DISTORTION OF PARAMETERS CONCERNING PASSENGER CARS IN THE CZECH REPUBLIC

Petr David[1], František Ostřížek[2]

Abstract

One of the basic requirements for the fiscal system of a state is that taxes serve their primary purpose, but do not cause other distortions of the market. This also applies to environmental taxes, including road tax. The aim of the present research is to find out whether there are distortions concerning the fleet in the Czech Republic in connection with the basic parameters of engine capacity and vehicle weight. The data of registered passenger cars in the Czech Republic were used and the frequency of occurrence of these parameters and their distribution across pre-defined intervals were examined. The results show that the parameter of engine capacity is affected not only by the requirements for utility characteristics of a vehicle but is also distorted by other features, road tax being one of them. Therefore, the road tax rates should be set as proportionate or flexibly progressive. The weight parameter is apparently not affected by distorting effects.

Keywords

Distortion, Engine Capacity, Weight, Passenger Car, Road Tax

I. Introduction and theoretical background

Efforts aiming at the mitigation of transportation impacts on the environment have been growing throughout the world. A fundamental step to be taken should be the correction of market failure to determine prices, as the externalities generated by transport are not reflected in prices. External costs of transport are mainly generated through local air and soil pollution, global air pollution, traffic congestions and accidents, exposure to noise and the need for infrastructure maintenance.

Economic and social sciences have always dealt with the efforts to incorporate externalities into the market processes. A significant element in the implementation of these efforts is the first best fiscal instrument in the form of a purely corrective tax. According to Pigou (1920), a tax which equals the marginal social damage should be applied in order to internalize external costs of producers' activities into their private costs. This requirement generally corresponds to institutional objectives of the European Union ensuing for example from the White Paper on Transport (European Commission, 2011), Decision No. 162/2013/EU (European Commission, 2013), Regulation No. 691/2011 of the European Parliament and of the Council (European Parliament and Council, 2011) or Decision 2015/1339 (Council of the European Union, 2015). The above-mentioned requirements are also in line with the UN goals, included in particular in the United Nations Framework Convention on Climate Change (UN, 1992) or the Kyoto Protocol (UN, 1997) and closely correspond to goals formulated by OECD (2011). The Czech Republic has also prepared binding documents supporting active solutions of transport externalities, such as the National Action Plan for Clean Mobility (Ministry of Industry and Trade, 2015).

[1] Mendel University in Brno, Faculty of Business and Economics, Department of Accounting and Taxes, Zemedelska 1, 613 00 Brno, Czech Republic. E-mail: david@mendelu.cz.
[2] Mendel University in Brno, Faculty of Business and Economics, Department of Informatics, Zemedelska 1, 613 00 Brno, Czech Republic. E-mail: xostrize@mendelu.cz.

In addition to the institutional sphere, the need to include transport externalities into the costs of vehicle operation is supported by the current state of academic knowledge, where it is appropriate to mention the recommendations of Leicester (2005); Nordhaus (2006), Stern et al. (2006); Parry, Walls and Harrington (2007); Sallee (2011); or Johnson, Leicester and Stoye (2013). However, there is a crucial complementary requirement accompanying the formulation of corrective measures, i.e. that such measures must not cause any other distortions or must restrict them to the least possible extent. The desired target condition must be better than the condition before the application of the corrective measure.

Kampas and Horan (2016) emphasize that in the event that the first best Pigovian tax causes additional distortions, the second best environmental taxation must be applied. Then the tax will be simply quantifiable and easily and economically collected without the consumers' welfare being affected. The issue is that the first best tax receipt should not be an additional revenue of public budgets, but only a transfer of funds to entities affected by a given externality. The role of environmental taxes in modern Czech and European practice is relatively insignificant and external costs are often addressed indirectly through substitute parameters with no feedback regarding the entities affected by the externalities. It is highly probable that environmental taxes in synergy with other taxes and fiscal instruments regulating the transport sector create distortions of the market.

For the purposes of this paper, the existing instrument in the form of road tax is accepted as given and unchangeable in terms of tax subject and base, although it is clear that these parameters are far from being optimally set in the Czech Republic (David, 2018). On the other hand, it was stressed by Cuervo and Ghandi (1998) that it is costly and even impossible to determine the exact social costs of environmental pollution and therefore, the second best solution should be used. Such solution may be reached with the help of the second best fiscal instrument in the form of road tax based on rather imperfect substitute parameters of environmental pollution, as the case is in the Czech Republic.

