How Carbon Taxes Reduce CO2 Emissions in Transportation

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Summary

Any effective climate policy must credibly address transportation, which emits more greenhouse gases than any other sector of the U.S. economy. Fortunately, research indicates that drivers faced with higher fuel prices–either from specific fuel taxes or broader carbon taxes–use significantly less gasoline and diesel over time as they adjust their driving behavior to save money. Most important in the long run, rising carbon fees will also incent more rapid customer acceptance of electric vehicles, as well as more innovation and cost-reduction by makers of EVs. The result will be much cleaner air and fewer climate emissions.

Introduction

Critical discussions of carbon pricing often assert that imposing rising fees on the sale of climate-polluting fossil fuels would do little to reduce emissions in several key sectors of the economy, most notably transportation. Fuel prices, many believe, have little impact on driving behavior because fuel is a small part of many people's budgets and many drivers have few alternatives to using their cars for commuting and errands.[1]

These claims, if true, would be damning. Transportation accounts for about 30 percent of all energy-related carbon dioxide emissions in the United States, more than any other economic sector. Emissions from motor gasoline and diesel-powered vehicles—the focus of this brief report—contributed about 84 percent of total emissions from the sector in 2020.[2]

In this document, we present evidence that carbon pricing in the transportation sector can reduce emissions far more than some have claimed.

How fuel taxes and carbon fees take a bite out of fuel consumption

Drivers do have choices. They can respond to higher fuel prices by combining errands and taking shorter discretionary trips. They can conserve substantial fuel simply by avoiding excessive highway speeds and by inflating their tires to proper pressures.[3] They can switch to public transportation or carpool where available. Over time, they can even move closer to work to avoid long commutes. Following the Russian invasion of Ukraine in February 2022, the International Energy Agency identified 10 such demand-reducing measures to largely offset the potential loss of Russian oil supplies on world markets in the short term.[4]

Why, then, are critics pessimistic about the effectiveness of carbon taxes? Several influential studies in the early 2000s suggested that the measured response of U.S. drivers to changes in gasoline price has declined over time. Typically they concluded that a 10 percent increase in the price of gasoline would cut short-term consumption by less than 1 percent; in the longer run (usually not defined), as people acquire more efficient vehicles or adjust their commuting behavior, such a price change might induce a drop in gasoline demand of 2 to 4 percent—still nothing dramatic.[5] Analysts argued that rising incomes, better vehicle mileage, and sprawling land use patterns have made drivers relatively insensitive to fuel costs.

But newer empirical studies offer solid grounds for more optimism. They report that *consumers are much more responsive to price changes caused by new taxes than by ordinary market fluctuations*. One reason may be that most tax changes are accompanied by considerable publicity, making consumers more sensitive to what they are paying. Consumers realize that taxes raise costs over the long term, unlike short-term price hikes they can "ride out."

An important 2011 paper by Lucas Davis and Lutz Kilian found that state and federal fuel tax changes had nearly *five times* as much short-term impact as ordinary price changes on demand for gasoline. A 10 percent price increase driven by a tax would cut gasoline use (and carbon dioxide emissions) by nearly 5 percent. "The long-run response is likely to be considerably larger as drivers substitute toward more fuel-efficient vehicles," they added. This effect is of the same magnitude as the impact of tobacco taxes in discouraging cigarette smoking in high-income countries.[6]

In the transportation sector, carbon taxes look much like fuel taxes. For perspective, a carbon fee of $30 per ton of CO_2 would raise gasoline prices almost $0.30 per gallon, or roughly 10 percent if gasoline were still selling for $3.00 per gallon. Based on new studies of consumer behavior inspired in part by Davis and Kilian, Columbia's Noah Kaufman used Rhodium Group modeling to estimate that a $50 per ton carbon tax would cut U.S. gasoline consumption up to 9 percent after five years, reducing annual emissions of carbon dioxide by 100 million tons.[7] That's a great start. It's clearly not sufficient to decarbonize the transportation sector, which is why a carbon tax must continue to rise. Fortunately, as we will see, the prospect of such a rising tax will almost certainly cause consumers and manufacturers to find even cleaner options for mobility over time.

