

Theodoros I. Zachariadis *Editor*

# Cars and Carbon

Automobiles and European Climate  
Policy in a Global Context

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# Chapter 1

## Introduction

Theodoros I. Zachariadis

Transportation is a major contributor to global energy consumption and greenhouse gas (GHG) emissions, accounting for about one fourth of total energy-related carbon dioxide (CO<sub>2</sub>) emissions worldwide. Together with power generation, it is the fastest growing sector in the world. But unlike power generation, whose emissions may be easier to control because they come from a few thousand power plants around the world and because low-carbon or zero-carbon energy sources are already available on a large scale, transport emissions are created by the individual tailpipes of more than one billion motor vehicles (mostly passenger cars) as well as from fuel combustion in airplanes and ships, depending almost entirely on petroleum products with still limited low-carbon alternatives. The global car population is projected to exceed two billion by the year 2050, mainly due to increased car ownership in China, India and other rapidly growing economies (IEA 2009, Sperling and Gordon 2010). And car travel is among the economic activities that are least responsive to price changes: increased mobility improves the standard of living, and automobiles are associated with freedom and comfort. Most citizens of the world wish to have the opportunity to use a car – but can this wish be made compatible with the increasingly strained carrying capacity of the earth and the associated climate challenges?

It is quite simple to calculate car carbon emissions: multiply the number of cars with the average distance travelled by each car, the amount of fuel consumed by a car per kilometer travelled and the carbon content of each fuel, which determines the amount of carbon emitted during combustion of that fuel. These four factors indicate also the options policymakers have in order to curb emissions – they have to reduce or mitigate the growth rate of one or more of these factors: car ownership, use of each car, fuel intensity (the inverse of fuel economy) and fuel carbon content respectively. The first two of these factors, which together amount to total automobile use, are most difficult to tackle because they are associated with individual preferences

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and living standards. The latter two factors – fuel intensity and carbon content – are more prone to technological solutions that may not compromise comfort and personal welfare. Unsurprisingly, most international carbon mitigation policies have primarily addressed these two parameters; this was also a natural continuation of earlier successful attempts to reduce emissions of conventional air pollutants such as carbon monoxide, sulfur dioxide and nitrogen oxides.

Unlike air pollutants, however, CO<sub>2</sub> is not an unnecessary by-product of fuel combustion that can be eliminated by using cleaner fuels and exhaust treatment technologies; it is the main product of fossil fuel combustion, which forms the basis of our economic welfare. Apart from some technological measures that can modestly reduce the growth rate of CO<sub>2</sub> emissions – such as technological improvements in combustion efficiency and a shift toward the use of fossil fuels with lower carbon content (e.g., from petroleum products to natural gas) – a real technological breakthrough is required if automobile CO<sub>2</sub> emissions are to decrease significantly in the future, in line with the stated global objective to contain average global temperature increase to two degrees Celsius (compared to pre-industrial standards) by the year 2050.

For historical and political reasons, the European Union (EU) has attempted to assume a leading role in climate change mitigation worldwide. EU climate policies that have addressed passenger cars have mainly focused on the technological aspects mentioned above – improving fuel economy and reducing the carbon content of fossil fuels used. Thus, apart from initiatives to inform citizens about the fuel consumption of cars (aiming to increase public awareness), a voluntary commitment of the auto industry to reduce CO<sub>2</sub> emissions of new cars was agreed in the mid-1990s. A decade later, it became apparent that this agreement would not deliver the emission reductions it was meant to, which led the EU in 2009 to implement mandatory regulations on car CO<sub>2</sub> emissions and demand a minimum penetration of biofuels as automotive fuel blends. At the same time, as taxation remains at the competence of each EU member country, there are attempts to partly harmonize vehicle taxation and shift it in order to be more favorable to low-CO<sub>2</sub> cars. High taxes on motor fuels, although not designed for this purpose and despite the low responsiveness of car travel to fuel prices mentioned above, may currently be the most effective climate mitigation policy in the continent.