In the Czech Republic, the road tax proper is levied on vehicles used for business or even regardless of the purpose of use, in case their weight exceeds 3.5 t. The proportion of such vehicles within the fleet of the CR is relatively low, their number being 1,143,692 (CDV, 2019). The road tax base for passenger cars is engine capacity. For semi-trailers and other vehicles, it is the number of axles and weight. The tax rates are graduated. The rates for passenger cars are divided into six grades as fixed amounts depending on engine capacity. Annual tax rates range from 1,200 CZK to 4,200 CZK. For semi-trailers and other vehicles, the rates are first differentiated according to the number of axles and subsequently divided into 7 to 15 grades according to weight. Annual tax rates range from 1,800 CZK to 50,400 CZK. Rates of taxes on all vehicles may be subsequently reduced by up to 48 % based on the age of the vehicle.

Despite the mentioned graduated setting of road tax which has the potential of affecting the distortions of the fleet, it cannot be assumed that Czech road tax, which is levied on only a part of the vehicles anyway, should significantly determine and thus distort the parameters of the fleet vehicles. Therefore, the aim of this text is not to find a connection between the road tax setting and fleet condition in the Czech Republic.

The aim of the present paper is to find out whether there are distortions concerning the fleet in the Czech Republic in connection with the basic parameters of engine capacity and vehicle weight. In case fleet distortions are ascertained, the findings will be used in the theoretical formulation of the optimal conception of road tax rates so that they do not contain distorting parameters.

II. Data and methods

This paper focuses on the basic parameters of passenger cars registered in the Czech Republic, i.e. engine capacity and vehicle weight. These parameters are often included in Czech and European fiscal instruments regulating transport, such as mandatory or additional insurance of the vehicle, registration tax, toll or motorway fees, and are widely used as bases of road tax. Engine capacity is part of the tax base for passenger cars in 11 EU countries including the Czech Republic. Weight is part of the tax base for passenger cars in 5 EU countries (ACEA, 2018 and PwC, 2018).

Our efforts to identify fleet distortions are based on internal data of the Czech Register of Motor Vehicles as prepared by the Transport Research Centre (TRC, 2019). From the aggregate set of all vehicles registered in the Czech Republic, passenger cars have been filtered. Their number reaches 5,548,934. Of this number, 0.00115 % are defective records that do not enable technical processing of the data. The records concerning passenger cars are subsequently classified according to the frequency of occurrences of various values of engine capacity and weight. The indicator of frequency of occurrence of particular place values of the engine capacity and weight parameters is also used. For the engine capacity and weight, these are place values of ones, tens, hundreds and partly thousands.

Vehicle users show certain preferences concerning engine capacity due to the fact that it determines the utility characteristics of the vehicle. Thus, the information about engine capacity reflects expectations of the user concerning the vehicle properties during operation. Automobile manufacturers produce vehicles with certain engine capacities in order to meet requirements of users for vehicle operating characteristics. Users also have preferences regarding the size and equipment. These preferences determine the weight of the vehicle, which is not important for the user as such. Manufacturers produce vehicles of weights depending on the required size and equipment.

From the technical point of view, there is no other reason for preferring certain values of engine capacity and weight except the requirement for utility characteristics of road motor vehicles. In such case, the vehicle frequency distribution should to an extent correspond to the Gaussian normal distribution. The distribution of frequency of occurrence in the case of ones or tens as place values of the chosen parameters should be even. This is because we expect that such place values have no influence on the utility value of the vehicle.

Higher place values may be determined by specifics of user preferences, such as demand for luxury goods represented by large engine capacity or demands concerning the load capacity and thus the weight of the vehicle. Such specifics may become apparent in higher place values of the examined parameters, i.e. thousand or hundreds, as the case may be.

