A Review and Comparative Analysis of Fiscal Policies Associated with New Passenger Vehicle CO_2 Emissions

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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

The International Council on Clean Transportation is an independent nonprofit organization that works directly with regulatory agencies and policy makers in the world's ten largest vehicle markets to control greenhouse gas emissions and conventional pollution in the transportation sector.

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Executive Summary

GOVERNMENTS WORLDWIDE ARE INCREASINGLY using fiscal policies to influence vehicle purchase decisions. Ideally, such policies should be designed to directly enhance and reinforce regulatory approaches to reduce vehicle CO_2 emissions. Although few existing policies meet the desired ideal, several have shown some movement in the ideal direction. Moreover, many existing policies serve as indirect, albeit nonideal, influences on CO_2 because of relationships between CO_2 emission rates and the vehicle attributes around which the policies are designed.[1] To investigate the potential CO_2 reduction effectiveness of such policies, as well as the extent to which existing polices could be improved through CO_2-based redesign, we analyzed many existing fiscal policies in place in various global jurisdictions.

“In this report, we provide a methodology to quantitatively compare the CO_2 price signal offered by various existing fiscal policies.

Stringency and design are the most important factors that determine the potential CO_2 reduction effectiveness of fiscal policies. Accordingly, we evaluated fiscal policies for passenger vehicles that influence or potentially influence vehicle CO_2 emissions along these two dimensions in an effort to determine a best-practices policy design. Because existing policies vary widely in stringency, design, timing, and other details, comparison across countries is challenging. In this report, we provide a methodology to quantitatively compare the CO_2 price signal offered by various existing fiscal policies; we also qualitatively compare the design characteristics that influence the potential impact of the policies.

The scope of our analysis includes taxes, rebates and subsidies, and other fiscal incentives applied to new private passenger vehicles in eight of the world's leading auto markets. The policies we found to be in place generally can be categorized into three types: (1) *direct CO_2 measures*—policies that vary directly with vehicle CO_2 emissions or fuel consumption, (2) *indirect CO_2 measures*—policies that vary with a vehicle attribute (such as engine size or vehicle weight) that is related to CO_2 emissions, and (3) *targeted incentives*—policies designed to promote alternative fuels or advanced technology vehicles.

Depending on the jurisdiction, these taxes and incentives are applied at the point of purchase, annually, or both. Our analysis did not focus on one-time or annual charges not tied to vehicle emissions in any way, such as a license fee. In addition, usage-focused policy instruments, such as fuel taxes or congestion charges, were excluded from the analysis. Finally, we did not focus on purely vehicle price-based policies such as sales and value-added taxes. There is a relationship between vehicle price and CO_2 emissions (because price and CO_2 both generally increase with vehicle size and performance), so that price-based policies can be viewed as an indirect CO_2 policy. However, given that such policies are easily compared across countries on the basis of their numeric "tax" rates, we elected to exclude such policies from our analysis. Table ES–1 summarizes the policies that were reviewed.

To quantitatively compare the implied price signal provided by each policy, we generally compared direct CO_2, direct fuel consumption, and indirect policies on the basis of their relationship to the price signal of an equivalent direct CO_2 policy. Although this strategy is appropriate in that it provides a mechanism to compare otherwise divergent policies, such an approach has limitations. Because these limitations might not be apparent in presented policy statistics, failure to recognize their existence will result in an overestimation of the CO_2 reduction effectiveness of both direct fuel consumption and indirect CO_2 policies. Our analysis of such policies relied on current vehicle technology and

[1] As used in this document, the terms *direct* and *indirect* are intended to reflect the "degree of" CO_2 basis of a policy. An *indirect policy* is based on a vehicle attribute other than CO_2 emissions but can affect CO_2 emissions through an inherent relationship between the attribute that is the basis of the policy and CO_2. For example, a policy based on engine displacement can affect CO_2 emissions because engine size and CO_2 emissions are inherently related. Conversely, a *direct policy* is based on CO_2 emissions (with no intermediary). Unless stated otherwise, neither term is used to signify a directional aspect to the CO_2 relationship as would be the case in a strict mathematical interpretation.

Table ES-1: NEW PASSENGER VEHICLE TAXES AND INCENTIVES RELATED TO CO_2 EMISSIONS, BY COUNTRY (AS OF APRIL 2010)

Nation	Incidence	Direct CO_2 Measures	Attribute-Based CO_2-Related Measures	Targeted Incentives
United Kingdom	One time	First year special registration tax	—	—
	Annual	Excise duty based on CO_2 for regular cars and AFVs	—	—
United States	One time	Gas-guzzler tax	—	Tax credits for HEVs and AFVs
France	One time	Bonus-malus (feebate) based on CO_2 for regular cars and AFVs	Registration tax based on fiscal horsepower, reduced rates on AFVs	—
	Annual	Annual tax on high CO_2 cars	—	—
Germany	Annual	Annual circulation tax component based on CO_2	Annual circulation tax component based on engine size	Exemption for BEVs
Brazil	One time	—	Registration tax based on engine size	—
China	One time	—	Excise duty based on engine size	—
			Acquisition tax based on engine size	
India	One time	—	Excise tax based on vehicle classes	Lower tax rate for HEVs and zero tax for BEVs
			Special duty based on engine size	
Japan	One time	—	Acquisition tax based on engine size, reduced rates for special vehicles	Exemption for next-generation vehicles
	Annual	—	Tonnage tax based on weight, reduced rates for special vehicles[a]	Exemption for next-generation vehicles[b]
			Auto tax based on engine size, reduced rates for special vehicles and next-generation vehicles	—

[a] The special vehicles in Japan refer to vehicles that acquired four-star certificated emission level and that achieve a fuel economy at least 15% above the Japanese 2010 standard.

[b] Next-generation vehicles in Japan refer to fuel cell electric vehicles, HEVs, plug-in HEVs, compressed natural gas vehicles, and clean diesel vehicles.

Note. HEV = hybrid electric vehicle; AFV = alternative fuel vehicle; BEV = battery electric vehicles.

fueling characteristics to develop comparative statistics for direct CO_2 equivalent policies. To the extent vehicle technology or fueling characteristics change over time, the comparative statistics for indirect policies dependent on technology or fueling changes will similarly change, rendering the relationship of such policies to a direct CO_2 policy uncertain.

Take, for example, a fiscal policy based on fuel consumption. For a vehicle fleet that is largely homogeneous from a fueling perspective, CO_2 will vary directly with fuel consumption so that a policy based on direct fuel consumption will be equivalent to a direct CO_2-based policy. However, if the vehicle fueling market diversifies over time, the relationship between fuel consumption and CO_2 will weaken, and the variation in fuel consumption across vehicles may no longer be a reliable surrogate for the variation in CO_2 emissions across vehicles.

> "The scope of our analysis includes taxes, rebates and subsidies, and other fiscal incentives applied to new private passenger vehicles in eight of the world's leading auto markets.

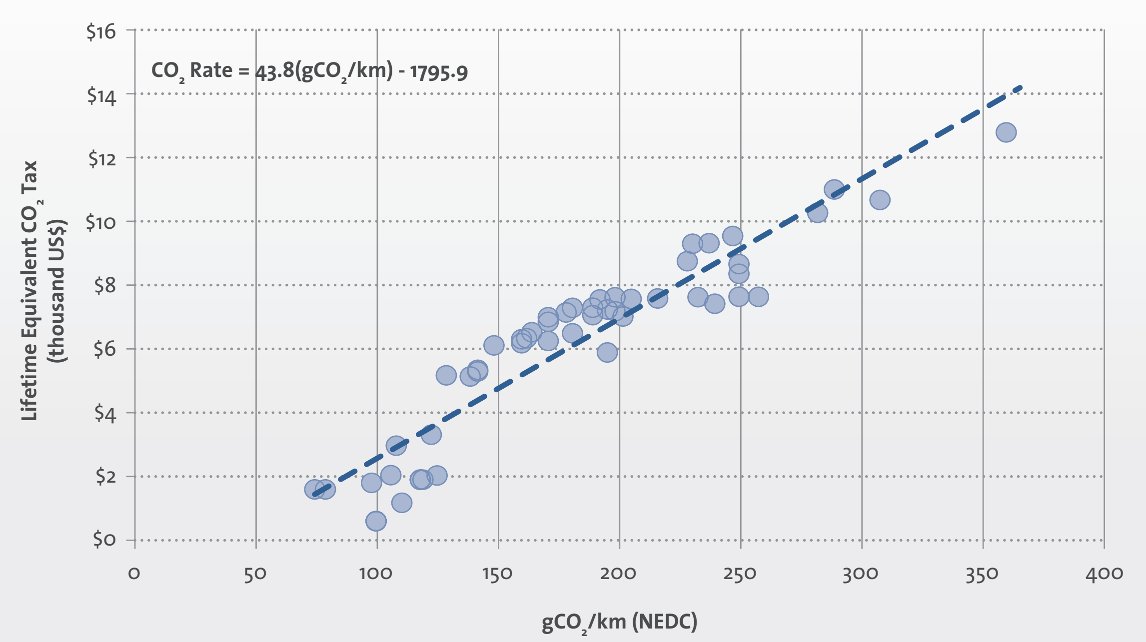
Similarly, fiscal policies based on vehicle attributes such as engine displacement or weight, which are treated as indirect indicators of CO_2 emissions in this report, can also be affected by future changes in vehicle technology. The future introduction of mass reduction, advanced turbocharging, and other technologies can influence the strength of the relationship between the vehicle CO_2 emissions and the attribute(s) on which an indirect fiscal policy is based, so that even attributes that are well correlated with CO_2 today may not be well correlated with CO_2 in the future. As a result, readers must recognize that fiscal policies based on attributes other than CO_2 emissions should always be viewed as less desirable than direct CO_2-based policies, even when the correlation between those attributes and CO_2 is high today. There is simply no way to assure that such correlation will persist over time.

> "Fiscal policies based on vehicle attributes such as engine displacement or weight, which are treated as indirect indicators of CO_2 emissions in this report, can also be affected by future changes in vehicle technology.

Figures ES-1 and ES-2 illustrate this issue graphically. The figures depict the aggregate fiscal policy impacts for Japan and India, respectively, both of which implement indirect CO_2 policies as described in Table ES-1, as well as an equivalent direct CO_2 policy structure that would generate the same revenue. The circular markers depict fees imposed on specific vehicles in each country's fleet, and the dashed lines indicate the fees that would be imposed for any given level of CO_2 emissions to generate equivalent revenues. The closer the circular markers are to the dashed line, the better the current policy mimics a direct CO_2-based policy. These figures show that Japan's current policy structure is superior to India's current structure from a CO_2 perspective. However, both countries rely on vehicle attributes other than CO_2 emissions to assess vehicle fees, so there is no guarantee that the relationship between the defined policy and an equivalent direct CO_2 policy will not change over time. In fact, it is almost certain that the indirect policy will diverge from an equivalent direct CO_2 policy as advanced vehicle technology continues to enter the market (i.e., the circular markers will move away from the dashed line over time). Therefore, even though the indirect policies in effect in some countries may efficiently mimic a direct CO_2 policy structure today, it is likely that such efficiency is at a maximum today and will degrade in the future.

The body of the report presents figures similar to ES-1 and ES-2 for all of the countries we investigated. Figure ES-3 presents a summary of the current efficiency of existing fiscal policies in each country relative to an equivalent direct CO_2 policy. For example, a 90% efficiency measure means that an existing policy provides a CO_2 price signal that is 90% of the price signal that would be provided by a continuous, revenue neutral, CO_2 policy. The higher the ratio is, the more efficient the policy is from a CO_2 perspective. Although some countries

Figure ES-1: JAPAN'S CO_2-RELATED FISCAL POLICIES FOR PASSENGER VEHICLES, AS A FUNCTION OF CO_2 EMISSIONS



Note. NEDC = New European Driving Cycle.

have implemented direct CO_2 emissions-based policies, these policies tend to have discontinuities in that there is a range of CO_2 emissions over which fees do not change. This practice results in some inefficiency relative to a continuous direct CO_2 policy, the magnitude of which is depicted in Figure ES-3. Note that the efficiency depicted for each country is the aggregate efficiency of all fiscal policies in effect. For example, if a country has two policies in effect, the indicated efficiency reflects the combined impact of the two policies.

Figure ES-2: INDIA'S CO_2-RELATED FISCAL POLICIES FOR PASSENGER VEHICLES, AS A FUNCTION OF CO_2 EMISSIONS.

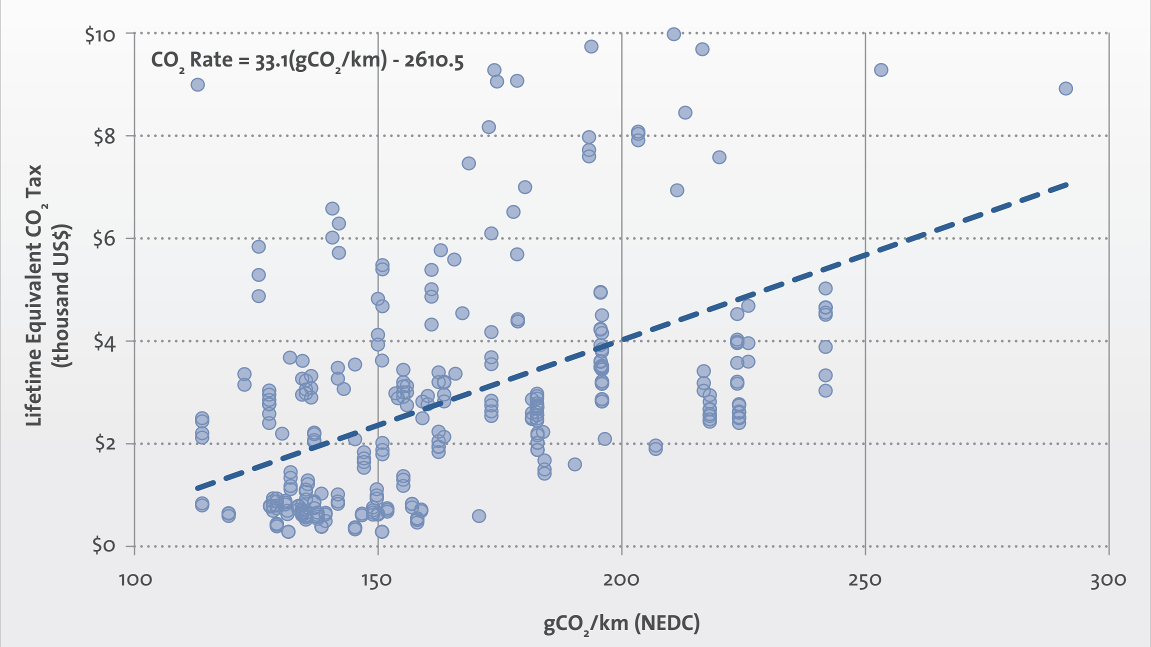
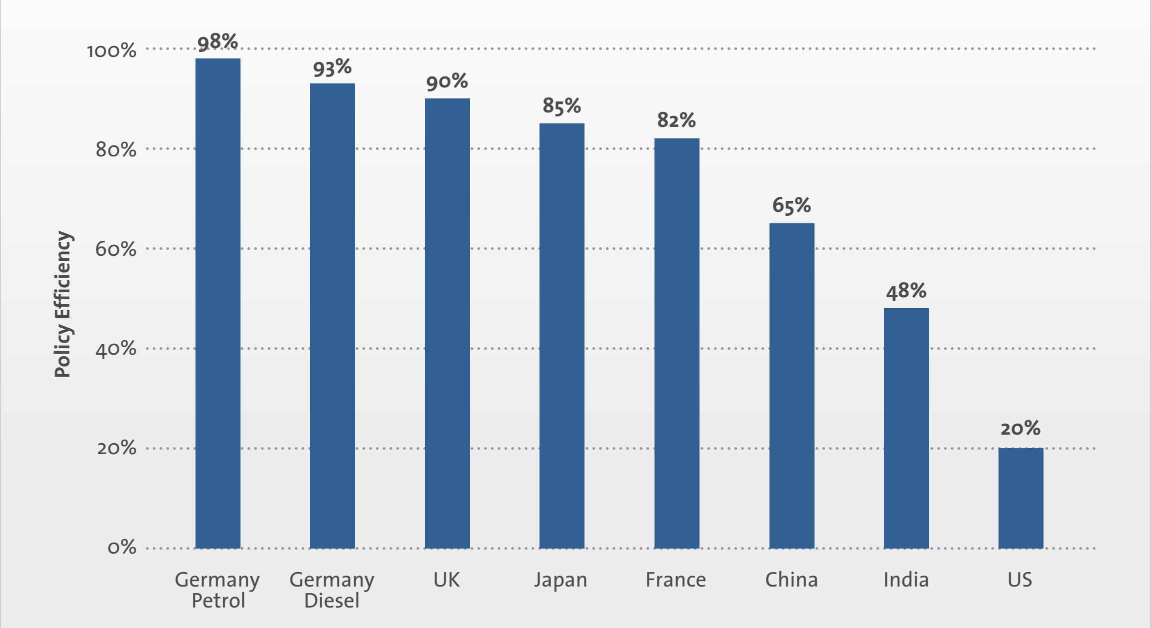
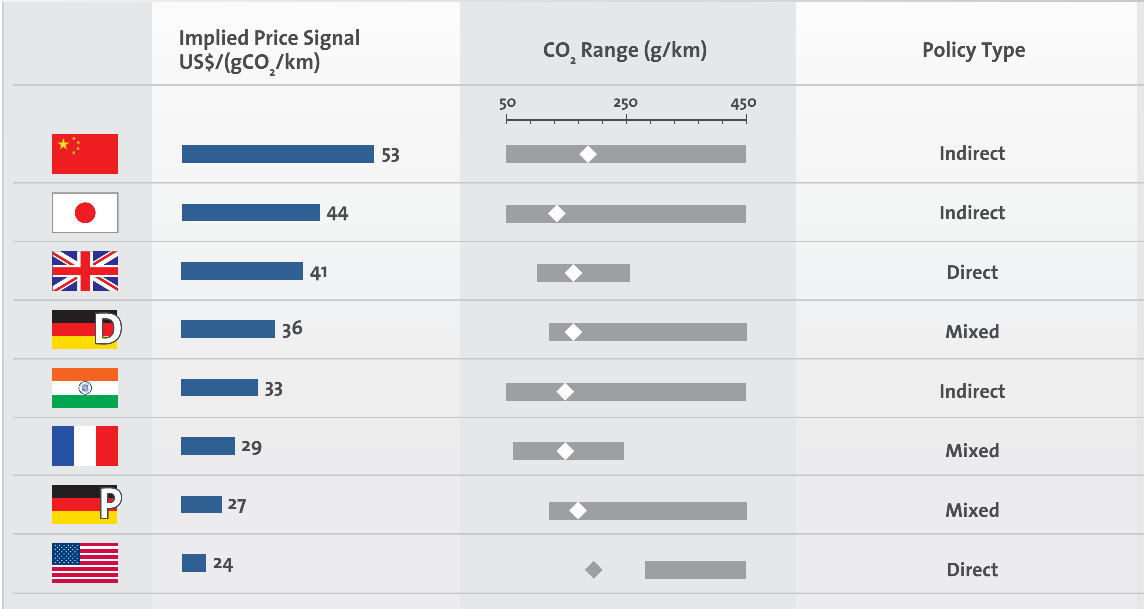


Figure ES-3: COMPARISON OF POLICY EFFICIENCY OF NONFIXED FISCAL MEASURES



> "Direct CO_2 emissions-based policies tend to have discontinuities in that there is a range of CO_2 emissions over which fees do not change.

Figure ES-4: COMPARISON OF POLICY STRINGENCY (MAGNITUDE OF PRICE SIGNAL), APPLICABLE RANGE, AND POLICY TYPE ACROSS COUNTRIES



Note. German flag with letter D denotes diesel vehicle policy, whereas the letter P denotes petrol policy. Diamonds denote the sales-weighted average CO_2 emissions level of each fleet.

"European nations tend to have higher CO_2 efficiencies as they tend to have more direct, albeit discontinuous in most cases, CO_2-based fiscal measures.

Not surprisingly, the European nations tend to have higher CO_2 efficiencies as they tend to have more direct, albeit discontinuous in most cases, CO_2-based fiscal measures. Japan's policy is nearly as efficient as the policies of the European countries, because the various components under Japan's tax scheme collectively function closely to a linear CO_2 tax (as depicted in Figure ES-1). Policies in China and India are significantly less efficient because both policies primarily link to vehicle engine size, whereas the U.S. policy is the least efficient because it affects only a very limited number of models in the market.

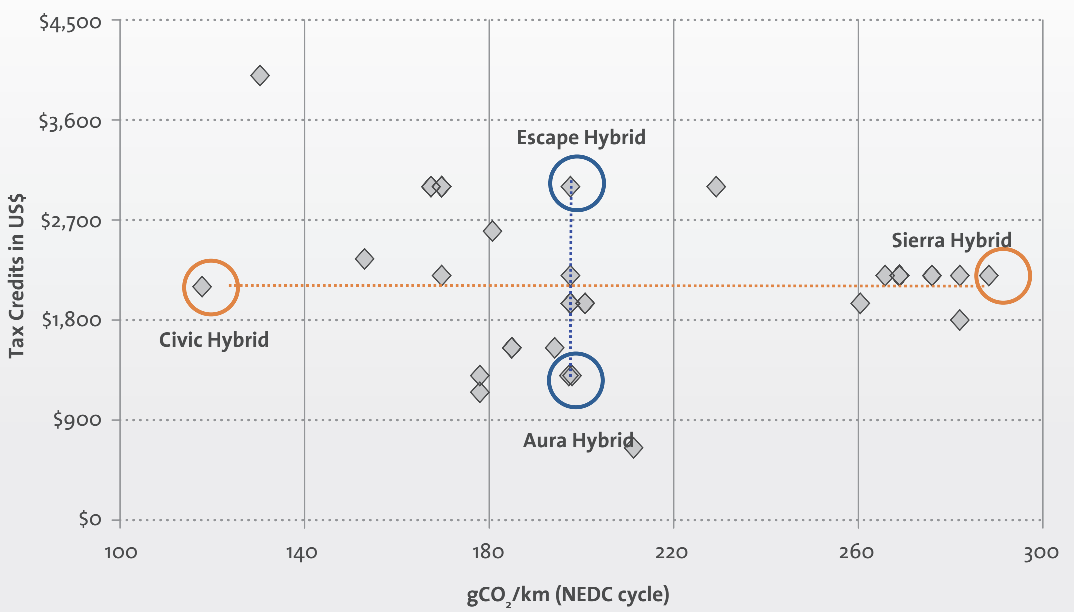
Figure ES-4 provides a broader comparison of the existing fiscal policies in each country. The leftmost section of the figure depicts the relative stringency of the policies in each country in terms of an equivalent revenue-neutral continuous CO_2 price signal.[2] This is the effective fee imposed for each unit of CO_2 emissions, so that higher fees provide a larger incentive to reduce CO_2 emissions. The center section of the figure depicts both the range of CO_2 emissions that the policies affect, as well as the current sales weighted average CO_2 emissions of the country's fleet. Policies affecting a wider range of CO_2 emissions are generally superior. The rightmost section of the figure depicts the types of policies in effect using the three generalized types defined earlier: policies directly affecting CO_2 (or fuel consumption), policies indirectly affecting CO_2 through an inherent relationship with another vehicle attribute, and policies targeting specific fuels or technologies. The mixed policy type indicates that multiple policies of differing types are in effect.

