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Transport sector energy use and carbon emissions: a study on sectoral fiscal policies

Zużycie energii i emisja dwutlenku węgla w sektorze transportu: badanie sektorowych polityki fiskalnej

Abstract. As the energy sector worldwide is largely based on fossil fuel consumption, the amount of global-scale carbon emissions continues to increase over the years. One of the most important reasons for the increase in emissions, the transportation sector, continues to develop with globalization. The development of land, sea, and air transport together with international trade brings environmental problems in parallel with the increase in energy consumption. Accordingly, it is estimated that one fourth of total carbon emissions today originate from the transportation sector. In this context, in order to combat environmental problems such as global warming and climate change on an international scale, initiatives such as the Paris Climate Agreement are being implemented and environmental policies to reduce the amount of emissions are being recommended. The aim of this study is to examine environmental policies, which have been discussed extensively in the literature, in terms of fiscal policy. In this context, fiscal policy tools such as taxes, subsidies, incentives, and regulations specific to the transport sector were discussed. This study, in which the descriptive method is used, argues that fiscal policy practices can be an effective method in reducing the amount of carbon emissions.

Key words: transportation, fiscal policy, carbon tax

Synopsis. Sektor energetyczny na całym świecie w dużej mierze opiera się na paliwach kopalnych, co skutkuje ciągłym wzrostem emisji dwutlenku węgla na skalę światową. Jedną z najważniejszych przyczyn wzrostu emisji jest sektor transportu, którego rozwój jest powiązany z procesami globalizacji. Rozwój transportu lądowego, morskiego i lotniczego wraz z handlem międzynarodowym i zwiększonym zużyciem energii powoduje problemy środowiskowe. W związku z tym szacuje się, że jedna czwarta całkowitej emisji dwutlenku węgla pochodzi obecnie z sektora transportu. W tym kontekście, w celu zwalczania problemów środowiskowych, takich jak globalne ocieplenie i zmiany klimatyczne w skali między-

narodowej, wdrażane są takie inicjatywy, jak porozumienie klimatyczne z Paryża, a także zalecana jest polityka środowiskowa mająca na celu zmniejszenie ilości emisji. Celem niniejszego opracowania jest analiza polityki środowiskowej, która była szeroko omawiana w literaturze, pod kątem polityki fiskalnej. W tym kontekście omówiono narzędzia polityki fiskalnej, takie jak podatki, dotacje, zachęty i przepisy specyficzne dla sektora transportu. Niniejsze badanie, w którym zastosowano metodę opisową, dowodzi, że praktyki polityki fiskalnej mogą być skuteczną metodą zmniejszania ilości emisji dwutlenku węgla.

Słowa kluczowe: transport, polityka podatkowa, podatek węglowy

Introduction

The transportation sector is one of the important components of an economy, and it is possible to see its impact on the economy both on a microeconomic level and in a macroeconomic context. In the macroeconomic context, transportation accounts for 6 to 12% of the gross domestic product in many developed countries, while logistics accounts for 6 to 25%; on the microeconomic level, transportation accounts for an average of 10% of household expenditures, and each unit of production accounts for approximately 4% of the cost of output [Rodrigue and Notteboom 2020]. However, population growth and economic dynamism both expand the transport sector and increase its effects. It is possible to see these effects as either positive or negative in many areas such as development, health, environment, energy usage and well-being.

One of the major impacts is on the transport sector and its systems, which also constitute this main theme, on energy use and the environment at both the global and local levels. In the transportation sector, fossil fuels are significantly consumed, especially by airplanes and vehicles, and they also emit many environmentally harmful substances such as carbon dioxide and noise while contributing to global climate change, which is one of the biggest problems today. Accordingly, when the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties was held in Paris in December 2015 at COP21, the parties officially announced their climate commitments to limit global warming below 2°C compared to pre-industrial temperatures. Although it is clear that transportation policies that respect the environment will contribute to sustainable economic growth on a national basis, the transportation sector is important and should be focused on when defining global emissions reduction goals, as it is a primary source of carbon emissions.