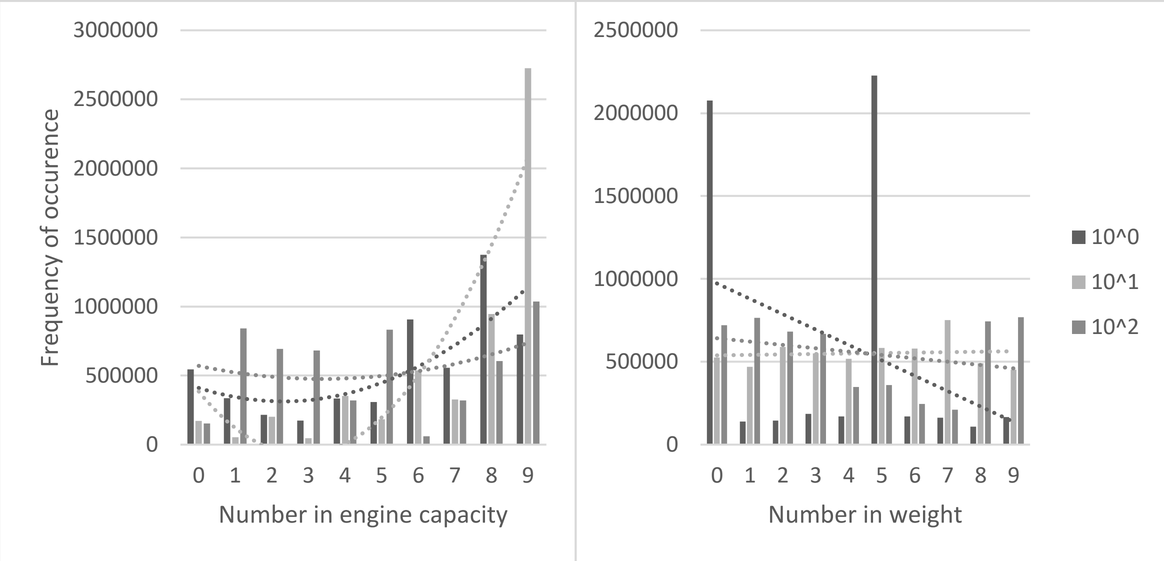
The intention is to identify the distortions of passenger car parameters as such. Thus, it is not important to distinguish such distortions from the viewpoint of production or consumption. It is important to identify them regardless of whether they originated through the distortion of the manufacturers' portfolio or through distortion of consumer behavior of buyers and users of the vehicles.

The identification of fleet (passenger cars) parameter distortions means the identification of inequalities in the place values of ones and tens in the selected parameters. It means that values on certain places accumulate and this fact cannot be explained through the utility value of the vehicle. The distortion regarding higher place values will be identified if there are fluctuations in the frequency of occurrence along the selected parameters of engine capacity and vehicle weight.

III. Results

Data concerning the frequency of occurrence of particular vehicles with certain engine capacity and weight can be obtained through the processing of these parameters concerning vehicles registered in the Czech Republic. In our effort to identify distortions in the selected parameters resulting from fiscal instruments, we first focused on place values of ones, tens, and hundreds of cubic centimeters of engine capacity, and ones, tens and hundreds of kilograms of vehicle weight. Graphic depiction of the mentioned facts seems as the most appropriate illustration for the given purposes.

Picture 1: Frequency of place value figures concerning engine capacity and weight of passenger cars in the Czech Republic



Source: Authors, based on data from TRC (2019)

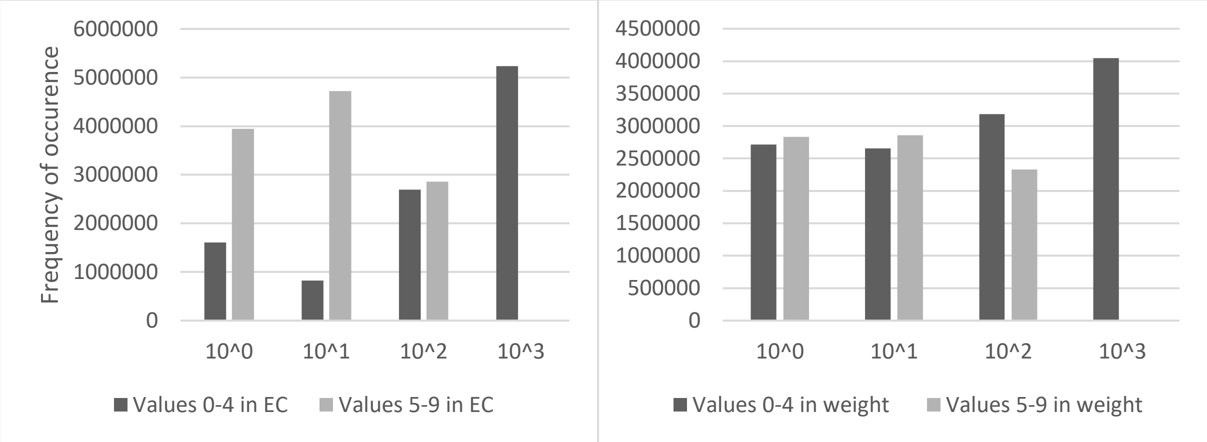
The place values of ones, tens and hundreds have been chosen both for the engine capacity and vehicle weight in Picture. 1 as the most significant. Let us first concentrate on the engine capacity parameter. The most frequently represented figures of the place value of ones are 8, 9 and 6. The dominant figure of the place value of tens is 9. Much higher frequency of occurrence than the other figures is represented by 8. The trend of frequency of occurrence is logically markedly increasing with the increasing figures of place value of tens. The place value of hundreds is most frequently represented by 9, followed, however, by 5 and 1.