As indicated, the United Kingdom's policy provides the strongest direct incentive for CO_2 reduction. China's and Japan's fiscal policies translate into high potential price signals, but they rely on indirect, attribute-based charges. Fiscal policies in Germany, France, and India rank in the middle in terms of policy stringency, with Germany and France offering mixed price signals while those of India are fully indirect. U.S. policy creates the lowest direct incentive, both in terms of the magnitude of the price signal and its range of applicability.

On the basis of our analysis, this report proposes a set of qualitative design criteria for maximizing the effectiveness of fiscal policies aimed at encouraging the manufacture and purchase of low-CO_2 emission vehicles:

[2] Sometimes a policy may offer different price signals at different CO_2 emissions levels (as described in detail in the body of the report). For this graphic, we compared the highest price signal of each policy, and its applicable CO_2 emissions range is shown in the center section of the graphic.

Figure ES-5: U.S. FEDERAL TAX CREDITS FOR ALTERNATIVE FUEL AND HYBRID ELECTRIC LIGHT-DUTY VEHICLES



- The policy should be directly linked to vehicle CO_2 emissions.
- The policy should apply to the entire vehicle fleet, not a subset thereof.
- The policy should set fees that vary continuously across the spectrum of CO_2 emissions, as opposed to fees that apply to a limited CO_2 range or fees that are invariant across a covered range of CO_2 emissions, as is the case with stepwise or bin-based policy structures.
- Policies that apply both at the time of purchase and throughout a vehicle's lifetime influence a consumer's vehicle replacement decision and, thus, can yield greater CO_2 reductions than a single time-of-purchase policy alone.
- Targeted incentives promoting the use of alternative fuels or advanced vehicle technology should be linked to vehicle CO_2 performance.

Of these criteria, the first is most important. An attribute-based (i.e., indirect) policy does not provide a consistent incentive to lower CO_2 emissions. Vehicles with the same attributes may have widely differing CO_2 emissions, so that although a CO_2 price signal is established on average, the price signal varies widely for any given vehicle.[3] In theory, manufacturers could change vehicle design and technology in response to indirect policies in a fashion that would minimize penalties without actually lowering CO_2 emissions.

The same criteria should apply to both conventional and advanced technology vehicles. An increasing number of countries are introducing special policy incentives to promote the commercialization of various advanced technology or alternative fueled vehicles, most notably electric-drive vehicles. Unfortunately, these temporary policies usually do not directly link incentives to CO_2 emissions. Instead, the incentives are either invariant or dependent on indirect attributes, such as vehicle weight or size, so that the price signal to encourage low-carbon vehicles can be compromised. The U.S. hybrid vehicle tax credit policy, for example, is designed partially in such a manner. As illustrated in Figure ES-5, the policy plays an ambiguous role in rewarding low-CO_2 vehicles given that vehicles with widely varying CO_2 emissions can receive identical tax credits at the same time that vehicles with identical CO_2 emissions can receive substantially different tax credits.

> "The U.S. hybrid vehicle tax credit policy plays an ambiguous role in rewarding low-CO_2 vehicles.

[3] See, for example, Figure ES-2 for India, where the range of fees for a given level of CO_2 varies by as much as an order of magnitude—as opposed to the alternative policy structure represented by the dashed line in that figure, which would maintain a similar level of revenue while imposing a fee that varied continuously with CO_2.

Table ES-2: QUALITATIVE COMPARISON OF DESIGN ELEMENTS OF FISCAL POLICIES, BY COUNTRY

Criteria	United Kingdom	United States	France	Germany	Brazil	China	India	Japan
All policy measures directly link to CO_2 emissions	no	no	no	no	no	no	no	no
Price signal applied fleetwide	partially	no	yes	yes	yes	yes	yes	yes
Continuous incentive at every CO_2 level	no	no	no	yes	no	no	no	partially
Incentives provided at purchase and through-out vehicle lifetime	yes	no	yes	yes	no	no	no	yes
Targeted incentives linked to CO_2 emissions	yes	partially	yes	yes	no	no	partially	partially

"We recommend that all countries link fiscal policy directly to CO_2 emissions and provide the strongest price signal politically feasible for carbon reduction from passenger cars.

Table ES–2 summarizes how the policies of countries analyzed in this report compare with the proposed design criteria. Countries with more "yes" ratings are considered to have a stronger policy design. In terms of current design structure alone, Germany's policies represent the closest to an ideal CO_2 incentive structure among the various countries that we reviewed.

In our analysis, we found the following:

- Countries have not, in general, optimized fiscal policies to maximize CO_2 emission reductions from passenger vehicles across the new vehicle fleet.
- Existing policies and associated CO_2 price signals could be significantly improved by linking policy fees to CO_2 emissions rather than fuel consumption or indirect vehicle attributes.
- Converting fixed taxes and fees to CO_2-based incentives could further enhance the CO_2 price signal without changing the overall vehicle tax burden.

We recommend that all countries link fiscal policy directly to CO_2 emissions and provide the strongest price signal politically feasible for carbon reduction from passenger cars. Ideally, the magnitude of such price signal for each marginal unit of CO_2 emissions should be higher than the marginal cost of eliminating that same unit of CO_2 emissions. For certain countries, simply refining existing policy design structures according to the qualitative criteria defined here, without adjusting the monetary magnitude of those policies, would enhance the role of these policies in encouraging carbon reduction from vehicles.

All of the countries included in our analysis have room for improvement. Although tax policies are typically developed over many years and may be challenging to revise, the following country-specific findings and recommendations are offered:

- The United Kingdom imposes a bin-based annual CO_2 tax on private cars. Currently, the tax does not provide any additional incentive to manufacture or purchase vehicles emitting <101 g/km, nor does it penalize the manufacture or purchase of vehicles emitting >255 g/km. The United Kingdom should further tighten its policy by adopting a continuous CO_2 tax or "feebate" over the entire CO_2 emissions spectrum.
- The U.S. gas-guzzler tax, although based directly on fuel economy, is incurred by only a small fraction of new cars. Tax credits for hybrid and alternative fuel vehicles also exist, but they are determined by both fuel economy and weight class and thus send a mixed price signal to consumers. The United States should refocus the gas-guzzler tax on CO_2 emissions, expand its coverage to all vehicle types and all emissions levels, and realign hybrid and alternative fuel tax incentives to absolute CO_2 emissions, regardless of weight class.
- The feebate (bonus-malus) component of France's fiscal policies has not only stimulated its domestic auto market but also has directed consumers to buy lower CO_2 emission vehicles. However, the program structure is bin based. Like the United Kingdom, a continuous tax structure applying to the full CO_2

emission range of the subject fleet would enhance the power of the bonus-malus.

- Germany has recently shifted its fiscal policies to a partial CO_2 basis, becoming the only nation in our review with a continuous linear CO_2 tax applied on car emissions >120 g/km. However, this CO_2 tax is combined with an engine displacement tax. Germany could enhance its program by converting the displacement tax to a similar CO_2 basis.
- Brazil, China, and India are similar to each other in their fiscal policy design. Fiscal charges in the three nations are proportional to both vehicle price and engine size and, thus, are not precisely related to vehicle CO_2 emissions performance. Shifting from attribute-based policies to CO_2 and shifting from purchase price percentage-based taxes to absolute dollar taxes would make these policies more efficient as low-CO_2 emission incentives.
- Japan has imposed several fiscal charges on passenger cars based on a variety of vehicle attributes. These fiscal charges collectively function reasonably well as an equivalent CO_2 tax, except in the case of new vehicle technologies, such as hybrids. The combined fiscal policies offer a stringent disincentive for high fuel consumption cars. Japan could replace these taxes with a single continuous CO_2-based tax to ensure a consistent continuing incentive for low-CO_2 emission vehicles as engine and vehicle energy supply technologies continue to evolve.
- Company cars represent half of the entire passenger car fleet in Europe, and their purchase is subsidized. This subsidy has the effect of greatly diminishing the effect of existing fiscal policies, and substantially greater CO_2 reduction can be realized if this incentive-distorting subsidy is removed. Both company and private car taxes should be linked to vehicle CO_2 performance. A similar set of design principles will maximize the carbon reduction potential of European fiscal policies.

> "For certain countries, simply refining existing policy design structures according to the qualitative criteria defined here, without adjusting the monetary magnitude of those policies, would enhance the role of these policies in encouraging carbon reduction from vehicles.

Introduction

> "Regulatory standards need to be strengthened over time to achieve continuous long-term reduction, and well-designed fiscal policies automatically provide continuous incentive.

Background

TAXES, FEES, REBATES, AND OTHER FISCAL INCENTIVES are crucial instruments to support policies that promote energy efficiency and reduce emissions in the transportation sector. Traditionally, governments around the world have relied on regulatory measures for reducing greenhouse gas (GHG) emissions and fuel consumption from passenger vehicles (An, Gordon, He, Kodjak, & Rutherford, 2007). In 2007, the International Council on Clean Transportation (ICCT) published a report reviewing and comparing standards from nine countries and regions that have adopted light-duty vehicle fuel economy or CO_2 emission regulations (An et al., 2007). Today, many nations are using fiscal policies to complement standards in pursuing the goal of energy conservation and reducing GHGs. This trend is being led by the European Union (EU). In 2005, only nine EU member states had adopted fiscal policies aiming directly at reducing light-duty vehicle CO_2 emissions or fuel consumption. In 2010, this number increased to 17 and covered all major car manufacturing countries in western Europe [European Automobile Manufactures' Association (ACEA), 2010].

Both mandates and fiscal policies are important in curbing climate impacts caused by vehicle CO_2 emissions. Regulatory standards need to be strengthened over time to achieve continuous long-term reduction, and well-designed fiscal policies automatically provide continuous incentive (German & Meszler, 2010). Regulations push manufacturers through supply-side requirements toward cleaner and more fuel-efficient products. Properly crafted fiscal policies can create a demand-side market pull to reduce emissions further.

The fiscal instruments may have policy goals other than reducing vehicle GHG emissions. For example, taxes on vehicles and fuels often play a critical role in supporting transportation infrastructure and raising operating revenue for governments. This report focuses on the role of fiscal policy in reducing fleet GHG emissions and provides insights in how to enhance such a role. Policymakers must balance their broad policy objectives with effectiveness in reducing vehicle GHG emissions. Recent developments regarding vehicle CO_2 emission taxes in Europe suggest that such a balance can be achieved with appropriate changes in policy structure.

Fiscal policies can be imposed on manufacturers, consumers, or both. The effects of fiscal policies are ultimately realized by encouraging manufacturers to adopt the most state-of-art technologies to reduce emissions and improve efficiency. Manufacturer investment in advanced technologies often cannot be fully passed on to consumers. Consumers tend to severely discount the lifetime fuel-saving benefit from the advanced technologies (Greene, German, & Delucchi, 2009). With fiscal policies, rewards to manufacturers for adopting such technologies are more certain. Fiscal policies provide consumers with price signals for fuel efficiency and lower emissions immediately and help foster eco-friendly purchasing habits in the long term.

Empirical evidence suggests that fiscal policies can be successful in addressing oil consumption and associated GHG emissions. For example, a study using data from 1995 to 2004 in the 15 EU Member States (EU-15) countries showed that for each 10% increase in vehicle taxes, new fleet CO_2 intensity (measured by gCO_2/km) decreased by approximately 1% to 1.6% (Ryan, Ferreira, & Convery, 2009). This reduction was achieved even though the 15 member state fiscal policies were not linked directly to CO_2 emissions at the time.

If fiscal policies are designed to meet CO_2 reduction goals, their impact can be even more significant. For example, Denmark achieved a fuel economy improvement (equivalent to a precise CO_2 reduction for a given vehicle fuel) of 4.7 km/L (approximately 11 miles per gallon or mpg) for diesel vehicles and 0.6 km/L (1.4 mpg) for gasoline vehicles during a 5-year period (1998–2002) when a vehicle purchase tax based on fuel-efficiency was in place (Smokers et al., 2006). In France, since the introduction of a CO_2 bonus-malus system, the fleet average CO_2 levels of its new car fleet decreased by 9 g/km or 6% over the previous year (Agency for Environment and Energy Management of France, 2009).

Considerable literature exists on vehicle fiscal policies during the past decade from various perspectives. For example, Johnstone and Karoukakis (1999) and Fullerton (2001) discussed the economic theory of fiscal policies. Hirota and Minato (2002) and the Asian Development Bank (Boyle, Courtis, Huizenga, & Walsh, 2008) reviewed fiscal policies across nations without in-depth quantitative analysis and comparison. Kunert and Kuhfeld (2007) compared policies on vehicle taxes broadly but without a focus on climate change–oriented fiscal measures. Fullerton, Gan, and Hattori (2005), Diamond (2009), and Hirota and Poot (2005) conducted empirical studies to analyze the impact of fiscal policies within a single jurisdiction or region.

In particular, there has been increasing discussion on vehicle CO_2 taxes advanced in European nations. In 2009, the Organisation for Economic Co-Operation and Development (OECD) published a comprehensive online fiscal policy database. Users can search for all environment-related fiscal policies and carry out quantitative comparisons across nations (OECD, 2009). Motor vehicle fiscal policies are a subset of the database. The database focuses mainly on European member states and a few OECD nations from other continents, such as Canada and Australia. In terms of vehicle fiscal policies, it focuses on policies driven directly by CO_2 emission or fuel consumption reduction goals.

In addition to discussions generated from the policy-making perspective, another OECD discussion paper (Bastard, 2010) examined the impact of the European car CO_2 taxes from the manufacturer's point of view. The paper concluded that properly designed fiscal instruments can effectively help the industry achieve the EU carbon reduction goals.

Current Report

We reviewed and evaluated fiscal policies formulated up to April 2010 from nine leading auto markets that comprise approximately 60% of the world's car sales (Automotive News, 2008); we included emerging markets in the developing world. Several aspects of this report set it apart from the existing literature. First, it focuses on policies that influence vehicle CO_2 emissions. Second, it is the first of its kind to develop a methodology to quantitatively compare selected fiscal policies on the basis of their relation to vehicle CO_2 emissions. Third, it creates a set of qualitative criteria for evaluating the important aspects of national fiscal policies that cannot be quantified. Finally, it makes specific recommendations for best practices on reorienting existing policies and steering new fiscal policies to encourage the purchase and use of low-CO_2 emission vehicles without significantly altering the revenue stream. Specifically, this report offers insights to policymakers from multiple perspectives and helps answer questions such as the following:

- What policy options are available worldwide to encourage CO_2 reductions from passenger vehicles?
- How strong are the incentives provided in one country compared with others?
- What general principles can be used to design effective incentive policies, and how do different countries measure up against these design principles?

Fiscal measures related to passenger vehicles are quite diverse. In this report, we chose to limit our research and analysis on fiscal assessments applicable at new vehicle purchase and ownership stages with a focus on the nonfixed charges. *Fixed charges* refer to those imposed equally (either equal absolute amount or equal rate) on all vehicles that are independent of vehicle attributes or CO_2 emission performance, such as sales tax, value-added tax (VAT), license plate fees, and the like. The exclusion of policy measures applied during the usage stage of cars, such as fuel tax, road pricing, congestion charging, and early scrappage incentives, does not imply that these policies are not important but rather that they are simply outside the scope of this work. Moreover, the report focuses on domestically produced vehicles and does not include any discussion about custom tariffs on imported vehicles.

We considered three types of fiscal measures: direct CO_2 measures, attribute-based CO_2-related measures, and targeted incentives. *Direct CO_2 incentives* are fiscal charges that vary according to vehicle CO_2 emission levels, such as the CO_2 tax used in some European nations. The fuel-economy based gas-guzzler tax in the United States is considered to be a direct CO_2 incentive, because the fleet fuel use is dominated by gasoline currently. As vehicles running on various biofuels, electricity, and hydrogen become available in the coming decade, a CO_2-based

"Empirical evidence suggests that fiscal policies can be successful in addressing oil consumption and associated GHG emissions.

policy will not necessarily have an equivalent impact on fuel consumption. *Attribute-based CO_2-related measures*[4] are fiscal charges that vary according to vehicle attributes, such as weight, size, displacement, or power; these are correlated to CO_2 emissions under certain technology settings. *Targeted incentives* are special policies applied only to vehicles running on alternative fuels [e.g., ethanol, liquefied petroleum gas (LPG)] or with advanced technologies (e.g., hybrid and electric vehicles). These incentives are different from policies applied to the majority of the fleet that consume conventional fuels. These policies are often formulated with energy security in mind and are intended to be temporary to help the initial commercialization of the targeted vehicles. Therefore, these incentives are treated separately from the other two categories.

The company car tax is beyond the scope of this report. However, because company cars now represent half of the entire car fleet in Europe, their tax policies have a significant impact on car CO_2 emissions in Europe (Næss-Schmidt and Winiarczyk, 2009). *Company cars* refer to cars purchased by a business enterprise that are offered to its employees for business or private use as a fringe benefit. Company cars are often indirectly subsidized in European countries, meaning that they are undertaxed compared with the amount of tax attracted by the equivalent amount of cash remuneration. Such indirect subsidies encourage more cars, more driving, and, consequently, more CO_2 emissions. The European Commission estimated that the tax distortion may result in excessive 21 to 43 million tons of CO_2 emissions across the European Union (Næss-Schmidt and Winiarczyk, 2009). Conversely, the structure of a company car tax can affect car choice and, if aligned with environmental goals, can encourage the purchase of low-emission vehicles. Compared with taxes and incentives for private passenger cars, fewer company car taxes vary directly with car CO_2 emissions. In 2002, the United Kingdom reformed its company car tax to be a CO_2-based tax to reduce CO_2 emissions from its entire fleet. Appendix A of this report provides more detail on company car taxes in selected European countries. In general, we recommend reforming company car taxes following the same set of design principles as for private cars, but we will not further discuss this issue in the report.

> "We considered three types of fiscal measures: direct CO_2 measures, attribute-based CO_2-related measures, and targeted incentives.

[4] Countries may adopt attribute-based vehicle fiscal charges for the following reasons. First, fuel consumption or CO_2 emission information is often not available to either governmental agencies or consumers. As a result, policymakers often choose one or more vehicle physical attributes for which information is easier to obtain and that is more transparent to consumers to index vehicle taxes. Second, vehicles with a large engine capacity are often viewed as a proxy to luxury or sports vehicles that are consumed by wealthy people. Many developing countries are still using engine size–based vehicle tax to function as a luxury tax. Finally, similar to setting vehicle fuel economy or GHG emissions standards over a physical attribute, attribute-based fiscal policies can help reduce the competitive impact on manufacturers and allow a diverse auto market.

Review of Passenger Vehicle Fiscal Policies in Eight Nations

THIS SECTION REVIEWS THE PASSENGER vehicle fiscal policies that potentially reduce CO_2 emissions in eight nations—the United Kingdom, the United States, France, Germany, Brazil, China, India, and Japan.

Table 1 (following page) summarizes all policy components that can be related to CO_2 emissions in each of the eight countries as of April 2010. Specifically, the table lays out the type of each measure on the basis of its degree of approximation to a CO_2 charge (direct CO_2-based and attribute-based CO_2-related fiscal measures). Most developed nations, with the notable exception of Japan, have linked their fiscal policies solely or partially to vehicle CO_2 (or fuel economy) performance. By contrast, developing nations have based their policies on vehicle attributes, mainly engine displacement. Targeted incentives for alternatively fueled or so-called advanced technologies such as hybrids, electric, and fuel-cell vehicles, have been introduced widely in developed nations and are increasingly applied in developing nations.

The following subsections review each nation's policies in detail. Measures that have direct or potential impact on vehicle CO_2 emission are listed in the shaded area that accompanies each subsection.

United Kingdom

- First year registration tax based on CO_2 emission bins
- Annual vehicle excise duty based on CO_2 emission bins

During the past decade, the United Kingdom has redirected the focus of its fiscal policy for private cars toward carbon reduction. Before 2001, annual vehicle tax in the United Kingdom was imposed only on vehicles with an engine displacement >1.55 L. Since 2001, the tax has been linked to vehicle CO_2 emission levels (European Automobile Manufacturers' Association [ACEA], 2009). The basic tax structure defines several emission rate *bins*, as shown in Table 2. The number of bins has increased over time, from 4 in 2001, to 7 in 2006, and to 13 in 2009. This trend is generally

> "Most developed nations [...] have linked their fiscal policies solely or partially to vehicle CO_2 (or fuel economy) performance.

Table 2: U.K. LIGHT-DUTY VEHICLE TAX RATE SCHEDULE (IN £, EFFECTIVE 2010–2011)

CO_2 Bin	Emission (gCO_2/km)	First-Year Registration		Annual		Lifetime	
		Rate for Regular Vehicles	Rate for AFVs	Rate for Regular Vehicles	Rate for AFVs	Rate for Regular Vehicles	Rate for AFVs
A	≤ 100	0	0	0	0	0	0
B	101–110	0	0	20	10	166	83
C	111–120	0	0	30	20	249	166
D	121–130	0	0	90	80	748	665
E	131–140	110	100	110	100	1024	931
F	141–150	125	115	125	115	1163	1070
G	151–165	155	145	155	145	1442	1349
H	166–175	250	240	180	170	1745	1652
I	176–185	300	290	200	190	1961	1868
J	186–200	425	415	235	225	2377	2284
K	201–225	550	540	245	235	2585	2492
L	226–255	750	740	425	415	4280	4187
M	> 255	950	940	435	425	4563	4470

Note. AFV = alternative fuel vehicle.
Source. European Automobile Manufacturer's Association (ACEA, 2009).

“During the past decade, the United Kingdom has redirected the focus of its fiscal policy for private cars toward carbon reduction.