For more than five years after the Paris Climate Agreement, the entire world, particularly the European Union, has focused on how to reduce carbon emissions. At this point, the transportation sector, an energy-intensive sector due to the use of fossil fuels, draws special attention. It has become increasingly important that countries implement policies to reduce greenhouse gas emissions in the transportation sector in order to achieve the objectives of the agreement. In this regard, the energy use of the transportation sector and its impacts on the environment accordingly were analysed with the purpose of revealing the current situation, and preventive or mitigating policy tools were discussed in the study. Although various policy tools can be suggested for adaptation and mitigation, the impor-

tance of fiscal policies for the transportation sector is at the core of the study. Data from international organizations were also used for comparison in this study, which indicates the reason why such certain fiscal policy implementations as tax and market regulations are important with the help of descriptive analysis, one of the qualitative analysis tools.

The current energy use of the transport sector and its environmental impacts: drivers and trends

More than 20 years after the transport sector was recognized as one of the foundations of sustainable development for the first time at the United Nation's Earth Summit in Rio in 1992, 193 countries were present in New York in 2015 to adopt safe, affordable, accessible, and sustainable transport systems by 2030 under the goal of providing access. This indicates that global interest in transportation continues and highlights the desire to provide more sustainable and green transportation to future generations on a global level.

Increasing urbanization, population, mobility, industrialization, and economic growth, have increased energy consumption in every sector. While the industrial sector has been a leader for many years in the trend of global energy consumption and thus greenhouse gas emissions, it is seen that the global energy consumption of the transportation sector has caught and even surpassed the industrial sector, especially since 2017 (Table 1).

Table 1. Total final consumption [ktoe] by sector, world in 1990–2018
Tabela 1. Całkowite zużycie końcowe [w ktoe] według sektorów, świat w latach 1990–2018

Years	Industry	Transport	Residential	Commercial and Public Services	Agriculture/ /Forestry	Fishing	Non- -specified	Non- -energy Use
1990	1 803 105	1 575 288	1 530 461	450 350	164 032	6 048	260 520	477 373
1995	1 791 088	1 716 062	1 726 692	502 760	174 387	6 048	88 345	530 906
2000	1 871 304	1 962 766	1 804 114	555 003	149 194	6 169	77 382	606 101
2005	2 236 928	2 218 273	1 897 469	642 824	174 375	8 054	99 106	702 822
2010	2 638 047	2 429 780	1 987 340	717 378	182 748	8 031	109 118	765 290
2015	2 784 319	2 691 655	1 995 755	761 226	197 573	7 173	135 777	834 508
2016	2 782 538	2 751 468	2 018 412	776 961	200 186	6 656	144 239	849 307
2017	2 805 617	2 821 408	2 052 914	788 970	207 737	6 955	148 846	884 054
2018	2 839 313	2 890 900	2 109 205	808 619	214 719	7 005	151 179	916 762

Source: [IEA 2020b].

It is possible to see a similar reflection of the global transportation sector taking leadership in total energy consumption from the industrial sector in the European Union as well. According to data from the European Energy Agency, 31% of the total final energy use of member countries was realized by the transportation sector, followed by households with 27% and the industrial sector with 25% as of 2017. It is evident that the transportation sector's portion of energy use will be significant in the future as well. Although renewable energy is the fastest growing source of energy in the world, according to estimates for 2050, fossil fuels will continue to meet most of the world's energy demands, although their use in primary energy consumption will decline from 32% in 2018 to 27%

in 2050. This decline will stem from the residential and electrical energy sectors, while the consumption of oil and other liquid fuels in the industrial, commercial and transport sectors will increase [EIA 2019].

The transport sector is energy intensive and highly dependent on petroleum and petroleum products, such as gasoline and diesel fuel. As can be seen in Figure 1, all the energy consumed by the transportation sector originates from fossil fuels. However, in recent years, it is possible to observe that the gap between the transportation sector's total energy consumption and total fossil fuel use has begun to expand, although slightly. The difference is the result of increasing use of biomass and electricity in the transport sector. Nevertheless, the share of these two sources is still quite small.