In the distribution of values according to engine capacity, the place value of tens is never represented by the figures of 0–4 in the frequency of occurrence above 500,000 vehicles. This is apparent in the second columns of the individual figures 0, 1, 2, 3 and 4 in the left part of Picture 1. The frequency of occurrence exceeding 500,000 concerning the place value of tens is attributed to 76 % of the fleet of passenger cars in the Czech Republic.

The second part of Picture 1 depicts the parameter of vehicle weight. The most dominant figures of the place value of ones are 0 and 5. This fact determines the decreasing trend of frequency of occurrence with the growing figures of the place value of ones. For the place value of tens, the highest frequency of occurrence is with the figure 7; in general, the occurrence of all figures from 0 to 9 is much balanced. The trend corresponds to the situation. For the place value of hundreds, the occurrence of figures from 4 to 7 is relatively low. The occurrence of other figures is rather balanced and the trend is slightly decreasing.

Possible distortions of the parameters of engine capacity and passenger car weight on the level of individual place values (ones, tens, hundreds and thousands) can be well illustrated through the summary information concerning figures 0-4 and 5-9. For this purpose, we use the graphic depiction of the condition of passenger car fleet in the Czech Republic.

Picture 2: Summary occurrences of figures concerning the parameters of engine capacity and weight of passenger cars in the Czech Republic



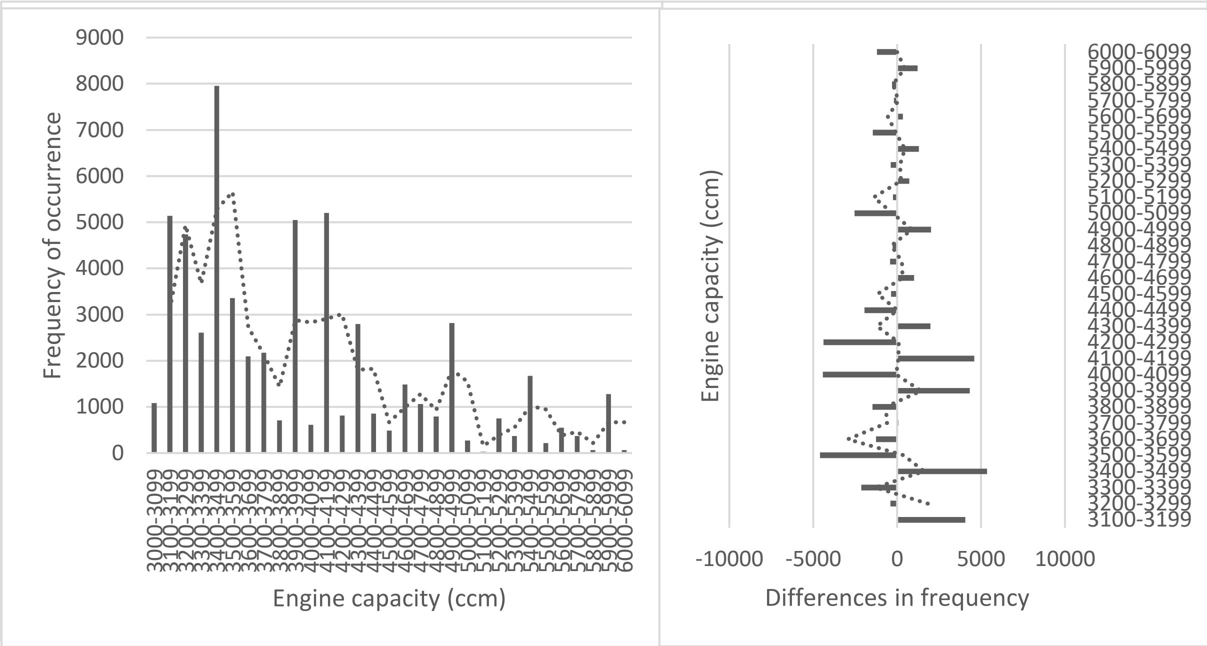
Source: Authors, based on data from TRC (2019)

Picture 2 shows the summary information concerning figures 0-4 and 5-9 for the parameters of engine capacity and weight. For engine capacity, the frequency of occurrence of figures 0-4 and 5-9 is balanced only for the place value of hundreds. Figures 5-9 are much more frequent for place values of ones and tens. On the other hand, figures 0-4 prevail in the place value of thousands.

The weight parameter is relatively balanced for summary information regarding figures 0-4 and 5-9, which applies to the place values of ones, tens and more or less also hundreds. The place value of thousands is predominantly represented by figures 0-4, similarly to the parameter of engine capacity.