Table 1: NEW PASSENGER VEHICLE TAXES AND INCENTIVES RELATED TO CO_2 EMISSIONS, BY COUNTRY (AS OF APRIL 2010)

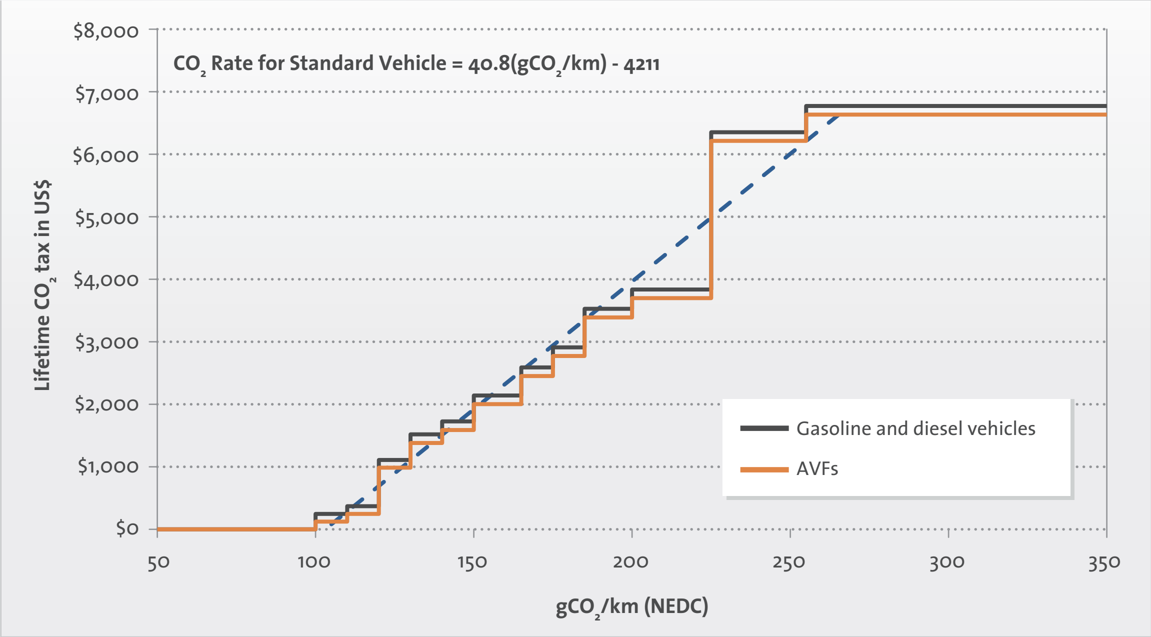
Nation	Incidence	Direct CO_2 Measures	Attribute-Based CO_2-Related Measures	Targeted Incentives
United Kingdom	One time	First year special registration tax	—	—
	Annual	Excise duty based on CO_2 for regular cars and AFVs	—	—
United States	One time	Gas-guzzler tax	—	Tax credits for HEVs and AFVs
France	One time	Bonus-malus (feebate) based on CO_2 for regular cars and AFVs	Registration tax based on fiscal horsepower, reduced rates on AFVs	—
	Annual	Annual tax on high CO_2 cars	—	—
Germany	Annual	Annual circulation tax component based on CO_2	Annual circulation tax component based on engine size	Exemption for BEVs
Brazil	One time	—	Registration tax based on engine size	—
China	One time	—	Excise duty based on engine size	—
			Acquisition tax based on engine size	
India	One time	—	Excise tax based on vehicle classes	Lower tax rate for HEVs and zero tax for BEVs
			Special duty based on engine size	
Japan	One time	—	Acquisition tax based on engine size, reduced rates for special vehicles	Exemption for next-generation vehicles
	Annual	—	Tonnage tax based on weight, reduced rates for special vehicles[a]	Exemption for next-generation vehicles[b]
			Auto tax based on engine size, reduced rates for special vehicles and next-generation vehicles	—

[a] The special vehicles in Japan refer to vehicles that acquired four-star certificated emission level and that achieve a fuel economy at least 15% above the Japanese 2010 standard.

[b] Next-generation vehicles in Japan refer to fuel cell electric vehicles, HEVs, plug-in HEVs, compressed natural gas vehicles, and clean diesel vehicles.

Note. HEV = hybrid electric vehicle; AFV = alternative fuel vehicle; BEV = battery electric vehicles.

Figure 1: ILLUSTRATION OF U.K. CO_2 TAX ON REGULAR VEHICLES AND ON ALTERNATIVE FUEL VEHICLES (AFVS)



Note. NEDC = New European Driving Cycle.

positive because a greater number of bins provides for a greater distinction in vehicle CO_2 emissions, although in the case of the 2009 fiscal year tax schedule, there are actually only 8 distinct tax rates for the 13 bins. Beginning in the 2010 fiscal year, each bin is associated with a distinct tax rate. The first bin (≤100 g/km) and last bin (>255 g/km) are especially wide. Alternative fuel vehicles receive a discount ranging from £15 to £20 for each CO_2 bin. Tax rates have changed for each fiscal year since 2008. Compared with 2009, vehicles emitting <151 g/km have reduced rates, whereas those emitting >150 g/km have increased rates, which reflects the government's determination to encourage lower emission vehicles while punishing the heavy emitters.

In April 2010, United Kingdom changed its first-year registration tax from a fixed amount into varied amounts, depending on CO_2 emissions. Similar to the annual tax, alternative fuel vehicles are subject to slightly lowered tax rates. Table 2 provides details of initial registration tax and annual tax, as well as computed vehicle lifetime total tax using our vehicle lifetime and annual discount rate assumptions.

The two step-functions depicted in Figure 1 show the slightly different tax structures for vehicles powered by gasoline or diesel, as well as for alternative fuel vehicles. Using our conversion strategy for Group 1 countries specified in the methodology section of this paper, the United Kingdom excise duty represents an approximate equivalent marginal CO_2 rate of US$40.8 per gCO_2/km for regular vehicles.

United States

- Gas-guzzler tax
- Federal hybrid-electric and alternative fuel vehicle tax credits
- Tax deductions for heavy sport utility vehicles and light trucks purchased by small businesses

Fiscal policies in the United States relating to vehicle fuel economy date back three decades to the enactment of the Energy Tax Act of 1978 after the oil embargo and resulting supply and price shocks of the 1970s. The act established a gas-guzzler tax, which, as the name suggests, applies to passenger cars with poor fuel economy. In the past decade, concerns over national energy security have spurred additional fiscal policies to advance purely or partially electric-powered vehicles as well as vehicles running on alternative fuels such as ethanol.

A tax break provided to small business owners for the purchase of sport utility vehicles (SUVs) as capital investments is not, strictly speaking, a vehicle fiscal policy. However, because it essentially provides a

“In the past decade, concerns over [U.S.] national energy security have spurred additional fiscal policies to advance purely or partially electric-powered vehicles as well as vehicles running on alternative fuels such as ethanol.

disincentive for fuel economy improvement, we have included it in our discussion.

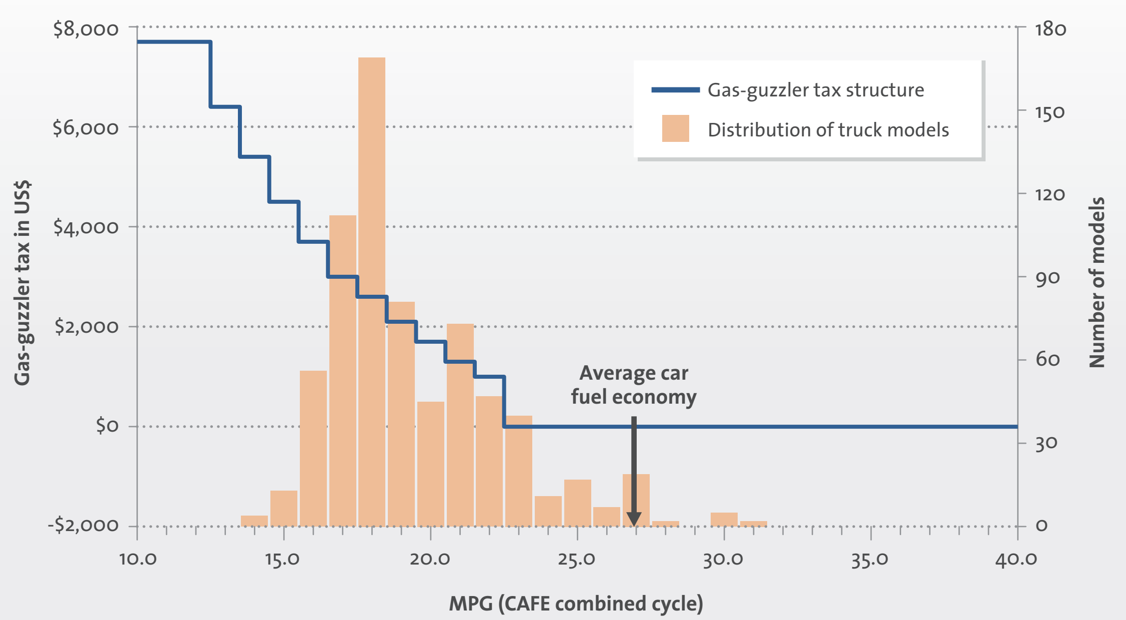
Finally, in 2009, the U.S. federal government introduced a temporary *Cash for Clunkers* incentive program to subsidize the replacement of older and lower fuel economy vehicles with the new purchases subject to a minimum fuel economy improvement (U.S. Department of Transportation, 2010). However, this program lasted only 2 months and was aimed at stimulating new vehicle sales in response to the severe economic downturn of 2008–2009. It is not expected to have any durable impact on longer-term new vehicle fuel economy and thus is not considered in this report.

The gas-guzzler tax is an excise duty assessed on manufacturers of new cars that fail to meet a minimum fuel economy requirement. Vehicles are divided into 12 classes, depending on their fuel economy, and each bin shown in Figure 2 is associated with a specific tax level. The tax is normally passed on to consumers and is made transparent to them through information displayed on a window sticker (also known as Monroney sticker in the United States) attached to the vehicle. As the name suggests, the tax is intended to discourage the purchase of vehicles with high fuel consumption. The threshold for the tax began at only 15 mpg in 1980, but increased to 22.5 mpg by 1991, where it has remained since (U.S. Environmental Protection Agency, 2006). The biggest shortcoming of the gas-guzzler tax is that it does not apply to minivans, SUVs, or pick-up trucks. When the tax was introduced three decades ago, these types of vehicles were a small fraction of the fleet and were mainly used by farmers and small business owners. Now SUVs and other light trucks represent almost half of the U.S. light-duty vehicle market [U.S. Department of Transportation and National Highway Traffic Safety Administration (NHTSA), 2008]. NHTSA defines a *light-duty truck* as any motor vehicle with a gross vehicle weight of not >8,500 lbs (3,856 kg; 40 C.F.R. 86.082-2). Some manufacturers produce light-duty trucks or SUVs just above this weight threshold to be exempted from U.S. CAFE (corporate average fuel economy) regulations. If these vehicles are considered, the share of light trucks and SUVs is even larger. Because these bigger vehicles normally consume more fuel, the gas-guzzler tax does not apply to all of the highest fuel consumption vehicles in the fleet.

Only a few luxury and sports vehicle models now remain under the reins of the gas-guzzler tax. Select manufacturers (e.g., Aston Martin, Ferrari, Mercedes) routinely pay this tax as a "cost of doing business in their market segments," whereas most major

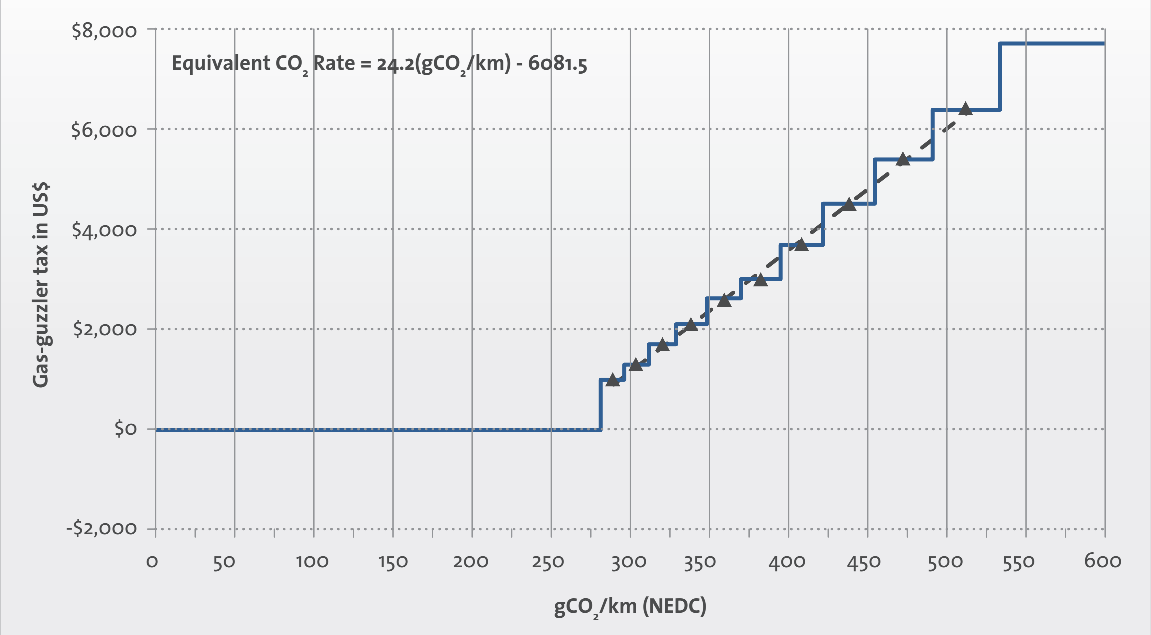
> "The threshold for the [gas-guzzler] tax began at only 15 mpg in 1980, but increased to 22.5 mpg by 1991, where it has remained since.

Figure 2: U.S. GAS-GUZZLER TAX VS. FUEL ECONOMY DISTRIBUTION OF LIGHT TRUCKS



Note. The bars show fuel economy distribution of truck models, not sales. Note that light-trucks, even though they are in the range applicable to the gas-guzzler tax, are not subjected to the tax. CAFE = Corporate Average Fuel Economy.

Figure 3: U.S. GAS-GUZZLER TAX AS A FUNCTION OF CO_2 EMISSIONS



automakers in the U.S. market typically do not produce cars that are subjected to the gas-guzzler tax.

Figure 2 depicts the *step* structure of the gas-guzzler tax (solid line). To illustrate the fleetwide coverage of the tax, we overlaid the fuel economy distribution of light truck and SUV models (bars). As shown, most light trucks and SUVs would face the tax if they were subject to its coverage. The figure also shows that the gas-guzzler tax starts way below the sales-weighted average fuel economy level of cars.

Figure 3 depicts the same tax converted to a gCO_2/km basis. As indicated in the chart, the equivalent marginal CO_2 rate of the gas-guzzler tax is approximately $24 per g$CO_2$/km.

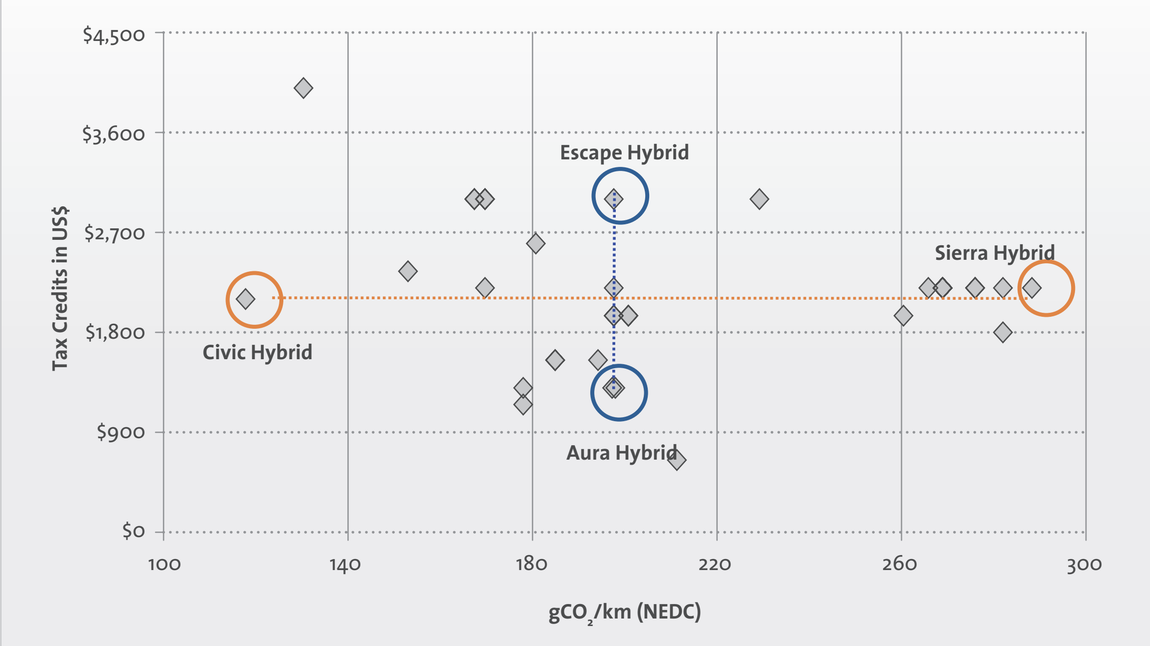
The Energy Policy Act of 2005 established a tax credit of up to $3,400 for the purchase of a new hybrid light-duty vehicle. In the United States, Canada, and the United Kingdom, a *tax credit* means a dollar-to-dollar reduction in income tax. For example, a tax credit of $500 would reduce a $2,000 tax liability to $1,500. The tax credits begin to phase out for a given manufacturer once it has sold more than 60,000 eligible vehicles and ends 1 calendar year after the 60,000 sales milestone is reached. Although the amount of tax credit is tied to fuel economy performance, it is also determined by a formula incorporating the vehicle's weight class. As a result, the real impacts of the tax credit program on vehicle fuel economy are mixed. Hybrid technology can significantly improve fuel economy. For example, the most efficient model year 2009 hybrid is rated at 48 mpg for city driving and 45 mpg for highway driving. But the least fuel-efficient hybrid qualifying for a tax credit is rated at only 20 mpg (U.S. Department of Energy, 2010). Programs indexed to vehicle attributes such as weight focus on increased vehicle efficiency within the same vehicle class rather than encouraging fuel consumption or CO_2 emissions reduction across all vehicles.

In addition to tax incentives for hybrid-electric vehicles, the United States offers an array of federal tax credits for purchasing alternative fuel vehicles. *Alternative fuel vehicles* include vehicles powered by ethanol, compressed natural gas (CNG), and lean-burn diesel. Some of these tax credits have already ended. Tax credits currently remain for certain CNG and lean-burn diesel models (IRS, 2008). Such credits reflect concerns about oil dependence and security in the United States. Similar to the hybrid vehicle tax credits, this fiscal policy sends an inconsistent message when it comes to tailpipe CO_2 emissions, because the tax credit is offered regardless of CO_2 performance of vehicles.

Figure 4 shows the available tax credits for all light-duty vehicle models currently eligible for the federal hybrid vehicle tax credit and the alternative fuel vehicle tax credit, as well as their CO_2 emission levels. As indicated by the random distribution of the data points, there is no direct relation between the tax credits and

"Hybrid technology can significantly improve fuel economy. But the least fuel-efficient hybrid qualifying for a tax credit is rated at only 20 mpg.

Figure 4: IMPACT OF U.S. FEDERAL TAX CREDITS FOR ALTERNATIVE FUEL AND HYBRID ELECTRIC LIGHT-DUTY VEHICLES



Source. U.S. Environmental Protection Agency (2010).

> "A *tax deduction*, in contrast to a tax credit, is a reduction in gross income for tax purposes.

vehicle CO_2 emissions levels. This is a result of the tax credits focusing on vehicle efficiency compared with other vehicles of similar size and weight or fuel type instead of overall CO_2 emissions. For example, the Honda Civic hybrid with a CO_2 emission level of 118 g/km and the Chevy Sierra hybrid rated at 288 g/km are eligible for similar tax credits. Conversely, vehicles with similar CO_2 emissions, such as the Ford Escape hybrid and Saturn Aura hybrid, are offered vastly different incentives.

The U.S. government also provides a tax deduction for small business owners for their purchase or lease of SUVs and light trucks as capital goods under Section 179 of Internal Revenue Service Code (Section179.org, 2010; U.S. Internal Revenue Service, 2010). A *tax deduction*, in contrast to a tax credit, is a reduction in gross income for tax purposes. For example, a $500 tax deduction would reduce a taxable gross income of $10,000 to $9,500 and generate a reduction in taxes equivalent to $500 multiplied by the $10,000 tax rate. In effect, a tax deduction is considerably less incentive than an equal magnitude tax credit. The original intent of the provision was to reduce the tax burden of capital investment by farmers and small business owners. However, the provision defines eligible vehicle models mainly by their weight class (>6,000 lbs), so that most SUVs and pick-up trucks meet the weight limit, and the scope of the tax deduction has expanded well beyond its original intent.

The original allowable tax deduction was up to $25,000 before 2003. The amount was increased in 2003 to $100,000 with the introduction of the *Jobs and Growth Act of 2003* (P.L. 108-27 sec. 202.). Such a big incentive helped SUVs and light trucks become more popular business vehicles. In the wake of mounting criticism, on both tax policy and environmental grounds, lawmakers have narrowed the so-called *SUV loophole*. The *American Jobs Creation Act of 2004* added a weight limit to the vehicle eligibility for the full allowance amount so that only vehicles heavier than 14,000 lbs (such as refrigerated trucks) are still eligible for the $100,000 deduction, whereas the maximum deduction for vehicles with a gross weight between 6,000 and 14,000 lbs was scaled back to $25,000 (P.L. 108-27 sec. 202.). The *Small Business Jobs and Credit Act of 2010* further lifted the maximum allowance of deduction to $500,000 for vehicles with Gross Vehicle Weight (GVW) above 14,000 lbs, while keeping the deduction for vehicles with a gross weight between 6,000 and 14,000 lbs unchanged (Section 179.org, 2010). Regardless, the provision could save a Hummer buyer (with a sticker price of $60,000) up to $7,500 [assuming a 30% tax bracket, the cash saved from the purchase of a Hummer equals 30% of the $25,000 deduction allowance, or $7,500 ($25,000 x 30% = $7,500)].

Although California and other states have introduced some programs on a local level, this report is limited to a review of federal policies. Examples of local programs include the 2006 California passage of Assembly Bill 32, the Global Warming Solutions Act, aimed at reducing human-made GHG emissions to 1990 levels by 2020. California is considering the implementation of a feebate program for new vehicles as a primary policy measure under the Global Warming Solutions Act. This fiscal measure would modify existing tax and fee structures (e.g., sales taxes or new vehicle registration fees) to raise costs for high-CO_2 emission vehicles and lower costs for low-CO_2 emission vehicles. Under Assembly Bill 32, California policymakers are also developing a carbon cap-and-trade program for implementation before 2012. A carbon trust that would use revenues from an auction of carbon emission allowances to further reduce GHG emissions is also under development. Pay-as-you-drive insurance, which would assess insurance premiums on the basis of miles driven, is being considered under Assembly Bill 32 and is being pilot tested in other states, including Texas and Oregon.