Meanwhile it has become apparent that, in order to make real progress in curbing automobile carbon emissions, it is necessary to enrich policy options with non-technological interventions in the first two factors of the emissions 'equation' mentioned above, i.e., in car ownership and use. In response to this need various policies addressing personal transportation have been initiated at a regional or local level across Europe. Such measures comprise urban road charges, 'ecodriving' seminars, speed restrictions in urban areas, and environmental zones where access to high-emission vehicles is prohibited. Although most of these actions have primarily intended to tackle other, more localized negative impacts of car travel such as congestion, accidents, noise and air pollution, they usually contribute to

CO<sub>2</sub> reductions as well.<sup>1</sup> According to 2009 Economics Nobel Laureate Elinor Ostrom, a ‘polycentric’ approach to climate change is required if we are to achieve meaningful emission reductions worldwide (Ostrom 2009); localized measures may thus prove to be a critical ingredient of such a ‘polycentric’ approach in the transport sector, where billions of individual drivers are involved. And whereas it is desirable to achieve global economy-wide greenhouse gas mitigation agreements in which transportation will have its ‘fair share’ of obligations, a portfolio of smaller scale actions such as those mentioned here may be more realistic within a complex world with different circumstances and priorities (Barrett and Toman 2010).

This book intends to shed light into the lessons that can be learned from the European experience to mitigate carbon emissions from private cars in the last two decades. Inevitably, it cannot focus on all aspects mentioned above at the same time. Its emphasis is on EU-wide and national policies, not on local measures, because they are crucial not only for the formulation of actions on a local scale, but also for the future EU position in the negotiation of international climate change mitigation actions. However, as there are particularly interesting and promising success stories of local initiatives, the book also looks into such stories – in Europe and elsewhere in the world – and attempts to derive general implications for policymakers. And while our focus is on Europe, we should not lose sight of the global picture; therefore we have attempted to frame all analyses in the context of global policies.

This collective work attempts to distinguish between EU-wide and nation-wide policy responses. This is not always straightforward because of the interaction between these two policy-making levels. However, as many initiatives remain at the discretion of national governments, it is appropriate to examine these two levels in a distinct manner. Broadly speaking, technical regulations such as technology and fuel standards are primarily determined at the EU level, but fiscal measures are largely decided by national authorities – and some of these measures may even contradict stated EU-wide carbon mitigation objectives. The book thus reports not only on types of policies but also on the challenges associated with harmonizing different policy levers toward a common target. Its aim is not merely to present the various policy options but to critically assess them in light of the experience gained during the last two decades in Europe, and keeping in mind the future of climate policies worldwide. These critical reflections address both the nature of each policy measure and the way policies are implemented in the real world.

The book is basically organized in four parts: Part I provides the background of the ‘cars and climate policy’ topic; Part II reports on and evaluates EU-wide policies of the past with an outlook to the future; Part III gives examples of national fiscal policies as well as other national initiatives aiming at sustainable mobility, discussing their effectiveness in tackling car carbon emissions and their distributional impacts; and Part IV describes the international scene – both the non-European

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<sup>1</sup> In fact, economists have calculated that the social costs caused by automobile use due to congestion and accidents are more significant than those related to the emission of greenhouse gases from motor vehicles (Parry et al. 2007).

industrialized world and the developing world – in which transport policy makers have to act. The following paragraphs provide a more detailed account of each chapter.

Following this introductory chapter, Part I sets the stage by putting the whole discussion in context. [Chapter 2](#) focuses on the first two parts of the emissions equation, which together constitute the main variable ‘car use’ expressed in total kilometers travelled, whereas [Chapter 3](#) deals in more detail with the two latter parts of the equation, i.e. with the prospects of low-carbon vehicle technologies and fuels.

In [Chapter 2](#), Arie Bleijenberg states clearly that we should not expect car traffic to stop growing in Europe (and the rest of the industrialized world) any time soon. Increasing travel speed is a strong driving force behind the growth in mobility and car use, and this trend is unlikely to be reversed. Although investments in public transport and high speed rail links as well as better urban planning are useful in specific circumstances, they will probably not have a strong effect on the growth rates of mobility and car use at national and European level. The author suggests that technology can provide the necessary CO<sub>2</sub> emission reductions in Europe through a combination of very fuel efficient cars with low-carbon fuels. To achieve this combination, however, strong political will is necessary in order to set stringent emission and fuel standards, adopt pricing for all transport services so as to reflect marginal social costs and evaluate plans for future urban infrastructure investments with the aid of a proper social cost benefit analysis. Finally, he notes that the developing world has more options to switch to low-carbon transport since mass motorization is still at an early phase and there is still time to adopt more sustainable mobility options.