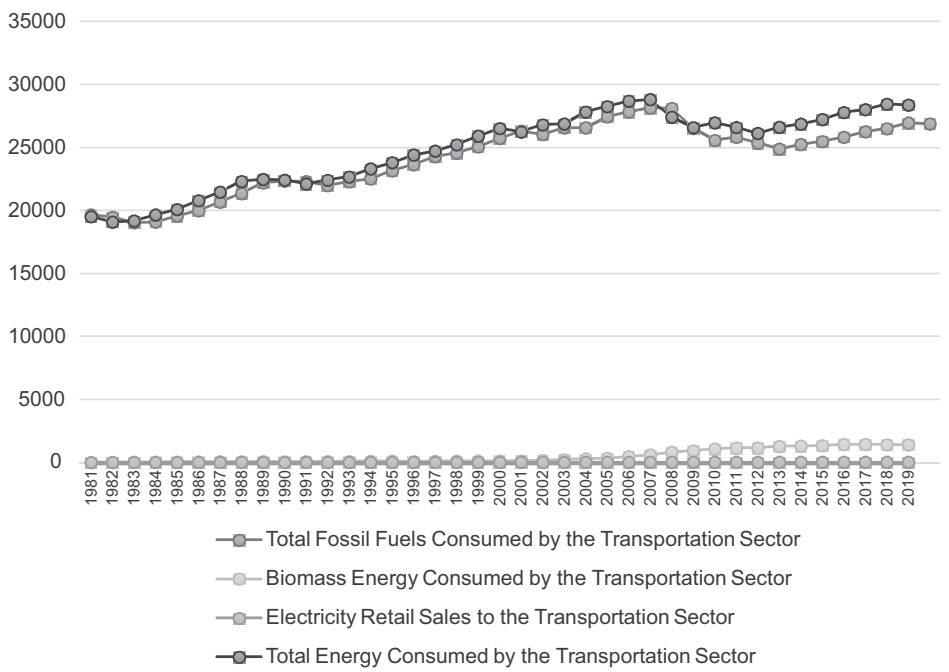

Figure 1. Transportation sector energy consumption
Rysunek 1. Zużycie energii w sektorze transportu
Source: own study based on [EIA 2020].

More than 60% of the petroleum products used in OECD countries and nearly half of those used in non-OECD countries are used as transportation fuel. Regarding passenger cars, even in the European Union with its important environmental and greenhouse gas emissions goals, in 13 of 24 EU Member States for which 2017 data are available, more than 50% of passenger cars (the most important for passenger transport in all European Union member states) used gasoline, while road transport continues to constitute the largest portion in European Union freight transport [European Commission 2019]. However, energy consumption is expected to increase in the transport sector particularly

in non-OECD countries in the coming years. The U.S. Energy Information Administration predicts this increase will be 77% in the period from 2018 to 2050 and expects that non-OECD countries will realize approximately 65% of the energy consumption related to transportation in the world in 2050. As for OECD countries, as the increases in vehicle fuel efficiency are expected to exceed travel demand, the total transport energy use for OECD countries is projected to decrease by 1% from 2018 to 2050 [EIA 2019].

Increasing mobility around the world is one of the main reasons for the increase in energy use in the transport sector. It is an established fact that increased income increases the demand for travel [Goodwin et al. 2004, Dargay 2007]. Fuel consumption related to passenger or personal mobility accounted for 61% of total world transport energy consumption in 2012 [EIA 2016]. However, due to the global pandemic and mobility affected by the pandemic in 2020, the energy demand of the transportation sector has decreased. According to International Transport Forums 2020 data, pandemic-struck sea freight and air freight volumes were the at lowest level since the global financial crisis of 2008 in the EU-27 [ITF 2020]. Conversely, it is expected that there will be a rebound effect and that the sector will recover once the pandemic is brought under control [IEA 2020a]. Therefore, it becomes important to create a sustainable transportation policy without reducing the quality of life of individuals. At this point, electric vehicles have a remarkable opportunity to change the rules of the game in favour of energy efficiency and the environment, and policy practitioners need to implement measures to encourage electric and hybrid electric vehicles.