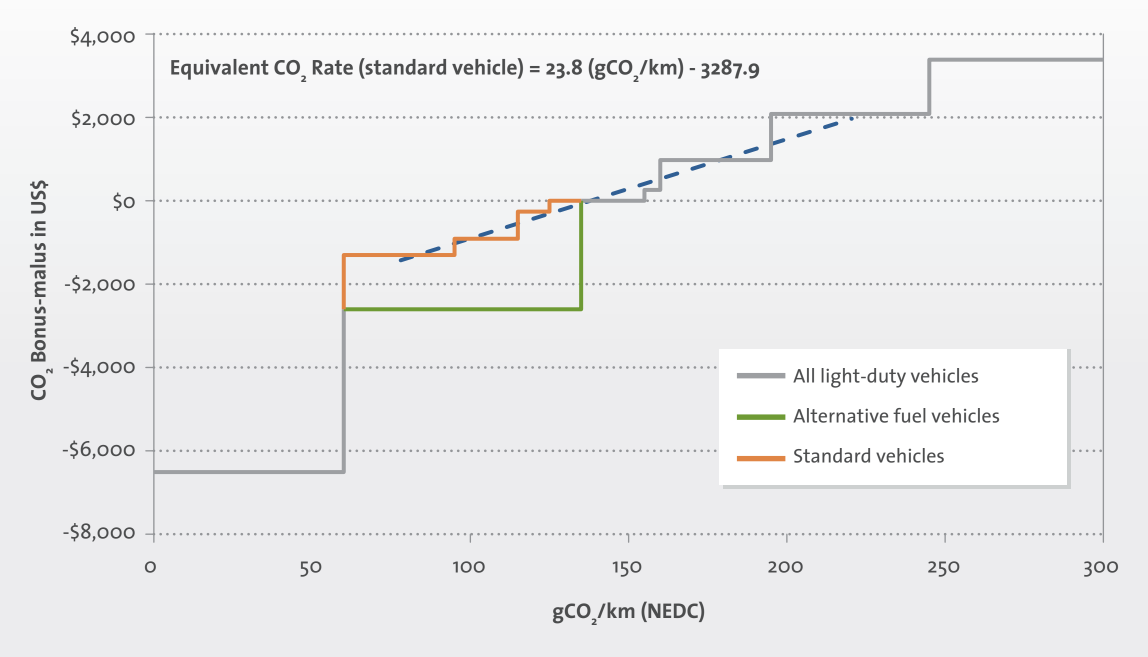
France

- CO_2 based bonus-malus system on all cars registered for the first time in France
- Registration tax (carte grise) based on fiscal horsepower
- Annual tax on high-CO_2 emission passenger cars

In January 2008, France introduced the first feebate system in Europe based on vehicle CO_2 emissions. The so-called *bonus-malus* program penalizes buyers of high CO_2 emission models while rewarding buyers of lower CO_2-emitting vehicles at the time of first sale. According to the 2010 bonus-malus rate schedule, buyers of gasoline or diesel cars emitting <125 gCO_2/km are granted a bonus (rebate) ranging from €200 (US$260) to €5,000 (US$6,510) at the point of their first registration, depending on the specific CO_2 emission level of the vehicle (ACEA, 2009). All passenger cars registered for the first time in France (including vehicles previously registered in another EU state) must pay the fee (if any), but only new vehicles qualify for rebates. The program penalizes buyers of gasoline or diesel cars emitting >155 gCO_2/km, with fees ranging from €200 (US$260) to €2,600 (US$3,385), depending on the vehicle CO_2

> "The so-called *bonus-malus* program penalizes buyers of high CO_2 emission models while rewarding buyers of lower CO_2-emitting vehicles at the time of first sale.

Figure 5: CO_2-BASED BONUS-MALUS SYSTEM FOR REGULAR AND NONCONVENTIONAL VEHICLES IN FRANCE, EFFECTIVE IN 2010



> “Because the greater-than-expected consumer response of the bonus-malus program resulted in higher rebates than fees, an annual tax component was added to the fiscal policy in 2009.

emission level. Nonconventional vehicles, such as hybrid-electric vehicles or vehicles powered by LPG or CNG are subject to a slightly different rebate or fee schedule. Figure 5 illustrates the current feebate structures for both regular (petrol and diesel) and nonconventional cars. The bonus-malus system for regular vehicles translates into an equivalent marginal CO_2 rate of $23.8 per gCO_2/km, as shown by dotted line in Figure 5.

The new program has proven successful, so far, both in reducing CO_2 emissions from passenger cars and in stimulating the otherwise recession-depressed vehicle sales environment in France. The French Environment and Energy Management Agency reported that French manufacturers have increased their offerings of low-CO_2 emission models driven by the bonus and by doing so lowered their fleetwide CO_2 intensity by 9 g/km during the single year of 2008 (Department of Statistics of Ministry of Ecology, Energy, Sustainable Development and Spatial Planning, 2009).

Among all manufacturers, Fiat achieved the largest reduction in average CO_2 emissions—13 g/km in 2008 alone (Agency for Environment and Energy Management of France, 2009). At the same time, the incentives for low-emission vehicles helped limit France's sales decline to 0.7%, in contrast to as much as a 28% sales decline evidenced in the EU as a whole. The bonus-malus system costs the French government approximately €300 million per year plus approximately another €300 million reduction in collected VAT because of higher sales of smaller and cheaper cars with lower CO_2 emissions (Blanc & Derkenne, 2010).

Because the greater-than-expected consumer response of the bonus-malus program resulted in higher rebates than fees (Blanc & Derkenne, 2010), an annual tax component was added to the fiscal policy in 2009. The tax is designed to reinforce the CO_2 reduction incentive by charging an additional €160 (US$225) annually on vehicles emitting >245 gCO_2/km. Vehicles tailored for physically challenged drivers are exempted from this tax. France plans to toughen both the one-time CO_2 bonus-malus and the annual CO_2 tax programs by lowering the threshold for paying the tax by 5 g/km each year through 2012.

In addition to the two measures directly related to vehicle CO_2 emissions, the French policy includes a local-level vehicle registration tax called *carte grise* that is indirectly related to CO_2 emissions. The basis of the tax is fiscal horsepower, a long-established metric that varies with actual vehicle horsepower. Fiscal horsepower (PA) has historically been used for tax purposes in several European countries. Fiscal horsepower is determined as a function of vehicle horsepower and CO_2 emissions. Since 1998, the French government has calculated fiscal horsepower using the following formula:

$$P_A = CO_2/45 + (P/40)^{1.6}$$

where P is the maximum engine power in kilowatts, and CO_2 is gCO_2/km

Depending on the region, the charge per fiscal horsepower varies between €27 and €46. The average regional tax rate converts to an equivalent marginal CO_2 rate of $5.4 per gCO_2/km. Regions may provide an exemption—either in total or at a rate of 50%—for CNG, LPG, electric, gasoline/diesel hybrid, and E85 vehicles (vehicles designed to run on 85% ethanol fuel; ACEA, 2009).

Figure 6 shows the combined effect of the three policy instruments as a step function. Flatter slopes for both low and high CO_2 emission rates show the effect of the carte grise. The steeper slope in the for midrange CO_2 emission rates shows the combined impact of the CO_2 bonus-malus and the carte grise. The jump at 60 gCO_2/km is caused by a large step change in the feebate structure, whereas the jump at 245 gCO_2/km is caused by the imposition of the annual tax on heavy emitters. The portion of the aggregate policy structure ranging from 60 g/km to 245 g/km yields an equivalent marginal CO_2 rate of US$29 per gCO_2/km.

Germany

- Annual ownership tax based on CO_2 emissions
- Annual ownership tax based on engine displacement
- Tax exemption for electric vehicles

Historically, Germany has based its annual circulation tax for light vehicles on engine size and non-CO_2 tailpipe emissions. In March 2009, Germany announced a tax reform that included the institution of an annual CO_2 tax component, effective July 2009 (ACEA, 2009). The new car ownership taxes, consisting of a base tax determined by vehicle engine displacement and a CO_2 tax, are due at annual registration. Electric vehicles are exempted from both taxes for their first 5 registration years.

The German annual ownership tax consists of two components—a base tax of €2 (US$2.6) per 100 cubic centimeter (cc) for gasoline vehicles and €9.5 per 100 cc for diesel vehicles and an additional CO_2 tax set at €2 (US$2.6) for each g/km above a 120 g/km threshold for both gasoline and diesel vehicles (ACEA, 2009). The reason for the higher annual tax on diesel vehicles is the lower tax on diesel fuel. Historically, the diesel fuel tax has been low to protect the German logistics companies. To compensate, the annual circulation tax for passenger diesel vehicles is higher. Unlike the bin-based (step function) systems adopted in the United Kingdom and France, part of CO_2 tax is assessed in a continuous fashion. The CO_2 tax threshold will be lowered to 110 g/km in 2012 and 95 g/km after 2013 (ACEA, 2009).

Figure 6: FRANCE'S FISCAL POLICIES ON PASSENGER VEHICLES, AS A FUNCTION OF CO_2 EMISSIONS

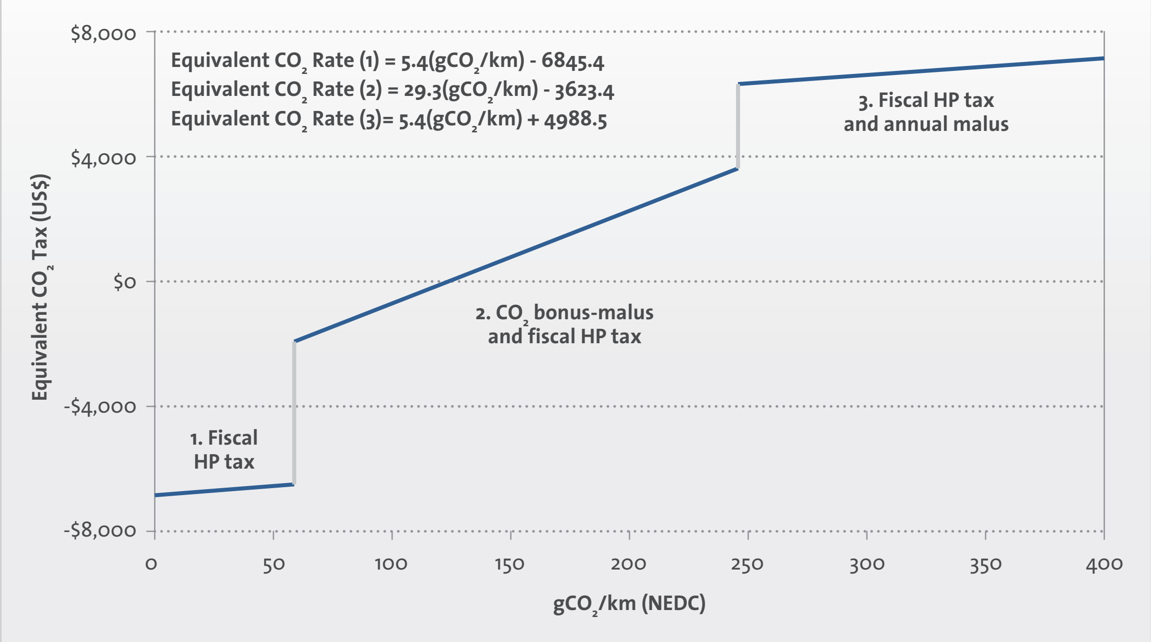
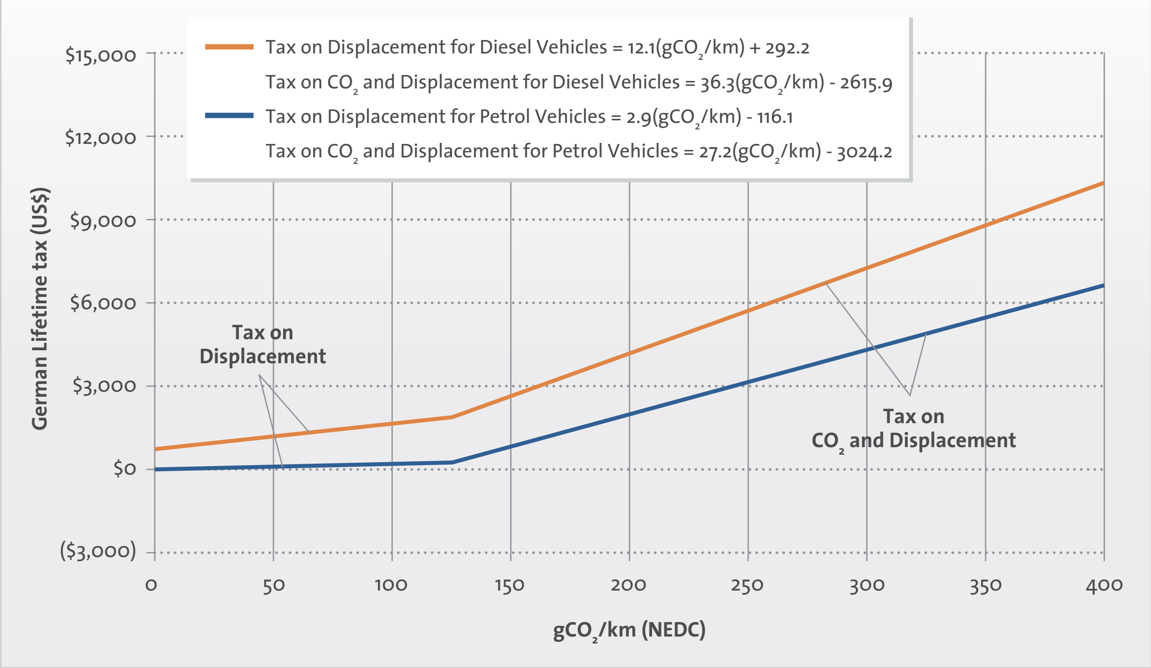


Figure 7: GERMANY'S FISCAL POLICIES ON PASSENGER VEHICLES, AS A FUNCTION OF CO_2 EMISSIONS



"In March 2009, Germany announced a tax reform that included the institution of an annual CO_2 tax component, effective July 2009.

Figure 7 illustrates the impact of the German fiscal policies over a vehicle's lifetime. The higher curve reflects the assessment on diesel vehicles, whereas the lower curve depicts that for gasoline vehicles. Similar to France, the different slopes of the lines are attributable to the different policy components. The flatter parts of the two curves between 0 and 120g/km trace the engine displacement tax component in isolation. The steeper parts of the curves represent the combined impacts of the engine displacement and CO_2 taxes. The portion of the policies that includes a CO_2 tax (120 gCO_2/km and above) indicates equivalent CO_2 charges of US$36 and US$27 per g/km emission for diesel and gasoline vehicles, respectively.

Brazil

- Excise tax based on engine size and fuel type

Brazil has done little by the way of fiscal policies on passenger cars to reduce GHG emissions. Brazil assesses a single excise duty on car manufacturers based on engine size and fuel type. The tax rates are assessed as a percentage of vehicle price and vary over three specific groups of engine size: engines <1 L, engines between 1 and 2 L, and engines >2 L. Table 3 summarizes Brazil's tax rates for light-duty vehicles (Borges, 2009).

"Brazil has done little by the way of fiscal policies on passenger cars to reduce GHG emissions.

Table 3: BRAZIL LIGHT-DUTY VEHICLE TAX BY ENGINE SIZE AND FUEL TYPE (EFFECTIVE IN 2009)

Engine Size	Vehicle Fuel Type[a]	
	Gasoline	Ethanol or Flex Fuel
< 1 L	27.1%	27.1%
1–2 L	30.4%	29.2%
> 2 L	36.4%	33.1%

[a] *Brazil currently does not have diesel passenger cars; therefore, the taxes are established only for gasoline and ethanol vehicles.*
Source. Borges (2009).

In 2008, the federal government in Brazil temporarily reduced the tax rates on new cars to mitigate the economic slowdown in Brazil by stimulating domestic vehicle sales. Vehicles with engines <1 L are considered as popular cars in Brazil, and taxes on these vehicles have been eliminated entirely. The rate for ethanol and flexible-fuel cars with engines between 1 and 2 L was reduced to 5.5%, and the rate on similarly sized engines running on gasoline was lowered to 6.5%. Rates on cars in the largest engine category were not reduced. This tax waiver was extended into 2009. As of April 2010, taxes were returned to the levels shown in Table 3 (Borges, 2009).

China

- Excise tax, with the percentage tax rates indexed to engine size
- Acquisition tax, including a temporary tax reduction for vehicles with ≤1.6-L engines
- Small and energy-saving vehicle subsidy
- Subsidy for private purchase of battery electric and plug-in hybrid cars

China has reported vehicle sales growth of more than 20% per year recently and now is the leading passenger car market in the world [China Automotive Technology Research Center (CATARC), 2009]. Growing oil imports and GHG emissions from passenger vehicles have motivated the Chinese government to adopt both regulatory and fiscal measures.

In 2006, China instituted a fiscal policy to support its fuel-saving goal by raising the excise tax rates for vehicles with larger engine displacements while reducing taxes on vehicles with smaller engine displacements. In late 2008, China further widened the tax gap between small and large engine vehicles to encourage the sale of smaller cars (China Ministry of Finance and State Administration of Taxation, 2008). In early 2009, a temporary tax incentive designed to stimulate the auto economy reduced the acquisition tax rate by 50% for passenger vehicles with engines size ≤1.6 L (China Ministry of Finance and State Administration of Taxation, 2009a). In 2010, the tax deduction for smaller engine vehicles was extended but with a reduced magnitude of 25%(China Ministry of Finance and State Administration of Taxation, 2009b). Figure 8 illustrates both the excise tax and acquisition tax structure effective in 2010 in China.

Figure 9 shows the equivalent CO_2 tax relative to vehicle CO_2 emissions converted from both engine displacement taxes using the methodology specified in the methodology section of this paper. The wide spread of data points suggests that China's policy to reward vehicles with smaller engines does not necessarily provide a clear incentive for fuel-efficient cars nor a clear disincentive for gas-guzzlers. The overall potential price signal for reducing CO_2 emissions from both taxes is equivalent to approximately US$53/($gCO_2$/km).

Figure 8: ILLUSTRATION OF THE ACQUISITION TAX AND EXCISE TAX IN CHINA, EFFECTIVE IN 2010

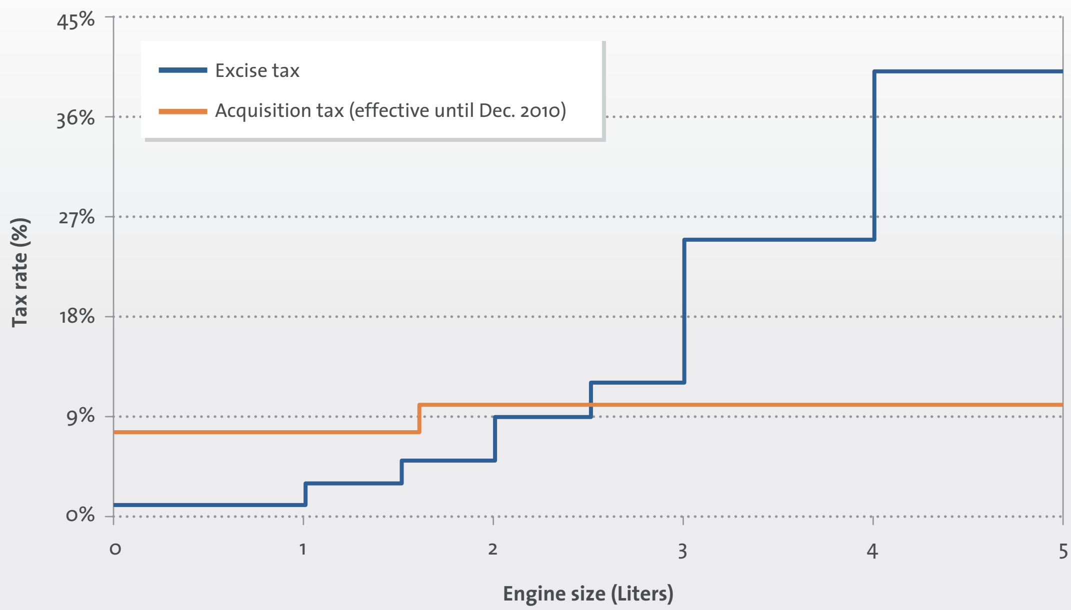
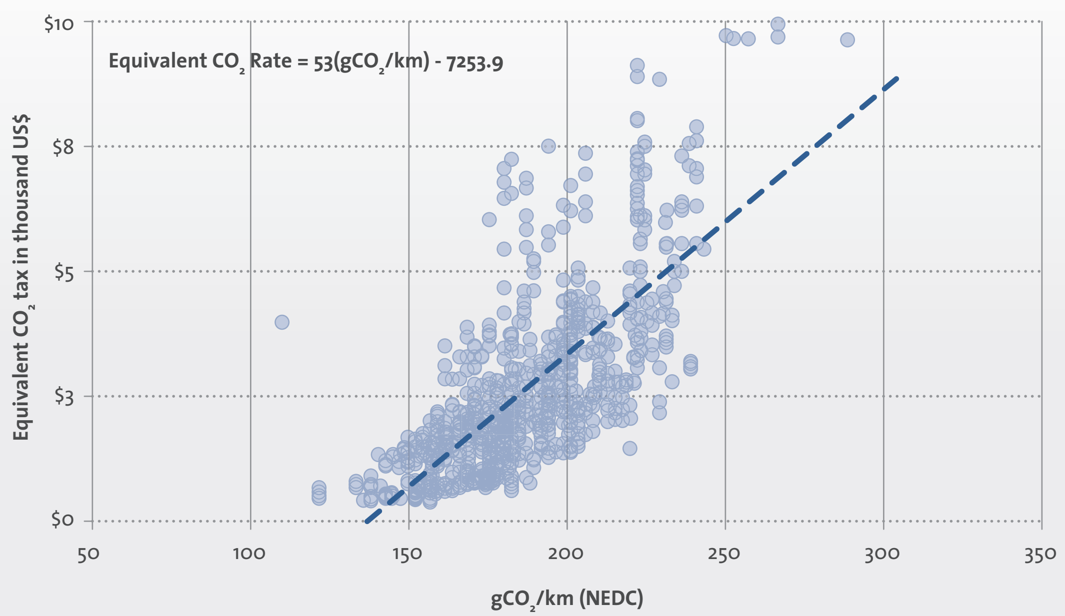


Figure 9: CO_2-RELATED NEW LIGHT-DUTY VEHICLE TAXES IN CHINA, AS A FUNCTION OF CO_2 EMISSIONS.



"Growing oil imports and GHG emissions from passenger vehicles have motivated the Chinese government to adopt both regulatory and fiscal measures.