Lew Fulton shows in [Chapter 3](#) where the transport sector stands in terms of greenhouse gas emissions and where it heads to in the coming decades. Under business-as-usual assumptions, worldwide passenger kilometers and GHG emissions are expected to double by 2050, whereas they are projected to remain stable in Europe, despite improving fuel economy of new cars. However, scenarios prepared by the International Energy Agency and presented in this chapter give some signs of hope: exploiting the full potential for fuel economy improvements in current technologies and widespread adoption of new technology vehicles and low-carbon fuels could cut CO<sub>2</sub> emissions from cars around the world by more than half in 2050, compared to 2005 levels. To explain how this can be achieved, the author deals in more detail with the prospects of low-carbon vehicle technologies and fuels. The focus here is not on a detailed account of specific technologies and fuels – this is provided extensively in other publications such as the excellent book of Schäfer et al. (2009) – but rather on an outline of the policies required to develop the necessary infrastructure and enable the widespread adoption of low-carbon engines and fuels within a tight time schedule. Although an unprecedented automobile market transformation is required for all this to be achieved, the author is optimistic because a related market transformation is already under way: a new direction for fuel economy of today’s vehicles, now clearly on a path toward much more efficient vehicles in the future – in contrast to the stagnation in fuel economy levels that prevailed in recent decades.

The next two chapters provide a historical account and a future outlook of EU policies in the field of CO<sub>2</sub> regulations and fuel standards respectively. Their authors have actively participated in the relevant policy analyses, discussions and consultations in or around EU institutions for many years. In [Chapter 4](#), Karl-Heinz Zierock outlines the milestones of EU climate policies aimed at automobiles, starting already in the late 1980s and reaching the more extensive decarbonization strategy that unfolded publicly in 2007, including mandatory CO<sub>2</sub> emissions standards, a low-carbon fuel standard and several additional provisions. The author provides background information on how decisions have been made in EU legislative and executive bodies, and concludes that the key for the long-term success of transport decarbonization lies outside the transport sector, namely in the production of renewable electricity that may be used as future transport fuel or as an energy source for the generation of low-carbon fuels. He finds, however, that the way toward realizing this vision is full of obstacles and requires re-inventing motorized transport, entailing significant changes in the automobile industry and even more drastic changes in the oil industry.

Sandrine Dixson-Declève reinforces Zierock's argument in [Chapter 5](#), which looks at the lessons learned in the area of cleaner fuels as well as the problems confronting policy makers in trying to move toward low-carbon fuels. After an extensive account of past policies and an analysis of the elements and challenges of current EU fuel policy, she underlines that we are confronted with the need to take an entirely new approach to liquid fuels and their role in society; the feat ahead, she says, is far more complex than any challenge that the fuels industry and policy makers have faced before. The author reminds us of the 'quantum leap' industry and European governments have made over the last decade by working together to develop new more environmentally friendly vehicles and fuels as a result of the Auto Oil Programs. In view of this successful track record, she stresses the need to establish a comprehensive stakeholder program similar to the Auto Oil Program in order to agree on sustainability criteria for low-carbon fuels and to ensure the adoption of appropriate fuel legislation. She concludes that only through bold political and industry action to address real low-carbon options and innovative solutions will Europe enable transformational change in the fuels industry and meet its 2050 GHG emission reduction targets.

The discussion on the most appropriate policy instrument (fuel taxes, regulations and/or complementary measures) for curbing automobile GHG emissions continues unabated: theoretical arguments are countered by practical considerations, engineering approaches are questioned by economists and vice versa. Per Kågeson provides in [Chapter 6](#) a thorough overview of this policy debate, drawing from findings of studies around the world. Based on the lessons learned worldwide, but also from recent research results, he offers crucial guidelines to policymakers: harmonize incentives across Europe in order to allow the industry to adapt faster; regulate energy use rather than CO<sub>2</sub> emissions per kilometer; offer technologically neutral incentives, with some cautious extra support to very promising technologies; apply continuous functions to calculate incentives such as vehicle taxes or subsidies, and avoid thresholds and notches; treat private and company cars in the same way; allow

for different treatment according to vehicle size, not vehicle weight; and determine the magnitude of the incentives so that they correspond to the social cost of the problem they are supposed to tackle – i.e. the marginal damage costs of climate change. Finally, the author offers a proposal for a harmonized European system of taxes and incentives, which can provide efficient incentives to reduce car fuel consumption and carbon emissions. Although this chapter refers to policies that can be adopted at both EU-wide and national level, it is included in this part of the book since the author's proposals are based on the judgment that the most cost-effective solutions are associated with harmonized EU-wide policies that send clear messages to both consumers and the auto and oil industry.

