ERASMUS UNIVERSITEIT ROTTERDAM
ERASMUS SCHOOL OF ECONOMICS

THE COSTS OF FUEL CONSUMPTION DISCREPANCIES

Mohamed el Koubai

Master Thesis

Supervisor: Giuliano Mingardo

Urban, Port and Transport Economics

Economics and Business

Erasmus University Rotterdam

July 2014

Preface

This thesis is the final examination of the master program Urban, Port and Transport Economics at the Erasmus University Rotterdam. It also forms the end of my academic career and I am proud that I could close this chapter of my life with a study that aligns perfectly with my fields of interest. I would like to use this opportunity to thank my supervisor Giuliano Mingardo for his continuing support and valuable insights. Furthermore, I would like to thank my parents for supporting me all the way. Lastly, but most importantly to myself, I am grateful for the Lord Almighty for giving me the chance to complete my academic career and this thesis successfully.

I hope you will enjoy reading this thesis and hopefully it will broaden your horizon.

Mohamed el Koubai

July, 2014

Executive summary

The aim of this thesis is to determine the welfare loss instigated by the discrepancy in theoretical and actual fuel consumptions of company cars in the Netherlands. With this is mind, the research focuses on three areas, namely the fiscal losses for the government, the non-financial costs for the government as measured by the carbon emissions, and the financial costs for the companies. The importance of this research is highlighted by the increasing popularity of offering company cars as fringe benefits to employees and the implementation of emission based taxation. In order to address these issues, a company car dataset provided by Athlon Lease Company will be analyzed. The dataset spans from 2006 to 2011 and provides data about 14,361 cars. These data will be used to proximate population characteristics by making use of sample averages. Since the emissions based taxation scheme was only implemented from 2010 onwards, this research will focus on 2010 and 2011.

The analyses performed resulted in a number of conclusions. Firstly, it supported the findings by earlier research (e.g., Ligterink and Bos, 2010; TNO, 2013) that huge differences exists between the theoretical fuel consumption, as indicated by the car manufacturers, and the actual fuel consumptions, as measured by tank cards. Secondly, it provided evidence that cars with a lower theoretical consumption have larger deviations, indicating that evidence for improvements in fuel consumptions are more equivocal than expected. Thirdly, it highlighted, as proposed by this research, that current fiscal policies are based on inaccurate information. After aggregation to the whole company car fleet, this resulted in a net fiscal loss of €250,914,084 in 2010 and €612,890,348 in 2011. The increase is mainly driven by increasing deviations, but also by higher tax rates in 2011. The fiscal loss is expected to increase in the following years, as the taxation schemes are becoming more stringent. Furthermore, the discrepancy resulted in additional carbon emissions of 812,433,394 kg of CO_2 in 2010 and 1,097,042,963 kg of CO_2 in 2011. This represents respectively 0.39% and 0.53% of the total carbon equivalents emitted. Fourthly, it derived that the additional financial costs for the companies offering these fringe benefits equaled €265,486,218 in 2010 and €430,972,269 in 2011.

In order to address the above raised issues, new legislations are needed to regulate the fuel consumption test procedures. These are often branded as non-realistic and consequently lead to a systematic underestimation of fuel consumption. Moreover, it is advisable that the Dutch government incorporates these discrepancies into the current tax framework by utilizing either actual emissions as a basis, or adding a yet to determined fixed percentage on the theoretical emissions. Furthermore, it is also possible to incorporate a taxation scheme based on the 'kilometerheffing' principle by levying a variable tax (i.e., incorporating road tax in the fuel price). Lastly, given the importance of driving behavior on fuel consumption, the Dutch government and companies alike must aim at making the installation of fuel efficiency driving tools mandatory.

Inhoud

Introduction

Over the past two decades most of the industrialized world experienced large increases in car ownership, resulting in rapid increases in total travel on the roads and declining absolute market shares for public transport (King, Manville and Shoup, 2007). This trend is clearly illustrated by Bonsall (2000), who notes that, in the United Kingdom, car ownership rose from 30% of the households in 1960 to over 70% in 1995. This trend is not only limited to the UK, but also apparent in the US and other countries in the world, including in the Netherlands. By 2000, car ownership in for example the US had surpassed the average of one car per licensed driver in many urban areas.

This explosion of car ownership has led to severe consequences, which is widely acknowledged by literature. Foster (1972), for example, identified thirteen specific local forms of adverse environmental effects, which can be directly attributed to urban transport alone. Thomson (1974) extended this list even further and asserted that matters such as the size of cities, residential densities, and migration of population are influenced by the provision of transport. However, the focus has recently been more on the growing emissions of carbon dioxide (CO_2), which is known as the main global-warming gas. Currently, over 15% of the world's emissions of CO_2 are attributed to motor vehicles. This figure is expected to rise to 40% in the developed countries (Button, 2006). Furthermore, transport is also responsible for 50% of the emissions of nitrogen oxide (NO_x) which, when combined with other pollutants, forms nitric acid and consequently falls as acid rain. Aggregation and quantification of all these adverse effects is however very difficult. Despite this, Quinet (1989) aggregated the findings of individual studies in order to get an impression of the overall environmental costs of transport. Herein it is argued that these constitute about 23% of the gross domestic products of most industrialized economies. This number should of course be interpreted with caution, but it gives nevertheless an indication of the overall effect of road transport. The table depicted below gives a breakdown of these so-called negative externalities.

At the core of these externalities lies the passenger transport, which is accountable for a significant portion of the total domestic energy use and has shown a substantial increase over the last two decades. In the Netherlands, the total fuel consumption by passenger cars increased from 184 Peta Joule (10^{15} Joule) in 1980 to over 260 PJ in the year 2000, which equals 8% of the total energy use in the Netherlands. Between 1995 and 2005, the total number of cars increased by 24% and still increasing (Geilenkirchen et al., 2004). This signifies a challenge for current and future policy makers.

Table 1: Breakdown negative externalities attributable to transport

Broad Estimates of the Costs of Selected Environmental Damage Due to Land Transport, Expressed as a Percentage of Gross Domestic Product

Environmental problem	Costs (% of GDP)	
	Road	Other modes
Noise	0.10	0.01
Pollution	0.40	
Accidents	2.00	
Time	6.80	0.07
Use expenditure*	9.00	0.30
Total	18.30	4.71

Note: * This embraces such items as infrastructure management.
Source: Derived from Quinet (1989).

It is however important to note that passenger transport can be subdivided into 2 main groups, namely private cars and company cars. The latter saw an increase in the period 1995-2005 of over 41% (from 548,000 to 771,531 cars). The majority of passenger transport is nevertheless formed by private cars, but the company cars possess an important dilemma. In the Netherlands, company lease cars are often provided to employees as an attractive co-benefit besides salary, but are also offered simply because of the travel requirements associated with a function. The car can in addition to professional use also be used in private, but the fuel costs are generally paid by the company through the usage of a fuel card. This scheme results in a situation where employees with a company car have limited to no financial incentive to conserve fuel consumption and costs that are fully covered by the company. In addition to other notable factors, this form of the 'principal agency problem' results in higher fuel consumptions. Consequently, higher carbon emissions are emitted in practice than is theoretically expected (Graus and Worrell, 2008).

This theoretical consumption is however used a basis for procurement for consumers and business alike. However, a huge difference exists between the theoretical and actual fuel consumption. Numerous causes for this difference exist, but the discrepancy is often credited to structural underestimation of the theoretical consumption due to testing in ideal or non-existent situations. Moreover, the driving behavior of employees is also considered to be conducive to this discrepancy. This is especially exacerbated due to the earlier mentioned agency problem between companies and employees. But this discrepancy is not only detrimental to consumers and business, but it also harmful for the Dutch government, since it uses the carbon emissions derived from theoretical usage as a basis for tax purposes, such as the Bijtelling[1], BPM[2] and quarterly road tax. This discrepancy is especially of upmost importance for the government for reasons of both distribution and efficiency. If current policies fail to tax company cars adequately, gains accrue to the holder or provider of the company car, which may not fit well with the government's overall distributional objectives. In addition to this, the effective price of car services will be reduced for company car holders. This will encourage more cars and possibly larger cars to be bought, and will discourage the use of other means of transport. The latter is particularly important, as the government invests significantly in public transport. But the differences between theoretical and actual consumption means that these current tax policies endure huge losses in tax revenues and that company cars are not taxed optimally. Additionally, societal damages take place due to increased pollution. Damages for which no party is held accountable, as is usual the case with transportation. This all begs the following question:

What is the welfare loss due to the discrepancy in theoretical and actual fuel consumption of company cars?

This problem is, to the best of the author's knowledge, not addressed earlier by existing literature. Although the supply and demand for fringe benefits received a lot of attention in economics textbooks (e.g., Ehrenberg and Smith, 2003), the effects of distortionary fringe benefits on taxation received little attention in the recent empirical literature. This is remarkable, especially since the government has a long history of promoting more environmental friendly passenger cars. This aspiration is largely founded on the policy of offering tax reductions for cars with lower carbon emissions. Using the theoretical values of the car manufactures as a basis, Geilenkirchen et al. (2004) deduced that the average carbon

[1] Bijtelling: Amount added from lease cars on taxable income (see chapter 2.3).
[2] BPM: One-time tax that is paid when the vehicle is bought or registered for use in the Netherlands (see chapter 2.3).

emission per driven kilometer of new cars sold, between 2010 and 2014, are approximately 4 to 5% lower. Furthermore, the authors argue that this development is primarily driven by the green-oriented taxation schemes. But the fuel consumptions and therefore emissions are in practice much higher, so the results of this policy could be more equivocal than one would initially expect. Additionally, the costs of implementing such policies could also be much higher than is now acknowledged. This is repeatedly argued by the CBS (e.g., Geilenkirchen et al., 2004) and to this data no earlier research addressed this issue. Hence, this research attempts to fill this gap by assessing the overall costs that can be attributed to the discrepancy in theoretical and actual fuel consumptions.