Let us examine the parameter of engine capacity in more detail. The fleet of passenger cars is classified according to this parameter in the place value of hundreds of cubic centimeters. The intention is to identify possible accumulation of occurrences before certain margin values of the engine capacity parameter. For the sake of clarity of significant changes in occurrences, we shall first use the level of measurement for the engine capacity interval of 700-3,099 cc with high frequency of occurrence in the register of the Czech Republic. Within this interval, we shall also depict the differences for the graphic identification of turning points in the development of the frequencies of occurrence.

Picture 3: Frequency of occurrence of passenger cars in the CR according to the engine capacity parameter



Source: Authors, based on data from TRC (2019)

Picture 3 shows the interval of engine capacity from 700 to 3,099 cc. It is apparent that the frequency distribution is very different from the Gaussian curve. Most passenger cars registered in the Czech Republic have the engine capacity of 1,500 to 1,599 cc, followed by the interval of 1,100-1,199 cc. The frequency of occurrence of the next three intervals 1,200-1,299 cc, 1,300-1,399 cc and 1,900-1,999 cc) is balanced. The accumulation of occurrences of registered vehicles is apparent here. The turning points, where the frequency of occurrence drops, are intervals of 1,000-1,099 cc, 1,400-1,499 cc, 1,600-1,699 cc and 2,000-2,099 cc. Further irregularities are apparent from the accumulation of occurrences in the intervals of 2,100-2,199 cc, 2,400-2,499 cc and 2,900-2,999 cc. Turning points, or drops, are also well identified by the moving average curve in places where the column of values does not reach this average.

The graphic depiction of differences in the frequency of occurrence is made for the same interval of 700-3,099 cc. If the Gaussian curve, i.e. even frequency distribution, applied, there would be only one turning point from positive to negative values. In Picture 3, we can see 13 changes from positive to negative values. This situation has been caused by accumulation and subsequent drops in the frequency of occurrence in the case of certain intervals of engine capacity. The most significant drops in the frequency of occurrence are apparent after reaching the engine capacity of 1,000 cc, 1,200 cc, 1,400 cc, 1,600 cc, 2,000 cc, 2,200 cc, 2,500 cc and 3,000 cc.

There are 98.90 % of passenger cars in the Czech Republic in the first selected interval of engine capacity from 700 to 3,099 cc. It will be interesting to apply the same method and examine the next engine capacity interval of 3,000-6,099 cc with lower frequency of occurrence in the Czech Register. Within this interval, we shall also depict the differences for the graphic identification of turning points in the development of the frequency of occurrence.

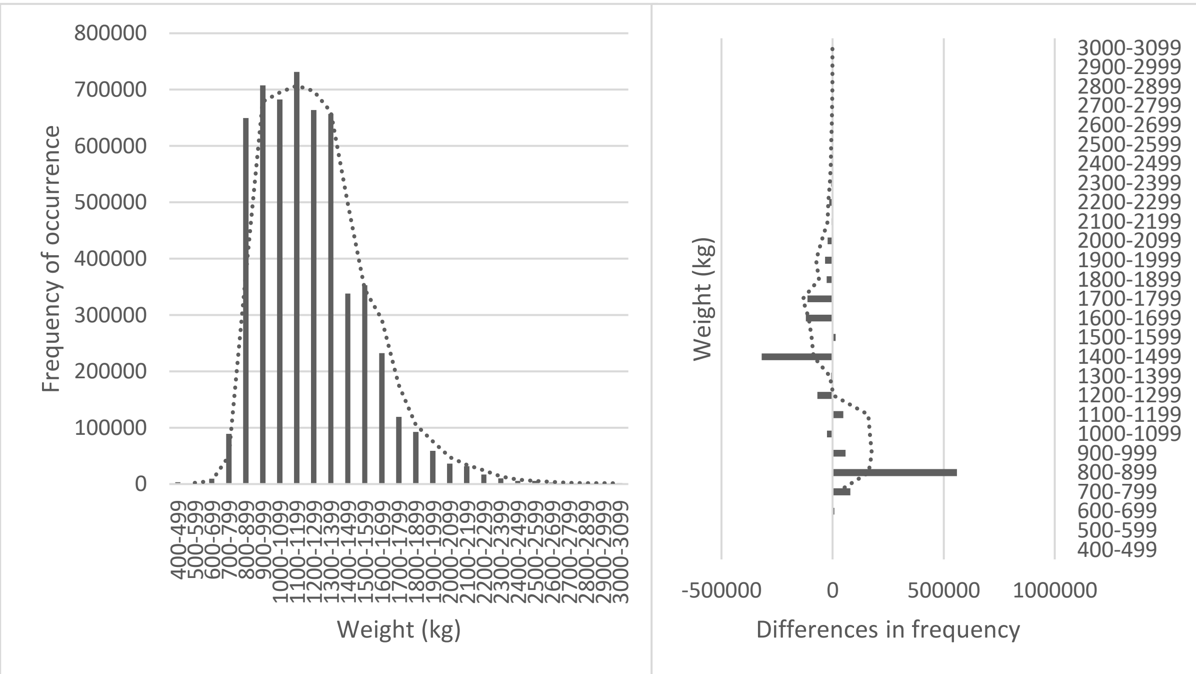
Picture 4: Frequency of occurrence of passenger cars in the CR according to the engine capacity parameter
Source: Authors, based on data from TRC (2019)