**Chapter 7** evaluates EU policies from the point of view of an environmental non-governmental organization that has monitored the EU policy making process in the field of transport and the environment for the last 20 years. In line with the focus of Part II of the book, Jos Dings discusses the past and the future of EU-wide regulations, i.e., carbon-related regulations for vehicles and fuels and fuel taxation. He argues that the co-existence of command-and-control policies with fuel taxes is economically justified, and that carbon prices in transportation should be higher than those applied to industrial sectors through the EU Emissions Trading System. He addresses in detail the loopholes that exist in the current automobile CO<sub>2</sub> legislation, which in his opinion may considerably compromise its environmental effectiveness, and provides recommendations for alleviating these problems. He also questions the *ex ante* estimates provided by auto manufacturers on the costs of compliance with stricter environmental regulations, which he finds highly exaggerated, and cautions against relying on the current test procedures to determine car CO<sub>2</sub> emissions. He recommends that fuels should be taxed on the basis of their well-to-wheel carbon footprint, which in turn requires a strong improvement in the carbon accounting of fuels. He further explains that future automobile regulation should not be based on a CO<sub>2</sub> emission standard but rather on an energy efficiency standard in order to be fair toward the automobile industry and to account for the increased penetration of hybrid and electric cars. The paper also suggests raising minimum tax rates for diesel fuel and addressing the 'diesel tourism' phenomenon that prevents EU member states from taxing diesel more aggressively.

Part III of the book presents and discusses policy options that, although implemented in many European countries, are determined at national level and hence are not characterized by harmonization across the continent. Such policies are vehicle and fuel taxes, incentives to encourage the use of low-carbon cars or to reduce the use of cars altogether, and road charging schemes. In the case of vehicle and fuel taxes, which are everywhere similar in nature, a general overview of regulations around Europe is provided, whereas other measures are much more specific to the country or even the city adopting them. Therefore, **Chapters 8** and **9** offer an outline of vehicle taxes and fuel taxes respectively as existing in early 2011, while **Chapters 10** through **13** present specific case studies that can provide useful conclusions to policy makers.

In **Chapter 8**, Nils-Axel Braathen describes vehicle taxation policies implemented in Europe, in which the tax (a one-off registration tax paid at the

purchase of a new car and/or a vehicle tax paid annually by all licensed cars) is determined on the basis of a car's CO<sub>2</sub> emission levels. Such taxes have been increasingly adopted in European countries in the 2000s, partly replacing older taxes levied on cars according to their weight, price or engine size, in order to encourage the purchase of low-carbon vehicles. The author also calculates the implied tax rates of these policies (expressed in Euros per tonne of CO<sub>2</sub> emitted or abated over the lifetime of a vehicle). He notes that, while other fiscal measures such as fuel taxes and road charging would be the first-best approach, some CO<sub>2</sub>-related tax rate differentiation of motor vehicles can be useful if political economy constraints (i.e., low public acceptance) make it difficult to put in place an 'ideal' system. However, he finds the degree of tax differentiation applied in some countries to be disproportionately high compared to the marginal abatement costs of CO<sub>2</sub> mitigation options in other economic sectors.

In a similar fashion, Jessica Coria provides in [Chapter 9](#) a comprehensive account of motor fuel taxation in Europe. This measure remains at the discretion of national governments, and only a minimum tax level is determined at the EU level in order to avoid excessive differences between member countries. She summarizes the fuel tax rates applied in different EU countries by the end of year 2010 and mentions how these rates are related to per capita income and per capita government expenditure in each country. She points out that, although most fuel tax regimes have been designed in order to generate public revenues, fuel demand and CO<sub>2</sub> emissions would have been much higher in the absence of the existing high fuel taxes in Europe. After reviewing the literature on price elasticities of fuel demand, which are crucial for the estimation of the effect of a fuel tax on automobile energy use and carbon emissions, the author examines issues of political economy – to what extent consumers are willing to accept higher fuel taxes – as well as distributional aspects – whether a fuel tax increase affects proportionately more the rich or the poor. Obviously, concerns that a fuel tax rise puts a larger burden on lower-income households (a concern that is not always confirmed by empirical research) render fuel taxation unpopular among citizens.