The international record

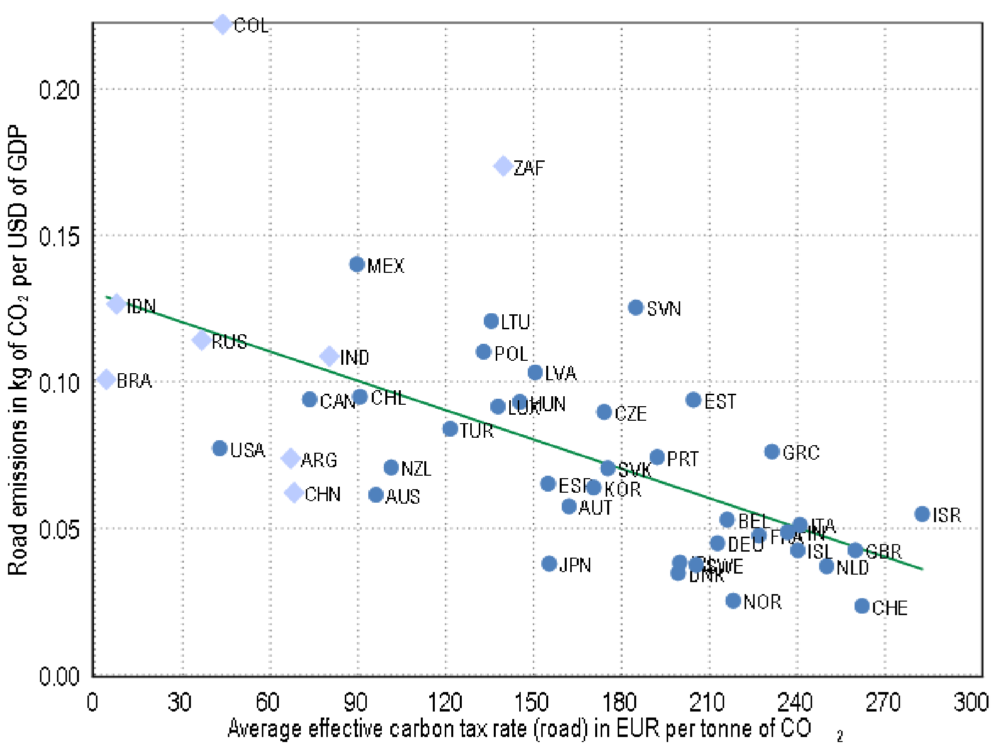
Studies of other advanced economies have also reported impressive changes in demand for transportation fuels in response to fuel and carbon taxes.[8] Economists at the University of Ottawa reported that a modest revenue-neutral carbon tax introduced in British Columbia, starting at C$10 per ton in 2008 and rising to C$30 in 2012, strongly affected driver behavior. At a rate of $25 per ton of CO_2, the tax drove down short-term gasoline demand more than 12 percent, far more than predicted by traditional studies of consumer behavior. Over the first four years, they calculated, “the BC carbon tax led to a total reduction in emissions from gasoline consumption of over 3.5 million tCO_2e when compared with a counterfactual scenario of no tax.”[9]

In the early 1990s, Sweden replaced existing transport fuel taxes with a carbon tax and a value-added tax. These higher taxes drove down CO_2 emissions in Sweden’s transportation sector by 11 percent, *more than three times* what would be expected from ordinary price increases.[10] Costly fuel, combined with tax incentives for the purchase of clean vehicles, have helped make Sweden one of the world’s leading adopters of electric vehicles.[11]

German economist Thomas Sterner reported in a 2007 study focused on European countries with high gasoline and diesel taxes that “fuel taxes are the single most powerful climate policy instrument implemented to date. . . . Had the whole OECD instead had fuel (gasoline and diesel) prices like the US then consumption would be . . . 30% higher than actual current use.”[12]

His point can be seen at a glance from the striking international correlation between high national fuel taxes and lower carbon dioxide emissions from vehicles per dollar of GDP, captured in the OECD chart below.