Picture 4 shows the next interval of engine capacity from 3,000 to 6,099 cc. The interval of 3,000-3,099 cc was selected as an area overlapping both the depicted intervals. There is an apparent difference from the part of the Gaussian curve on the right of its peak, where similarity to the shape of frequency of occurrence of the registered vehicles could be assumed. The accumulation of occurrences of registered vehicles can be seen mainly in the intervals of 3,100-3,299 cc, 3,400-3,499 cc, 3,900-3,999 cc, 4,100-4,199 cc, 4,300-4,399 cc, 4,900-4,999 cc, 5,400-5,499 cc and 5,900-5,999 cc. The turning points, where the frequency of occurrence drops, are the intervals of 3,000-3,099 cc, 3,300-3,399 cc, 3,500-3,599 cc, 4,000-4,099 cc, 4,200-4,299 cc, 4,400-4,499 cc, 5,000-5,099 cc and 6,000-6,099 cc. Turning points, or drops, are also clearly identified by the moving average curve in places where the column of values does not reach this average.

The differences in occurrences in the right part of Picture 4 are also depicted in the interval of 3,000-6,099 cc of Czech car fleet. In the decreasing part of the uniform distribution of the Gaussian curve, all points should be in negative values, whose absolute value should decrease with the increasing engine capacity, and approach zero. However, Picture 4 contains 21 changes from positive to negative values and vice versa, which is a result of accumulations and drops in the frequency of occurrence. The mentioned accumulations and drops are not as significant as those identified in the interval of 700 to 3,100 cc, on the absolute scale of frequency changes; nevertheless, they are significant on the relative scale. In summary, the drops in the frequency of occurrence have been identified after reaching the engine capacity of 3,000 cc, 3,300 cc, 3,500 cc, 3,800 cc, 4,000 cc, 4,200 cc, 4,400 cc, 4,500 cc, 5,000 cc, 5,500 cc and 6,000 cc.

The last parameter to be examined is that of weight of passenger cars registered in the Czech Republic. The fleet of passenger cars is classified by hundreds of kilograms according to this parameter. Accumulation of occurrences before certain margin values of the weight parameter could be expected here, too. For the sake of clarity of significant changes in occurrences, we shall first use the level of measurement for the weight interval with the frequency of occurrence exceeding 1,000 passenger cars in the Register of the Czech Republic. Within this interval, we shall also depict the differences for the graphic identification of turning points in the development of the frequency of occurrence.

Picture 5: Frequency of occurrence of passenger cars in the CR according to the weight parameter



Source: Authors, based on data from TRC (2019)

Picture 5 shows the interval of weight between 400 and 3099 kg for vehicles with frequency of occurrence over 1 000. This interval includes 99.23 % passenger cars registered in the Czech

Republic. Despite the obliqueness in the left-hand part and certain partial deviations, the frequency distribution is relatively similar to the Gaussian curve. Most of the vehicles registered in the Czech Republic are within the interval of 1100-1199 kg. The surrounding intervals (800-1099 kg and 1200-1399 kg) comprise slightly lower and almost balanced occurrences. Frequency of occurrence in the remaining intervals is much lower. In the intervals of 900-999 kg and 1,500-1,599 kg, there is certain accumulation of occurrences of registered vehicles. The intervals of 1,000-1,099 kg and 1,400-1,499 kg, which neighbor on intervals with identified accumulation, are turning points with drops in the frequency of occurrence. It is not possible to clearly identify other irregularities in the shape of frequency of occurrence. The moving average curve confirms the above mentioned assessment of frequency of occurrence of weight intervals for passenger cars registered in the Czech Republic.

The differences in frequency of occurrence are also identified for the interval of 700-3,099 kg. The shape of differences relatively corresponds to the shape of differences in the case of equal distribution of the Gaussian curve. The real shape of frequency of occurrence differs from the Gaussian curve only in the weight intervals of 900-999 kg and 1,500-1,599 kg, identified earlier, whereas the deviation in the interval of 900-999 kg is more significant. We have identified accumulations and subsequent drops in the frequency of occurrence in the above weight intervals. Such drops are apparent after reaching the weight of 1,000 kg and 1,400 kg.