Energy use in the transport sector is increasing in both developed and developing countries. The emission of carbon dioxide and other greenhouse gases into the atmosphere from the burning of fossil fuels such as gasoline and diesel also triggers problems such as climate change. The rate of increase in direct global carbon emissions resulting from fuel combustion in the transport sector has been 1.9% annually since 2000. Moreover, although ship and aircraft-based carbon emissions have increased more than other modes of transport in recent years, the amount of emissions from cars, trucks, buses, and other types of road transport account for three quarters of total emissions. Most of these emissions originate from road freight transportation [IEA 2020c].

Presently, although the share of parties defining certain transport reduction goals as per the Paris Agreement is low at 10%, 60% of them go beyond simply mentioning the transport sector in their nationally determined contributions (NDCs) and mention at least one transport reduction "measure" [ITF 2018]. In order to achieve the "far below two degrees" target defined at COP21 in Paris in 2015, upper- and high-income countries should intensify their transport carbon reduction targets as they are more responsible for the main share of transport carbon emissions. Measures to reduce carbon emissions and the relationship between the transport sector and the Paris agreement can be read in more detail in the next section.

Air and noise pollution are other environmental factors caused by the transportation sector. This sector is the largest contributor to NOX emissions, accounting for 46% of total EU-28 emissions (and 47% of EEA-33 emissions) in 2014. It also contributed 13 and 15% of total PM10 and PM2.5 primary emissions in the EU-28 in 2014, respectively. The external costs of noise in the European Union are at least 0.35% of GDP and mostly stem from road traffic [European Commision 2017].

Policies regarding carbon emission reduction in the transport sector

The fact that the transportation sector is heavily dependent on fossil fuels causes adverse effects on the environment and human health, primarily global warming. Although the rate of increase in emissions from transportation relatively decreased on a global scale in 2019, today, 24% of carbon emissions are a result of fuel consumed due to transportation. Considering the necessity of reducing carbon emissions in the transport sector [Trevisan and Bordignon 2020] to keep the world at an average temperature increase, more international initiatives are needed to reduce the emissions in question [IEA 2020c].

Governments in different parts of the world set standards for fuel and carbon emissions, especially for new vehicles, to combat climate change and tackle problems based on energy supply. The implementation of performance-based standards is often supported by fiscal policy tools such as taxes and incentives. Thus, it is argued that fiscal policy choices of policy implementers may reduce carbon emissions on one hand and have positive effects on fuel demand on the other [German and Meszler 2010]. Therefore, the relatively high cost of clean energy sources will increase the chances of success in policies to be implemented with the help of tools such as environmental taxes and subsidies [Santos 2017]. It is recognized that fiscal policies regarding energy have long-term effects on environmental quality [Ike et al. 2020]. Considering that the number of electric vehicles on the roads exceeded seven million at the end of 2019, high-speed train projects have been implemented, and solar-powered aircraft are being studied, it can be argued that these are a result of these policies.

For global warming to be kept at a scientist-advocated level of 2°C or less, the world, especially countries with high emission levels, should act collectively. The future of the 2015 Paris Climate Agreement, which was established with this in mind, is uncertain because of the USA's withdrawal from the agreement and the delay of some countries in approving it. However, it has been argued that if the goals defined in the Paris Climate Agreement are not achieved, natural disasters based on climate change may be experienced more frequently and that this will be very costly [Pigato and Black 2019].

According to the IMF, the global average emission amount, which is currently USD 2, should increase to USD 75 by 2030. On the other hand, other negative effects of said carbon tax implementation, such as increasing energy prices and increasing energy poverty, worry governments. Accordingly, electricity prices with a USD 75 carbon tax applied are estimated to increase 40% in Turkey, 64% in China, 89% in South Africa, 83% in India and 18% in Germany. Regardless, the belief that more than fifty countries around the world have some form of carbon tax planning and that this can be achieved is supported by examples of successful implementations. Notably, Sweden has reduced its emissions by 25% and expanded its economy by 75% by increasing its carbon tax per ton to USD 127 since 1995. Thus, it is argued that through an increase in carbon tax, there will be positive changes in the lives of households, businesses and societies, and that death rates due to air pollution will decrease [Devarajan et al. 2011, IMF 2019]. In this context, it is stated that carbon taxes are the most effective method that enables households and companies to switch to clean and low-cost energy sources by reducing the amount of carbon emissions. Accordingly, there are many studies in the literature on the effects of fiscal policy implementations on carbon emissions [Speck 1999, Timilsina and Shrestha 2009,