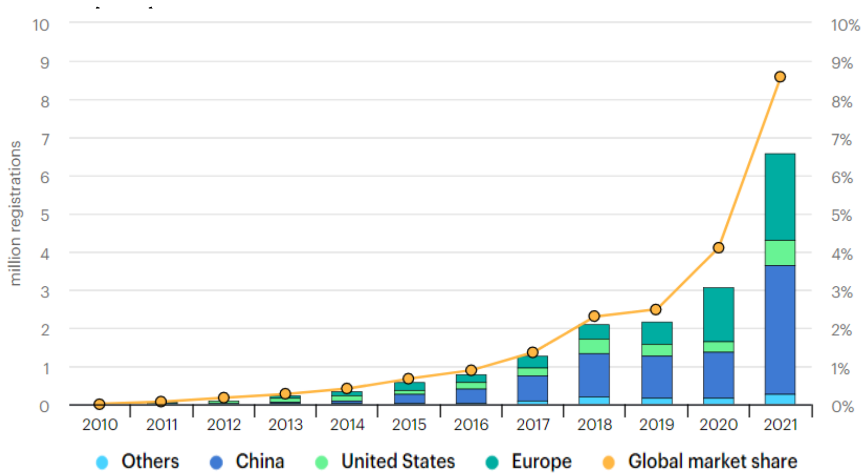
Countries with Higher Fuel Taxes Tend to be Less Emissions Intensive



The *long-run* impact of carbon taxes on transportation will be far more significant

The biggest opportunity for tackling harmful greenhouse gas and toxic air emissions from cars and trucks lies not in changing the short-term behavior of drivers but their choice of vehicles, which may operate for two decades before being scrapped. Fuel prices have great bearing on their choices. A long stretch of relatively low gasoline prices thus contributed to a sharp rise in the market share of heavy SUVs in California, driving its transportation emissions up in recent years despite all the state's well-meaning environmental programs.[13] Reversing that dynamic will be critically important for bringing national greenhouse gas emissions under control.

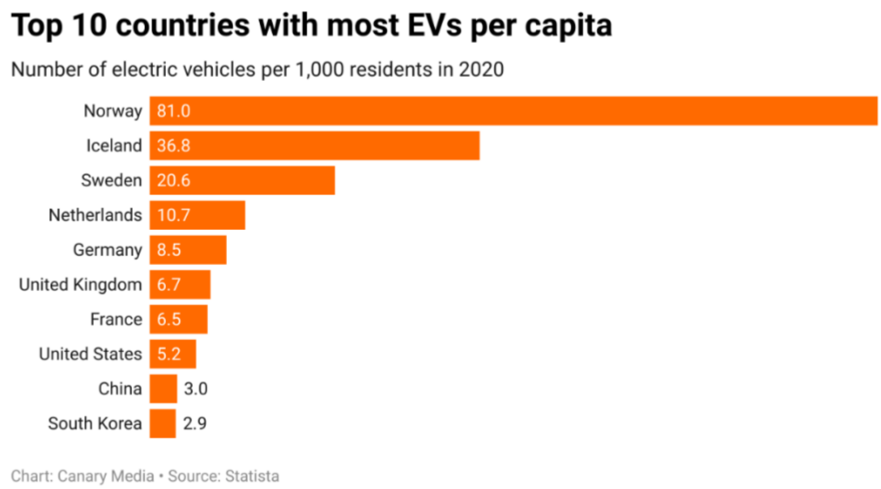
Global Sales and Market Share of EVs, 2010-2021



The good news is that carbon fees can help promote such a healthy reversal. Studies have repeatedly shown that drivers buy more fuel-efficient vehicles in the face of persistently higher fuel prices.[14] Today, drivers no longer have to settle for marginal increases in fuel economy from vehicles dependent on fossil fuels. A proliferation of new zero-emission electric vehicles is transforming the global consumer marketplace (see chart)[15]. With equivalent fuel economy exceeding 100 miles per gallon, high-performance plug-in vehicles cost more up front but can save consumers money over time through lower fuel and maintenance costs.[16]

Millions of potential new customers woke up to that fact during the gasoline price spike that accompanied the Russian invasion of Ukraine in February 2022. Electric vehicle sales in the United States soared 76 percent in the first quarter of 2022, as purchases of traditional cars and trucks slumped. Volkswagen, the second largest supplier of EVs in the U.S. market behind Tesla, reported that several of its plug-in models sold out their entire 2022 production run by March.[17]