These distributional aspects of fuel taxes are illustrated in a case study in [Chapter 10](#). Milan Ščasný explores household expenditures on transport fuel by income group during the 1990s and 2000s in the Czech Republic. He uses two different indices to measure the progressivity of fuel expenditures, and finds these to be almost uniform (neither strongly progressive nor strongly regressive) across income groups. He also analyzes the effects of changes in automotive fuel taxation on household expenditures, depending on how the increased public revenues are recycled in the economy – through reductions in personal income tax rates, social security contributions of workers or tax credits. The overall impact is quite small and the burden to households varies according to social status and the size of residence of each household rather than across income deciles. These results are in line with those of other empirical analyses in industrialized countries and reinforce the view outlined in [Chapter 9](#): fuel taxation – a strong economic instrument of climate policy – should not be abandoned on the grounds of equity concerns as the latter may not be justified – or can be alleviated through targeted interventions to those types of households that will be adversely affected.

The second case study comes from Sweden. Muriel Beser Hugosson and Staffan Algers describe in [Chapter 11](#) national policies that have been designed in order to accelerate the introduction of clean cars, i.e., cars with low CO<sub>2</sub> and air pollutant emissions, including those powered by ethanol blends and gas. In a country which, for many years, possessed the heaviest and highest CO<sub>2</sub>-emitting cars in Northern and Western Europe, such measures are important for reducing automobile carbon emissions. The article outlines first the institutional and fiscal measures taken by the government in order to prepare the market for the penetration of clean cars. Then it describes those regulatory and fiscal measures implemented to encourage the purchase of clean cars, and reports on the changes induced on the supply side as well: an increasing number of low-CO<sub>2</sub> models entered the Swedish market after 2005, particularly compact diesel and ethanol powered cars. The authors evaluate each one of the measures mentioned in the paper, and highlight problems associated with these initiatives: although sales of new clean cars in Sweden rose impressively between 2005 and 2010, the shares of low-carbon cars are sensitive to fuel prices, and ‘flexifuel’ cars, which can run on either petrol or a petrol-ethanol blend, may be run on pure petrol most of the time if petrol prices are favorable – thus diminishing a large part of the emissions benefit. Finally, the need for detailed policy simulation tools is explained in order to support policy makers in their decisions.

Perhaps contrary to what other authors describe, [Chapter 12](#) paints a more optimistic picture on the prospects of changing travel behavior. Bastian Chlond claims that the stabilization of transport CO<sub>2</sub> emissions in Germany since the year 2000 is attributable mainly to the increased use of public transport modes and bicycles. He describes the gradual shift of German society, from absolute car dependence in earlier decades to a slow relative decline in the use of private cars and a corresponding rise in utilization of other passenger transport modes. The author explains this slow paradigm shift as a combination of a demographic process, whereby young generations get used to driving less because there are plenty of alternatives to the automobile; economic policies such as financing public transport infrastructure and raising fuel taxes; and urban planning choices that discourage urban sprawl and enable a ‘cultural’ change, which reduces the symbolic status of car ownership and gives more emphasis to environmental protection and a healthy lifestyle. Next, the article outlines the basic ingredients of a strategy to create a multimodal transport system, which comprises a number of policies that increase the attractiveness of public transport and non-motorized travel, while at the same time reducing the attractiveness of car use. Then the author focuses on the particular case of the German city of Karlsruhe and refers to the specific institutional and regulatory arrangements that have helped make this city the most prominent example of such a shift toward multimodal behavior in Germany. To a cautious reader who might consider this case study to be the exception rather than the rule, the author responds that Karlsruhe is not an exception but just a pioneer among many German cities that follow in the same direction. ‘This gives hope for optimism’, he concludes.

Urban road charging systems have been implemented in a number of European cities. Currently there are plans to apply such schemes on a national basis too. Although such systems attempt to tackle multiple types of externalities of car use



(congestion, accidents, noise and air pollution), they are increasingly mentioned as carbon mitigation policy options as well. In [Chapter 13](#), Bryan Matthews and John Nellthorp review the theory and practice of implementing nationwide road charging systems. They point out that national road user charging appears to offer a holistic solution for tackling transport externalities; therefore they explore the role of climate change costs in this debate, and what impact on climate change such a solution might have. They review the theory on which the case for national road user charging is based and provide a global overview of attempts at implementation in a number of countries. Their survey shows that apart from Singapore, the city state that has adopted national road user charging, at least another ten countries have adopted or are considering adopting nationwide road charges – though not always targeting passenger cars. The authors focus on areas of progress as well as on the sticking points with this policy, and discuss how public acceptability barriers can be overcome through careful design. They conclude that if national road user charging is adopted, this charge could also be used for charging CO<sub>2</sub> emissions instead of using the fuel tax for this purpose.