In order to address this research question, a number of key sub questions are identified. This is necessary in order to preserve some focus and structure in this study, as the term costs encompasses an unlimited array of components. Table 1 already highlighted this by displaying many cost drivers related to transportation besides pollution, such as noise and accidents. Consequently, this research will concentrate only on the financial and non-financial costs for the government, whereby the latter group is measured solely by carbon emissions. The reason for this is rather straightforward. The last few decades displayed increasing attention on carbon emissions, which is attributable to the fact that it has been identified as the main driver of global warming. Moreover, it forms by far the largest portion of pollutants in gasoline and diesel. Also interesting to note, is that the carbon emissions also affects people's health through global warming (Tol, 2005). The government is however not the only actor that incurs hidden costs due to the discrepancy between theoretical and actual fuel consumption. Also the market endures adverse effects, since it provides the cars as a fringe benefit. As such, the financial costs for the market will be derived. The non-financial costs will hereby be ignored, since this will display the same result as the non-financial costs for the government. In conclusion, the following questions are derived:

1. *What are the financial costs for the government ?*
2. *What are the non-financial costs for the government?*
3. *What are the financial costs for companies?*

These questions will be answered by means of a dataset that is acquired from Athlon, which is one of the largest car lease company in the Netherlands. Given the nature of the problem, this research is divided into 5 parts. Firstly, a review of relevant literature and background information will be presented. Secondly, the scope of this research is further specified, which includes a comprehensive description of the data used. Thirdly, a thorough elaboration of the methodology will be presented. Fourthly, the results of the analyses will be presented. This paper will finally conclude with the implications for policymakers, the overall conclusion of the study, limitations of the research, and recommendations for future research.

2. Theoretical framework

This chapter will give an overview of the relevant literature and information necessary to address the research question. For this purpose, this chaptered will be structured in 2 main parts. Firstly, the current fuel consumption test procedures will be discussed, followed by a review of past literature. Secondly, vital background information will be presented, namely relevant information about the company car market in the Netherlands, the related principal-agent problem, and the current taxation scheme.

2.1 Fuel consumption test procedures

Fuel consumption is generally expressed by the amount of liters needed per 100 kilometers. As earlier mentioned, the theoretical consumption is determined after performing numerous tests by car manufacturers. This theoretical consumption must comply with a number of directives (i.e., Euronorm), which determines the boundary of the acceptable for four types of pollutants, namely CO, NO_x, HC and CO_2. It is also important to note that these results are further communicated to governmental institutions, which uses it as a basis for tax purposes. The test procedures are therefore of upmost importance.

A central actor in the assessment of fuel consumption, is the New European Driving Cycle (NEDC). This laboratory test is used to test the fuel consumption of cars and is constructed such that all cars are subject to the same trials. This ensures unbiased tests and enables clear benchmarking. Given the different conditions cars usually are subjected to, the tests consists of 2 main parts, more specifically the so-called ECE-15 and the Extra Urban Driving Cycle (EUDC). The former is performed in order to determine fuel consumption under typical driving conditions in a typical European city (e.g., Paris/Rome). The car is hereby subject to conditions such as multiple accelerations and decelerations and is performed four times. The latter aims at simulations driving conditions outside urban areas (at high speeds), which are often less dynamic than urban areas and is simulated one time after the fourth ECE-15 (Tzirakis, Pitsas, Zannikos, and Stournas, 2006). These processes are summarized in figure 1.

Despite the logic behind the NEDC, the test procedure has endured a constant barrage of criticism. It is often argued that the NEDC fails to meet the objective of the test and that is determining the fuel consumption cars. Firstly, the test is characterized by slow accelerations, low dynamic driving conditions, and a very small interval with higher speeds (i.e., only a few seconds with 120 km/h). In other words, the cycle simulates conditions that are not realistic. Consequently, the actual consumption will differ significantly from the figures derived through these laboratory tests (Tzirakis et al., 2006).

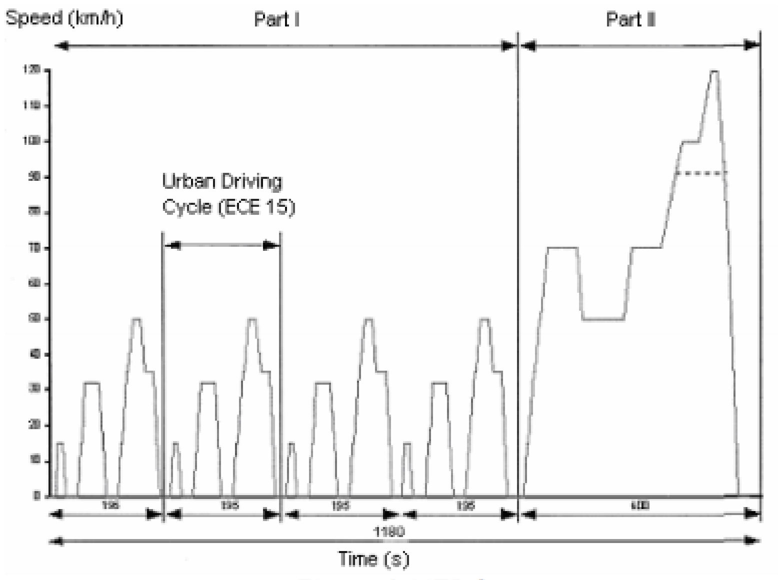
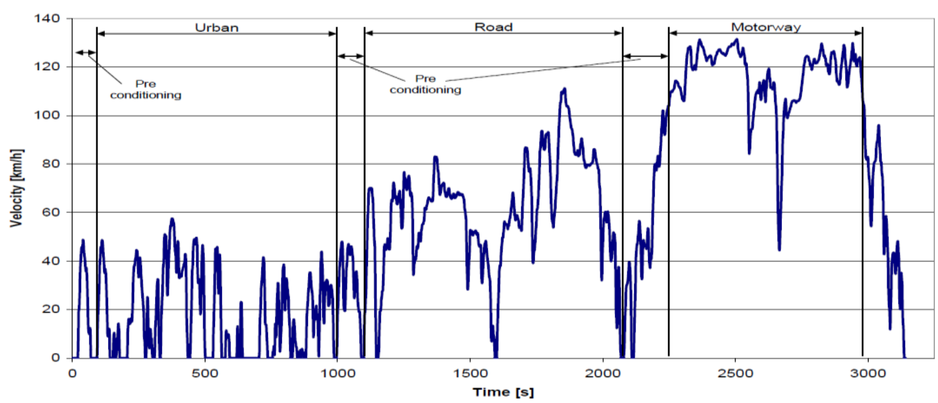


Figure 1: NEDC

Given these shortcomings, a number of alternative cycles are introduced. One of these is the so-called Common Artemis Driving Cycles (CADC), which is often praised as simulating real-life scenarios (see figure 2). It is characterized by stronger accelerations, higher dynamic driving conditions, and longer intervals with higher speeds (with peaks up to 130 km/h). The results of such a test are displayed in the figure below and show higher fuel consumption than the NEDC method.

Figure 2: CADC



2.2 Literature review

The issues surrounding the discrepancy between actual and theoretical consumption is addressed by Ligterink and Bos (2010). Using a comprehensive dataset with 240,000 tank cards, they offered empirical evidence that, despite common believe of decreasing fuel consumption and related carbon emissions, huge deviations exists between the consumption derived from tests and consumption in the real world. More precisely, a car typified by higher fuel efficiency demonstrates a larger deviation. According to the authors, the discrepancy between the CO_2 emissions values reported by the tank card company and manufactures increased from 11% in 2004 to over 28% in 2011. Ligterink and Bos (2010; p. 9) even argued the following: *"In particular for petrol vehicles for the most recent models, one can add 45-50 g/km to the type-approval CO_2 emission, to arrive at the real-world CO_2 emission".* This is troubling indeed, as this would mean that current tax policies are founded on inaccurate information. More troublingly, is the fact that the deviations are larger for the more efficient cars, which consequently profit more from the favorable tax benefits. Hence, the differences in taxes based on theoretical emissions are much larger for the most efficient cars. This is best illustrated by figure 3, which visualizes the continuous deviation between the theoretical and actual consumption.

The main reason for this deviation is already discussed in the section about NEDC, as it fails to mimic real-world driving conditions. This is also supported by Mock, German, Bandivadekar and Riesmersma (2012). The authors also attribute the deviation to a misplaced focus of car manufacturers. Fuel consumption is higher in urban areas due to increased intensity of accelerations/deceleration. Consequently, manufacturers have strongly focused on increasing fuel efficiency in these conditions, while ignoring fuel efficiency at higher speeds in other conditions (e.g., open roads). Lease car holders are however especially subject to the latter. It is therefore that the lower fuel consumption in urban areas is more than offset by the higher fuel consumption outside urban areas.

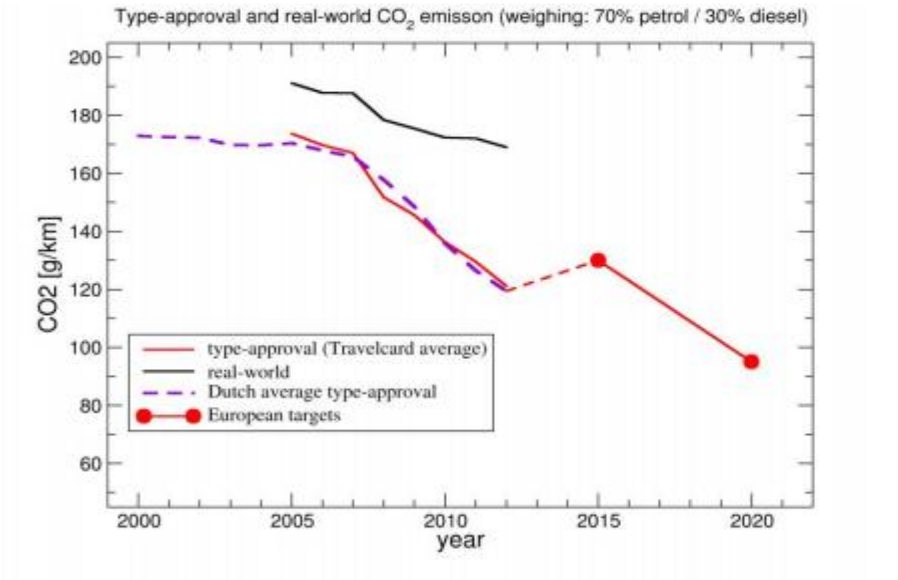


Figure 3: Discrepancy theoretical and actual CO_2 emissions

According to the TNO (2013), a Dutch research institute, the actual fuel consumption is generally speaking 23% higher than theoretical fuel consumption and can even amount to over 30%. This deviation seems to be larger for newer models, which is in accordance with the conclusions raised by Ligterink and Bos (2010). The deviations are often attributed to two main factors, namely the external factor and the optimization of test procedures by manufacturing companies. The first is related to the state of the vehicle, the driving behavior, and the driving location (i.e., urban vs. outside the city). The latter is related to the manipulation of test conditions (e.g., wind resistance, outside conditions) in order to lower the theoretical consumption to a minimum.