While many factors affect national rates of EV purchases, including buyer subsidies and charging station availability, it is striking that the top EV markets worldwide are all countries with high fuel taxes, as shown here.[18]



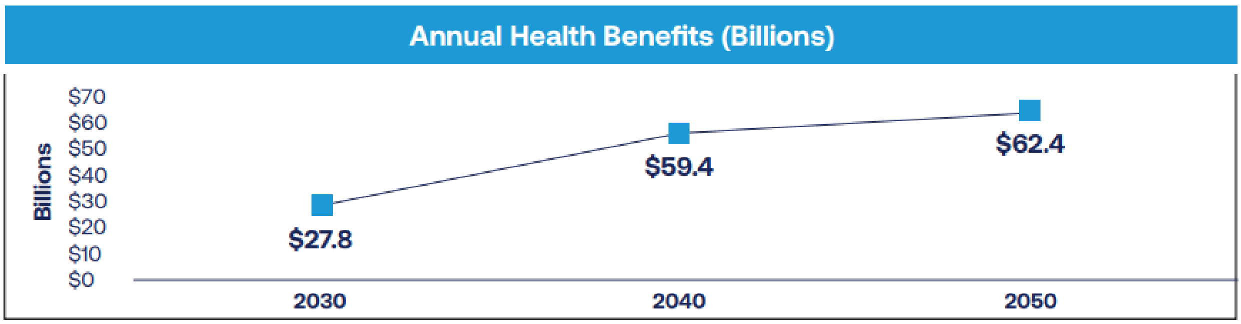
Higher fuel or carbon taxes encourage consumer adoption of EVs in several ways. They give drivers a strong nudge to scrap their old clunkers and look for more fuel-efficient replacements. They help close the cost-of-ownership gap between internal combustion and electric vehicles. They incentivize manufacturers to pursue cost-saving innovations in EV production and charging-station deployments.[19] Carbon taxes offer the additional benefit of hastening the transition to emissions-free electricity on grids that power plug-in cars and trucks.

Two recent studies, among the first of their kind, quantify the impact of rising gasoline prices on consumer purchases of electric vehicles. One 2022 study by three economists at UC-Davis concludes that a 40 cent per gallon increase in the price of gasoline in California translates into "a whopping 57 percent" increase in demand for EVs. Another study out of Norway, which has the world's largest market share of EVs, reports that every 10 percent increase in liquid fuel prices translates into a 6 percent increase in demand for all-electric vehicles.[20]

Owing to their high efficiency and ability to charge from zero-carbon electricity, plug-in models have a far smaller climate footprint than gasoline- and diesel-powered vehicles. "The average EV produces global warming pollution equal to a gasoline vehicle that gets 88 miles per gallon (mpg)—significantly better than the most efficient gasoline car available in the United States today (58 mpg) and far cleaner than the average new gasoline car (31 mpg) or truck (21 mpg)," according to the Union of Concerned Scientists.[21] As the U.S. power grid grows ever cleaner with the replacement of coal plants by wind and solar energy, the EV advantage will only grow.

A significant rise in EV market share would thus have dramatic effects on carbon emissions. Indeed, a summary report on major economic models of carbon tax impacts noted that virtually none considers the coming technological revolution in road transportation. "If electric vehicles or advanced biofuels gain market share," the report stated, "then oil use in the transportation sector may become much more responsive to a carbon price than models currently predict."[22]

Other social benefits of EVs will also become enormous over time. According to the American Lung Association, a rapid transition from new sales of traditional cars and trucks to electric vehicles over the next 15 years, along with cleaner generation to power them, would slash greenhouse gas emissions from road transportation 93 percent by 2050. It would also dramatically cut deadly fine particulates and smog-forming compounds, resulting in 110,000 fewer deaths, 2.8 million fewer asthma attacks, and 13.4 million fewer sick days by mid-century. Over three decades, the savings in public health costs would exceed $1 trillion.[23]



Note: Total values presented for all vehicles using high estimate of benefits using a 3% discount rate and using 2017$.