On June 1, 2010, China announced two new incentive policies to encourage fuel-efficient and advanced technology vehicles (Chinese Ministry of Finance, 2010b). Effective on the same day, conventional fuel (i.e., gasoline, diesel, flex-fuel vehicles) and conventional hybrid electric passenger cars with ≤1.6 L displacement and vehicles that beat the Phase III national passenger car fuel consumption standards for their weight class were eligible for a fixed amount of one-time subsidy of 3,000 yuan (or US$438) per vehicle (Chinese Ministry of Finance, 2010a). The Phase III passenger car fuel consumption standards are based on vehicle curb weight class. Each of the nine weight bins has a distinct standard. Plug-in hybrid and battery electric cars purchased between 2010 and 2012 are eligible for up to 50,000 yuan (US$7,300) or 60,000 yuan (US$8,760) subsidy, respectively (Chinese Ministry of Finance, 2010b). The exact amount of subsidy is a function of battery capacity—3,000 yuan (US$438) for each kilowatt-hour (KWh)—and with minimum battery power or range requirements. Battery capacity for qualified battery electric vehicles cannot fall below 15 KWh. The minimum battery capacity requirement for plug-in hybrid vehicles is 10 KWh (or battery-based range of ≥50 km) to be eligible for the subsidy. The subsidy for plug-in hybrid and battery electric vehicles will phase out after a manufacturer has sold 50,000 units for each type.

India

- Excise tax varied by vehicle class as a percentage of vehicle price
- Special excise duty indexed by engine displacement

The Indian central government currently levies an excise tax differentiated by vehicle class and a special duty that varies by engine displacement, both assessed at the point of vehicle purchase. Some metropolitan areas and states have instituted tax relief for alternative fuel and advanced technology vehicles, tax incentives for the early scrappage of in-use vehicles, road charges, and parking pricing (Centre for Science and Environment of India, 2010). Although most of these measures are beyond the scope of this report, these local programs can serve as diverse learning experiences for consideration by the central government in its future development of appropriate policy elements in India.

The definition of small cars has created a pathway for the accelerating dieselization of Indian car fleet. *Small cars* are defined as cars with a length not exceeding 4 m and with an engine capacity <1.2 L for gasoline cars or 1.5 L for diesel cars. The relaxed limit for diesel cars allows many midsized diesel cars to qualify

“The relaxed limit for diesel cars [in India] allows many midsized diesel cars to qualify for the reduced tax rates that are not available to similarly sized gasoline vehicles.

Figure 10: INDIA'S CO_2-RELATED FISCAL POLICIES ON PASSENGER VEHICLES, AS A FUNCTION OF CO_2 EMISSIONS

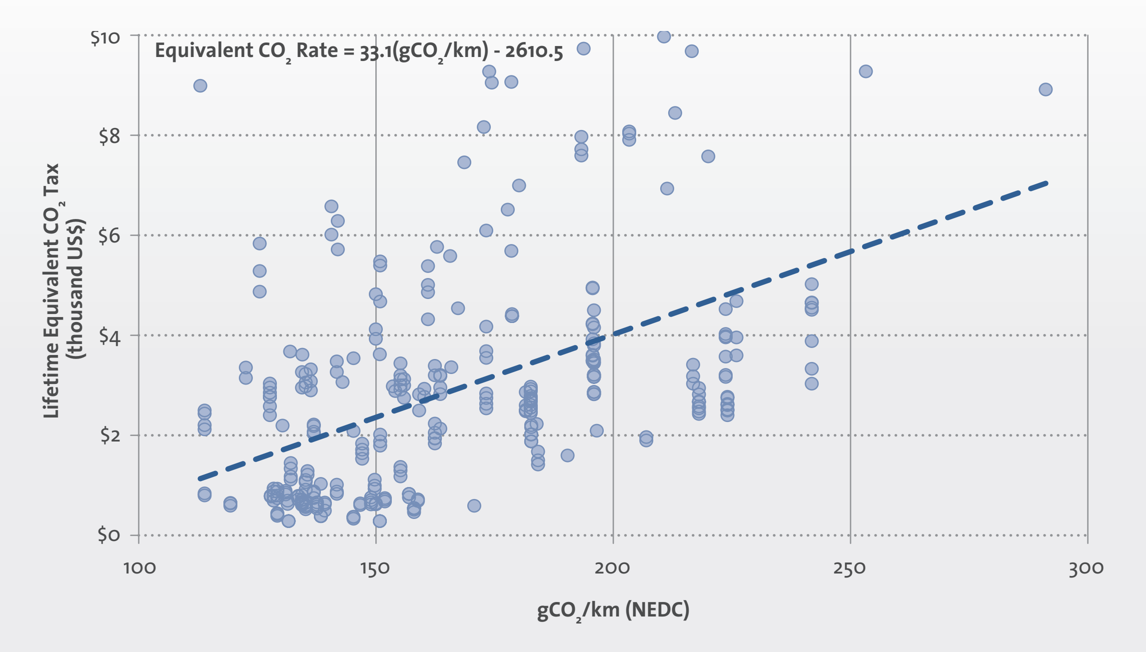


Table 4: JAPANESE PASSENGER VEHICLE FISCAL MEASURES RELATED TO CO_2 EMISSION (EFFECTIVE FROM 2009)

Vehicle Categories	On Acquisition	During Ownership (Annual Taxes)	
	Acquisition Tax	Tonnage Tax	Automobile Tax
Standard Car	3% on engines ≤ 0.66 L 5% on engines > 0.66 L	6,300 yen (US$63) per 500 kg	0–0.66 L: 7,200 yen (US$72) 0.66–1: 29,500 yen (US$295) 1–1.5 L: 34,500 yen (US$345) 1.5–2 L: 39,500 yen (US$395) 2–2.5 L: 45,000 yen (US$450) 2.5–3 L: 51,000 yen (US$510) 3–3.5 L: 58,000 yen (US$580) 3.5–4 L: 66,500 yen (US$665) 4–4.5 L: 76,500 yen (US$765) 4.5–6 L: 88,000 yen (US$880) > 6 L: 111,000 yen (US$1,110)
Next-Generation Cars[a]	Exempted	Exempted	50% reduction
☆ ☆ ☆ ☆ + 25% Fuel Economy Improvement	75% tax reduction	75% tax reduction	50% reduction
☆ ☆ ☆ ☆ + 15% Fuel Economy Improvement	50% reduction	50% reduction	25% reduction

Source. Japan Automobile Manufacturers Association (2009)
[a] Next generation vehicles in Japan refer to fuel cell electric vehicles, hybrid electric vehicles, plug-in hybrid electric vehicles, compressed natural gas vehicles, and clean diesel vehicles.

for the reduced tax rates that are not available to similarly sized gasoline vehicles (Center for Science and Environment of India, 2009).

In 2008, India introduced a displacement-based special duty on top of the excise tax to discourage the manufacture and purchase of larger vehicles. The duty originally affected vehicles over three broad tiers—zero tax for vehicles with engine displacements <1.5 L, Rs15,000 (US$309) for vehicles with engines between 1.5 and 2 L, and Rs20,000 (US$412) for vehicles with engine displacements ≥2 L (Government of India, Central Board of Excise and Customs, 2008).

In the 2009–2010 budget for India, the special excise duty for vehicles with engines ≥2 L was temporarily reduced to the same level as that for vehicles with engines between 1.5 and 2 L to stimulate the automobile market (Government of India, Central Board of Excise and Customs, 2009). Although this tax relief does not significantly alter the statistical relation between the amount of taxes and vehicle CO_2 emissions, it does have at least a symbolic effect in reducing the incentive to purchase more fuel-efficient vehicles.

The Union Budget 2010–2011 imposed a 10% excise tax on small vehicles compared with a 22% excise tax on large vehicles, mostly SUVs, and multipurpose vehicles (Government of India, Ministry of Finance, 2010). Electric cars are exempt from the tax, and hybrid vehicles of any size enjoy a reduced tax rate of 14%, although neither have an established market at this time in India (MapsofIndia.com, 2010).

Figure 10 depicts the aggregate tax caused by both policy measures for all nonluxury car models in the current Indian market relative to their CO_2 emission levels. A linear regression of this data reveals an equivalent marginal CO_2 rate of approximately US$33.1/(g$CO_2$/km). Although this marginal rate may appear high compared with some European countries, the greater uncertainty of indirect measures used in India compared with a direct CO_2 tax in several European countries should be considered when evaluating the relative stringency.

Japan

- Acquisition tax differentiated by vehicle segment
- Annual tonnage tax determined by vehicle weight
- Annual automobile tax tiered with engine displacement
- Green tax scheme—tax break for selected types of vehicles

Table 4 reflects Japan's tax rates as effective from April 2009. A standard car (a car powered by gasoline or diesel fuel) faces an upfront acquisition tax that offers

"[Under Japan's 2001 green vehicle tax scheme], four-star vehicles are defined as vehicles with non-CO_2 tailpipe emissions that are at least 75% lower than Japan's 2005 emission standards.

> “[The “next-generation vehicle” designation] refers mainly to electric vehicles, hydrogen fuel cell vehicles, hybrid electric vehicles, plug-in hybrid electric vehicles, and cars running on CNG or clean diesel that meet criteria pollutants emissions standards.

a reduced rate for the subcompact segment (cars with an engine displacement <0.66 L), an annual tonnage tax that varies linearly with vehicle weight, and an annual automobile tax indexed by engine displacement, in addition to several fixed fees and taxes. Although none of these components is based on vehicle CO_2 emissions directly, the measures are collectively related to a vehicle CO_2 tax (Japan Automobile Manufacturers Association, 2009).

As one of the strategies to meet Kyoto Protocol commitments, the Japanese government introduced a green vehicle tax (also called Eco-car tax) scheme in fiscal year 2001 that provides a tax break for clean and high-efficiency vehicles [Japan Ministry of Land, Infrastructure, Transport and Tourism (MLIT), 2010a]. Eligible vehicles must meet both non-CO_2 tailpipe emissions and fuel economy requirements, simultaneously. A star-rating label was developed to indicate the criteria pollutant emissions performance of a vehicle. Four-star vehicles are defined as vehicles with non-CO_2 tailpipe emissions that are at least 75% lower than Japan's 2005 emission standards. A separate fuel efficiency label was granted to vehicles that beat national 2010 fuel economy targets by at least 15%. Only vehicles with both a four-star emission sticker and a fuel efficiency sticker simultaneously are eligible for reduction on all three taxes. Depending on fuel efficiency gain, the range of reduction is from 25% to 75% for both tax items (Japan Automobile Manufacturers Association, 2009).

The other component of Japan's green tax program offers lower tax rates for so-called next-generation vehicles. This designation refers mainly to electric vehicles, hydrogen fuel cell vehicles, hybrid electric vehicles, plug-in hybrid electric vehicles, and cars running on CNG or clean diesel that meet criteria pollutants emissions standards. Hybrid vehicles must receive both a higher fuel efficiency rating and a four-star emission rating, as required for standard-fuel vehicles, to be eligible for the next-generation vehicle tax reduction. The acquisition tax and tonnage tax are completely eliminated, and the automobile tax is reduced by 50% for next-generation vehicles purchased between April 2009 and March 2012 [Japan Ministry of Land, Infrastructure, Transport and Tourism (MLIT), 2010b]. For example, the buyer of a 2.63 million Yen (US$26,300) Toyota Prius will save approximately 350,000 yen (US$3,500), or approximately 13% of the tax it would have accrued otherwise over its lifetime without the next-generation vehicle provisions.

Figure 11 depicts the acquisition tax (in absolute dollars) and automobile tax (as a percentage of vehicle price) that vary according to engine size. Given the complexity of the Japanese tax scheme, we plotted these different taxes and incentives on a CO_2 basis on Figure 12 to obtain an equivalent marginal CO_2 rate under the fiscal measures, with our methodology specified in the methodology section of this paper. The combined impact of these various measures approximates a continuous CO_2 tax of US$43.8 per gCO_2/km.

Figure 11: ILLUSTRATION OF ACQUISITION TAX AND AUTOMOBILE TAX IN JAPAN

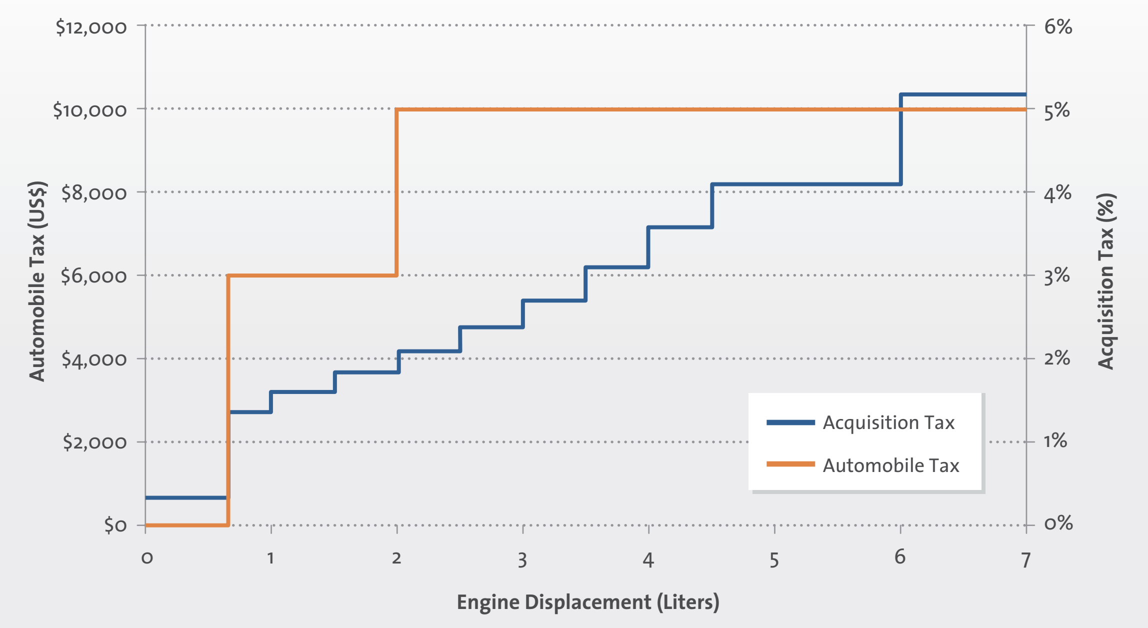
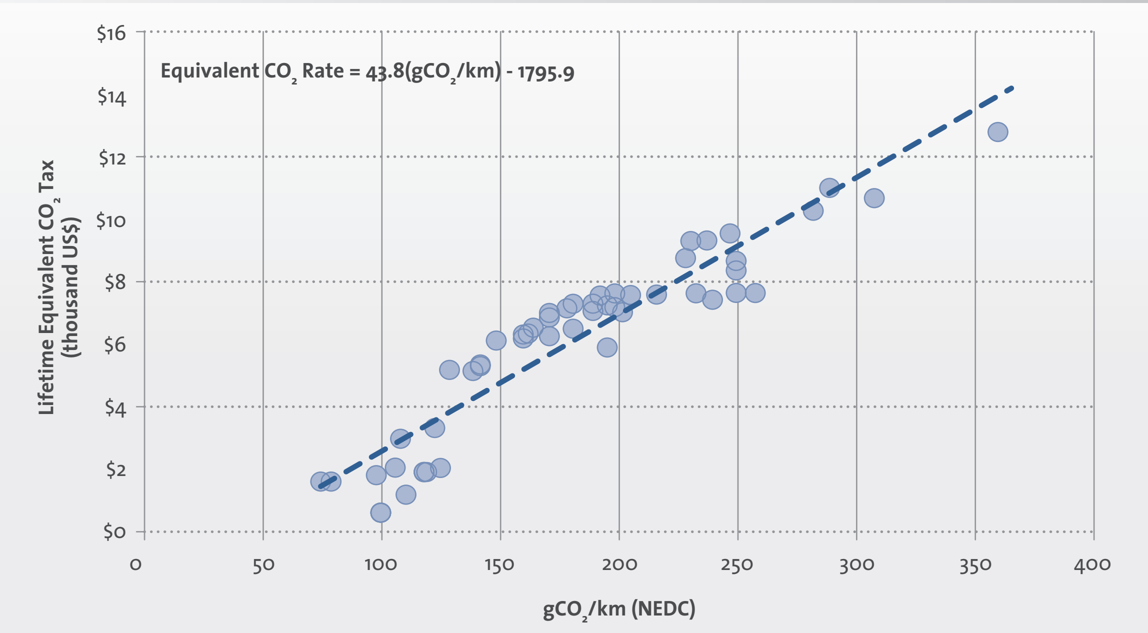


Figure 12: REGRESSION OF TOTAL VARIED VEHICLE TAX OVER FLEET CO_2 EMISSION IN JAPAN



"The buyer of a 2.63 million Yen (US$26,300) Toyota Prius will save approximately 350,000 yen (US$3,500), or approximately 13% of the tax it would have accrued otherwise over its lifetime without the next-generation vehicle provisions.

Comparison of Fiscal Policies on Passenger Vehicles Across Countries

“*Stringency* of a fiscal policy refers to the strength of a price signal that the policy provides for reducing CO_2 emissions from vehicles.

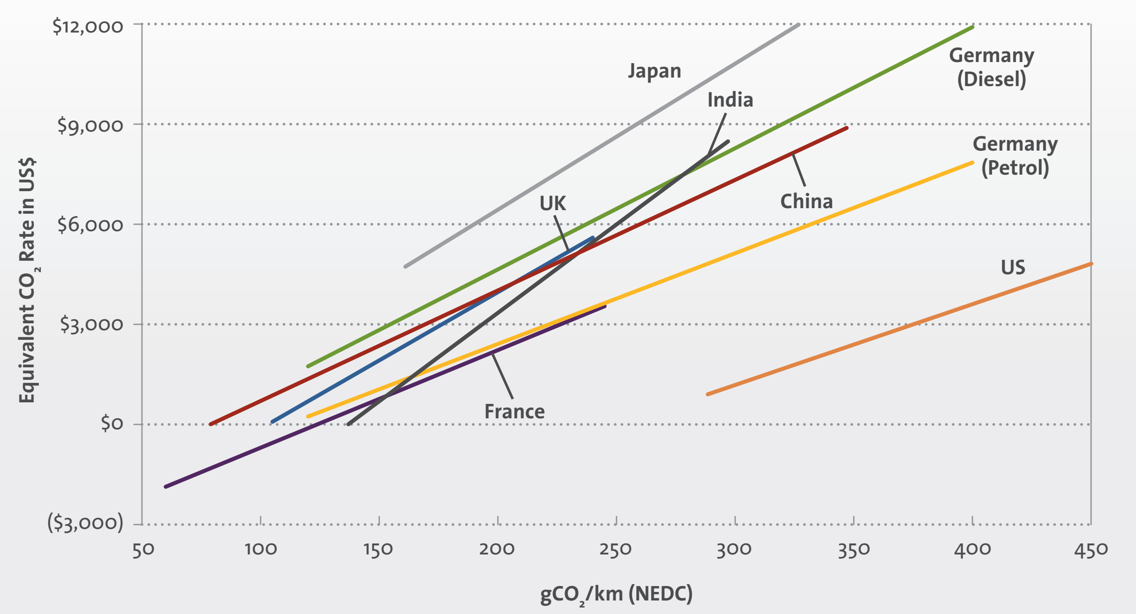
BOTH STRINGENCY AND STRUCTURE ARE IMPORTANT in designing a successful fiscal policy program. We conducted quantitative comparisons on the stringency and qualitative comparison on the design structure of the policies discussed earlier. Quantitative analysis requires a country-specific database that includes vehicle specification, fuel efficiency or CO_2 emissions, and market price data by model. We excluded Brazil from our quantitative analysis because of a lack of data. All other countries in this report provide such data.

Comparison of the Stringency of Passenger Car Fiscal Policies

Stringency of a fiscal policy refers to the strength of a price signal that the policy provides for reducing CO_2 emissions from vehicles. We used the metric of an equivalent marginal CO_2 rate within a specific applicable CO_2 emission range derived from each nation’s fiscal policy. For countries adopting direct CO_2 incentives, their equivalent marginal CO_2 rates revealed the actual price signal of their policies. For countries with only attribute-based fiscal charges, their equivalent marginal CO_2 rates indicated only the potential CO_2 price signals.

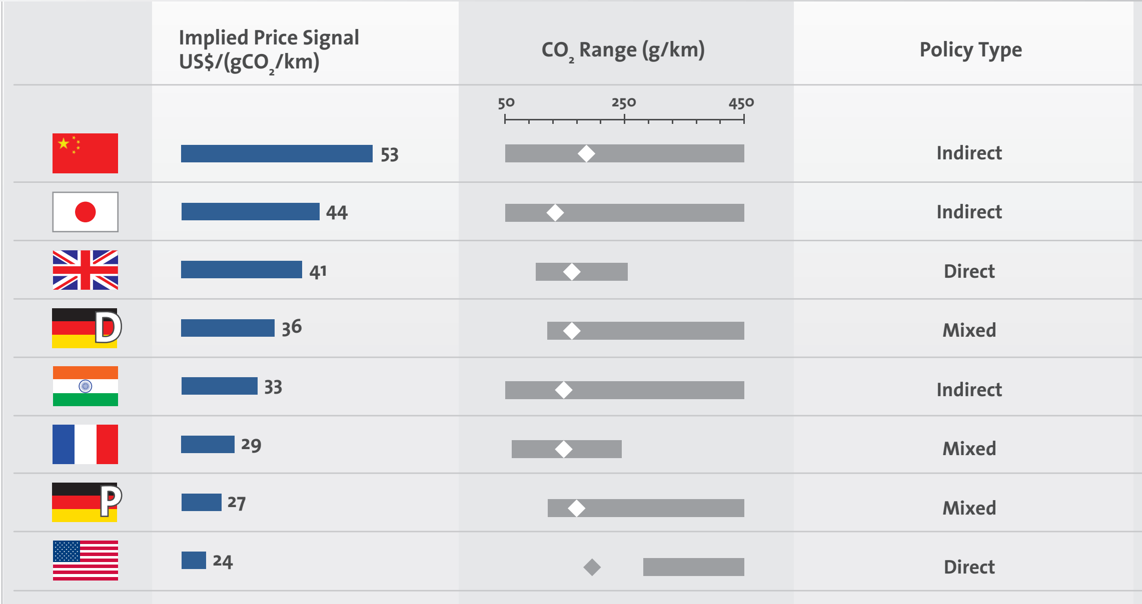
Figure 13 depicts the equivalent CO_2 rate curves of all countries. Each line approximates a linear function of a country’s equivalent CO_2 curve. The degree of slope associated with a line indicates the marginal equivalent CO_2 rate for that particular country. A steeper slope

Figure 13: COMPARING ABSOLUTE DOLLAR VALUE EQUIVALENT CO_2 CHARGES ACROSS NATIONS



Note. The US curve accounts only for its fiscal policy on cars, whereas policies in other nations cover the full private light-duty vehicle fleet including cars, SUVs, and light trucks.