The notion that non-technical factors are also pertinent in explaining these deviations is supported by Rouwendal (1996). By investigating a wide range of predictor variables (e.g., gender, income, distance etc.), Rouwendal (1996) found not only empirical evidence for the technical characteristics, but also for non-technical factors, namely the age of the driver, type of employment, and the price of fuel. In addition to this, Rouwendaal (1996) found strong evidence for the existence of a short term effect of fuel pricing on the driving behavior and consequently fuel consumption. More precisely, an increase in fuel price leads to a short term fuel consumption (due to more sustainable driving). The latter finding is supported by Sivak and Schoettle (2011), who asserted that making use of eco-driving – making optimal strategic decisions (e.g., vehicle selection), tactical decisions (e.g., route selection), and operational decisions (e.g., driving behaviors) – can significantly reduce the fuel consumption. It is argued by the authors that, of all eco-driving strategies, vehicle selection has by far the most dominating effect, followed closely by driving behavior which can induce 45% reduction in fuel consumption. This conclusion was also supported by Barkenbus (2010), who found that driving behavior can induce a reduction of fuel consumption by 10%.

The influence of the driving behavior on fuel consumption is gradually being acknowledged as a source for improving the fuel consumption positively. For example, Van der Voort, Dougherty, and van Maarseveen (2000) studied the merits of using tools that calculate fuel consumptions of driving maneuvers carried out by the chauffeur, whereby recommendations are given for minimizing fuel consumption. Remarkably, the use of tools resulted in a 16% reduction of fuel consumption, whereas eco-friendly driving without the tools led to a decrease of only 9%. The positive influence of tools on fuel consumption is also highlighted by Barth and Boriboonsomsin (2009) and Corcoba Magana & Munoz Organero (2011). This research highlights a more fundamental issue, namely the role information in transport and the promises it has for fuel consumption and sustainability in general. Seaver and Patterson (1976) demonstrated this by means of an experiment. Three groups were hereby investigated and results indicated that fuel consumption was significantly lower in the group that received information as well as a recommendation. These results are further supported by Boriboonsomsin, Vu, and Barth (2010), who argued that providing information (and other support tools) can improve fuel efficiency with 6% in urban settings and 1% in highways. Further research by Satou, Shitamatsu, Sugimoto & Kamata (2010) demonstrated that the provision of information can result in an 18% increase of fuel efficiency.

2.3 The company car in the Netherlands

As mentioned in the introduction, company lease cars are often provided to employees as an attractive co-benefit besides salary. This offer is based on an employee’s salary and work description; if an employee has to travel or has a high position, he or she might be offered a lease car. These cars can be offered at a lower price than employees would pay in the market, which is mainly due to favorable taxation of company cars. Consequently, company cars are extremely common. In the Netherlands, which will be the focus of our empirical analysis, about one in seven male employees and one in 38 female employees has a company car (van Beuningen et al., 2003). In comparison with the rest of Europe, the Netherlands seems to take an average position, whereas in the UK company cars seem to be more commonly used than anywhere else in the world. Company cars are not only regularly received by employees as a fringe benefit, but are, apart from the wage, the single most important compensation for the employees' labor activity. The average annual cost of a company car is around €10,000 (which depends of course on the use of the car), which is substantially more than other fringe benefits (including pensions).

It comes as no surprise that this increased tendency of employers to provide company cars to workers, as a substitute for wage increases, started in the UK, mainly as a response to anti-inflationary policies to keep wage increases limited (Wyatt, 2008). Thus, different reasons exist for the allocation of company cars. These are not always related to the mobility requirements of employees. Tolley (1986), for example, surveyed over 1,000 companies that provide company cars. Herein it was found that while 78% of these companies used mobility need as a criterion for offering a company car, but 82% of them also, or only, used seniority as their criterion. Fringe benefits can boost an employer’s image, as this enables employers to gain a strong position in the labor market and thereby facilitate recruitment and help in retaining valued staff.

The latter emphasizes the importance of the company car as a status symbol, which is also in line with the findings of Steg (2005). Herein, two groups of respondents, one from Groningen and the other from Rotterdam, illustrated that symbolic and affective motives (and not the instrumental ones) are important drivers for car ownership in general. Especially frequent drivers, respondents with a positive car attitude, male and younger respondents valued these non-instrumental motives the most. It comes therefore as no surprise that the total number of cars in the Netherlands has shown a steady increase, which is especially exacerbated by the economic growth of the last few decades. In 1995, there were approximately 5.3 million passenger cars. 17 years later, roughly 7.8 million passenger cars were registered in the Netherlands (an increase of almost 50%) (Vereniging Nederlandse Autoleasemaatschappijen, 2013).

The lease market is an important driver of this growth. As earlier mentioned, the number of company cars increased over 41% in less than 10 years. In addition to this, company cars are known to play an important role in the greening of the vehicle fleet in the Netherlands. According to the VNA (2013) the average emissions of newly leased vehicles have declined significantly: from 165 g/km in 2006, to 119 g/km in 2012, which is lower than the average carbon emissions in the EU (165 g/km in 2007 and 132 g/km in 2012). Generally speaking, there are two kinds of company cars. The first group is formed by company cars that are owned by car lease companies, whereas the second group consists of cars that are administered and financed by companies themselves (i.e., company-owned car fleets).

The overall breakdown of the total car fleet in the Netherlands into these different groups is depicted below in figure 4. Herein, it is clearly visible that the majority of cars in the Netherlands are formed by private vehicles (6.9 million). This will however not be taken into account in this research. The company car constituted in 2012 approximately 11.5% of the total car fleet in the Netherlands, of which 36% (±4% of total car fleet) is owned by companies themselves and the remaining 64% (±7.5% of total fleet) by lease companies. Also important to note, is the fact that company cars are not the only method to fulfill the mobility requirements. As is visible, almost 2.1 million cars are used for business purposes. The fuel consumption of these cars is also covered by companies. Given the fact that these employees are not directly affected by the fuel consumption, differences between the theoretical and actual consumptions will also be present in this group.

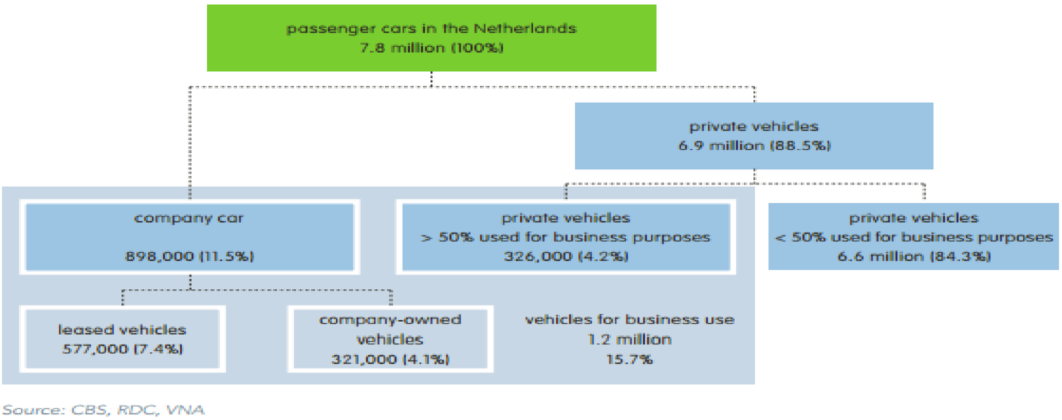


Figure 4: Passenger transport in the Netherlands

Also interesting to note, is that huge differences exists in the characteristics of the average car fleet and the company car fleet. These differences are especially visible when comparing the age distribution, vehicle sizes and fuel mixes of the cars in the respective fleets. Company cars are generally speaking much younger than private cars, which is clearly visualized in figure 5. Almost 90% of the company cars are less than five years old. The younger cars have a large influence on the energy consumption, which is affected by factors such fuel efficiency of the car and the distance travelled. The first depends of course on the age of the car. The younger the car, the newer the technology and consequently the lower the fuel consumption (Graus & Worrell, 2008). The rejuvenation of the car fleet can mainly be attributed to the fast turnover of the last few years. In 2012, the lease companies disposed over 159,800 cars in 2012, which was counterbalanced by 166,500 new deployed passenger cars. This rate of replacement is increasing; in 2009-2010, one-fourth of the fleet was replaced, whereas 2011-2012 saw a replacement of nearly one-third (VNA, 2012).

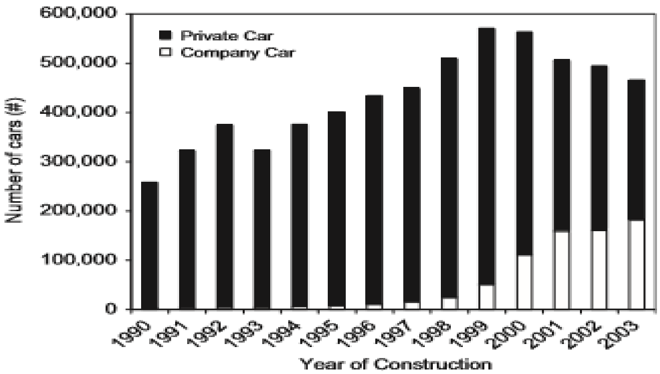
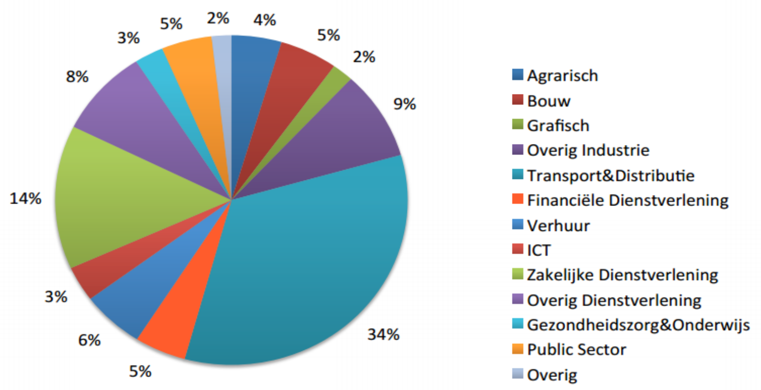


Figure 5: Age distribution

Another major difference between the two segments is the vehicle fuel mix. Company cars consume, for instance, more diesel than gasoline, and also the share of LPG is larger than in the private car segment. More precisely, 47% consume diesel, 10% LPG, and 43% consume petrol, while private cars use only 10% diesel, 86% petrol and 4% LPG (Wilmink et al., 2002). This overrepresentation of diesel cars in the company car segment translates itself in lower fuel consumption on a per km basis (in comparison with private cars), since diesel based cars are currently more efficient than gasoline cars. More concretely, the average fuel consumption by private cars equals 2.99 MJ/km, whereas this 2.94 MJ are consumed by company cars (Graus & Worrell, 2008). Ironically, the reduction in fuel consumption due to newer technology is more or less mitigated by the overrepresentation of large size cars in the company car segment. For example, the share of small cars in the private car segment is 32%, while a mere 12% of the company cars are characterized as such. Moreover, the share of large medium-sized cars for company cars is 34%, whereas this is only 22% for private cars. According to Nijland et al. (2012) a 10% drop in car size can result in a 4% decrease of pollutants. In addition to this, Graus and Worrell (2008) observed that company cars drive on average nearly twice as much per year than private cars.