Despite the book's focus on Europe in all previous chapters, it is evident that European policy makers cannot act alone – particularly if the EU aspires to maintain its leading role in climate policy. Climate change is a truly global problem; the contribution of Europe to global anthropogenic GHG emissions is less than one fifth and expected to decline in the future due to the rise of emissions in developing nations; and the automobile and oil industries are globalized to a very large extent. Therefore, Part IV of the book is devoted to the international context of the 'cars and climate policy' topic. It comprises two chapters on major automobile-related climate policies in the rest of the industrialized world and the developing world respectively, which deal primarily with technical measures – fuel economy regulations and fuel standards; and one chapter on non-technical measures, i.e., mobility management practices around the world.

In [Chapter 14](#), Todd Litman explores the role that mobility management can play in a sustainable and economically efficient transport system. He describes the background of such measures: Many current policy and planning practices tend to favor mobility over accessibility and automobile travel over alternative modes, which often results in economically excessive motor vehicle travel. Similarly to what has been described in the previous chapter, he notes that a paradigm shift is occurring among transport planners, from the current mobility-based to accessibility-based planning; this calls for mobility management strategies that increase (and provide incentives to use) transport options such as walking, cycling and public transport, and enable appropriate land use planning so as to improve accessibility. The chapter outlines the basic principles of proper mobility management strategies, discusses the critiques toward these concepts and provides a number of case studies from around the world where elements of such policies have been implemented. The example of the city of Karlsruhe, presented earlier in [Chapter 12](#), seems to be compatible with the best cases presented by Litman. According to the author, if these strategies are implemented appropriately and in a cost-effective fashion, they can reduce motor vehicle travel by 30–50% compared with what results from conventional policies

and planning practices, and make people better off. He concludes by underlining that transport planning reforms in line with the new accessibility-based paradigm are particularly appropriate in developing countries to support economic development as well as environmental and social equity objectives.

**Chapter 15** focuses on non-European OECD countries. Michael P. Walsh explains that there has been a fundamental change in the approach to regulating fuel economy or GHG emissions from road vehicles over the past decade, which was mainly induced by concerns of human-induced climate change. The number of countries adopting some form of regulation has grown dramatically. Moreover, the form of the fuel economy or GHG standard is starting to shift away from a mass-based approach toward a footprint-based approach, which will open up additional opportunities to take advantage of lightweighting as a key element of a control strategy. The chapter describes the history and most recent developments (up to the beginning of 2011) on such standards from non-EU OECD countries around the world, namely in Canada, Japan, South Korea and the United States. Other OECD countries such as Australia and Mexico are also considering the implementation of similar standards. While command-and-control standards are expected to remain the backbone of control efforts, economic incentives or disincentives including fuel taxes are expected to play a more important role in the future than they do today.

In **Chapter 16**, Cornie Huizenga and James Leather assume the difficult role to describe the situation in the developing world and propose policy solutions. They highlight the importance of the developing world in terms of their growth in transportation GHG emissions, which underlines the urgent need for low-carbon solutions. The chapter describes the currently dominant planning paradigm as the 'Predict and Provide' approach, which has been financially supported by Multilateral Development Banks and has focused almost exclusively on building sufficient road infrastructure for new cars and trucks, thereby ignoring other transport modes and leading overall to unsustainable solutions. In order to move to a low-carbon, sustainable transport future the authors emphasize the need for a paradigm shift from the 'Predict and Provide' approach to an 'Avoid-Shift-Improve' approach; this can enable both controlling the growth in motorization and providing alternative transport modes to meet the rising demand for welfare-improving mobility in the developing world. They proceed with recommendations for the shaping of external assistance policies in the future, in terms of private investments, development assistance from bilateral or multilateral funding mechanisms, as well as climate-related financing instruments. The authors point out that the developing world has the possibility to opt for a leapfrog approach to transport and climate change, which will be required if the transport sector is to meet the drastic global GHG emission reductions required up to 2050.