Figure 14: COMPARISON OF POLICY STRINGENCY (MAGNITUDE OF PRICE SIGNAL), APPLICABLE RANGE AND POLICY TYPE ACROSS COUNTRIES



Note. German flag with letter D denotes diesel vehicle policy; while German flag with letter P denotes petrol vehicle policy. Diamonds denote sales-weighted average CO_2 emissions level of each fleet.

indicates a higher rate and a stronger incentive to reduce CO_2 emissions.

Figure 14 reinterprets and simplifies the key elements for comparing policy stringency in Figure 13. Figure 14 compares the magnitude of the price signal to reduce vehicle CO_2 emissions offered by the fiscal policies, their applicable ranges in terms of vehicle CO_2 emissions levels, and the policy type. Policies adopted in the United Kingdom and United States are both direct incentives offering actual price signal. We also estimated the revenue-neutral equivalent price signal associated with attribute-based fiscal charges for comparison with actual incentives provided by direct CO_2 measures. Attribute-based measures are indirect incentives, and they do not function as effectively as direct CO_2 incentives in encouraging the production or purchase of low-CO_2 emission vehicles. Instead, they have only the potential to influence vehicle CO_2 emissions and need to be realigned to a CO_2 basis to fulfill such potential. Policies adopted in China, India, and Japan are all indirect policies, because all of the policy components are based solely on vehicle attributes. Policies adopted in France and Germany consist of both direct and indirect policy components, and thus they are assigned with the "mixed" policy type. Sometimes, a policy may offer different price signals at different CO_2 emissions levels (more details in country sections). Here we compare only the highest price signal of each policy, and its applicable CO_2 emissions range is shown next to the price signal.

As shown in Figure 14, the United Kingdom's policy provides the strongest direct incentive for CO_2 reduction. China and Japan's fiscal policies translate into high potential price signals, but they rely on indirect, attribute-based charges. Fiscal policies in Germany and France rank in the middle in terms of policy stringency, and they offer mixed price signal. U.S. policy creates the lowest direct incentive.

Given the very different socioeconomic situations in these countries, the real-world impact of these absolute amount price signals differs. A dollar in developing countries does not have equal power to the same dollar in developed countries. We do not address factors such as cost of living and income levels, because they are beyond the scope of this report.

The applicable CO_2 emission range of a policy also has an impact on its effectiveness. An ideal incentive policy should cover the full CO_2 range of the vehicle fleet rather than influencing only a limited portion of the range. At a minimum, the incentive should cover the majority of vehicle models in each market. This is indicated by whether the fleet-average CO_2 emission level falls in the applicable emission range of a nation's policy. As shown in Table 5, although all nations except for the United States apply the incentives to at least the "average" models in their fleets, the United Kingdom

" A dollar in developing countries does not have equal power to the same dollar in developed countries. We do not address factors such as cost of living and income levels, because they are beyond the scope of this report.

and France do not extend disincentives to purchase high CO_2 emission vehicles to the highest emitters. The United Kingdom's marginal equivalent CO_2 charges stop at 255 g/km. France's marginal equivalent CO_2 charge remains relatively high between 61 g/km and 245 g/km, but for the rest of the fleet, the French policy provides a substantially reduced marginal incentive. The U.S. policy affects neither an average car nor any light truck but rather only the highest-emission car models.

Enhancing the stringency of a fiscal policy does not necessarily require increasing taxes significantly, which is a political concern to many governments around the world. Increased stringency can be realized by means of pure structural reform of the existing fiscal policies. One option is to replace a vehicle tax with a feebate system, like the French bonus-malus (German & Meszler, 2010). Where a feebate is politically unpalatable, shifting non-CO_2 based charges to direct CO_2 (or fuel consumption) incentives offers a good solution.

To illustrate the potential of each country to fully take advantage of its current fiscal policy scheme to encourage low CO_2 emission vehicles, we developed a policy efficiency measure, a ratio that indicates the degree to which the current fiscal measures in general mimic a revenue-neutral, continuous CO_2-based policy. For example, a 90% efficiency measure means that the current country policy provides a CO_2 price signal that is 90% of the price signal that would be provided by a continuous, revenue neutral, CO_2 policy. The higher the ratio is, the more efficient a policy will be.

Consequently, the "inefficiency ratio"—the difference between 1 and the efficiency ratio—measures the overall differentials between the amount of tax dollars actually assessed on each vehicle model and the corresponding fee (or rebates) under an ideally designed CO_2 incentive policy. Therefore, the inefficiency ratio indicates how much room is left within each policy framework to further increase the price signal for low-CO_2 emission

"Enhancing the stringency of a fiscal policy does not necessarily require increasing taxes significantly, which is a political concern to many governments around the world.

Table 5: ACTUAL AND POTENTIAL CO_2/ FUEL CONSUMPTION REDUCTION INCENTIVES OF FISCAL POLICIES, BY COUNTRY

Country	Type of Incentive	Magnitude of Incentive in US$ per gCO_2/km[a]	Applied Range (gCO_2/km)	Sales-Weighted New Fleet Emissions (gCO_2/km)[b]
United Kingdom[d]	Actual	40.8	101–255	162
United States[e]	Actual	24.2	Cars > 281	196[b]
France[d]	Potential	5.4	Entire fleet	149
	Actual	23.8	61–245	
Germany (petrol)[d]	Potential Actual	2.9 24	Entire fleet > 120	170
Germany (diesel)[d]	Potential Actual	12.1 24	Entire fleet > 120	162
China[f,g]	Potential	53	Entire fleet[c]	185
India[h]	Potential	33.1	Entire fleet[c]	149
Japan[i,j]	Potential	43.8	Entire fleet[c]	135

[a] In France and Germany, when the CO_2 emission range of a direct CO_2 policy overlaps with that of a nondirect CO_2 policy, the overall incentive for that range equals the sum of both incentives. For example, the overall incentive offered by the French policy between 61 and 245 g/km equals US$29.2/$gCO_2$/km (5.4 + 23.8 = 29.2). Such overall incentive is considered as potential incentive given the nondirect policy part.

[b] This is the fleet-average CO_2 level of new cars (not including light trucks) in the United States.

[c] When analyzing China, India, and Japan's fiscal policy stringency, we limited to nonluxury vehicles with retail price ≤US$50,000. This is because the stringency of the policies depends partially on vehicle price. Inclusion of luxury vehicles may distort the true price signal offered to the majority of the fleet.

[d] R. L. Polk, & Co. (2006).

[e] Ward's Automotive Group (2007).

[f] International Council on Clean Transportation (2010a)

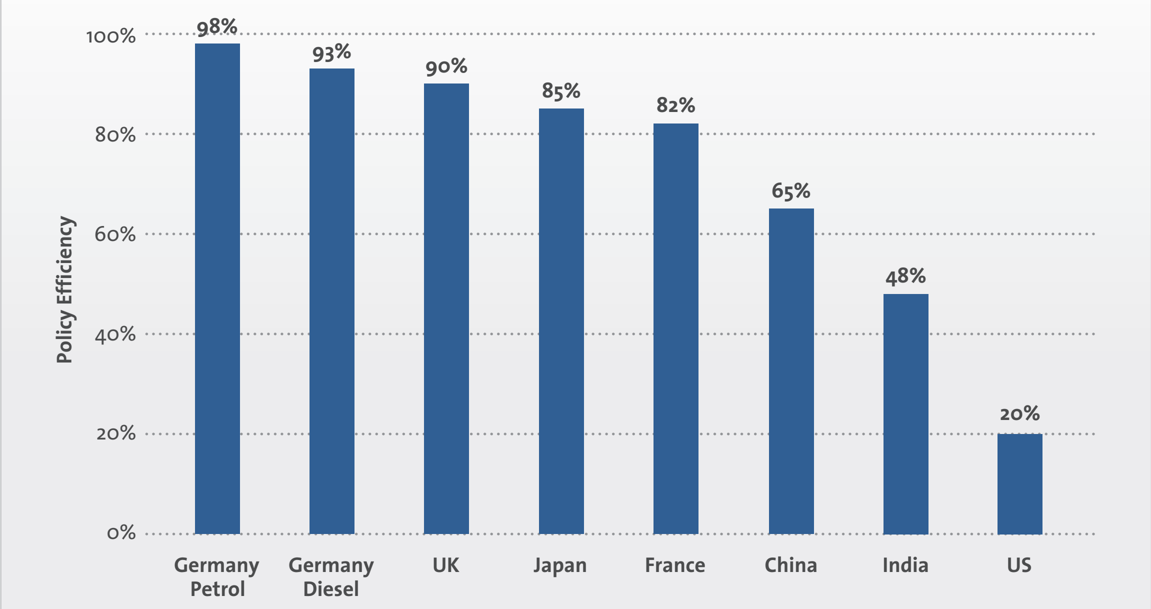
[g] China Automotive Technology Research Center (2009).

[h] India Central Board of Excise and Customs (2009).

[i] Japan Ministry of Land, Infrastructure, and Transport (2007).

[j] International Council on Clean Transportation (2010b).

Figure 15: COMPARISON OF POLICY EFFICIENCY OF NONFIXED FISCAL MEASURES



vehicles. A lower ratio suggests greater opportunity to improve the tax structure for a particular country.

Figure 15 compares the policy efficiency of nonfixed fiscal measures across countries. Not surprisingly, the European nations have higher scores, because they adopt more directly CO_2-based fiscal measures. Japan's policy ranks almost as efficient as the European countries, because the various components under Japan's tax scheme collectively function closely to a linear CO_2 tax. Policies in China and India are significantly less efficient, because both primarily link to vehicle engine size. The U.S. policy is the least efficient given that the incentive affects only a very limited number of models in the market.

Finally, it is important to distinguish between high vehicle tax and strong CO_2 incentive. The vehicle tax burden is less relevant to the extent of stringency of an incentive policy. Imposing a high base tax may reduce the demand for all vehicles and raise the necessary revenue for the government, but it may not particularly reduce the demand for high-emission vehicles. Merely imposing high taxes on all vehicles does not encourage manufacturers to develop and adopt fuel-efficiency and emission-reduction technologies. A stringent incentive assigns high monetary value to the reduction of CO_2 emission from vehicles. High-emission vehicles pay high tax while low-emission vehicles pay low tax (or even receive a rebate). The greater the difference in amount paid between the high and low-emission vehicles is, the stronger an incentive will be.

Comparison of the Design Structure of Passenger Car Fiscal Policies

Five design elements affect the effectiveness of a fiscal policy in reducing CO_2 emissions. The importance of each element is discussed, and fiscal policies from eight countries are evaluated along these five dimensions. The first four criteria address all fiscal policies, and the last one specifically focuses on targeted incentive programs. Depending on the extent to which each country's policies meet these criteria, we assigned a rating of "yes," "no," or "partially" (or unclear). The criteria considered were as follows:

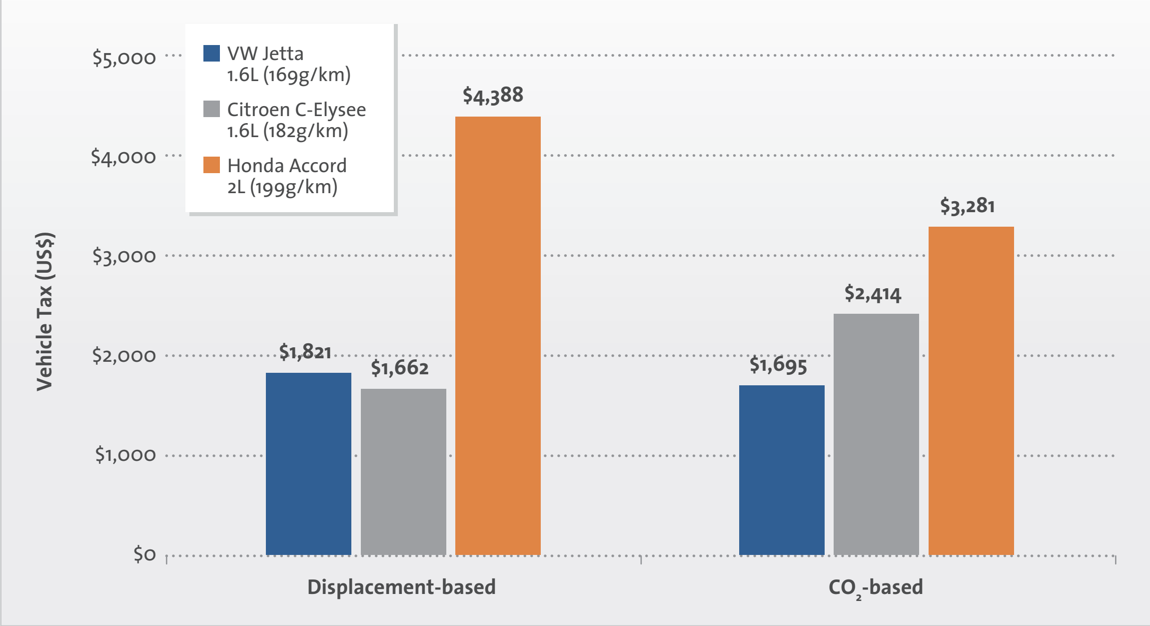
- Are all the fiscal charges driven by CO_2 reduction goal?
- Are incentives provided widely across the fleet?
- Are incentives continuous at every CO_2 level?
- Are incentives provided both upfront and throughout vehicle lifetime?
- Are targeted incentive programs linked to CO_2 performance?

Are all the Fiscal Charges Mainly Driven by CO_2 Reduction Goal?

Direct CO_2-based fiscal policies provide the clearest, most consistent, and most distinct price signal for CO_2 reduction from cars. Such a clear and distinct price signal cannot be achieved with an attribute-based fiscal

> "Merely imposing high taxes on all vehicles does not encourage manufacturers to develop and adopt fuel-efficiency and emission-reduction technologies.

Figure 16: ILLUSTRATION OF EFFECTS OF AN ATTRIBUTE TAX AND A CO_2-BASED TAX STRUCTURE



> “A direct CO_2-based system ensures an incentive to manufacturers to reduce vehicle CO_2 emissions.

policy. Other things being equal, consumers are likely to respond better to a market signal they can interpret in terms of vehicle CO_2 emissions than an engineering attribute. Similarly, vehicle manufacturers are likely to respond to an attribute-based system quite differently than a direct CO_2-based system. Manufacturers may adjust vehicle attribute in response to an incentive based on that attribute without changing vehicle performance and CO_2 emissions. A direct CO_2-based system, conversely, ensures an incentive to manufacturers to reduce vehicle CO_2 emissions. Finally, fixed fiscal charges do not provide any incentive for consumers to choose low-CO_2 emission vehicles over higher CO_2 emission models.

Figure 16 shows the difference between an attribute-based and a CO_2-based policy structure using the Chinese passenger car tax scheme as an example. Three bars of each cluster from left to right illustrate representative low-, medium-, and high-CO_2 emission models in the current market. The first cluster shows the amount of tax paid under China's current displacement-based vehicle tax; the second cluster shows the amount under an equivalent CO_2-based tax structure. Figure 16 shows that under the displacement tax, the low- and medium-CO_2 emission models attract very similar amounts of tax for having the same engine size, even though their CO_2 emissions differ by more than 8%. By contrast, under the hypothetical CO_2-based tax scheme, tax level is proportionate to CO_2 emissions. Note the change of tax structure from displacement to CO_2 basis did not lead to significant change in total revenue—the tax collected from the three models under the two structures differs by only 6%, although tax amount for individual model changed as much as 45% (Citroën Elysée).

An attribute-based tax in addition to a direct CO_2 incentive may be justified in certain cases, depending on the policy objective. For example, if the goal is to reduce CO_2 emissions and at the same time discourage heavier vehicles, then an additional weight-based fiscal policy may be necessary. A CO_2-based fiscal policy is technology neutral, and CO_2 emission reduction can be achieved with or without reduction in vehicle weight. We do not give any special consideration to such additional attribute-based fiscal policies in this report because CO_2 reduction is the primary policy goal under consideration.

As the first qualitative criteria, we simply measure whether all fiscal measures of a country are designed to reduce vehicle CO_2 emissions. Through our country review, no single country in our analysis currently earned a “yes” rating. Policymakers can make full use of the existing tax schemes to address a carbon reduction goal by shifting non-CO_2 based taxes and fees to direct CO_2 incentives. Table B–1 in Appendix B shows the potential level of incentive in each country if all non-CO_2 related charges were converted to a CO_2 basis.

Are Incentives Provided Widely Across the Fleet?

A fiscal measure can be considered comprehensive only if it applies to the entire fleet. Programs that affect only a portion of the fleet reduce the opportunity for carbon reduction from all vehicles and potentially allow manufacturers to modify their fleet mix to avoid the measure. For example, the U.S. gas-guzzler tax applies only to passenger cars while excluding the light trucks. To avoid the tax, a manufacturer might introduce "crossover" models constructed on a car platform but with attributes that allow them to be classified as light trucks (SUVs). For example, the Toyota Highlander is a crossover SUV with a fuel economy rating of 19 mpg constructed on the Camry passenger car platform (Edmunds, 2007). This car-based SUV avoids the $2,100 gas-guzzler tax that would otherwise apply to a passenger car of the same mpg rating.

Table 5 shows that Germany has implemented fiscal policies with a broader applicability range than other countries. Even though the U.K. CO_2 tax differentiates vehicles over only a relatively narrow emission range (101 g/km–255 g/km), the incentive affects the majority of current new vehicle sales. The French CO_2-based bonus-malus assigns different rates over only the 61 gCO_2/km to 245 gCO_2/km range, but its fiscal horsepower and gross CO_2 emitter taxes provide incentives to reduce emissions beyond that range, although at a much lower price signal than the bonus-malus. Because of this extended incentive, we rate France as a "yes," while we rate the United Kingdom as "partially." Brazil, China, India, and Japan set fiscal policies on the basis of engine size or vehicle weight, but the policies affect the entire fleet. These nations are thus rated as "yes." U.S. policy applies only to highly inefficient cars and thus is considered to be an incomplete incentive policy and is rated as "no."

Are Incentives Continuous at Every CO_2 Emission Level?

Bin-structured fiscal policies are often considered easier to implement from an operational perspective. Under a bin-based system, the fleet is divided into several segments, each covering a range of CO_2 emission levels and each associated with a certain tax rate. Such a system is not ideal, because within each bin the amount of tax remains the same, regardless of vehicle CO_2 performance. In other words, CO_2 emissions have no value within a bin and can be increased or decreased without any change in the associated tax. Manufacturers and consumers are likely to respond to such structure by introducing vehicles with emission levels just below a threshold, but no further, to qualify for a reduced tax rate.

Such an undesired boundary effect can be avoided by adopting a tax that is continuously proportional to vehicle CO_2 emissions—each gram of CO_2 emitted should be assigned the same nonzero value. This follows from the fact that each gram of GHG emission reduced should be valued equally, regardless of whether the reduction is from high-emitting vehicles or low-emitting vehicles. A tax that varies linearly with vehicle CO_2 emissions provides a continuous price signal within the applicable range of the policy and thus provides a continuous incentive to reduce CO_2. Such a program would ideally drive vehicle CO_2 emissions to their most cost-effective control level—the level at which the cost of further reducing CO_2 exceeds the associated tax benefit of that reduction.

Only Germany has adopted a continuous CO_2 tax. Japan's data show a close linear approximation when evaluated on a CO_2 basis, but because only one of its attribute-based policy components is of an actual linear design, we rate it as "partially." The other countries all use step-function policies with a varying number of steps, and thus all are rated "no."

> "To avoid the [U.S. gas-guzzler] tax, a manufacturer might introduce "crossover" models constructed on a car platform but with attributes that allow them to be classified as light trucks (SUVs).

Are Incentives Provided Both Upfront and Throughout Vehicle Lifetime?

Some fiscal charges are assessed one time, usually at the time of purchase or first registration, whereas others are assessed annually. A strong one-time fiscal policy can influence consumer choice in favor of low-emission vehicles at the time of purchase. One-time fiscal charges are ideal for specific policy instruments like feebate. Consumers tend to ignore the fuel-efficiency or carbon reduction technologies adopted on the vehicles, but they do care about their additional cost internalized in the new vehicle price. The loss-averse nature of consumers and the uncertainty of future fuel savings make consumers even less willing to pay for the additional cost. A rebate that rewards carbon reduction converts the future revenue stream from fuel conservation into an upfront payment, influencing consumer willingness to accept immediate costs of fuel efficiency improvement (German & Meszler, 2010).

Charging a fee on a regular basis affects consumers' vehicle replacement decisions and thus can help to influence fleet turnover if the new lower CO_2 emission vehicles are subject to a much lower tax than existing vehicles. During a period of rapid technology changes, annual charges prod consumers to make a "cost-effectiveness" determination more frequently than simply a one-time assessment at the time of purchase. This benefit will be more obvious if a policy also targets vehicles leased on an annual basis. Annual charges can also encourage early replacement of older and high-polluting vehicles. Because older vehicles tend to emit more conventional air pollutants (such as carbon monoxide, nitrogen oxides, and particulates) than new vehicles, a multiyear incentive policy may provide greater benefits from an air pollution control perspective. Annual charges do not replace, but rather complement, one-time incentives. The two policy instruments affect consumer behavior differently, and they collectively contribute to a well-designed fiscal policy package. However, if both upfront tax and annual tax occur in a country's taxation system, the country should also take the opportunity to encourage lower CO_2 emission vehicles through annual tax.

All developing nations currently focus primarily on purchase-based fiscal measures ("no"). Among developed nations, the United States does not offer a carbon reduction incentive on an annual basis ("no"). Conversely, Japan and the three European nations in our study have both upfront and annual incentive programs ("yes").

"Charging a fee on a regular basis affects consumers' vehicle replacement decisions and thus can help to influence fleet turnover if the new lower CO_2 emission vehicles are subject to a much lower tax than existing vehicles.

Are Targeted Incentive Programs Linked to CO_2 Performance?