Carbon taxes are more cost-effective than regulations

Carbon taxes alone may not supercharge the EV market fast enough to meet national and global climate goals. Additional policies such as income-based purchase subsidies and subsidies for the build-out of charging stations show promise of stimulating consumer demand for these clean vehicles with reasonable efficiency and equity.[24] Broader measures to address transportation emissions will need to encourage alternative forms of transportation (such as bicycling and walking), public transit, and land-use planning to support them.[25]

But regulations and subsidies lack many of the benefits of carbon taxes. Consider, for example, fuel efficiency standards like CAFE as alternative tools to lower greenhouse gas emissions in the vehicle fleet. Unfortunately, they apply only to new vehicles. They do nothing to lower emissions from existing vehicles. They fail to stimulate consumer demand for clean vehicles. Indeed, by raising the price of new cars, they may induce consumers to delay scrapping their older, less efficient cars. Last but not least, they suffer from what economists call the "rebound effect": more efficient vehicles reduce the per-mile cost of driving, inducing some people to drive more, which in turn offsets some of the predicted drop in emissions. Higher fuel taxes, on the other hand, encourage customers to replace their old cars, purchase cleaner vehicles, *and* to drive less. To quote the unhedged conclusion of two experts on how to make cars greener, "No regulatory alternative achieves the efficiency of a fuel tax."[26]

A 2013 study published in *Energy Economics* by four economists at MIT determined that increased CAFE standards would cost the US economy six to 14 times more than a federal gas tax to achieve the same reduction in fuel use over a period of four decades. As the lead author explained, "That is because a gas tax provides immediate, direct incentives for drivers to reduce gasoline use, while the efficiency standards must squeeze the reduction out of new vehicles only. The new standards also encourage more driving, not less."[27] UC Davis economist Mark Jacobsen calculated that owing to their high compliance costs and modest effectiveness, national fuel economy standards cost roughly $307 to eliminate one ton of CO_2

emissions—a price far higher than any mainstream carbon tax proposal.[28] Finally, studies show that fuel economy standards fall relatively harder on the poor (are more regressive) than carbon taxes, particularly when compared to carbon tax revenues that are returned to individuals as lump-sum payments.[29]

Conclusion

One must agree with critics who point out that "at the tax levels that have been politically feasible thus far, carbon taxes alone are unlikely to solve the climate change problem."[30] The problem, of course, lies not with carbon taxes, but with the lack of political will in the United States and many other countries to set taxes high enough in the face of entrenched opposition. However, a predictable and rising carbon fee, coupled with a dividend back to individual consumers and a border adjustment to avoid disadvantaging US businesses internationally, may win widespread public support in today's political climate.[31]

Most proponents of carbon taxes also agree they should not be the *only* means of tackling climate disruption. Many economists endorse well-designed government subsidies and standards to spur research and development, reduce costs for early-stage clean technologies, and cut emissions from sources that carbon taxes do not address.[32]

But as the empirical evidence cited here demonstrates, higher carbon taxes should be the foundation of any program to reduce greenhouse gas emissions in transportation, the sector most responsible for them. Claiming otherwise will only slow political momentum for adopting this most promising and cost-effective policy to curb global climate disruption.

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[1] See, for example, Justin Gillis, "Forget the Carbon Tax for Now," *New York Times*, December 27, 2018; David Roberts, "The 5 most important questions about carbon taxes, answered," Vox.com, October 18, 2018; Jeffrey Ball, "Why Carbon Pricing Isn't Working," *Foreign Affairs*, July/August 2018.

[2] U.S. Energy Information Administration, "How much carbon dioxide is produced from U.S. gasoline and diesel fuel consumption?," December 2021; also U.S. Environmental Protection Agency, "Sources of Greenhouse Gas Emissions" (2019 data).

[3] The typical passenger car's rated fuel efficiency at 55 miles per hour drops 17 percent at 70 mph, and even more at higher speeds (MPGForSpeed.com and "Driving More Efficiently" at fueleconomy.gov).

[4] IEA, "A 10-Point Plan to Cut Oil Use," March 2022.