Lee Schipper provides an eloquent epilogue to this book in **Chapter 17**. The future of the transport sector will greatly affect the future of carbon emissions, as it is the fastest rising source of CO<sub>2</sub> emissions in the world. At the same time, he notes, high CO<sub>2</sub> emissions are only one of the symptoms of poor urban transport, particularly in cities of the developing world; light duty vehicles are at the centre of broader urban transport problems such as congestion, accidents and air pollution.

If we are to attack these problems effectively, Schipper claims, we have to frame the issue as a transport problem and not merely as a CO<sub>2</sub> problem. In fact, some of the largest benefits of CO<sub>2</sub> reduction come as indirect benefits of other strategies to improve transportation. Although technology improvements to cars – such as greater fuel economy and use of low-carbon fuels – are important, technology per se is the smallest uncertainty; the major problem is the future growth in global vehicle kilometers travelled. Therefore, a sustainable long term approach will involve a coordinated effort encompassing efficient vehicles and low-carbon fuels, congestion pricing and other strategies to reduce externalities, provision of viable public transport options, and promoting land use policies that discourage automobile use. At any rate, he concludes, in line with many other authors of this collective volume, the future of the automobile cannot be like its past. The future will be grim if individuals, their elected officials and stakeholders in fuel and vehicle companies continue as if there are no profound problems confronting the choices automobiles give their users.

Trying to distil the analyses and viewpoints presented in the chapters of this book in order to come up with some broad conclusions is a daunting task. However, I would single out four major findings:

1. *Irrespective of the GHG emission mitigation effort in other economic sectors, global transport emissions should decrease greatly in the coming decades if the two-degree-Celsius objective is to be met.* Research shows that transportation is not the sector of top priority for reducing GHG emissions since marginal carbon abatement costs in other sectors of the economy may be lower (McKinsey 2010, Proost 2008). Nevertheless, if global climate forecasts are able to capture the relationship between GHG emissions, GHG concentrations and temperature changes with reasonable accuracy, it is not justified for policy makers to postpone transport-related climate policies until other sectors have assumed their ‘fair share’ of mitigation effort. Keeping in mind the potential bias in assessing costs of stringent climate policies (Tavoni and Tol 2010), and notwithstanding the lively discussions on how to discount the distant future, it is clear that if there is indeed a probability for catastrophic climate change, even if very low, action must not be delayed (Weitzman 2009).
2. *To reduce automobile GHG emissions we need mandatory regulations, which should go hand-in-hand with fiscal policies as well as local and national economic incentives.* Many economists might disagree with this finding: there is ample theoretical and empirical evidence that a fuel/carbon tax is a more efficient solution than a command-and-control regulation of GHG emissions, with considerably lower transaction and enforcement costs (Austin and Dinan 2005, Parry et al. 2005, Sallee 2010). The design of such regulations often makes things even worse since regulations include thresholds and notches, and their implementation induces short-term producer and consumer behavior that reduces their effectiveness (Sallee and Slemrod 2010). Despite these well-known limitations, and irrespective of the continuing debate as to whether consumers undervalue fuel economy savings (Greene 2010), one thing is certain: raising fuel taxes is

unpopular, hence very few governments implement tax increases. If, as explained in the previous paragraph, we must act soon to curb automobile GHG emissions, there is little point in waiting for ‘enlightened’ leaders to risk their political future by raising fuel taxes; if a first-best option is infeasible, second-best or even third-best policies are better than nothing.<sup>2</sup>

Moreover, economic analysis has its caveats too: Firstly, a regulation is often considered to reduce welfare because it may induce consumers to purchase products different than the ones they would ‘ideally’ prefer. As Hanemann (2008) has pointed out, however, consumer preferences are not fixed (as neoclassical economic theory assumes) but evolve; mandated constraints that were once considered to affect consumer welfare are not regarded as welfare-reducing any longer. For example, citizens who were initially disturbed by an anti-littering law or non-smoking obligations have adapted over the years so that a littering or smoking ban may not be considered adverse to their welfare any longer. In a similar fashion, if a GHG regulation makes some consumers purchase smaller, less powerful or less convenient automobiles this welfare loss may be negligible after some time.