The lease market is responsible for a gross turnover of approximately 9 billion euros. Over 195,000 new cars were purchased in 2012, which represented a total list price of around 4.9 billion euros. The total amount of BPM tax paid for these cars was equal to 780 million euros in 2012. The biggest recipient of company cars is the transportation industry and represented almost 34%, which is not really unexpected. The breakdown of the lease market over the different branches is visible in figure 6 (VNA, 2013).

Figure 6: Distribution company cars per branch



In general, companies can acquire company cars via different methods. Although the majority of companies purchase the cars outright, various forms still exist. In addition to this car purchase, companies acquire a car via the so-called hire-purchase, closed-end leasing and open-end leasing. According to the earlier mentioned survey of Tolley (1986), over 70% of the companies use cash purchase an acquisition method, while 13% used hire-purchase, 29% closed-end leasing and only 12% used open-end leasing. The difference between the two last methods is that an open-end leasing contract offers the option to acquire the car after the contract term is fulfilled. Furthermore, in an open-end lease the lessee assumes the depreciation risk, but has more flexible terms, while in a closed-end lease, the lessor assumes the depreciation risk but the terms are more restrictive. Depending per company, each of these different schemes has its own merits and drawbacks. Despite these differences, the (financial) relationships between the relevant stakeholders can be summarized in figure 7.

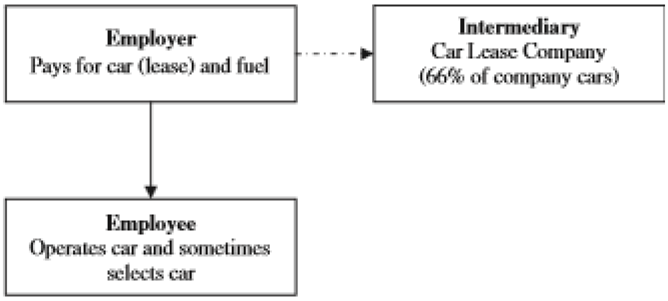


Figure 7: Relationships between relevant stakeholders

2.4 The principal-agency problem

The principal agent problem plays an important role in the market of company cars. It is widely acknowledged by economic theory that different objectives exists within an organization. Arrow (1963) asserted that:

"By definition the agent has been selected for his specialized knowledge and the principal can never hope to completely check the agent's performance".

The delegation of tasks to an agent who has different objectives than the principal who delegates this task is problematic when information about the agent is incomplete. Each of the two parties, that are the agent and principal, is expected to maximize their own utility, despite the obvious conflicts of interest that could arise in these situations. The parties in question are far enough apart such that one perceives no additional utility when the other's costs are reduced.

This phenomenon is highly related to the so-called moral hazard problem. Moral hazard takes place when a party tends to take risky or undesirable decisions because the costs that could arise will not be felt by the risk-taking party. Hence, a party would be inclined to make decisions that could result in potential costs or burdens for other parties. It is widely recognized by literature that moral hazard plays an important role in company cars market (Graus and Worrell, 2008; Gutierrez Puigarnau and van Ommeren, 2007; Ashworth and Dilnot, 2005). The principal agent and moral hazard problem is hypothesized to exist in company car fleets maintained by organizations/companies (i.e., principal) who pay the full cost of ownership and use, including fuel use, while operated by employees (i.e., agent). It is argued that, since employees do not pay for fuel and other related expenditures, they do not have an incentive to conserve fuel. This despite the goal of the principal to minimize fuel costs. This lack of incentives can lead to changing and non-environmental friendly driving behaviors, which are as earlier mentioned one of the main drivers of the discrepancy between theoretical and actual fuel consumption (Rouwendal, 1996; Barkenbus, 2010). This will be further elaborated in Chapter 2.4.

According to Graus and Worrell (2008), the principal agent problem can induce two effects in the company car market. Firstly, it is asserted that company cars will be larger, more powerful and less-efficient than privately owned cars. Secondly, the distance that is travelled by company cars will be much higher than that of privately owned cars. The latter may be attributed to more private travel (since fuel consumption in private use is also covered by the principal) and/or higher travel distance for commuting. But both effects can be traced back to the fact that the travel behavior of employees is influenced in such a way that these are not inclined to reduce fuel consumption. This is especially exacerbated due to fact that, generally speaking, no financial incentives are in place to promote fuel conservation behavior. This despite the known effects incentives can have on influencing the behavior of agents (e.g., allocation of company shares to CEO).

The principal agent problem in company car market can, according to Graus and Worrell (2008) and also by Vernon and Meier (2012), be categorized into 4 main groups according to a two-by-two matrix (i.e., user's ability to choose the technology and the user's responsibility for paying the resulting energy costs). The first group chooses the technology and pays the energy bill and chooses the technology. This is the ideal situation because there is no distinction between the principal and the agent and the costs (Vernon & Meier, 2012). The second group does not choose the technology, but does pay the energy bills, while the third group chooses the technology and does not pay the energy bill. Finally, the fourth group does not pay the energy bill and does not choose the technology. The second and fourth group can be characterized by an efficiency and usage problem respectively. The third group has both an efficiency and usage problem. The majority of company car schemes in the Netherlands belong in category 3 and 4. The four different categories are depicted in the figure below.

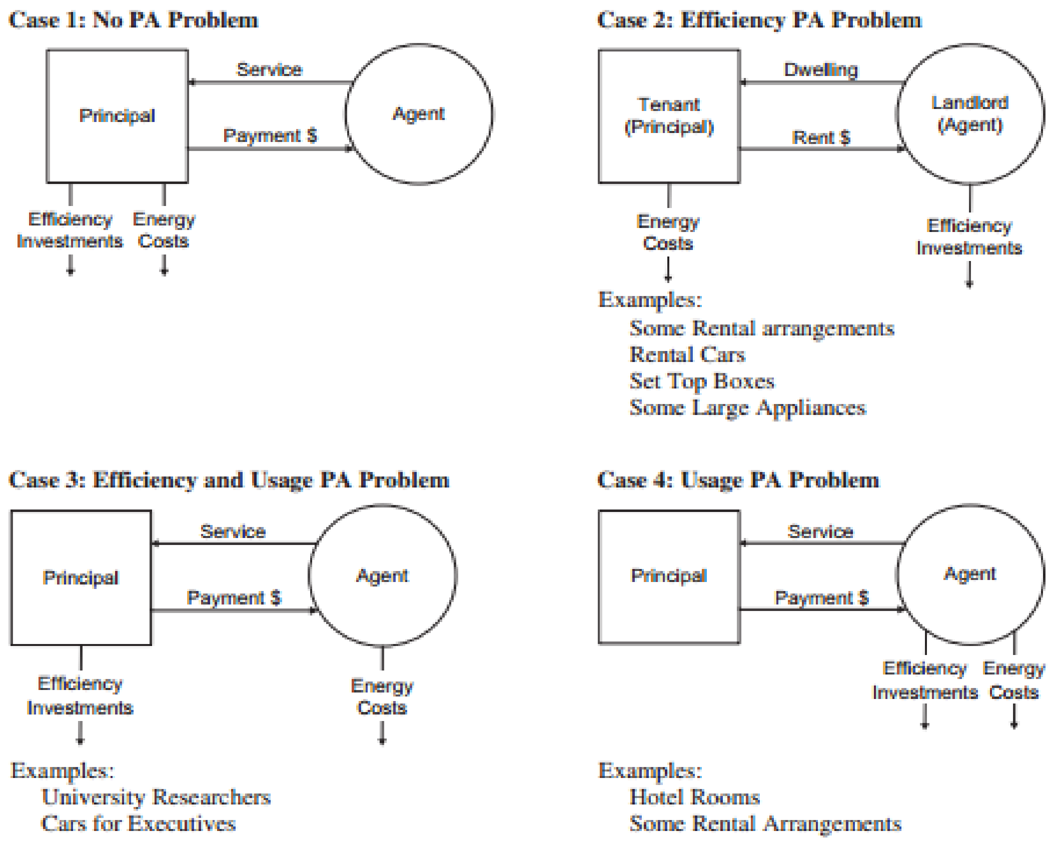


Figure 8: Categorization of the principal-agent problem

This phenomenon is especially of importance due to the focus of governments to promote more environmental sustainable policies by companies through the use of market mechanisms, such as pricing strategies (Meier and Eide, 2007). This will be discussed in Chapter 3, but the effectiveness of such policies depends highly on the ability to reach the end-consumers (i.e., employees). Since this is not the case, policies cannot and will not reach desired levels. Graus and Worrell (2008) calculated that the energy savings potential reached a total 0f 19 PJ/year. This is driven by two main pillars, namely the reduction of the average size of cars and the reduction of the commuting distance. This is equal to 7% of the total consumption of passengers' cars and to 32% of the fuel consumption by company cars. To put this in perspective, 19 PJ equals 6% of the total energy consumption in the Netherlands and equals to the average energy consumption of almost 280,000 households.