VI. Conclusion

The research into the parameters of engine capacity and weight concerning 5.5 million passenger cars registered in the Czech Republic (TRC, 2019) has identified facts whose interpretation is rather serious due to the undesirable nature of market distortions caused by fiscal instruments (Kampas and Horan, 2016). It has been ascertained that the representation of individual figures of place values of ones, tens, hundreds and thousands concerning the engine capacity parameter is not balanced. The most pronounced inequality of distribution is in the place value of tens, where the figures 9 and 8 prevail. The most frequently represented figures of the place value of ones are 8, 9 and 6. Inequality in the place value of hundreds is not as distinct; however, it has been identified, with figures at the end of the series 0-9 prevailing. In the distribution of values according to engine capacity, the place value of tens is never represented by the figures of 0–4 in the frequency of occurrence above 500,000. The place value of thousands is predominantly represented by figures 0-4. However, the place value of thousands corresponds to utility characteristics of vehicles, and therefore this cannot be considered a fact distorted by other instruments. It can be summarized that if the assumption of equal distribution of manufacturers' and users' preferences of engine capacity in the place values of ones, tens and hundreds is valid, the identified distortions have been caused by other factors, which include fiscal instruments and thus the road tax.

The distortions of the parameter of engine capacity identified through the measurement of frequency of occurrence of certain figures are further evidenced by the graphic depiction of frequency distribution into intervals determined in such manner that it is possible to identify accumulation of occurrences and their turning points. Unjustifiably low frequencies of occurrence have been identified in the intervals beginning with 1,000 cc, 1,400 cc, 1,600 cc, 2,000 cc, 2,500 cc and 3,000 cc. Logically, accumulation of occurrences can be seen before these values. When depicting the intervals of engine capacity exceeding 3,000 cc, whose frequency of occurrence is generally lower, unjustifiably low frequencies of occurrence have again been identified in the intervals beginning with 3,000 cc, 3,300 cc, 3,500 cc, 4,000 cc, 4,200 cc, 4,400 cc, 5,000 cc and 6,000 cc. Again, there is accumulation of occurrences before these values.

The existing distortions of the engine capacity parameter concerning passenger cars registered in the Czech Republic are further illustrated by the different shape and by the number of changes from positive to negative values in the calculation of the indicator of differences in occurrences of registered passenger cars within the individual intervals of engine capacity. If the frequency of distribution was even, there would be only one change of the sign. However, 13 such changes have been identified in intervals with higher frequency of occurrence (700-3,099 cc), which includes 99 % of vehicles. In the next interval with the lower frequency of occurrence (3,000-6,099 cc) there are 21 changes of the sign.

The second parameter of passenger cars, where the representation of figures was examined, was the vehicle weight. In the place values of ones, the figures 0 and 5 prevail; other figures are relatively evenly represented. There is a simple interpretation of such results: a tendency to round off when reporting the parameter and thus insignificance of such parameter in the place value of ones from the point of distortion. This is confirmed also by balanced occurrences of figures of place values of tens and hundreds in the weight parameter. Uneven distribution is only in the case of place value of thousands. Similarly to the engine capacity parameter, this fact can be explained through the dependence of this place value on the utility characteristics of the vehicle, not on the examined distorting effects. Therefore, if the assumption of even distribution of manufacturers' and users' preferences in the place values of ones, tens and hundreds is also valid for the weight parameter, then additional factors, i.e. fiscal instruments and road tax, are not determining, and thus do not create significant distortions.

A detailed view of the distribution of frequency of weight values in the individual intervals confirms the existence of relatively even distribution with 99 % of vehicles.If we should identify areas with the highest irregularities in the frequency of occurrence, it would be the weights of 1,000 kg and 1,400 kg. However, the frequency of occurrence of the mentioned turning points is not as significant as the turning points identified in the parameter of engine capacity. Also the graphic depiction of differences more or less corresponds to the shape of differences in the Gaussian even distribution.

In conclusion it may be summarized that the distorted parameter is that of engine capacity, not the weight of the passenger car, which is not present in the road tax base of passenger cars in the Czech Republic, anyway. The instruments with potential distorting effects on the engine capacity of passenger cars, which also include road tax, should therefore be set and applied in such way that the distortion of the engine capacity parameter is eliminated. The proposed solution is to set the road tax rates proportionately, so that each cubic centimeter is levied the same amount of tax. If progressive rates are required, the progression should be flexible, not based on grades. Such recommendations do not contradict theoretical and practical research conclusions (Sallee, 2011; Johnson, Leicester and Stoye, 2013) nor institutional requirements (European Commission, 2011; UN, 1997; OECD, 2011; Ministry of Industry and Trade, 2015) in the area of environmental taxation.