[5] Giovanni Circella et al., "Impacts of Gas Price on Passenger Vehicle Use and Greenhouse Gas Emissions," September 30, 2014; Jonathan E. Hughes et al., "Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand," September 2006, NBER Working Paper 12530; Kenneth Small and Kurt Van Dender, "Fuel Efficiency and Motor Vehicle Travel: The Declining Rebound Effect," *Energy Journal*, vol. 28, no. 1 (2007), pp. 25-51. For a tabulation of other estimates dating back to the 1990s, see James Hamilton, "Understanding Crude Oil Prices," December 6, 2008. Slightly higher estimates of elasticity of demand for gasoline (-0.2 short run, -0.7 long run) were reported in a 2017 meta-analysis, reflecting some of the work

cited in this paper. See Xavier Labandeira, et al., "A meta-analysis on the price elasticity of energy demand," *Energy Policy*, 102:C (2017), 549-68.

[6] Lucas W. Davis and Lutz Kilian, "Estimating the Effect of a Gasoline Tax on Carbon Emissions," *Journal of Applied Econometrics*, 26 (2011), 1187–1214. Shanjun Li and two colleagues later confirmed that "gasoline taxes would be more effective at reducing gasoline consumption than suggested by previous empirical estimates of the effect of gasoline prices on gasoline consumption;" "Gasoline Taxes and Consumer Behavior," *American Economic Journal: Economic Policy,* 6 (Nov. 2014), 302-42. John Coglianese, et al., "Anticipation, Tax Avoidance, and the Price Elasticity of Gasoline Demand," *Journal of Applied Econometrics*, 32:1 (January/February 2017), 1-15, pegs the short-term elasticity of demand at -0.37. A slightly lower estimates comes from Larry Levin, et al., "High Frequency Evidence on the Demand for Gasoline," *American Economic Journal: Economic Policy,* 9:3 (August 2017), 314-47. For confirmation that long-run elasticities are greater than short-run, see Javier Donna, "Measuring Long-Run Price Elasticities in Urban Travel Demand," November 2018, MPRA Paper 90260. On tobacco taxes, see Pearl Bader, et al., "Effects of Tobacco Taxation and Pricing on Smoking Behavior in High Risk Populations: A Knowledge Synthesis," *Int J Environ Res Public Health*; 8:11 (Nov. 2011), 4118–39.

[7] Noah Kaufman, "Putting a Price on Vehicle Emissions is Better Policy than it Seems," Columbia Center on Global Energy Policy, August 2018.

[8] For a useful summary, see Steven Nadel, "Learning from 19 Carbon Taxes: What Does the Evidence Show?" ACEEE, Summer 2016. An important recent study, using microdata from Japan, reports a short-run elasticity there of almost -0.4. Christopher Knittel and Shinsuke Tanaka, "Driving Behavior and the Price of Gasoline: Evidence from Fueling-Level Micro Data," MIT CEEPR Working Paper 2019-019, November 2019.

[9] Nicholas Rivers and Brandon Schaufele, "Salience of Carbon Taxes in the Gasoline Market," January 24, 2015, reports a remarkable tax elasticity of about -2.5 (a roughly 5 percent increase in price reduced demand 12.5 percent). Another study of the BC market estimates an even more disproportionate tax effect; Jean-Thomas Bernard, Grant Guenther, and Maral Kichian, "Price and Carbon Tax Effects on Gasoline and Diesel Demand," 2015, University of Laval. For a somewhat smaller result, see C. Lawley and V. Thivierge, "Refining the evidence: British Columbia's carbon tax and household gasoline consumption," *The Energy Journal* 29 (2018), 147-71. Further evidence of a strong tax effect on transportation in British Columbia comes from Felix Pretis, "Does a Carbon Tax Reduce CO_2 Emissions? Evidence from British Columbia," *Environmental and Resource Economics* (April 2022). Across Canada, two economists reported an overall tax elasticity of fuel demand of -1.44; Werner Antweiler, and Sumeet Gulati, "Estimating the Fuel-tax Elasticity of Vehicle Miles Travelled from Aggregate Data," March 2018.

[10] Julius J. Andersson, "Cars, Carbon Taxes and CO2 Emissions," March 2017, London School of Economics and Political Science. Andersson estimated a price elasticity of demand of -0.51 and a tax elasticity of demand of -1.57 over an "intermediate" period of several years. Sweden's carbon tax would likely have had a much more dramatic effect on fuel consumption if the country had not already had substantial fuel taxes averaging about 4 SEK per litre of gasoline (Andersson, 7).