2.5 Dutch fiscal framework

Given the fiscal nature of this research, it is of upmost importance that the current taxation scheme is analyzed. Depending on the philosophical and ideological viewpoints, the role of the government is to assure the overall well-being of the society and to protect the rights of its citizens. Different mechanisms are available to achieve this, but one of the most effective is of course taxation. According to Cobham (2002), four main purpose of taxes can be distinguished, namely revenue, redistribution, representation, and re-pricing economic alternatives. The first is rather obvious and relates to the creation and maintaining of public infrastructure and governmental institutions. The second is necessary in order to achieve human development gains by lifting its poorest members out of (broadly defined) poverty. The third reason is rather outdated, but is related to the principle 'no taxation without representation'. The final reason is of more importance in this study. It relates to the ability of the government to use taxation as a tool by which to influence the behavior of their individual and corporate citizens. Hence, taxation can be used to address externalities by, for example, increasing the costs of polluting behavior, or offering incentives to save energy in the form of subsidies.

Dutch tax revenues are based on four main drivers, notably the car taxes (e.g., BPM), taxes from usage (e.g., duties and VAT), income taxes (e.g., Bijtelling and taxable travel reimbursements), and assurance taxes. In total, the Dutch government accumulated over

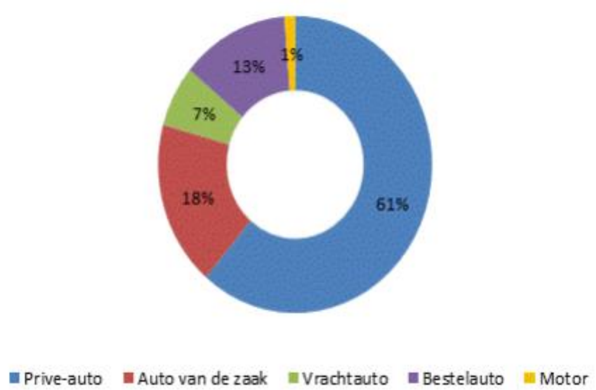
€14 billion in 2013 through taxes, while expenditures equaled €7 billion. This means that, for every driven km, the government collected €0.10 of taxes, while spending only €0.05 per km. In general, the revenues from all road taxes are 70% higher than expenditures and this spread is expected to increase significantly in the coming years due to increased taxation rates. It is expected that the difference will increase with almost €1.3 billion in 2014 alone (Ecorys, 2013). The overall breakdown of tax revenues in 2013 is displayed in the table below.

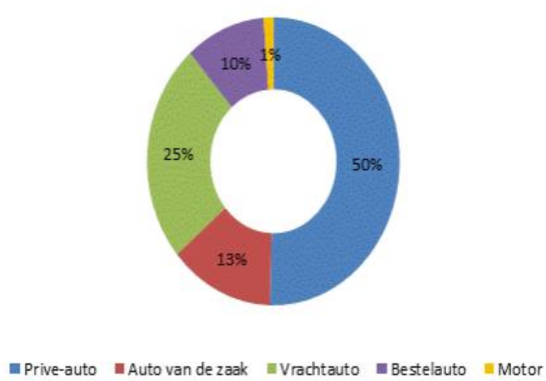
Table 2: Overall breakdown of tax revenues

	Revenues (* € 1 mln) 2013
BPM	1.266
MRB: national level	3.541
MRB: provincial level	1.450
Duties on petrol	3.941
Duties on diesel and LPG	3.880
Eurovignet/taxes on heavy vehicles	134
Total	**14.212**

Also interesting for the purpose of this research, is the overall breakdown of the revenues and expenditures per origin. As is visible from the figure below, company cars ("auto van de zaak") accounts for 18% of the total tax revenue, while it corresponds with only 13% of the total governmental expenditure on transportation infrastructure (Ecorys, 2013).

Figure 9: Overall breakdown revenue and expenditure per origin.





As earlier mentioned, one of the foremost challenges of the government in the area of transportation is the reduction of carbon emissions. The average carbon emission per car is, after a long period of barely any reductions, per 2005 significantly reduced (EFA, 2013). Different reasons exist for this trend. Nijland, Gerlagh and Koetse (2013) identified five main drivers of this growth. First of all, more stringent European regulations were put into place. Secondly, economic downturn in different countries resulted in increased purchasing of smaller, more efficient cars, since the alternative is simply too expensive. Thirdly, fuel prices have increased considerably. Fourthly, the growth can in partial be attributed to temporary fashion changes. Finally, the last decade saw increasing national fiscal policies aimed at promoting more efficient cars (i.e., re-pricing economic alternatives). Especially the latter is acknowledged as one of the main drivers of this growth. There are three types of taxes that are relevant for the scope of this research, namely the income tax (and the “Bijtelling”), the “Belasting van Personenauto’s en Motorrijtuigen” (BPM) and road tax. These will now be discussed.

Income tax

The Dutch tax system is subdivided into 3 categories, also known as “boxen”. The first box consists of taxable income derived from employment and living, the second concerns other interests (e.g., company shares) and the third relates to taxes on equity (e.g., savings). The Dutch tax system can be described as a progressive one, since the percentage of taxation increases as the income level rises. Taxation in the Netherlands consists of two main parts, namely the payroll taxes and social premiums. The latter is primarily used to cover for the social welfare expenses by the government. Additionally, a difference exists between two kinds of tax payers, notably citizens under and citizens that older than the AOW-age. This is however not relevant for this research, but it is nevertheless important to note for the sake of completeness. The concrete percentages are shown in the table 3.

For example, an employee earning an annual salary of €40,000 would pay a yearly tax of €15,870 (i.e., box 1). The taxable income depends however, as mentioned above, on more factors than only income from work. The taxable income is augmented by other assets, such as the value of property (e.g., house) or lease cars. The latter is of course especially of interest for this research. The exact amount that is added on the taxable income is called the “Bijtelling”. Initially, it was calculated by using a fixed percentage of the catalog price, notably 22% for all types of cars. However, from 2008 onwards, a distinction was made between efficient/environmental friendly cars and their counterparts. Not entirely within the scope of this research, but nevertheless important to note, is that this environmental friendly policy is covered by the income tax, making it the only income tax law of its kind. Vrauwdeunt (2009) even argued that this law is in conflict with the equality principle of the constitution, since huge differences in charges can exist between citizens that operate exactly the same car, but can nevertheless not enjoy the same benefits from this policy.

Table 3: Income tax

Income in Box 1 below AOW-age	**Payroll taxes**	**Social premiums**	**Total**
Segment 1 IB: until €19,645	5.85%	31.15%	37%
Segment 2 IB: between €19,646 and €33,363	10.85%	31.15%	42%
Segment 3 IB: between €33,364 and €55,991	42%		42%
Segment 4 IB: from €55,992	52%		52%

The rationale of switching from taxation based entirely on catalog price based to a more pollution based policy fits in a larger attempt of national governments to allocate societal damages to their sources. In other words, “de vervuiler betaalt” (the polluter pays). In addition to this, the policy aims at realizing a greener passenger car fleet (Geilenkirchen et al., 2004). At the heart of these type of policies lays a variable cost driver, which is necessary to transfer costs to those who utilize or damage the public sphere (e.g., pollution or use of public infrastructure). As such, a variable tax system is introduced, whereby the percentage of the catalog price that is added on the taxable income depends on the amount of pollution a respective car produces. The pollution is hereby measured by the amount of carbon dioxide a car emits. It is hereby important to note that specifications about carbon emissions are provided by the car manufacturers themselves. This is rather interesting, since research has indicated that the drop in average carbon emissions of cars can be attributed to the method used to determine the official fuel consumption and corresponding carbon emission. It seems that, in the period 2006-2012, car manufacturers made more use of certain leeways in European test protocols to reduce the carbon emissions (Geilenkirchen et al., 2004). This possesses of course some ethical dilemmas due to conflict of interests, as car manufactures have benefited enormously from increasing sales driven by tax benefits. This is however part of a larger discussion that lies outside the scope of this research. The exact percentages are depicted in the table below.

Table 4: Percentages and emission criteria concerning "Bijtelling"

Bijtelling

% of catalogue price	Fuel type	CO_2 emissions in 2014 (gram/km)
0%	-	-
4%	Diesel	0
	Petrol or other	0
7%	Diesel	≤50
	Petrol or other	≤50
14%	Diesel	≤88
	Petrol or other	≤85
20%	Diesel	≤117
	Petrol or other	≤111
25%	Diesel	≥117
	Petrol or other	≥111

Source: Belastingdienst

Interesting to note is that these percentages have undergone a lot of changes in the last few years (see Appendix A). Whereas in 2012 company cars were eligible to 0% "bijtelling", in 2013 and onwards this policy has been suspended. The lowest category is now formed by 7% and in order to be eligible for this segment, the car must emit less than 51 gram of CO_2 per km. In 2012, this would result in 0% "bijtelling". Moreover, government policy on the emissions is tightening, as the criteria become more and more stringent. In less than four years, the average emissions must be reduced by 20 gram/km in order to profit from the same tax reductions. This tightening of government policy is primarily the consequence of the underestimated costs involved. According to the Ministry of Finance (2011), the policy has led to tax losses equal to approximately €5 billion in the period 2007-2013, which is equivalent to almost €1000 per ton CO_2. This was much larger than initially expected. Especially if compared with alternative measures that were much more cost-effective. In light of this, the government aimed at reducing tax losses by maintaining a stricter policy. An additional side-effect can also be that, given these alterations, companies are forced to offer more efficient cars to their employees. This is order to still be eligible to relatively lower segments.

The “Bijtelling” can best be illustrated by means of an example. A diesel car with a catalogue price of €35,000 and emitting 100 gram/km would result in a “Bijtelling” of €7,000. Using the same example of the employee that earned an annual salary of €40,000, the annual amount of taxes equals €18,810. This increase is of course the result of a taxable income of €47,000, whereas this was only €40,000 without the lease car.

BPM

The BPM (“Belasting van Personenauto’s en Motorrijtuigen”) is a one-time tax that is paid when the vehicle is bought or registered for use in the Netherlands (Belastingdienst, 2013). No distinction is herein made in the origin of the car. In line with the earlier mentioned greening of tax policies, the BPM is also calculated based on the CO_2 emission of the respective car. The BPM is composed of a fixed and a variable part. The variable part ensures that pollution is as much as possible transferred to the responsible parties. It is expected that the discrepancy between theoretical and actual fuel consumption will be especially noticeable in this segment due to this variable portion of the BPM. Moreover, as earlier mentioned, rejuvenation of company car fleets is a very common practice (e.g., 195,000 new cars in 2012), resulting in fast turnovers. A distinction is again made between diesel engines and petrol/other engines. The exact percentages (for petrol/other and diesel) are shown in the tables below.

