Second, some of the product changes described above may lead to benefits. For example, while the more fuel-efficient vehicle costs more to produce, the lifetime fuel costs of that vehicle will fall, benefiting the owner. Finally, insofar as the policy generates revenue (e.g., auctioning off allowance or a carbon tax), the revenues from the policy can be used to lower distortionary taxes, such as income taxes, leading to macroeconomic benefits.

In principle, the benefits can outweigh the costs. Greenhouse gas emissions are a classic example of a negative externality. That is, when I emit greenhouse gases I don't fully face the cost of that decision. Therefore, I will continue to emit greenhouse gases even though my incremental benefit is less than the social cost of that action. Policies that lead me to reduce my consumption of these greenhouse-gas-intensive products can lead to a positive social benefit, even though my utility may fall.

A second reason why climate change policies may lead to a net benefit is that there may be other facets of the economy, other than the negative externality just described, that keeps the market from achieving the socially optimal mix of goods and services—other so-called market failures. In the context of climate change policy, people often point to market failures that lead consumers to undervalue energy efficiency. For example, when purchasing a vehicle a consumer is unwilling to pay an extra $100 at the time of the purchase even though this investment will save more than $100 in lifetime fuel costs, suitably discounted.

Whether the policy is a net benefit depends not only on the presence of the negative externality and these other market failures, but also on whose benefits are included in the calculation (e.g., do we restrict ourselves to those within the policy's jurisdiction) and how efficient the policy is. Furthermore, the efficiency of the policy will critically depend on whether we think other market failures are present.

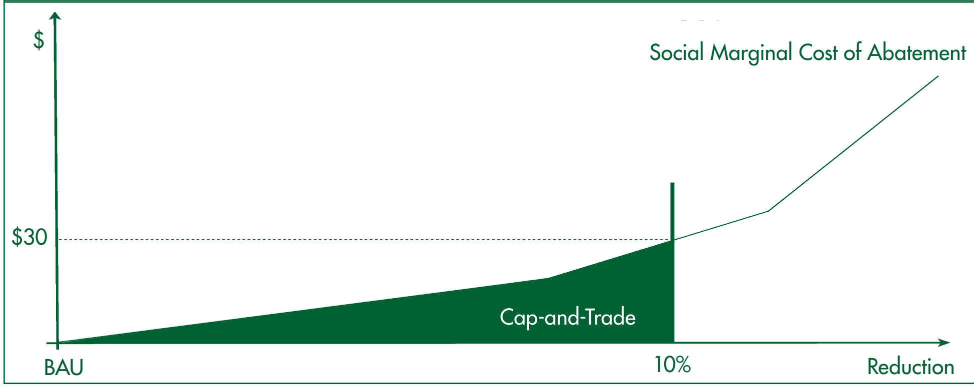
Climate Change Policies: The Models

At the most basic level, modeling the costs of a climate change policy requires four separate components. First, the modeler requires "technology cost curves," those costs faced by firms from de-carbonizing their products. Again, this can come from either product changes (more efficient vehicles), or process changes (switching from coal to natural gas).

Second, calculating the consumer costs associated with buying less of a product requires a system of demand curves. The key components in this system of demand curves are the own-price elasticity of the demand for products, as well as the cross-price elasticities across products. With these in hand, the modeler can then calculate the loss in consumer surplus from a change in prices and the cost of firms producing lower greenhouse-gas-intensive products.

The third part of the model is a macroeconomic model relating general

Figure 1. Stylized Marginal Abatement Cost Curve and an Efficient Policy



macroeconomic activity to prices. Finally, the modeler requires a model of "business as usual." That is, what would happen in the absence of the policy.

More extensive models will also include models of "offsets"—the cost of achieving greenhouse gas emission reductions outside of the jurisdiction or covered industries, as well as models of leakage or reshuffling. Leakage occurs when firms not regulated under the policy increase their output in response to regulated firms reducing their output. Reshuffling occurs when more of the high greenhouse gas products get sold outside of the regulated jurisdiction, as a result of the policy.