The U.S. hybrid and alternative fuel vehicle tax credit programs are examples of targeted incentive programs. The amount of tax credit granted under the U.S. programs depends only on fuel economy performance relative to other vehicles within the same class. This practice leads to an unclear incentive with regard to absolute fuel economy improvements across all car types. In the United Kingdom and France, alternative fuel vehicles (including hybrid vehicles) are first gauged by vehicle CO_2 performance to qualify for reduced tax rates. Germany's targeted incentive considers only electric vehicles with zero tailpipe CO_2 emissions. Ideally, vehicle CO_2 emissions should reflect full fuel-cycle emissions, but this report considers only tailpipe CO_2 emissions. From this perspective, the German incentive for electric vehicles is CO_2 driven. Thus, the three European nations are all rated as "yes." Japan defines a benchmark fuel consumption improvement level for next-generation vehicles to qualify for various tax reductions. However, once a vehicle qualifies, the amount of tax reduced is not further dependent on the extent of fuel consumption improvement beyond the qualifying threshold. Therefore, Japan's targeted incentive program is rated only as "partially." Policies that

Table 6: REPRESENTATIVE VEHICLE MODELS AND THEIR CO_2 EMISSIONS (IN gCO_2/km) BY COUNTRY

Country	25th Percentile	50th Percentile	75th Percentile
United Kingdom[a]	158: Vauxhall Astra 1.6L	181: BMW 1 Series 1.6L	214: Lexus IS 250 2.5
United States[b]	230: Toyota Camry XLE	262: Nissan Altima SL 3.5L	296: Audi A4 3.2L
France[a]	159: Renault Grand Scenic 1.9	187: Hyundai Tucson 2L	226: Peugeot 407 2.7L
Germany (petrol)[a]	173: Volkswagen Golf 1.6L	204: Volkswagen Eos 2L 1.6L	230: Audi A6 2.4L
Germany (diesel)[a]	135: Volkswagen Golf 1.9L	159: Volkswagen Passat 2L 1.9L	184: BMW 3 Series 2L
China[c,d]	169: Volkswagen Jetta 1.6L	182: Citorën C-Elysée 1.6L	199: Honda Accord 2L
India[e]	138: Maruti WagonR 1.1L	183: Mahindra Bolero 2.5L	196: Chevrolet Tavera 2.5L
Japan[f,g]	128: Toyota Corolla 1.5L	171: Toyota RAV4 2.4L	230: Toyota Harrier 3.5L
Approximate CO_2 Ranges (without US)	130–175	160–205	185–230

[a] R. L. Polk, & Co. (2006).
[b] Ward's Automotive Group (2007).
[c] International Council on Clean Transportation (2010a)
[d] China Automotive Technology Research Center (2009).
[e] India Bureau of Energy Efficiency (2009).
[f] Japan Ministry of Land, Infrastructure, and Transport (2007).
[g] International Council on Clean Transportation (2010b)

consider both alternative fuels alongside carbon emission performance hold the most promise for dual energy and climate benefits. China's pilot subsidy program does not directly link to CO_2 performance.

To observe how various policy design elements might affect real-world purchase decisions, we compared the CO_2-related tax burdens of representative vehicle models with low-, medium-, and high-CO_2 emissions from each country. The selected representative low-, medium-, and high-CO_2 emission vehicle models are either best sellers (for United Kingdom, France, Germany, China, and India) or popular models to our best judgment (for the United States and Japan) if sales data are not available corresponding to the 25th, 50th, and 75th percentile CO_2 emissions value for each market. Sometimes, there are no exact matching data for the 25th, 50th, and 75th percentile CO_2 emission level. In searching for the best seller models, we relaxed the range to the exact emission level ±5 g/km. The models are listed in Table 6.

Note that because vehicle market specifications differ from country to country, low-, medium-, and high-CO_2 emission vehicle models are not uniform between countries. For example, Japan's representative model with 25th percentile CO_2 emissions ranking (Corolla) emits less CO_2 than the selected model of the same rank in the United States (Camry). These sample vehicle models and their CO_2 emission data are listed in Table 6. Except for the United States, where each "milestone" CO_2 emission level is significantly higher than the rest of the world, emissions in all nations follow a similar distribution with some variations. Emission ranges of typical low-, medium-, and high-CO_2 emission vehicles are 130 to 175, 160 to 205, and 185 to 230 gCO_2/km, respectively.

The results of tax comparison shown in Figure 17 reinforced some of our previous findings about design structure of a fiscal policy. First, the U.S. policy fails to influence the typical low- and medium-CO_2 emission cars in its market, as indicated by the two missing bars. Second, the indirect CO_2 incentives in China and India essentially do not function effectively to reduce vehicle CO_2 emissions in that they do not provide a consistent price signal among low-, mid-, and high-emission vehicles. This phenomenon is primarily caused by the displacement-based policy structure applied in both countries. Charging the tax as a percentage of vehicle price also contributes to this distortion. In China, the tax scheme provides reversed incentive for the low- and medium-CO_2 emission representative models because the 1.6 L Volkswagen Jetta is less expensive than Citroën Elysée of the same engine size. In India, medium- and high-CO_2 emission sample models attract similar tax amounts for the same engine size. Note that the specific findings mentioned earlier depend on the models chosen, but they do illustrate the drawbacks and uncertainties of certain policy designs. It is possible that policymakers view higher taxes on high-priced vehicles as fair, even if that policy is inconsistent with the goal of reducing CO_2 emissions.

> "To observe how various policy design elements might affect real-world purchase decisions, we compared the CO_2-related tax burdens of representative vehicle models with low-, medium-, and high-CO_2 emissions from each country.

Figure 17: COMPARING TAX BURDENS OF LOW, MEDIUM, AND HIGH CO_2 EMISSION PASSENGER CARS

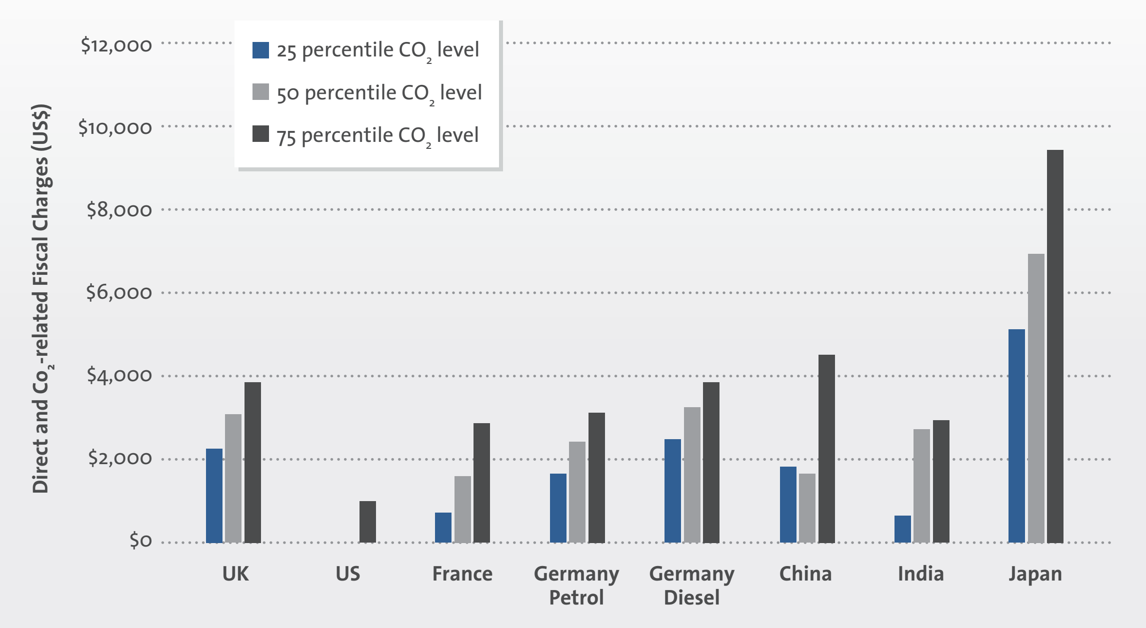


Table 7: QUALITATIVE COMPARISON OF DESIGN ELEMENTS OF FISCAL POLICIES, BY COUNTRY

Criteria	United Kingdom	United States	France	Germany	Brazil	China	India	Japan
All policy measures directly link to CO_2 emissions	no	no	no	no	no	no	no	no
Price signal applied fleetwide	partially	no	yes	yes	yes	yes	yes	yes
Continuous incentive at every CO_2 level	no	no	no	yes	no	no	no	partially
Incentive provided at purchase and throughout lifetime	yes	no	yes	yes	no	no	no	yes
Targeted incentives linked to CO_2 emissions	yes	partially	yes	yes	N/A	no	partially	partially

"Although important, quantitative stringency is only one piece of the puzzle when evaluating a policy. Policymakers need to consider the policy design criteria in detail.

Table 7 summarizes our qualitative analysis results. Countries receiving the most number of "yes" ratings would be expected to have a generally better policy design to reduce vehicle CO_2 emissions. No single country in our study group performs well along all five criteria, and all countries have plenty room to improve their policy structure. The current German policy design is closest to a desirable policy structure that will encourage a low-CO_2 emission light-duty vehicle fleet.

Summary of Comparative Analyses

To summarize, we quantitatively compared the stringency of CO_2 reduction incentives offered by light-duty vehicle fiscal policies in seven nations and qualitatively compared the design elements of the policies in eight nations. In terms of stringency, the fiscal policies in China and Japan rank among the highest for their policy potential. However, their actual effectiveness is reduced because of the indirect nature of their fiscal measures. By contrast, the United Kingdom adopted a direct CO_2 incentive that provides an actual and strong price signal for vehicle CO_2 emission reduction.

Although important, quantitative stringency is only one piece of the puzzle when evaluating a policy. Policymakers need to consider the policy design criteria in detail, including directly targeting CO_2 emissions across the entire fleet, using a continuous fee structure and an annual incentive to truly assess the effectiveness of the fiscal policies. In terms of policy structure, our comparative analysis shows that currently, Germany's fiscal policy presents the closest to an ideal CO_2 reduction incentive policy.

Methodology for Comparing Stringency of Fiscal Measures Across Nations

As discussed earlier, the **stringency** of a fiscal policy refers to the strength of the price signal it offers to reduce CO_2 emissions from vehicles. It is expressed by an equivalent marginal CO_2 rate—U.S. dollars per grams of CO_2 emitted per kilometer of driving (gCO_2/km) or US$/$gCO_2$/km.[5] The term reveals the lifetime monetary impact of a fiscal policy owing to a marginal increase in gCO_2/km from passenger vehicles. To examine the lifetime impact of a policy, we assumed that annual charges throughout a standard 12-year vehicle life span are discounted into present value with a 5% annual discount rate. *Annual discount rate* reflects the rate of future capital return of current money. The 5% discount rate assumption is a simple average of the central bank discount rated announced in our reviewed nations (U.S. Central Intelligence Agency, 2010).

We converted the fiscal policies based on non-CO_2 attributes, such as weight or engine size, into equivalent stringency based on our defined CO_2 metric. For nations with multiple policy components, we aggregated the impact of individual fiscal charges to derive an overall price signal of the policy package. Vehicle lifespan varies in different nations. A longer assumed vehicle lifetime may increase the lifetime impact of an annual fiscal policy, but the increase does not occur in a linear fashion because of the discount of value of future assets. The assumption on vehicle lifetime has no effect on evaluation of any upfront fiscal charges. Depending on how far their policy formats differ from our chosen metric, we divided the nations into three groups, each associated with a strategy to convert the country's policy into an equivalent marginal CO_2 rate. The following subsections discuss each of the country groups and analytical strategies used to calculate the equivalent marginal CO_2 rate.

Group 1: Policies Based Solely on CO_2 Emissions or Fuel Economy

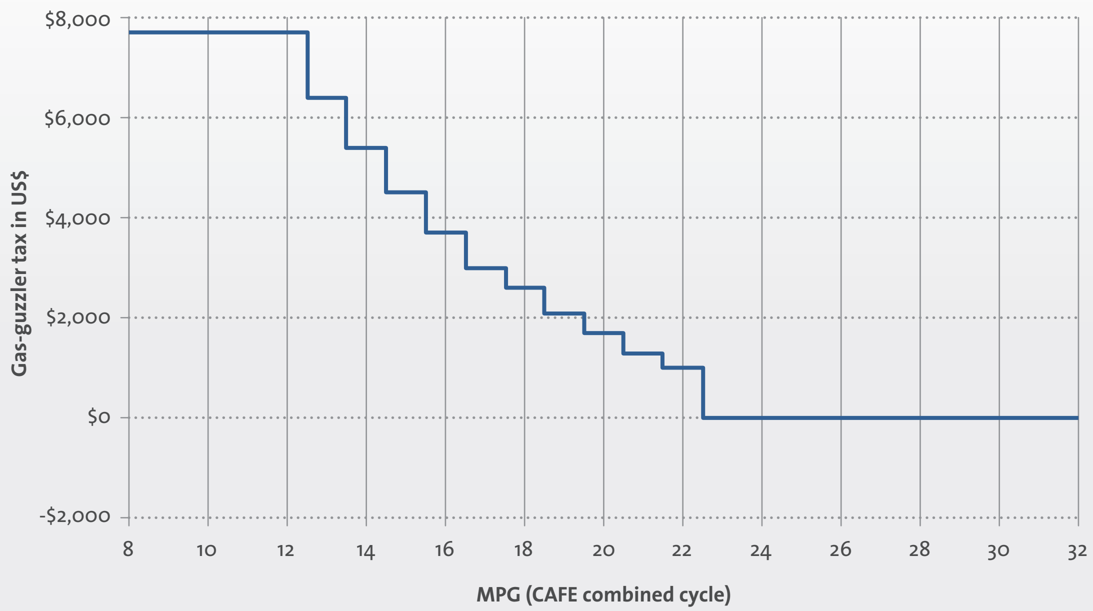
Group 1 nations, the United Kingdom and the United States, base their fiscal policies solely on vehicle CO_2 emissions or fuel economy. The United Kingdom bases its first year registration tax and annual vehicle ownership tax on vehicle CO_2 emissions. The gas-guzzler tax in the United States is based on fuel economy, expressed in mpg, which can be easily converted to a gCO_2/km basis given that nearly the entire light-duty passenger vehicle fleet is using a single fuel—gasoline. Both policies are closest in their format to our desired metric, although they both use a step function (bin format) rather than a linear function (continuous format).

A step CO_2 tax divides the vehicle fleet into classes, or bins, according to vehicle CO_2 emission level. Each class is associated with a different fixed tax level. It is difficult to compare the stringency of step-function fiscal charges directly because the bin settings vary across countries. Therefore, we compare the slopes of the linear proxies derived by regressing the midpoints of each step, excluding any unbounded steps. For example, normally the last bin extends to infinity, so it is impossible to define its midpoint. Similarly, first bins normally extend to zero, which is generally equally unattainable with current technology. Attempting to define midpoints for these steps involves arbitrary assignment and skews the regression line. A similar approach also applies to attribute-based fiscal policies with binned structures, discussed later in this report.

"Depending on how far their policy formats differ from our chosen metric, we divided the nations into three groups, each associated with a strategy to convert the country's policy into an equivalent marginal CO_2 rate.

[5] The exchange rates used in this report are obtained from Yahoo Finance as of March 2009 and are as follows: 1 JPY=0.01 USD; 1 Euro = 1.302 USD; 1 GBP = 1.484 USD; 1 INR = 0.019 USD; 1 CNY = 0.146 USD; 1 BRL = 0.465 USD; 1 CAD = 0.85 USD (Yahoo, 2009). Since exchange rates are volatile, all currency conversions are approximate.

Figure 18: THE U.S. GAS-GUZZLER TAX



“Group 2 nations, France and Germany, represent countries that have adopted fiscal policies pegged to vehicle attributes that correlate with CO_2 emissions.

Figures 3 and 18 illustrate our approach using the U.S. gas-guzzler tax as an example. Figure 18 shows the original format of the tax, which varies according to vehicle mpg. The step function in Figure 3 shows this tax converted to gCO_2/km basis.[6] The dashed line is the linear proxy of the step function for the U.S. Gas Guzzler tax, which is obtained by regressing the midpoints of each step, except for the first and last steps (An et al., 2007). The value of the slope, in practice, indicates the equivalent marginal CO_2 rate under the U.S. policy: approximately US$24.2 per gCO_2/km.

Group 2: Policies Based Partially on CO_2-Correlated Attributes

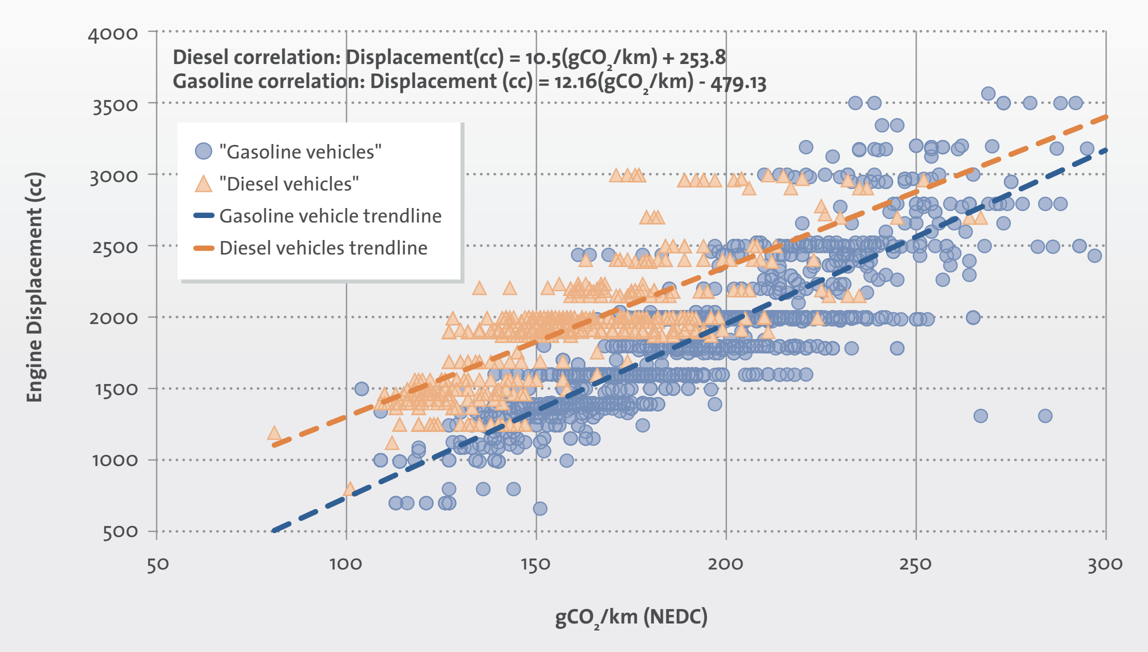
Group 2 nations, France and Germany, represent countries that have adopted fiscal policies pegged to vehicle attributes that correlate with CO_2 emissions. The French fiscal policy consists of three components: a registration tax based on fiscal horsepower, a CO_2-based feebate program also applicable at the time of registration, and an annual tax applicable only to vehicles emitting >245 gCO_2/km. A feebate is a program that imposes a fee on vehicles that perform worse than a specified benchmark and awards a rebate to vehicles that perform better than the specified benchmark (German & Meszler, 2010).

Germany’s fiscal policy consists of a two-part annual tax based on vehicle CO_2 emissions and engine displacement. Although these multicomponent policies appear complicated, their analysis requires us to translate only the attribute-based components into a CO_2 basis. The individual components can then be added to the direct CO_2-based measures to determine the policy impact in terms of CO_2 emissions.

Of course, policies that are based on attributes other than CO_2 can be converted to an equivalent CO_2 basis only if there is an underlying relationship between the

[6] The unit conversion is done using a fuel CO_2 content factor. The value of this factor varies depending on fuel type. In the United States, all vehicles affected by the gas-guzzler tax are gasoline powered, so we converted miles per gallon to gCO_2/km using a factor of 2,339 gCO_2/L. Because gasoline consists of a mixture of chemical compounds that can vary over in their respective proportions over limited ranges, there are other estimates for this factor, but all are similar in magnitude. In addition to the unit conversion, we converted the equivalent gCO_2/km under the U.S. Corporate Average Fuel Economy (CAFE) driving test cycle to the same metric under the New European Driving Cycle (NEDC). The United States, European Union, and Japan use different driving test cycles to measure the fuel economy or CO_2 emissions of light-duty vehicles. The 2007 ICCT report, Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update (An et al., 2007), developed a methodology to correct for such cycle differences.

Figure 19: CORRELATION BETWEEN ENGINE DISPLACEMENT AND CO_2 EMISSION BY FUEL TYPE IN GERMANY



attribute and CO_2. Intuitively, attributes such as engine displacement and horsepower can be expected to have an inherent relationship with CO_2 emissions, because bigger engines burn more fuel, creating higher power output, and, therefore, emitting higher CO_2 emissions. For example, as shown in Figure 19, the correlation between engine displacement and CO_2 emissions is statistically significant for both the diesel and gasoline vehicle fleet in Germany.

For the French and German policies, we used statistical correlation to convert the attribute-based policy component into a CO_2 basis and then summed up with other CO_2-based policy components to get the combined policy impact. This approach is limited in converting more complex policies, such as for the remaining countries in our analysis.

The *t* statistics for the gasoline and diesel correlations are 65 and 35, respectively, where any value >2 indicates a significant statistical relationship between the variables (at a 95% confidence level). A regression between CO_2 and a specific vehicle attribute would more correctly be structured with the vehicle attribute as the independent parameter and CO_2 as the dependent parameter. For Figure 19 in this report, we inverted this relationship for convenience because we are trying to define the typical CO_2 emission rates for a specified vehicle attribute. Although this inversion does not affect the statistical relationship between the parameters and allows us to more directly estimate the equivalent CO_2 tax structure, we in no way imply that the causal relationship between the regression parameters has been affected.

We used the correlation formulas as a bridge to calculate CO_2-based tax structures that are equivalent to the original attribute-based tax structures. For example, the German annual engine size tax for a gasoline-powered vehicle is US$0.026/cc. The vehicle lifecycle equivalent tax in present value terms equals US$0.24/cc. For any given level of CO_2 emissions, we can estimate the displacement portion of the tax structure using the following correlation:

cc = 12.2 per gCO_2/km–479.1

for which the applicable displacement tax would be as follows:

US$0.24 x (12.2 per gCO_2/km–479.1) =
US$2.9 per gCO_2/km–116

This tax is then added to the direct CO_2 tax to determine the German CO_2 equivalent tax structure.

Figure 7 depicts the combined equivalent lifetime CO_2 charges for the German policy. The two curves show the separate rates in Germany for petrol and diesel engines. Petrol vehicles between 40 and 120 gCO_2/km are exempt from the direct CO_2 tax. For vehicles with emissions of ≥120 gCO_2/km, the direct CO_2 tax also

"The correlation between engine displacement and CO_2 emissions is statistically significant for both the diesel and gasoline vehicle fleet in Germany.

applies, and the resulting curves show the combined impact of both taxes. Accordingly, two equivalent CO_2 tax rates are associated with light-duty vehicles. For diesel vehicles, a lower rate of US$12.1 per gCO_2/km applies to vehicles emitting up to 120 gCO_2/km, whereas a higher rate of US$36.3 per gCO_2/km takes effect starting from 120 gCO_2/km. The corresponding rates for gasoline vehicles are US$2.9 and US$27.2 per gCO_2/km. We adopted a similar approach to convert the French fiscal horsepower tax to a CO_2 basis.