[11] "New Swedish Car Policies Expected To Boost Electric Car Market Share In Sweden," CleanTechnica.com, May 2, 2018; Rikki Gibson, "What Can We Learn From Sweden About EV Adoption?" FleetCarma.com, July 5, 2018; "Demand for plug-in electric cars remains strong in Sweden," InsideEVs.com, October 3, 2018.

[12] Thomas Sterner, "Fuel taxes: An important instrument for climate policy," *Energy Policy*, 35:6 (June 2007), 3194-3202.

[13] Auditor of the State of California, "California Air Resources Board: Improved Program Measurement Would Help California Work More Strategically to Meet Its Climate Change Goals," Report no. 2020-114; Independent Emissions Market Advisory Committee Report to CARB, 2019.

[14] As two economists noted in a blog for Resources for the Future, "Several studies have demonstrated a strong link between gasoline prices and market shares, particularly when gas prices were high or rising. For example, between 2003 and 2007, rising gasoline prices explain about half of the shift from large sport utility vehicles (SUVs) to smaller crossovers." Benjamin Leard and Joshua Linn, "How Do Gasoline Prices Affect New Vehicle Sales?," Resources for the Future, February 3, 2016. Mansoureh Jeihani and Soheil Sibdari determined that a 10 percent increase in gasoline prices cuts demand for SUVs by 13.7 percent and increases demand for efficient hybrids by 9.1 percent; "The Impact of Gas Price Trends on Vehicle Type Choice," *Journal of Economics and Economic Education Research* 11:2 (2010). See also Arie Beresteanu and Shanjun Li, "Gasoline prices, government support, and the demand for hybrid vehicles in the U.S.," *International Economic Review*, 52:1 (February 2011), 161-82; Meghan Busse, et al., "Are consumers myopic? Evidence from new and used car purchases," *American Economic Review* 103:1 (February 2013), 220-56; Paul Burke and Shuhei Nishitateno, "Gasoline prices, gasoline consumption, and new-vehicle fuel economy: Evidence for a large sample of countries," *Energy Economics*, 36 (2013), 363-70; James Sallee, et al., "Do Consumers Recognize the Value of Fuel Economy? Evidence from Used Car Prices and Gasoline Price Fluctuations," *Journal of Public Economics*, 135 (March 2016), 61-73; W. McManus, "The Link Between Gasoline Prices and Vehicle Sales," *Business Economics*, January 2007; "Rising Gas Prices Finally Kill The Once-Mighty SUV," *Wired*, June 9, 2008.

[15] International Energy Agency, "Electric cars fend off supply challenges to more than double global sales," January 30, 2022.

[16] Department of Energy, "eGallon: Compare the costs of driving with electricity"; "These charts show how much it costs to charge an EV vs. refueling a gas vehicle," CNBC, March 19, 2022; "Will owning an electric vehicle save you money?" NBC News, March 16, 2022.

[17] "US Electric Vehicle Sales Soared in First Quarter, while Overall Auto Sales Slid," InsideClimateNews.com, April 28, 2022; "Volkswagen says high demand is helping its EVs turn a profit sooner than expected," CNBC, March 15, 2022.

[18] "Chart: These countries have the most electric vehicles," CanaryMedia.com, March 18, 2022

[19] For evidence on how higher fuel prices incentivize innovation in clean transportation technology, see David Popp. "Environmental Policy and Innovation: A Decade of Research," CESIFO Working Paper 7544, March 2019; Nils aus dem Moore, et al., "Driving Innovation? Carbon Tax Effects in the Swedish Transport Sector," Leibniz Institute for Economic Research, January 2022.

[20] James Bushnell, et al., "Energy Prices and Electric Vehicle Adoption," Haas Energy Institute Working Paper 326, March 2022; James Bushnell, et al., "A Silver Lining to the Oil Price Cloud," Energy Institute blog, UC Berkeley, March 14, 2022; Lasse Fridstrøm and Vegard Østli, "Direct and cross price elasticities of demand for gasoline, diesel, hybrid and battery electric cars: the case of Norway," *European Transport Research Review*, 13:3 (2021). See also Chenlei Xue, "Impact of Incentive Policies and Other Socio-Economic Factors on Electric Vehicle Market Share: A Panel Data Analysis from the 20 Countries," *Sustainability*, 13 (2021).