The Model's Outputs

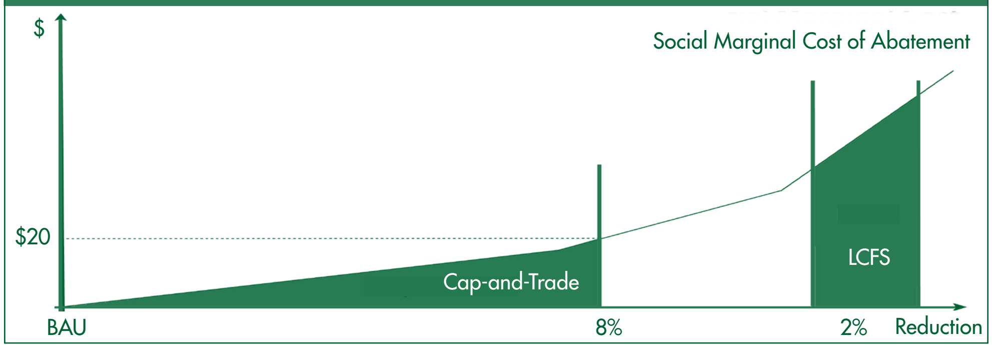
The outcome of the climate change model is a marginal social cost of abatement. That is, for any source of greenhouse gas reduction, the model predicts the cost of this reduction. The information about both technology costs and consumer demand allows the model to trade-off increases in the amount of technology embedded in products versus simply consuming less of the current set of products. In equilibrium, both occur. The macroeconomic model allows the modeler to account for any macroeconomic changes caused by a given change in product mix or prices.

Ranking these from lowest to highest yields the social marginal cost of abatement—a stylized example is in Figure 1—where we impose emission-reduction policies beginning from a no-reduction or (business as ususal—BAU) scenario. Three important features of this curve are worth noting. First, while this cost curve incorporates the benefits from product design changes that alter the lifetime operating cost of the product, it ignores the other two benefits discussed above: benefits from a cooler climate and any benefits from lowering distortionary taxes. Second, the total cost of the policy is the area under the curve where the reductions come from (this area need not be contiguous). Third, in the presence of other market failures, the social cost of some reductions may be negative.

Greenhouse gas reductions under an efficient policy will move along this curve from left to right, yielding the lowest total cost for a given reduction. In the absence of other market failures, a greenhouse gas tax or a cap-and-trade system achieves the lowest cost among those sectors included in the tax or cap-and-trade system. This is also depicted in Figure 1, where the cap-and-trade system reduces emissions by 10%.

A hybrid system of both a cap-and-trade system and other complementary policies (e.g., the Low-Carbon Fuel Standard), such as AB 32, is not guaranteed to minimize costs. Figure 2 represents such a case where the cap-and-trade portion of the policy reduces emissions by 8% and a Low-Carbon Fuel Standard (LCFS) reduces emissions by 2%. The curve is drawn consistent with my recent work with Holland and Hughes, which suggests that a Low-Carbon Fuel Standard is an expensive

Figure 2. Stylized Marginal Abatement Cost Curve and an Inefficient Complementary Policy



way to achieve emission reductions from the transportation sector.

In the presence of other market failures, the "lowest hanging fruit" may not be picked under a greenhouse gas tax or a cap-and-trade system because of other impediments in the market. When this occurs, complementary programs may be cost effective, minimizing the total cost of the reductions. Figure 3 represents such a case. Here, the complementary measure, building efficiency standards, falls to the left of the marginal abatement costs of reduction under cap-and-trade.

A final point, going back to Figure 1. In this scenario, cap-and-trade achieves a 10% reduction in emissions and the allowance price trades at $30 per ton of CO_2e. A frequent misconception is that the cost of these reductions is $30 times the total number of allowances. That is not the case! As noted, the total cost of the policy is the area under the curve.

Discussion of Models Related to AB 32

During my experience on the California Air Resource Board's Economic and Allocation Advisory Committee (EAAC), I reviewed the results and assumptions of a number of models specific to AB 32. The two most comprehensive models of the costs of AB 32 are the California Air Resource Board (ARB) and Charles River and Associates (CRA) models. Both employ detailed models of the energy sectors and a computable general equilibrium model, meaning they allow for the equilibrium mix of inputs to change as a result of the regulations.

Being a member of the EAAC's economic modeling subcommittee afforded me the opportunity to learn more about both models. I was impressed with the breadth of each model and the responsiveness of the modelers to our concerns.

Table 1 compares the results of the two models on a number of metrics. Each of the reports provide results under a variety of different assumptions, so a range is given. The sensitivity analysis changes such things as the supply curve of offsets, changes in the reductions from complementary measures (thus the required reductions from the cap-and-trade program), etc.

Figure 3. Stylized Marginal Abatement Cost Curve and an Efficient Complementary Policy

In terms of aggregate economic activity, the model results are consistent with each other—suggesting a relatively small impact on gross state product. The variation in household income is larger, with the CRA model predicting much larger reductions to household income.

Why the diferences? CRA present results in which "as best as possible employ the same assumptions as ARB." This holds constant many of the features of each model. The differences between the CRA and ARB results appear to come from different assumptions regarding the existence of other market failures. For example, when CRA replaces all of the complementary measures with a broader cap-and-trade program, CRA estimates that the costs of AB 32 fall by 50%.