Acknowledgments

This paper was supported by the Technology Agency of the Czech Republic. It is processed as an output of a research project TAČR ÉTA no. TL01000308.

References

ACEA. (2018). *Acea Tax Guide 2018*. Retrieved January 10, 2019, from https://www.acea.be/uploads/news_documents/ACEA_Tax_Guide_2018.pdf.

Council of the European Union (2015). *Council Decision (EU) 2015/1339/EU*. Retrieved Ferbruary 21, 2019, from https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1546425751756&uri=CELEX:32015D1339.

Czech Republic. (2017). *Act no. 16/1993 Sb., on Road Tax, as amended*. Retrieved January 15, 2019, from https://www.zakonyprolidi.cz/cs/1993-16.

David, P. (2018). Evaluation of Road Transport taxation in the Czech Republic in an Environmental Context. In: *Business Trends 2018*, University of West Bohemia.

European Commission (2013). *Commission Decision 2013/162/EU*. Retrieved Ferbruary 5, 2019, from https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1546425337416&uri=CELEX:32013D0162.

European Commission (2011). *White Paper. Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system*. Retrieved Ferbruary 13, 2019, from https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1546425457577&uri=CELEX:52011DC0144.

European Parliament and Council of the European Union (2011). *Regulation (EU) 691/2011*. Retrieved Ferbruary 14, 2019, from https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1546425554791&uri=CELEX:32011R0691.

Gandhi, V. P., Cuervo, J. (1998). *Carbon Taxes-Their Macroeconomic Effects and Prospects for Global Adoption - a Survey of the Literature*. IMF Working Paper WP/98/73. International Monetary Fund. Retrieved April 2, 2019, from https://www.imf.org/en/Publications/WP/Issues/2016/12/30/Carbon-Taxes-Their-Macroeconomic-Effects-and-Prospects-for-Global-Adoption-A-Survey-of-the-2601.

Johnson, P., Leicester, A., Stoye, G. (2013). *Fuel for Thought: The what, why and how of motoring taxation*. London: Institute for Fiscal Studies for the RAC Foundation.

Kampas, A., Horan, R. (2016). Second-best pollution taxes: revisited and revised. *Environmental Economics and Policy Studies,* 18(4), 577-597.

Leicester, A. (2005). *Fuel taxation.* Briefing Note No. 55. The Institute for Fiscal Studies. Retrieved March 30, 2019, from https://www.ifs.org.uk/bns/bn55.pdf.

Ministry of Industry and Trade. (2015). *Národní akční plán čisté mobility*. Retrieved March 28, 2019, from https://www.mpo.cz/assets/dokumenty/54377/62106/640972/priloha001.pdf.

Nordhaus, W. D. (2006). *The "Stern review" on the economics of climate change*. NBER Working Paper 12741. National bureau of economic research. Retrieved April 6, 2019, from https://www.nber.org/papers/w12741.pdf.

OECD. (2011). *Environmental Taxation.* OECD Publications. Retrieved April 8, 2019, from https://www.oecd.org/env/tools-evaluation/48164926.pdf.

Parry, I. W., Walls, M., Harrington, W. (2007). Automobile externalities and policies. *Journal of economic literature,* 45(2), 373-399.

Pigou, A. C. (1920). *The economics of welfare*. London: McMillan & Co.

PricewaterhouseCoopers. (2018). *2018 Global Automotive Tax Guide*, Retrieved January 11, 2019, from https://www.pwc.de/de/automobilindustrie/2018-pwc-global-automotive-tax-guide.pdf.

Sallee, J. M., (2011). The taxation of fuel economy. *Tax Policy and the Economy,* 25(1), 1–37.

Stern, N., Peters, S., Bakhshi, V., Bowen, A., et al. (2006). *Stern Review: The economics of climate change*. Cambridge: Oxford University Press.

Transport Research Center (TRC). (2019). *Registr silničních vozidel*. Retrieved March 28, 2019, from: Internal data.

United Nations. (1992). *United Nations Framework Convention on Climate Change*. Retrieved March 16, 2019, from https://www.mzp.cz/C1257458002F0DC7/cz/ramcova_umluva_osn_zmena_klimatu/$FILE/OMV-anglicky_umluva-20081120.pdf.

United Nations. (1997). *Kyoto Protocol to the United Nations Framework Convention on Climate Change.* Retrieved March 16, 2019, from https://www.mzp.cz/C1257458002F0DC7/cz/kjotsky_protokol/$FILE/OMV-anglicky_protokol-20081120.pdf.