[21] Union of Concerned Scientists, "Electric Vehicles Are Cleaner than Gasoline—and Getting Better," May 2020.

[22] Alexander Barron, et al., "Policy Insights from the EMF 32 Study on U.S. Carbon Tax Scenarios," *Climate Change Economics*, 9:1 (2018).

[23] American Lung Association, *Zeroing in on Healthy Air*, 2022.

[24] Joshua Linn, "Balancing Equity and Effectiveness for Electric Vehicle Subsidies," Resources for the Future Working Paper 22-7, January 2022; Cassandra Cole, et al., "Policies for Electrifying the Light-Duty Vehicle Fleet in the United States," MIT/CEEPR working paper 2021-014, September 2021; Erich Muehlegger and David Rapson, "Subsidizing Low and Middle Income Adoption of Electric Vehicles: Quasi-Experimental Evidence from California," NBER Working Paper 25359, January 2021; Easwaran Narassimhan and Caley Johnson, "The role of demand-side incentives and charging infrastructure on plug-in electric vehicle adoption: analysis of US States," *Environmental Research Letters*, 13:7 (July 2018). On the popularity of such inducements, see "Poll Finds Bipartisan Support for Policies Supporting EV Adoption," GreenCarReports.com, March 29, 2022.

[25] For an interesting look at the potential of road congestion fees to alter commutes, land use patterns, and carbon dioxide emissions, see Shohei Domon, et al., "The long-run effects of congestion tolls, carbon tax, and land use regulations on urban CO2 emissions," *Regional Science and Urban Economics*, 92 (January 2022).

[26] Soren Anderson and James Sallee, "Designing Policies to Make Cars Greener: A Review of the Literature," *Annual Review of Resource Economics*, 8 (2016), 157-80; see also Soren T. Anderson et al., "Fuel Economy Standards: Impacts, Efficiency, and Alternatives," *Review of Environmental Economics and Policy*, 5:1 (Winter 2011), 89-108.

[27] Valerie J. Karplus, et. al., "Should a vehicle fuel economy standard be combined with an economy-wide greenhouse gas emissions constraint?," *Energy Economics* 36 (March 2013), 322-333; Valerie Karplus, "The Case for a Higher Gasoline Tax," *New York Times*, February 21, 2013.

[28] Mark R. Jacobsen, "Evaluating US Fuel Economy Standards in a Model with Producer and Household Heterogeneity," *American Economic Journal: Economic Policy*, 5:2 (2013); see also Kenneth Gillingham and James H. Stock, "The Cost of Reducing Greenhouse Gas Emissions," *Journal of Economic Perspectives*, 32:4 (Fall 2018), 53-72.

[29] Arik Levinson, "Energy Efficiency Standards are More Regressive than Energy Taxes: Theory and Evidence," December 2016, NBER Working Paper 22956; Lucas Davis and Christopher Knittel, "Are Fuel Economy Standards Regressive," December 2016, NBER Working Paper 22925; Benjamin Leard, et al., "Pass-Through and Welfare Effects of Regulations that Affect Product Attributes," April 2019, Resources for the Future Working Paper 19-07.

[30] Steven Nadel, ACEEE, op. cit.

[31] Yale Program on Climate Change Communications, "Yale Climate Opinion Maps 2021," https://climatecommunication.yale.edu/visualizations-data/ycom-us/.

[32] See Gillingham and Stock, op. cit.; David Greene et al., "Analyzing the Transition to Electric Drive Vehicles in the U.S.," *Futures* 58 (April 2014), 34-52. But note that claims of market failure and program efficacy must be assessed carefully; see for example Joshua A. Blonz, "The Welfare Costs of Misaligned Incentives: Energy Inefficiency and the Principal-Agent Problem," November 28, 2018, U.C. Energy Institute Working Paper 297; Carl Blumstein and Margaret Taylor, "Rethinking the Energy-Efficiency Gap: Producers, Intermediaries, and Innovation," May 2013, Haas Business School Working Paper 243.