Theoretically, in the case of Germany, the calculated equivalent CO_2 tax could apply down to zero emissions or even become a rebate if CO_2 emissions were low enough. The tax would then take the form of a linear CO_2-based feebate program, with the extrapolated neutral point at approximately 40 gCO_2/km, providing strong incentive for lowering CO_2 emission from gasoline passenger vehicles. However, in reality, this tax is based on engine displacement. Even with a small engine size, the tax will not go below zero. Within this context, we plotted the converted tax considering this limitation. As shown in Figure 7, the extrapolated lower curve denoted by "petrol" hits the zero tax level at approximately 40 gCO_2/km.

> "Under an attribute-based tax such as those used in Germany or France, vehicles with varying CO_2 emissions are levied with the same amount of tax. Therefore, the policy may simply result in vehicles with smaller engines, not necessarily vehicles with lower emissions.

As indicated in Germany's case, the equivalent marginal CO_2 rate of a fiscal policy may not apply throughout the entire fleet CO_2 emissions range. Instead, a fiscal policy may be associated with multiple equivalent marginal CO_2 rates for different CO_2 emission sections. The applicable range of equivalent marginal CO_2 rates needs to be considered when comparing the stringency of fiscal policies. A policy is not stringent unless the incentive applies at least to the majority of the fleet CO_2 emission range. If a policy is stringent only for a small fraction of fleet, it is not a stringent policy.

The correlation between CO_2 emissions and any vehicle attribute over time varies from market to market. As the technologies advance in the future, the relationship derived using 2010 fleet data may not hold. At the same time, the relationship of a vehicle attribute with CO_2 emissions may vary across markets because of inherent technology differences. All regression analysis for this report is performed using only local data and serves as a tool for our conversion purpose. It does not imply that attribute-based policies are either fundamentally equivalent to or as effective as direct CO_2-based policies in providing a definite price signal to manufacturers or consumers.

As indicated in Figure 19, a given engine size may correspond to an array of CO_2 emission levels. Under an attribute-based tax such as those used in Germany or France, vehicles with varying CO_2 emissions are levied with the same amount of tax. Therefore, the policy may simply result in vehicles with smaller engines, not necessarily vehicles with lower emissions. For example, under an engine displacement incentive system, manufacturers are rewarded for adding turbochargers and downsizing the engine, even though the engine may be just as powerful and use just as much fuel and generate the same CO_2 emissions as the larger, naturally aspirated engine it displaced. In this light, the equivalent marginal CO_2 rates for all non-direct CO_2 fiscal measures indicate only their potential price signals for CO_2 reduction in contrast to actual price signals offered from direct CO_2 incentives.

In short, for French and German policies, we used statistical correlation to convert their attribute-based policy component into CO_2 basis and then summed them up with other CO_2 based policy components to get the combined policy impact. This approach is limited in converting more complex policies, discussed for the remaining countries in our analysis.

Group 3: Policies Based on CO_2-Correlated Attributes and Percentage of Vehicle Price

The last group of nations, China, India, and Japan, not only base their fiscal policies solely on vehicle attributes but also have one or more of their policy components assessed as a percentage rate of vehicle price rather than as an absolute amount. Specifically, India imposes two variable taxes according to vehicle attributes: a percentage-based excise tax differentiated by vehicle class, engine size, and fuel type and a special tax based on engine displacement. The Chinese policy includes an excise tax and an acquisition tax; both are set as a percentage of vehicle price and vary with engine displacement. Japan adopts more policy components than any country in our study: a percentage-based acquisition tax that varies by engine displacement, an annual automotive tax indexed by engine displacement, a tonnage tax based on vehicle weight, and tax incentives for all of these tax items for special vehicles.

These special features of the Group 3 countries pose some challenge in adopting the conversion strategy used for Group 2 countries—some components are proportionate on vehicle price in addition to their attribute-basis. Note that our universal metric for comparison is in absolute dollar terms. This means that in addition to the correlation between the attribute and CO_2 emissions, we also need to capture the correlation between vehicle price and CO_2 emissions and then use both relationships to estimate the equivalent policy impact on a CO_2 basis. As might be expected, data from all nations in our analysis showed that vehicle price is correlated with CO_2 emissions. This is because larger and luxury vehicles tend to emit more CO_2 and are, in general, more expensive. Not surprisingly, the variation of price data can be very wide for any given CO_2 emission level. By incorporating another layer of correlation, we introduce more uncertainty in our estimate of the effective CO_2 tax structure. In general, the more intermediate steps that are included in the equivalency analysis, the less certain the results will be, and, most important, the less transparent the CO_2 price signal of the policy will be.

This general principle also applies when a policy consists of multiple components, all of which are based on vehicle attributes rather than directly on CO_2 emissions. If we convert all components using their attribute correlations to CO_2 emissions, we introduce multiple intermediate steps associated with greater uncertainty. To minimize the compounding of uncertainty whenever possible, we regressed the actual amount of tax assessed on all models in our database over their CO_2 emission performance instead of aggregating individual correlations between attributes and CO_2 emissions.

We did not have complete passenger vehicle data for Japan; therefore, we collected a sample data set. The Japanese dataset contains observations for 62 models from 18 manufacturers, with engine displacements ranging from 0.66 to 5.5 L. For China and India, we used ICCT-compiled internal databases with 2008 and 2009 fuel consumption and model specification data and 2009 manufacturer suggested retail price data.

Figure 20 plots the lifetime CO_2-related tax burden of all passenger vehicle models in India based on CO_2 emissions performance. The regression curve indicates the statistical relation between the tax amount and CO_2 emission. We obtained this relationship not through a correlation between engine displacement and then a correlation between vehicle price and CO_2 but between actual taxes assessed and CO_2 emissions of specific Indian vehicle models.

One complexity associated with this approach arises with luxury vehicle models. Although, as indicated previously, vehicles with higher CO_2 emission levels are typically larger and higher-performance models, and therefore more costly, this relationship is exaggerated in luxury models. Luxury vehicles are more expensive not only for their greater utility but also for their brand names. Their price correlation with CO_2 emissions does not follow the general trend, and, therefore, the inclusion of luxury models distorts the price signal offered by the fiscal policy for the majority of fleet. For example, if we ignore the luxury models in the India fleet (defined as vehicles with a suggested retail price of at least US$50,000), the rest of data (indicated by the

"To minimize the compounding of uncertainty whenever possible, we regressed the actual amount of tax assessed on all models in our database over their CO_2 emission performance.

Figure 20: REGRESSION OF CO_2-RELATED TAX DOLLARS OVER CO_2 EMISSIONS OF ENTIRE INDIAN FLEET

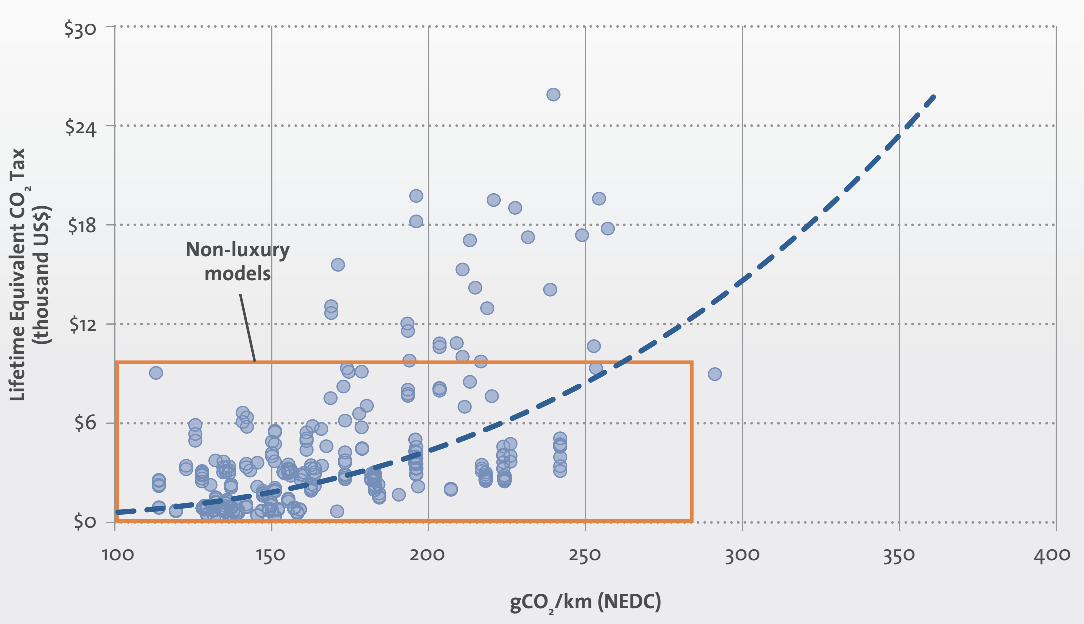
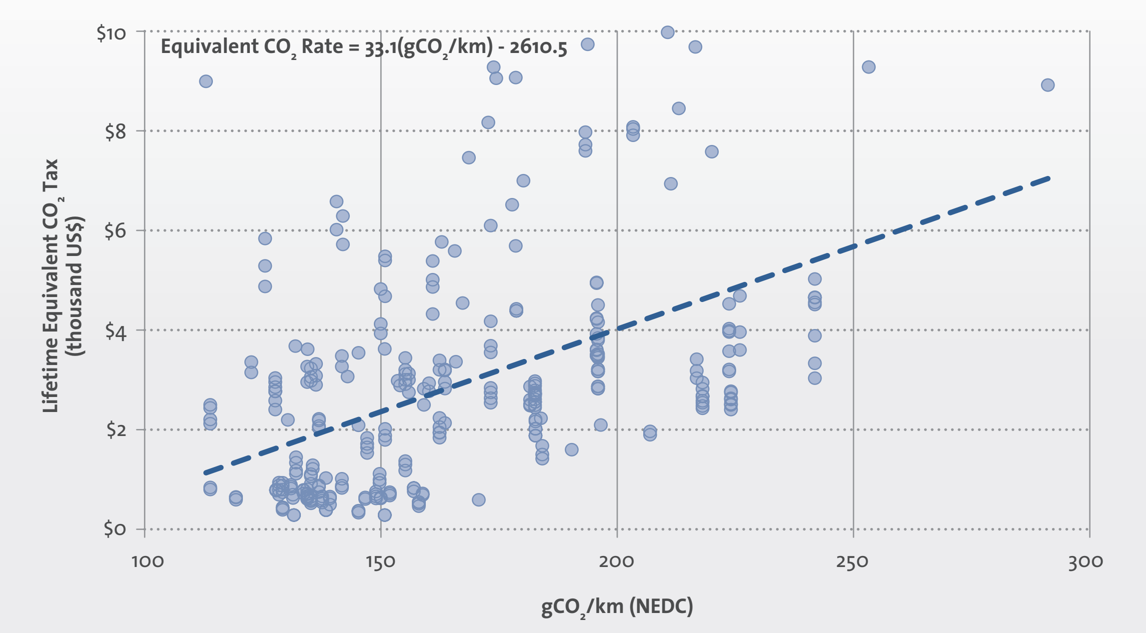


Figure 21: LIFETIME EQUIVALENT CO_2 TAX OF NONLUXURY VEHICLES IN INDIA



“Luxury vehicles are more expensive not only for their greater utility but also for their brand names. Their price correlation with CO_2 emissions does not follow the general trend.

dots inside the box in Figure 20) yields a trend line that is much flatter than the exponential curve associated with the luxury fleet. The nonluxury vehicle trend line is shown separately in Figure 21. We use this trend to better intimate the relationship between CO_2 and vehicle pricing for the analysis in this report.

Summary of the Methodology

To summarize, we developed a universal metric of equivalent marginal CO_2 rate to compare the actual or potential price signal of each country's fiscal policy. For countries whose policies are closely aligned with vehicle CO_2 emissions, our equivalency analysis was limited to determining equivalent continuous CO_2 tax structures from regression analysis of actual policies. The slope of these regression lines is considered a marginal equivalent CO_2 charge for such policies. For countries whose policies contain a component based on a vehicle attribute, we use the statistical correlation between that attribute and CO_2 emissions as a means to convert the policy component into a CO_2 basis and then summed up the different policy components. Finally, for countries that adopt more complicated policies from an analytical perspective, we regressed the absolute amount of fiscal charges paid over vehicle CO_2 emission levels and took the slope of the trend lines as their marginal equivalent CO_2 charge.

Findings and Policy Recommendations

Our study revealed the following findings:

- Countries have not, in general, optimized the use of their existing taxation policies and other incentives for the purpose of carbon reduction.
- By linking incentives to vehicle CO_2 emissions instead of a vehicle attributes, the existing incentives could be made more robust.
- Converting fixed vehicle fiscal charges into CO_2-based incentives would further enhance the price signal for CO_2 reduction.

We recommend that all countries apply direct incentives and provide the strongest price signal politically feasible for carbon reduction from passenger cars. Ideally, the magnitude of such a price signal for each marginal unit of CO_2 emissions should be higher than the marginal cost of cutting the same level of CO_2 emissions. For certain countries, refining their existing policy design structure alone without adjusting their monetary magnitude will enhance the role of these policies in encouraging carbon reduction from vehicles.

We provide the following guiding principles as best practice policy design:

- Base fiscal policies directly on vehicle CO_2 emissions by–
  - Shifting physical attribute-based fiscal measures to a CO_2 basis,
  - Changing existing fixed charges into CO_2-based fiscal measures, and
  - Linking fiscal measures that target vehicle technology or fuel to CO_2 emissions.
- Apply fiscal policies broadly throughout the fleet.
- Use a continuous structure rather than a step function structure as the basis for fiscal policies. If a bin-based (step function) structure must be used, avoid broad bins with steep between-bin changes.

Country-Specific Findings

It is clear that all countries in our analysis have room for improvement. Although tax policies are typically developed over many years and are often challenging to change, we provide our country-specific findings and recommendations on the basis of these general guidelines.

- The United Kingdom imposes a bin-based annual CO_2 tax on private cars. Currently, the tax does not provide any additional incentive to manufacture or purchase vehicles emitting <101 g/km or penalize the manufacture or purchase of vehicles emitting >255 g/km. The United Kingdom could further tighten its policy by adopting a continuous CO_2 tax or feebate over the entire fleet CO_2 emissions spectrum.
- The U.S. gas-guzzler tax, although based directly on fuel economy, is incurred by only a small fraction of new cars. Tax credits for hybrid and alternative fuel vehicles also exist, but they are determined by both fuel economy and weight class and thus send a mixed price signal to consumers. To improve, the United States could refocus the gas-guzzler tax on CO_2 emissions, expand its coverage to all vehicle types and all emissions levels, and realign hybrid and alternative fuel tax incentives to absolute CO_2 emissions, regardless of weight class.
- The feebate (bonus-malus) component of France's fiscal policies has not only stimulated its domestic auto market but also directed consumers to buy lower CO_2 emitting vehicles. However, the program structure is bin based. Like the United Kingdom, a continuous tax structure applying to the full CO_2 emission range of the subject fleet would enhance the power of the bonus-malus.
- Germany has recently shifted its fiscal policies to a partial CO_2 basis, becoming the only nation in our review with a continuous linear CO_2 tax applied

> "Ideally, the magnitude of [price signals for carbon reduction from passenger cars] for each marginal unit of CO_2 emissions should be higher than the marginal cost of cutting the same level of CO_2 emissions.

on car emissions >120 g/km. However, this CO_2 tax is combined with an engine displacement tax. Germany could enhance its program by converting the displacement tax to a CO_2 basis.

- Brazil, China, and India are similar in their fiscal policy design. Fiscal charges in the three nations are proportional to both vehicle price and engine size and thus are not precisely related to vehicle CO_2 emissions performance. Shifting from attribute-based policies to a CO_2 basis and shifting from purchase price percentage-based polices to absolute dollar taxes would make these policies more efficient as low-CO_2 emission incentives.
- Japan has imposed several fiscal charges on passenger cars based on a variety of vehicle physical attributes, which collectively function reasonably well as an equivalent CO_2 tax, except in the case of new vehicle technologies, such as hybrids. The combined fiscal policies offer a stringent disincentive for high fuel consumption cars. Japan could replace these taxes with a single CO_2-based tax with a continuous format to ensure consistent incentive for low-CO_2 emission vehicles as engine and vehicle energy supply technologies continue to evolve.
- Company cars represent half of the entire car fleet in Europe and are artificially subsidized. More CO_2 reduction can be realized from company car fleets if their distorted incentive is removed. Company car taxes should also be linked to vehicle CO_2 performance. The similar set of design principles for private cars also apply to company cars to maximize the carbon reduction benefit from the fleet (Appendix A).

“Tax policies are typically developed over many years and are often challenging to change.

Appendix A: Company Car Taxes in Selected Countries

United Kingdom

The private use of a company car (or van) by employees and directors of companies is taxed in the United Kingdom as a benefit in kind. The tax is levied only on those employees earning more than £8,500 per year. Since April 2002, an individual's company car tax liability has been based on the vehicle's CO_2 emissions (ACEA, 2009). A driver is taxed at a percentage of the vehicle's list price in accordance with CO_2 emissions, with current taxes ranging from 10% to 35%, depending on fueling type and CO_2, as shown in Table A–1.

Gasoline-fueled cars emitting ≤120 g/km are subject to a 10% tax rate. For gasoline-fueled cars between 120 and 135 g/km, the rate is 15%, with a 1% rate increase for each additional 5 g/km over 135 g/km up to a maximum charge of 35% of the car's price. Drivers of diesels pay a 3% surcharge but are similarly capped at a 35% maximum rate. Alternative fuel vehicles such as LPG, CNG, or battery-propelled cars, are currently assessed with discounted tax rates.

"The private use of a company car (or van) by employees and directors of companies is taxed in the United Kingdom as a benefit in kind. The tax is levied only on those employees earning more than £8,500 per year.

Table A-1: COMPANY CAR TAX SCHEDULE IN THE UNITED KINGDOM (EFFECTIVE 2009–2010)

CO_2 Band	Tax Rates				
	Petrol	Diesel	FFV and E85	Hybrid	Battery EV
≤120	10%	13%	8%	7%	4%
>121 and ≤135	15%	18%	13%	12%	9%
>136 and ≤140	16%	19%	14%	13%	10%
>141 and ≤145	17%	20%	15%	14%	11%
>146 and ≤150	18%	21%	16%	15%	12%
>151 and ≤155	19%	22%	17%	16%	13%
>156 and ≤160	20%	23%	18%	17%	14%
>161 and ≤165	21%	24%	19%	18%	15%
>166 and ≤170	22%	25%	20%	19%	16%
>171 and ≤175	23%	26%	21%	20%	17%
>176 and ≤180	24%	27%	22%	21%	18%
>181 and ≤185	25%	28%	23%	22%	19%
>186 and ≤190	26%	29%	24%	23%	20%
>191 and ≤195	27%	30%	25%	24%	21%
>196 and ≤200	28%	31%	26%	25%	22%
>201 and ≤205	29%	32%	27%	26%	23%
>206 and ≤210	30%	33%	28%	27%	24%
>211 and ≤215	31%	34%	29%	28%	25%
>216 and ≤220	32%	35%	30%	29%	26%
>221 and ≤225	33%	35%	31%	30%	27%
>226 and ≤230	34%	35%	32%	31%	28%
>231 and ≤235	35%	35%	33%	32%	29%
>236	35%	35%	33%	32%	4%

Source. European Automobile Manufactures' Association (ACEA, 2009, U.K. Section, p. 8).
Note. FFV = flex fuel vehicles; E85 = vehicles designed to run on 85% ethanol fuel; EV = electric vehicles.

France

Company cars for employee usage registered after January 2006 are subject to an annual CO_2 tax (ACEA, 2009). The tax treats company cars on the basis of seven CO_2 emission bins, as shown in Table A–2, with the tax rate generally increasing with CO_2 emissions. The tax on company cars is not due for "green vehicles" (functioning exclusively or not with electric drive, LPG or E85 fuel). The tax is reduced by half for vehicles bifueled LPG vehicles.

Table A-2: COMPANY CAR TAX IN FRANCE (EFFECTIVE 2009–2010)

CO_2 Emissions (in g/km)	Ethanol or Flex Fuel
≤100	€ 2
>100 and ≤120	€ 4
>120 and ≤140	€ 5
>140 and ≤160	€ 10
>160 and ≤200	€ 15
>200 and ≤250	€ 17
>250	€ 19

Source. European Automobile Manufactures' Association (ACEA, 2009, French Section, p. 6–7).

"[In France] the tax on company cars is not due for "green vehicles" [and] is reduced by half for vehicles bifueled LPG vehicles.

Germany

The use of a company car for private driving is treated as a benefit in kind under German income tax rules (ACEA, 2009). The basis for taxation is determined according to the list price of the company car and the distance between the residence and the office of the employee. The taxable amount is 1% of the gross catalogue price of the vehicle plus 0.03% of the gross catalogue price of the vehicle per km of distance between the employee's residence and office per month. The tax does not depend on vehicle CO_2 emissions.

Appendix B: Potential Incentive for Carbon Reduction of All Fiscal Policies Across Nations

TABLE B–1 SHOWS THE POTENTIAL CO_2 REDUCTION incentive that would be attained if every country converted existing fixed tax assessments to a CO_2 emissions basis. For comparative convenience, Table B–1 also shows the current equivalent CO_2 reduction incentives without any conversion of current fixed assessments (determined as documented in the main body of this report). The difference between these two incentive levels provides an indication of the degree to which current CO_2 price signals could be increased solely by changing existing tax structures while holding net tax revenue constant. For example, the equivalent CO_2 tax for China's engine-size based vehicle excise and acquisition taxes is $53 per gCO_2/km. If China converted its VAT and various fixed charges (including an urban construction tax of 1% on top of the VAT, and an annual vessel usage tax of $70) into an equivalent CO_2 tax, the incentive level would be increased by approximately 80% to $95 per gCO_2/km. As was the case with the variable tax structure analysis, the equivalent CO_2 charge associated with the conversion of fixed charges was obtained by linearly regressing the total vehicle tax assessment against vehicle CO_2 emissions for all vehicle models in the given market. In general, countries with a high VAT have a greater potential incentive when deploying all tax dollars to encourage low-CO_2 emission vehicles as would be expected because a higher the tax burden provides a greater pool of revenue across which CO_2 emissions can be distributed.

Table B-1: MARGINAL EQUIVALENT CO_2 CHARGE WITH AND WITHOUT FIXED CHARGES

Country	Marginal Equivalent CO_2 Charge *With* Fixed Charges	Marginal Equivalent CO_2 Charge *Without* Fixed Charges
China	95	53
Germany (diesel)	84	36
Germany (petrol)	72	27
India	71	33
France	67	29
United Kingdom	66	41
Japan	51	47
United States	25	24

"In general, countries with a high VAT have a greater potential incentive when deploying all tax dollars to encourage low-CO_2 emission vehicles.

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