A second caveat of the simple economic rationale that states ‘if an externality exists you just have to impose a (Pigovian) tax to reduce it’ is illustrated by Acemoglu et al. (2010). Instead of implementing just a carbon tax, a policy combining such a tax with economic support for research & development in low-carbon technologies may achieve an environmental objective at a lower cost than the tax-only policy. This finding seems to reinforce what was stated above: carefully designed regulations may be a reasonable way forward for climate policy in transport, particularly in Europe where fuel taxation is already high. Economic policies such as CO<sub>2</sub>-related vehicle taxes, road charging schemes and local incentives toward sustainable mobility – as long as they do not imply unreasonably high carbon abatement costs – are necessary complements to regulations; and, as stated earlier in this chapter, a ‘polycentric’ approach comprising measures at international, national and local level may be more appropriate for addressing the transportation-climate problem in the real world.

3. *There are some indications that ‘conventional wisdom’ transportation forecasts may not apply any more.* The evolution of automobile use and GHG emissions have clearly followed a business-as-usual path up to now, in contrast to more optimistic scenarios of earlier decoupling of travel demand from economic growth, which have not materialized. However, some things seem to be different now. Firstly, market transformations are happening around the industrialized world, leading to significant improvements in fuel economy and perhaps to changes in citizens’ behavior toward the private car. Secondly, space restrictions in densely populated areas of the developing world may be restraining the growth

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<sup>2</sup> See also Flachsland et al. (2011) for a discussion of alternative climate policy instruments in road transportation.

in automobile use already now, at low levels of motorization. Thirdly, rapidly developing economies such as China and India are adopting (or are expected to adopt soon) fuel economy regulations that would not have been expected a few years before. On the other hand, although such optimism is justified to some extent, one should always keep in mind that tremendous effort is required in order to accelerate technological improvements and restrain growth in automotive travel demand in the long run.

4. *The industrialized world can contribute to automobile GHG abatement thanks to near-saturation motorization levels, but the great hope comes from the developing world.* The overwhelming share of the increase in transportation GHG emissions will come from developing countries in the next decades. In contrast to the industrialized world, where travelling habits have been formed throughout the years and are changing only slowly, and where it takes time to replace the vehicle fleet with low-carbon cars, citizens of developing nations are just starting to own automobiles on a large scale. Hence, if national policies nudge consumers toward buying low-carbon vehicles and encourage sustainable mobility practices, it should be possible for large parts of the developing world to leapfrog to a sustainable transport path. International financing institutions can significantly contribute to this target by directing funds toward low-carbon investments in public and non-motorized transport infrastructure. Avoiding urban sprawl through smart land use policies and directing investments toward dense urban areas is not only environmentally sustainable but also seems to promote economic growth; [Chapter 2](#) has touched upon this topic, and Glaeser (2011) provides compelling evidence for the existence of this effect worldwide. Therefore, even if it takes a long time for the industrialized world to adjust, developing economies have the opportunity to shape their future with more sustainable, low-carbon mobility patterns.

We have strived to keep this book easily readable but also widely informative. The authors have attempted to write their chapters in a manner that is partly technical (which is inevitable due to the nature of the topics discussed herein) and partly accessible to a wider public having only basic familiarity with the transportation, energy and climate change terminology. To the extent possible, we have avoided providing equations and complex tables and charts. For readers interested in more technical aspects of a topic, a large variety of scholarly papers is available in academic journals. If this book is of some value to researchers, students and policy practitioners, it will be because of the reviews and recommendations made by its authors, encompassing – hopefully – most of the important aspects of the ‘cars and climate policy’ debate.

It was also impossible to avoid some technical language related to the decision-making process in the EU; we have nevertheless tried to keep this jargon to a minimum in order to maintain the interest of non-expert and non-European readers, without compromising the need to describe the policy-making process with reasonable accuracy. We hope – and readers will judge by themselves – that we have not entirely failed in this attempt.

I am indebted to all chapter authors, widely known professionals with mostly long experience in the analysis and formulation of transportation-related climate policies around the world, who have offered to contribute to this book with their knowledge and intellect. The formidable task of compiling such a collective work would have entirely failed if it were not for the willingness of these great analysts to devote some of their scarce time to the success of the book. I am also grateful to Gay Christofides for her excellent editing work and Panayiotis Gregoriou for his superior technical assistance. Finally, I would like to dedicate this volume to Lee Schipper, who passed away in August 2011, soon after he finalized the epilogue (Chapter 17) of this book. Together with hundreds of other people around the world, I have benefited enormously from his warmth, his encouragement and his incredible energy in analyzing transportation issues.

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