Indeed, in the EAAC's discussions with both ARB and CRA, this underlying issue—the presence of other market failures—did vary across models. The ARB's model assumes that certain investments, such as fuel economy and energy effciency, are not made even though consumers would be better off. It appears as though this is pervasive in their model. That is, these net-benefit investments are assumed to exist across a variety of facets of the economy. Given these, many of the complementary measures proposed under AB 32 will decrease its cost; some may even have negative net costs.

In contrast, CRA assumes that these other market failures do not exist; firms and consumers optimize without the aid of complementary policies. Under the CRA assumption, complementary measures can only have either no effect on costs or increase them. If the outcome of the complementary measure would have occurred under a broader cap-and-trade program, then its inclusion will have no affect on costs; if the outcomes would not have occurred under the broader cap-and-trade program, then it will increase the aggregate cost of AB 32.

Which assumption is more correct is an open question. Many argue that a vast number of negative-cost investments are not made by households and firms. Indeed, the well-known "McKinsey Curve," a supply curve for greenhouse gas-reducing investments, contains a large amount of negative-cost investments. Others argue the extent of these negative-cost investments is more limited. The empirical literature in economics is also mixed.

It is also worth noting that both models disregard two potentially large benefits from AB 32: the reduction in co-pollutants and the macroeconomic benefits of using revenues to lower distortionary taxes. Co-pollutant benefits exist because many criteria pollutants are positively correlated with greenhouse gases. Therefore, regulations that lead to greenhouse gas reductions are also likely to reduce these other pollutants. To date, a comprehensive study that seeks to measure these two benefits does not exist.

A Quick Note on Other Modeling Efforts

Two other models have garnered attention: reports by T2 and Associates, and the Brattle Group. While, again, the exact details of the T2 are not available, it appears as though their model is on a much smaller scale compared to the ARB and CRA model. In particular, there appears to be limited scope for the economy to adjust to the regulations. Consumers appear not to be able to change which appliances and automobiles they own, and firms appear not to be able to adjust the input shares of their production process. Furthermore, the T2 study assumes an allowance price, it does not actually use a model to predict an allowance price.

Table 1 reports the assumed allowance prices, the predicted change in gross state product and the estimated impact on household consumption. This last number is essentially taking the estimated change in prices (allowance prices are assumed to be fully passed on to consumers) and multiplying it by the current quantities of these products that consumers purchase.

Table 1. Key Results from Three Models Related to AB 32

	ARB	CRA International	Tanton
Emissions Reduction	25%	25%	25%
Allowance Price Range	\$25 to \$162	\$52 to \$78	\$20, \$60, \$200 (assumed)
Percent Change in Gross State Product	-0.2 to -1.4	-1.4 to -2.2	-2.0
Income Gain/Loss per Household	+\$86 to \$270	-\$1175 to \$1380	-\$930, -\$2800, -\$9300*

** Based on three assumed allowed prices*

This greatly overstates the impact on consumers for two reasons. First, the T2 study must be assuming that all of the allowances are given away to firms, while at the same time assuming that firms pass all of the increases in cost for these allowances onto consumers.

This need not be the case. How allowances are allocated is up to the discretion of the ARB. Since, under this assumption, firm profits increase by the same amount that consumers' consumption falls, in that sense AB 32 is largely a "wash." Second, it implicitly assumes that consumers don't change their purchasing behavior. In the presence of a \$200 allowance price, with all of this being passed through to prices, consumers are likely to react. They may react by cutting back consumption and/or investing in energy efficiency. These important decisions are incorporated in ARB and CRA's models.

The second study, done by the Brattle Group, focuses on the effects of AB 32 on small business. Similar to the T2 study, the Brattle Group estimates how AB 32 will change energy prices, using two assumed values of the allowance price and two allocation methods, and then calculates the cost impact of small businesses. They focus their report on two sets of results, representing the lowest and highest impact on energy prices. Their bottom line is that energy is a small share of the costs of small businesses, thus AB 32 will have a small impact on small business profits. The Brattle Group study misses two key indirect effects. First, they do not model the macroeconomic effects of AB 32. Second, they do not model the likely occurrence that in response to higher energy prices, households will have less disposable income to spend at many of these small business.

Conclusions

AB 32 is a broad set of policies aimed to reduce greenhouse gas emissions to their 1990 levels by 2020. A number of economic studies exist estimating the costs of AB 32. Despite not incorporating a number of potentially large benefits from AB 32, they all agree that AB 32 is likely to have a relatively small impact on the California economy.

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For more information, the author recommends:

Holland, S. P., J. E. Hughes, and C. R. Knittel. 2009. "Greenhouse Gas Reductions under Low Carbon Fuel Standards?" *American Economic Journal: Economic Policy*, 1(1), 106-146.