Brand et al. 2013, Mraïhi and Harizi 2014, Tscharaktschiew 2015, Ajanovic et al. 2016, Fridstrřm et al. 2016, Aggarwal 2017, Fridstrøm and Østli 2017, Liu et al. 2017, Østli et al. 2017, Cassen et al. 2018, Gloriant 2018, Yang et al. 2018, Zhou et al. 2018, Santarromana et al. 2020, Tsakalidis et al. 2020, Zhang et al. 2020]. In this sense, it is evident that policies enacted through instruments such as taxes, regulations and incentives reduce carbon emissions and have positive effects on the environment. These policies will be discussed in more detail in the next section.

Implementation of tax policies

It is clear that the transportation sector has also developed over the years as a result of the development of international relations through globalization, the increase in trade volume and the ease of transportation opportunities. This situation further expands the energy requirement of the sector as well. In particular, the increase in maritime and air transport has increased fossil fuel consumption substantially [OECD 2010]. Consequently, the increase in energy consumption negatively affects the amount of carbon emissions. These emissions nearly doubled from 4.6 million Mt in 1990 to 8.2 million Mt in 2018 [IEA 2020c]. The table shows the level of change in greenhouse gas emissions in the transport sector between 1990–2017 in the selected countries. Accordingly, Turkey, Poland and Luxembourg are ranked in the top three places in terms of greenhouse gas emissions in the transport industry (Table 2).

The transport sector's share of global carbon emissions is approximately one fourth. However, it is estimated that approximately 77% of the total carbon emissions in the transportation sector today are caused by road transportation. More than half of this is

Table 2. Change in total greenhouse gas emissions from transport
Tabela 2. Zmiana emisji gazów cieplarnianych w sektorze transportu

Countries	Change (1990–2017)	Countries	Change (1990–2017)
Austria	78.4	Latvia	15.1
Belgium	27.5	Liechtenstein	–20.7
Bulgaria	39	Lithuania	–2.7
Croatia	62	Luxembourg	144.1
Cyprus	57.7	Malta	101.8
Czechia	64.3	Netherlands	32.6
Denmark	28.7	Norway	32.4
EU-28 (convention)	28	Poland	206
Estonia	1.5	Portugal	78.6
Finland	3.7	Romania	43.5
France	15.8	Slovakia	13.6
Germany	11.8	Slovenia	102.2
Greece	21.8	Spain	66.9
Hungary	47.7	Sweden	–5
Ireland	141.9	Switzerland	14.1
Italy	3.9	Turkey	247.9

Source: [EEA 2020].

due to light-duty vehicles. Maritime transport accounts for 11% of total emissions, while the aviation industry accounts for 10%. Thus, carbon emissions from road transport have a significant portion of the total. Considering the development of the world's car market, the United States, China, European Union and India account for 46% of global carbon emissions within the scope of new vehicle sales [ICCT 2020, IEA 2020c]. Therefore, future projections of current policies show that they will fail to prevent the increase in emissions caused by the increase in demand in the transport sector. Estimates that the level of emissions in the sector will increase by 60% by 2050 require governments to take tougher measures [ITF 2019].

Carbon emissions, which are a type of negative externality, are on the agenda of politicians because of their negative effects on the environment and human health. For example, Hill et al. [2009], while considering all the impacts of one gallon of gasoline consumption, calculated that USD 0.37 is the cost of climate change resulting from carbon emissions and USD 0.34 is the cost of health-related pollution. Accordingly, as air pollution and global warming are among the most important risk factors threatening world health in the future [Gupta 2016], they are subject to public intervention to protect public health. It is not possible to reduce the amount of externality in the production or consumption process because the party that spreads the externality does not bear its cost. This situation, which is referred to as market failure in the literature, is one of the main factors that require public intervention in the economy [Ng 1980]. The main reason why externalities fail the market, from an efficiency perspective, is that an economic activity (consumption or production) creates an impulse to do too little or too much. And in this case, because the benefits or costs arising from the activity do not include external effects that cannot be priced, efficiency deteriorates [Rosen 2008, Case et al. 2012, Pindyck and Rubinfeld 2014].