Table 5: Percentages and emission criteria concerning BPM

BPM for petrol or other

CO_2 emission from g/km	CO_2 emission up to g/km	Fixed	Variable
-	88	0	0
88	124	0	€105
124	182	€3,780	€126
182	203	€11,088	€237
203	-	€16,065	€474

Diesel

CO_2 emission from g/km	CO_2 emission up to g/km	Fixed	Variable
-	85	0	0
85	120	0	€105
120	175	€3,675	€126
175	197	€10,605	€237
197	-	€15,819	€474

In line with the "Bijtelling", the BPM criteria has and will become even more stringent, as cars must be more efficient in order to be eligible for the lower segments (see Appendix B). Reasons for this trend are already discussed in the previous paragraph. The use of the BPM can best be illustrated by an example. For instance, let's assume that a petrol driven car emits 190 grams of CO_2 per kilometer.

1. From the figure above, we can conclude that this falls in the segment 182-203.
2. In order to deduce the BPM, one must subtract the value in the first column (i.e., 190-182).
3. This number must be multiplied by the variable cost driver, resulting in €2,370.
4. This value must be added to the fixed costs of the same segment, namely €11,088. Summing these up results in a total BPM of €13,458.

It is interesting to note that the same car would pay a BPM of €13,025 in 2013. The BPM will only become higher in the coming years.

Road tax

In addition to the taxes mentioned above, Dutch lease drivers also have to pay a quarterly road tax. In contrast with the "Bijtelling" and the BPM, the road tax is however determined by more than one factor. More specifically, road taxes on cars depend on the place of residence, car weight, CO_2 emissions and fuel type. In addition to this, cars older than 40 years are exempted from road taxes (Belastingdienst, 2013). The first two drivers make it less attractive for citizens to own a car in densely populated areas and enables provincial institutions to influence the driving behavior of their citizens. Moreover, the costs of maintaining road infrastructure in these areas are generally higher, as they are more often used. Consequently, the taxes are higher in these areas. Using car weights as a criteria is important for company cars, since, as earlier mentioned, company cars tend to larger than private cars. Moreover, a significant portion of company cars are diesel driven, and as shown in table 6, this results in higher quarterly road taxes.

In accordance with the previous two taxes, the use of more efficient cars are promoted by exempting cars that emit less than 50 grams of CO_2 per km. This includes of course electric driven cars. It must however be noted that the road taxes have also become stricter in comparison with previous years, whereby petrol cars that less 110 grams and diesel cars that produce less than 95 grams where exempted. It is expected that the discrepancy between the theoretical and actual fuel consumption will not induce any difference in the amount of road taxes that must be paid.

Table 6: Road taxes in South-Holland and Drenthe

Road tax

Province	Fuel type	Car weight (kg)	Road tax (quarterly)
South-Holland	Petrol	951-1050	105
	Diesel	951-1050	232
Drenthe	Petrol	951-1050	102
	Diesel	951-1050	228

Duties

In general, governments tend to tax not only the ownership of transportation vehicles, but also its usage. This is mainly accomplished by imposing a direct tax on fuel used for transportation (in Dutch “accijnzen”). It must be noted that fuels used for other purposes, such as agriculture, are liable to different tax regulations. It is often argued that the objective of these taxes is the mitigation of pollution and environmental damages instigated by transportation. But it is, paradoxically, also the largest revenue source for the Dutch government, equaling to almost €8 billion in 2013. The rationale behind fuel duties is illustrated by Goodwin, Dargay and Hanly (2004), who argued that a 10% increase of real prices of fuel would result in a short term decrease of traffic volume by 1%, while building up to a reduction of 3% in the longer run (i.e., 5 years). Furthermore, the volume of fuel consumed will fall by approximately 2.5% in the short term and to over 6% in the long term. It can therefore clearly characterized by the fourth reason of the earlier mentioned taxation purposes scheme by Cobham (2002), notably re-pricing economic alternatives.

In addition to the fuel dues, the government also levies a supplementary tax by adding a value-added tax (VAT). Ironically, this is done after the fuel duties are added to the fuel price, resulting in a situation whereby taxes are levied on taxes. It is especially this scheme that has resulted in one of the highest fuel prices in the world. The total amount of taxes is equal to almost 60% for petrol, 50% for diesel and 37% for LPG. The precise numbers are visualized in the table below. To put these numbers in perspective, two other countries are included.

Table 7: Breakdown taxation fuel price

Country	Fuel type	Fuel price ex. duties and VAT	Duties	Including duties	VAT (%)	VAT (€)	Total fuel price
Netherlands	Petrol	€0.762	€0.759	€1.521	21%	€0.320	€1.841
	Diesel	€0.761	€0.478	€1.239	21%	€0.260	€1.499
Belgium	Petrol	€0.752	€0.614	€1.366	21%	€0.287	€1.653
	Diesel	€0.611	€0.580	€1.191	21%	€0.250	€1.441
Luxemburg	Petrol	€0.705	€0.465	€1.170	15%	€0.175	€1.345
	Diesel	€0.691	€0.330	€1.021	15%	€0.153	€1.174

3. Methodology

In order to address the research question and the sub questions, a representative dataset must be used. This is especially relevant given the scope of the population. It is therefore that this chapter will discuss the dataset and the used methodology.

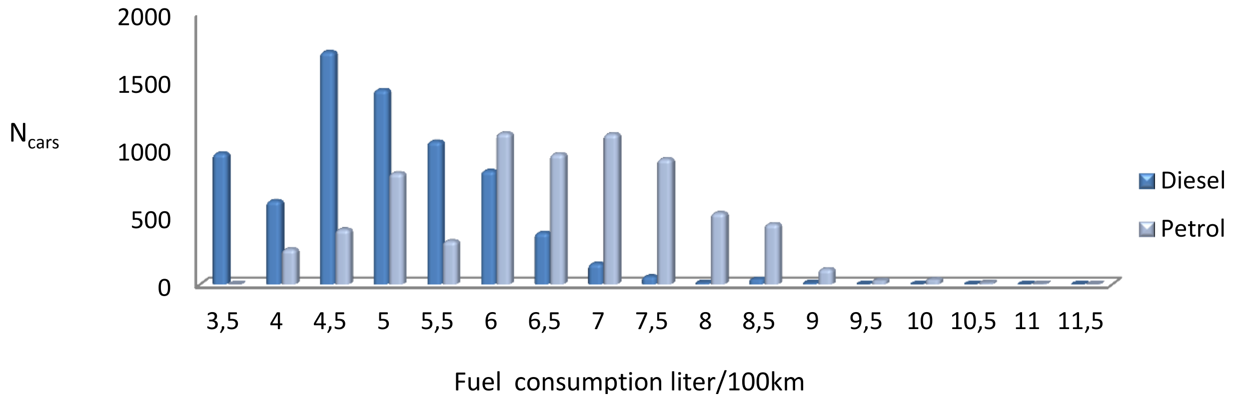
3.1 Data

As mentioned in the introduction, this research will make use of a dataset provided by the car lease company Athlon, which is the largest in the Netherlands. The data is derived from the Athlon car database and from tank cards operated by car users. It spans a 6 year-period, notably from the beginning of 2006 to the end of 2011, and is on a per car basis. The exact buildup of the dataset is included in Appendix C. It includes a wide variety of variables ranging from the catalogue price of the car, to the mileage, type, and consumption (and more). Given the scope of this research, only the theoretical consumption, the total distance travelled, the total volume tanked, the fuel type, and actual consumption deviations will be used.

The original dataset consisted out of 82,212 cars, but after filtering the data, this was reduced to 14,361 cars. The first filtering concerned the selection of companies for which all necessary data was available. This reduced the total number to 37,804 cars. Secondly, inaccurate reporting by drivers is excluded by means of an algorithm (which is supplied by Athlon). Thirdly, cars with less than 5,000 kilometers were excluded, since these were expected to be too unreliable for the detection of trends and/or fuel consumption. Finally, all outliers were eliminated, since this can induce strong biases.

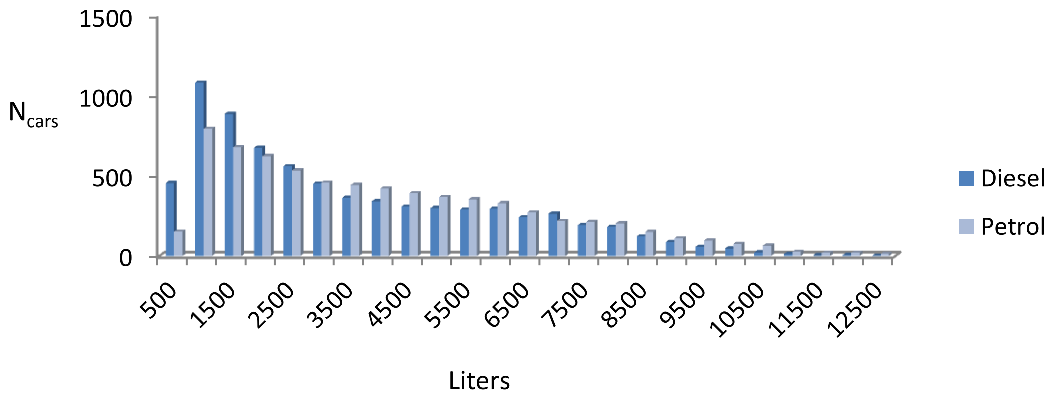
The dataset includes only petrol and diesel-based cars. More precisely, 51% of the cars are diesel, while 49% runs on petrol. The average age of the diesel cars is 537 days, while the petrol car is on average 654 days old. The theoretical consumption (liters/100km) is indicated by the car manufacturers and is determined by means of the NEDC-method. The theoretical consumption is displayed below in figure 10 and a distinction is made between petrol and a diesel group. The highest frequency for diesel-based cars is 4.5 liters per 100 km, while 6 liters per 100 km is the most common for petrol-based cars. This corroborates the idea that diesel cars are currently more efficient than petrol-based cars.