According to the solution suggestion against externalities proposed by British economist Pigou (1877–1959), a tax to be imposed on each unit of production (subsidy on positive externalities) equivalent to the external cost arising in the presence of negative externalities will equalize the costs of the firm to the social cost and reduce external damage [Nath 1973]. For this reason, it is known that the implementation of a Pigouvian Tax will reduce the spreading negative externality because it internalizes the spread external costs.

Governments tax fossil fuels, automobiles, highways, and emissions caused by automobiles to reduce fossil fuel consumption and prevent other negative impacts, especially carbon emissions, in the transport sector. Carbon tax, which is applied to the carbon content of fuels for this purpose, stands out as one of the most effective tools used in reducing carbon emissions [Perloff 2012]. Accordingly, to reduce carbon and other harmful gases generated from the burning of fossil fuels, legislators aim to increase the price of the products subject to externality by taxing one point in the consumption chain and consequently to reduce the spreading externality. There is a lot of evidence in the literature to support this idea [Timilsina and Dulal 2008, Fridstrřm et al. 2016, Gloriant 2018, Zhou et al. 2018, Ike et al. 2020, Santarromana et al. 2020].

By 2050, seventy-seven countries, ten regions and more than a hundred cities aim to reduce carbon emissions to zero. For this purpose, currently forty-six countries in the world apply carbon taxes. While Finland and Poland started applying carbon tax in 1990,

Norway and Sweden began in 1991 and Denmark in 1992. The level of tax applied varies from country to country. Consequently, while the tax applied per ton in Ukraine and Poland is below USD 1, it is USD 50 in France, USD 70 in Finland, USD 96 in Switzerland and USD 139 in Sweden. Although the tax amount foreseen to reach the temperature goal envisioned in the Paris Climate Agreement should be between USD 40 and 80, the amount of carbon taxes in effect worldwide is far below this. On the other hand, revenues from carbon taxes in 2018 totalled approximately USD 44 billion [WB 2019].

Carbon taxes in the transport sector have been applied by adding them to other taxes on fuel. This situation could further increase the price of fuels such as gasoline and diesel that are already taxed at high levels for various reasons, thereby reducing consumption levels. However, these taxes are often supported by different tools so that they do not negatively affect a society's low-income earners. For example, Portugal reduced its gasoline tax in 2019, despite the increase in its carbon tax [WB 2019]. Similarly, although the carbon tax applied in Finland has had a significant and negative effect, it is argued that the carbon tax has had a limited effect due to intensive tax exemptions and deductions applied in Denmark, Sweden, the Netherlands, and Norway [Lin and Li 2011]. Thus, the implementation of carbon tax is debatable in countries such as Turkey, where the taxes on fuel are quite high.

Another way of reducing carbon emissions is to create a tax structure (motor vehicle tax) that will ensure a preference for motor vehicles with low carbon emissions. Accordingly, a tax structure that references the carbon emission levels of vehicles will reduce carbon emissions by directly affecting both producer and consumer behaviour [Timilsina and Shrestha 2009]. Thus, low taxes on low-emission vehicles will encourage consumers to buy these vehicles, and vehicle manufacturers will compete to reduce emission levels. For example, the four-year tax advantage of a zero-emission vehicle compared to a vehicle with emissions of 200 g/km CO_2 is approximately EUR 6,000 in Germany, while it is approximately EUR 40,000 in Norway [Wappelhorst et al. 2018].

In conclusion, environmental taxes such as the carbon tax help to generate income while simultaneously reducing harmful emissions such as greenhouse gases. The fact that these taxes are included in the price mechanism and communicate the necessary signals to producers and consumers will lead to changes in production and consumption behaviour, and positively affect social welfare [Elgouacem et al. 2020]. In this context, countries' fiscal policies are gradually becoming more sensitive to carbon emissions [Gerlagh et al. 2018]. For example, there is evidence that annual road taxes implemented in Ireland and Norway reduce carbon emission as consumers tend to use diesel vehicles.

Regulations

Reagan expressed the state's role in the economy as follows: "Government's view of the economy could be summed up in a few short phrases: If it moves, tax it. If it keeps moving, regulate it. And if it stops moving, subsidize it". In this context, regulation can simply be defined as state intervention by legal means. States implement regulations in social, legal and economic fields in order to increase the welfare of societies. Thus, although the scope of regulation is very wide, it also has many types. According to the

OECD [1997, p. 6], regulation can generally be implemented in three areas: economic, social, and administrative. Economic regulation is directed at areas that do not function due to market failures. From this point of view, regulation can also be defined as the state's direct intervention in the market and the activities of economic agents to establish rules or impose prohibitions in such a way as to protect public interests [Chang 1997, p. 704]. Thus, the state can directly intervene in the market through methods such as pricing, competition, and market entry/exit via economic regulation.

Today, regulation is considered another important tool for the public sector's interventions in economic and social life. Accordingly, public regulations are encountered in many different areas of daily life, from smoking in closed areas to speed limits on highways. In this context, to reduce carbon emissions in the transport sector, governments can regulate the sector with the help of prohibitions and rules and thus direct them to the desired goals. For example, Japan has prepared various policies to reduce its carbon emissions by 90% before 2050 [Utagawa and Horio 2020].

The regulatory activities implemented by the European Union for the transportation sector can be used as an example of this idea. The European Union set average carbon emission standards in 2009, as previous commitments by automobile manufacturers to reduce carbon emissions did not yield the desired results. Accordingly, the targeted emission level for 2015 was 130 g/km CO_2. A similar regulation was introduced in 2011 for light commercial vehicles known as minibuses, and the target for 2017 was set at 175 g/km CO_2. With a new regulation introduced in 2014, the aim was to reduce the carbon emissions of new vehicles to 95 g/km CO_2 by 2021. In minibuses, a new target of 147 g/km CO_2 by 2020 has been announced. A third regulation proposed in 2017 was accepted on December 17, 2018. Accordingly, a gradual phase-down in the carbon emission levels of new passenger vehicles and light commercial vehicles is targeted by 2050. For example, the target for 2030 is 59 g/km CO_2. It has also been emphasized that significant penalties will be applied in the event of non-compliance with the determined standards [Dornoff et al. 2018, Gerlagh et al. 2018, Mock 2019].

Another practice conducted to reduce carbon emissions in the transportation sector is the regulation of urban transportation. In particular, traffic congestion caused by excessive numbers of vehicles increases carbon emission levels and causes air pollution. For this reason, increasing parking fees in cities both decreases the number of vehicles in traffic and provides positive effects through the increased use of public transportation [Liu 2020]. Similarly, measures such as reconsidering entry and exit times into the city, charging vehicles for city access, and facilitating shared bicycle systems and public transportation opportunities also yield successful results.

Conclusion

It is clear that in the coming years the transportation sector will be discussed regularly, and that accordingly, rapid change will occur. Environmental concerns arising from new technologies on the one hand and fossil fuel dependence on the other point to the future of a new transportation sector and a transformation. Because this sector is the world's most energy consuming and since demand in developing countries will increase in the future, many concerns about the sector's energy consumption arise from this change. This con-

cern highlights the need to increase sectoral energy efficiency, as well as focus on greener solutions. In terms of increasing energy efficiency, electric and hybrid vehicles constitute an important alternative for road transport.

The transport sector, by its very nature, has a great impact on carbon emissions. Therefore, a correction in the energy consumption of the sector directly affects the emissions from it. In a sector where petrol and other liquid fuels are used extensively, the higher cost of clean energy resources compared to fossil fuels also highlights policies to be implemented with the help of tools such as market regulations, environmental and carbon taxes, and subsidies.

Carbon taxes, which can be applied to the carbon content of fossil fuels, automobiles, and transport vehicles, are extremely effective tools for reducing carbon emissions. For this reason, many countries apply carbon taxes; however, most of these are OECD members, and the increase in costs associated with these types of taxes is a topic of much thought and discussion in many developing countries. Since it is expected that energy usage in the transportation sector in countries outside the OECD will increase in the future, it is important to develop market regulations that increase energy efficiency and reduce greenhouse gas emissions by taking these countries into account. At the same time, taking advantage of emerging technologies and shifting to low-emission transport systems through smart pricing should be encouraged by governments the world over.

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