Figure 10: Theoretical fuel consumption



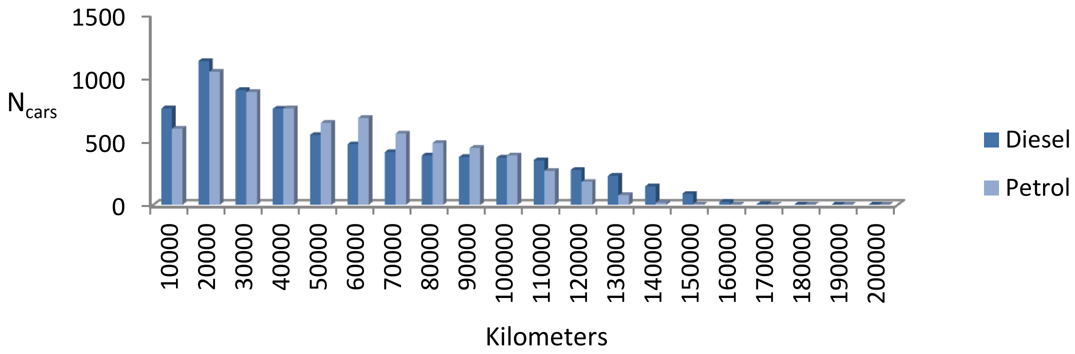
Additionally, the dataset also includes the total number of liters that has been tanked by the car owner. This is visualized in figure 11. Herein it is clearly visible that the majority of cars of both diesel and petrol used a total of 1,500 liters. Moreover, the graph demonstrates a decreasing trend, whereby petrol-based cars are overrepresented in the higher segments. The latter finding is in line with expectations, since diesel-based cars are currently more efficient. It must however be noted that this graph is biased, since it includes cars that have a longer usage period. This means that a number of cars are relatively young and used therefore less fuel. This is especially exacerbated by the increasing rejuvenation of car fleets.

Figure 11: Total fuel consumption



In figure 12, the total distance travelled per car is illustrated. This is calculated by subtracting the total number of kilometers a car travelled at the end of 2011 by the initial mileage. The graph has more or less the same shape as figure 11, since larger distances results in more fuel consumption.

Figure 12: Total distance travelled



Also important to note, is that the dataset represents companies from different industries. This seems trivial, but Romaszewski (2012) demonstrated that cross-industrial differences exist in terms of fuel consumption. Governmental institutions, for example, had the lowest actual fuel consumption on average compared to other business types. Based on this research, which made use of the same dataset, the data can be grouped into seven business types, namely: Financial Holdings & Banks (14), Non-Financial Holdings (4), Government (4), Consultancy & Accounting (5), Telecommunication & Software (5), Construction and Energy (8), and Office & Human Resources (7).

3.2 Methodology

In order to deduce the necessary data from the dataset described above, a number of calculations must be made. The objective is to calculate the total amount of lost taxes due to the discrepancy in theoretical and actual fuel consumption. Moreover, the total amount of carbon emissions (non-financial costs) and the costs for companies in general must also be derived. A total of 7 steps are made. These are described below:

Step 1: Calculation actual fuel consumption.

Before the above mentioned objectives can be achieved, the actual fuel consumption must be derived. This is realized by dividing the total amount of fuel used by the total distance travelled. This number will subsequently be divided by 100 in order to express the actual fuel consumption in the same units as the theoretical consumption, namely liters per 100 kilometers. Another method, which results of course in the same result, is using the deviation (which is also specified in the dataset) to calculate the actual consumption. For example, given a theoretical consumption of 4.7 and a deviation of actual consumption of 50.47%, the actual consumption equals 7.1 liters/100km.

Step 2: Calculation carbon emissions.

The next step concerns the calculation of carbon emissions from the fuel consumptions. This is necessary, since the taxation is based on the amount of CO_2 emitted. The distinction between diesel and petrol is hereby of upmost importance, as each fuel type has its own amount of carbon emission emitted per liter.

One liter of diesel weights 835 grams, which consists out of 86.2% of carbon or 720 grams of carbon. In order to combust this carbon to CO_2, 1,920 gram of oxygen is required, resulting in a sum of 2,640 grams of CO_2/liter (720+1,920). The carbon emission for petrol is slightly lower. One liter weighs 750 grams, of which 87% or 652 gram consists out of carbon. In order to combust this carbon to CO_2, 1,740 gram of oxygen is needed. The sum is then (652+1,740 =) 2,392 gram of CO_2 per liter of petrol (Carbon Trust, 2013).

After these minor calculations, the exact amount of carbon emission per km can be derived. For example, an average theoretical consumption of 4.7 liter of diesel per 100km corresponds with: ${(4.7\ x\ 2{,}640)}/{100}$ = 124.08 grams of CO_2 per km. Imagine that the actual consumption equals 7.1 liters of diesel per 100km, the total amount of carbon emissions would then be equal to ${(7.1\ x\ 2{,}640)}/{100}$ = 186.70 grams CO_2 per km. Hence, a difference exists of 62.62 gram of CO_2.

Step 3: Calculation taxation losses

in this part, the taxation based on the theoretical and actual carbon emissions will be derived. Two kinds of taxation are herein distinguished, namely the BPM and the "Bijtelling", which are discussed extensively in chapter 2.3. The procedures are as following:

- **BPM:** The BPM calculation is rather straightforward. Firstly, the taxation based on the theoretical consumption will be calculated, followed by the calculation of the taxation if actual consumption would be used. For example, the car illustrated above with a theoretical consumption of 4.7 liters diesel per 100 km would fall in segment three and would pay a BPM of €4,189. However, using the actual consumption of 7.1 liters diesel per 100 km would result in a taxation of €13,378, since the car would fall in higher tax-segment (segment four). This amounts to a difference of €9,189. For the BPM, only year 2010 and 2011 will be used, since the carbon-based taxation scheme was implemented in 2010.

- **Bijtelling:** The calculation of the "Bijtelling" is however more complicated. As mentioned in Chapter 2.2, the "Bijtelling" is expressed as a monetary amount that is added on the taxable income. The taxable income is however not included in the dataset. Ideally, a preference would exist for the exact income, but this research will make use of the modal income to derive the "Bijtelling". This was in 2010 approximately €32,500 and in 2011 €33,000. For example, imagine an employee earning a modal income of €32,500 and owning a diesel car with a catalogue price of €25,990 and a theoretical consumption of 3.77liters/100km. Based on the theoretical consumption, the car would fall in the 14% segment, resulting in a "Bijtelling" of €3,639 on the taxable income (€32,500+€3,639=36,139). Income taxes on this would amount to €14,194. Based on a deviation of 46.7%, the actual consumption would be 5.53 liters/100km, falling in the 25% tax-segment. This will amount to a "Bijtelling" of €6,498 on the taxable income (€32,500+€6,498=€38,998). Income taxes would then be equal to €15,395. Thus, the difference in theoretical and actual emissions leads in a loss of income taxes of approximately €1,201. This seems low, but in a population of around 700,000 company cars, this can easily amount to an impressive number. Especially since the "Bijtelling" is levied annually, which is not the case with the BPM. As is the case with the BPM, this research will only derive taxation losses through missed "Bijtelling" in the years 2010 and 2011.

Step 4: Additional income due to increased duties

The lower fuel efficiency of cars will not only lead to tax losses for the government, but also to additional revenues through duties and other types of taxes that aim at allocating costs to the user. Lower efficiency, that is cars with higher fuel consumption, will translate itself to higher fuel usage for the same distance. In order to derive the net costs, these increased revenues from fuel duties must be subtracted from the tax losses. The increased revenue from duties will be derived by means of the following formula:

$$\left(\frac{Total\ Distance\ travelled}{\left(\frac{100}{Actual\ fuel\ consumption}\right)}\right) - \left(\frac{Total\ Distance\ travelled}{\left(\frac{100}{Theoretical\ fuel\ consumption}\right)}\right) x\ Duties\ per\ liter$$

The total distance travelled is hereby expressed on an annual basis. This is calculated by dividing the total distance over the whole period by the number of days that is used, which is hereafter multiplied by 365. For example, imagine a diesel car with a theoretical consumption of 4.7 liters/100km, an actual consumption of 7.1 liters/100km, a total distance travelled of 48,679, and used for 458 days. The annual distance would be equal to 38,794 (=(48,679/458) x 365). After using the formula described above, the discrepancy in fuel consumptions leads to 931 liters of additional fuel. This corresponds with €709 of additional duties for the government. This procedure is followed for all cars, hereby deriving the sample mean which is then extrapolated to the whole population (see step 7).

Step 5: Calculation non-financial costs government

As mentioned in chapter 1, the non-financial costs for the government is measured by the total amount of CO_2 emitted by the company cars. The average carbon emission per car will be derived from the sample, which will be extrapolated to the total population. Firstly, the total amount of carbon emissions from the total fuel used as indicated by the theoretical fuel consumption. Secondly, the same will be done for the total fuel based on the actual consumption. The average of these differences is then taken as a proxy, which is extrapolated to over the whole population by multiplying the average difference in CO_2 emission with the total number of cars in the population.

Step 6: Calculation costs for the market

The discrepancy between the theoretical fuel consumption will not only lead to tax losses and non-financial costs for the government, but it will also result in costs for companies offering these fringe benefits. This is especially exacerbated by the earlier mentioned principal agent and moral hazard problem, since the employees are not responsible for the costs of additional fuel. Since a portion of the extra fuel usage is attributable to the driving behavior, companies can save costs by promoting more eco-friendly driving behaviors. More importantly, given the increased emphasis of customers on sustainability, companies are more incentivized to reduce their carbon footprint.

In order to calculate the financial costs for the market, the annual driven kilometers are multiplied by the difference between the theoretical and actual fuel consumption. This is further divided by 100 in order to derive the liters involved. According to the TNO (2013), the total amount of liters that can be saved must be adjusted by the 23% margin that is not susceptible to eco-friendly driving. This adjusted variable is then multiplied by the costs per liter fuel, resulting in the financial costs for the market. It must be noted that, in contrast with Romaszewski (2012), the total fuel price will not be used as a measure for the costs per liter fuel. The fuel price exists namely out of the three parts, the fuel duty, the VAT, and the price of fuel without taxes. The VAT is always reimbursed by the companies, while the other two (i.e., duties and fuel price excluding taxes) are not eligible for reimbursement. Hence, these two cost element will be summed up to represent the true cost for companies per liter fuel, while the VAT costs will be excluded.

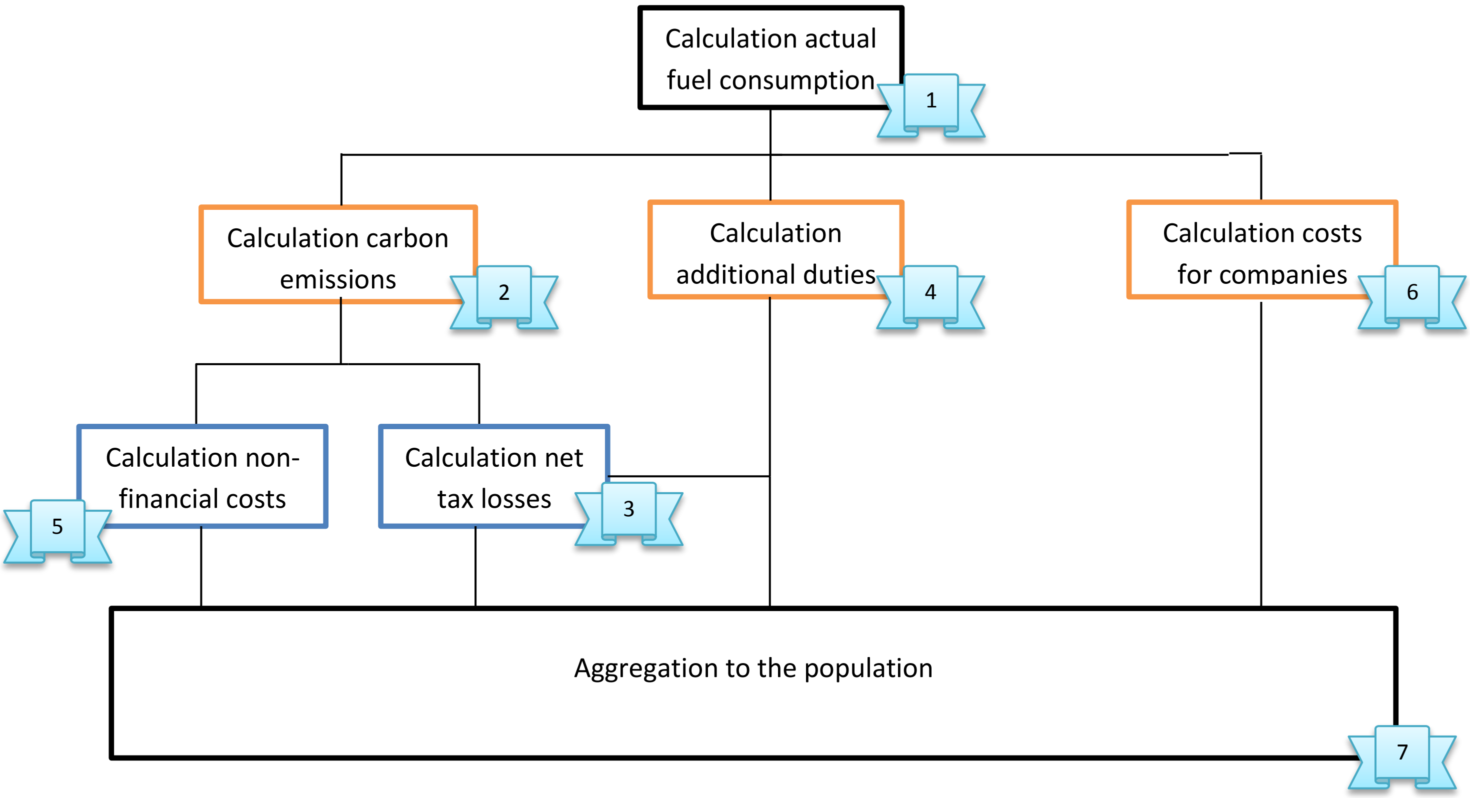
Step 7: Aggregation to the population

Since this research aims at providing insight about the total amount of losses in tax revenue (i.e., BPM and Bijtelling), the total amount of non-financial costs (CO_2) and the total costs for the market, the findings from the sample must be generalized over the whole population. Different methods exist for this with each having its unique merits and drawbacks (e.g., taking into account probabilities). But in this research, the results of the sample will simply be extrapolated to the population level through the use of sample averages. For the taxation losses, this is done by calculating the average BPM and Bijtelling loss per lease car (i.e., mean) over the whole sample, after which this is multiplied by the total number of cars in the population. The same procedure will be used for the non-financial costs and the total costs for the market. Using the mean is a rather crude manner to generalize sample effect to a population level, but it presents a number of advantages (Dean & Dixon, 1951). First of all, it is easy to calculate and to use. Secondly, it gives valuable insight in the central tendency of data (especially after deleting the outliers). Thirdly, the mean uses every value in the data and hence is a good representative of the data.

Given the importance of this step, it is necessary to elaborate further upon the degree of representativeness of the sample. Firstly, the sample size is large enough to provide insights about the population. Moreover, the data is randomly collected, which minimizes the chances of having biased results. Furthermore, the data covers all major types of businesses that make use of lease cars. It is necessary to take this into account as the driving behavior and thus fuel consumption differs per sector. Additionally, the dataset encompasses all types of cars, which is of course vital for the fuel consumption. All these factors contribute to the overall generalizability of the sample.

The overall methodology is summarized in the figure below.

Figure 13. Summary of methodology



4. Results

In this part, the results of the analyses discussed in chapter 3 will be presented. In order to address the main research question and the three sub questions, the same build up will be maintained as discussed in the methodology part.

4.1 Financial costs for the government

The first sub question concerned the financial costs for the government driven by the discrepancy between the theoretical fuel consumption as indicated by the car manufacturers and the actual fuel consumption as derived from the tank cards. The research argued that, given the difference and thus the use of flawed data, the government loses significant tax revenues in both BPM and the "Bijtelling", since the current taxation scheme is based on the theoretical carbon emissions. Five steps are taken to calculate these costs.

4.1.1 Calculation actual fuel consumption

As mentioned in chapter 3.2, the first step involved the calculation of the actual fuel consumption by dividing the total amount of fuel used by the total distance travelled. This number will subsequently be divided by 100 in order to express the actual fuel consumption in the same units as the theoretical consumption, namely liters per 100 kilometers. As is visible from the figure in Appendix D, huge discrepancies exists between the theoretical and actual fuel consumption. The theoretical consumptions are constantly overrepresented in the lower classes, while the actual consumptions are primarily present in the higher levels. This is in line with expectations and corroborates previous findings. The results of this part of the analysis are summarized in table 8. This is very troubling, since this means that consumers base their acquisition of cars on wrong information.

Table 8: Summary findings step 1

Petrol

	2010	2011
Average Theoretical consumption	6.12 liter/100km	5.96 liter/100km
Average Actual consumption	7.76 liter/100km	7.90 liter/100km
Average Deviation	28.29%	33.89%
Average Difference	1.64 liter/100km	1.94 liter/100km

Diesel

	2010	2011
Average Theoretical consumption	4.75 liter/100km	4.27 liter/100km
Average Actual consumption	6.09 liter/100km	6.09 liter/100km
Average Deviation	30.37%	44.61%
Average Difference	1.34 liter/100km	1.82 liter/100km

Some initial conclusions can be made based on this table. First of all, actual fuel consumption is always higher than the proposed consumption by the car manufacturers. The results are in line with the in Chapter 2.5 figures projected by the TNO (2013) and mentioned by Lighterink and Bos (2010). Despite the fact that this research covers only two years, the deviation seems to increase. This is also in line with Ligterink and Bos (2010), who found that the discrepancy increased from 11% in 2004 to 28% in 2011. Another important finding, is that despite indications that cars are more efficient (i.e., lower average theoretical consumption), the actual consumption is more or less the same or even higher for petrol-based cars. This is in accordance with findings provided by Romaszweski (2012), which indicated that for cars with lower theoretical fuel consumption, the deviation (and therefore actual fuel consumption) tends to be higher. In conclusion, these findings should lead to a significant difference in taxation.

4.1.2 Carbon emissions

Step two involved the calculation of the carbon emissions, which are used as a basis to derive the taxation rates for the company cars. This can be calculated by using the amount of CO_2 that is emitted per liter. These are chemical properties and changes therefore not in the course of time. The results of the analyses are summarized in table 9.

Table. 9 Summary results carbon emissions

Petrol

	2010	2011
Theoretical carbon emissions (gram of CO_2 per km)	146.44	142.49
Actual carbon emissions (gram of CO_2 per km)	185.64	188.89

Diesel

	2010	2011
Theoretical carbon emissions (gram of CO_2 per km)	125.42	112.77
Actual carbon emissions (gram CO_2 per km)	160.88	160.82

First of all, the actual carbon emissions are always higher than the theoretical emissions, which is not really surprising given the results of the previous step. Secondly, according to the data, the carbon emissions should be reduced in 2011. This should be more the case for the diesel-based cars, since the reduction is relatively large. Interestingly, the amount of carbon emissions emitted by the cars in 2011 is however, on average, more or less the same, making the difference between the theoretical and actual emissions much larger. For petrol-based cars, this is also the case, albeit the difference is smaller.

The consequences of these discrepancies are enormous. The goal of the carbon-based tax system was to allocate the burden of the costs to the polluter. However, this analysis suggests that cars that are segmented in a lower tax-class should actually be grouped in a higher tax-class. Consequently, these cars should pay more taxes, since these pollute more. This effect is clearly visualized in table 10 for the BMP and table 11 for the “Bijtelling”.

Table 10. Difference in actual and theoretical tax segment (BPM)

Difference actual and theoretical tax segment	Diesel 2010	Petrol 2010	Diesel 2011	Petrol 2011
-2	0.06%	-	-	-
-1	0.74%	0.33%	0.52%	0.47%
0	45.96%	42.79%	26.10%	29.60%
1	51.51%	56.65%	67.75%	68.91%
2	1.66%	0.22%	5.62%	1.02%
3	0.06%	-	-	-

This table shows the percentage of cars (in the sample) that should be segmented in a lower, equal or higher tax class when actual carbon emissions are taken into account. For diesel-based cars in 2010, only 45.96% are characterized by more or less the same amount of carbon emission emissions. Consequently these cars are grouped in the right tax-segment. More importantly, the data shows consistently that cars should be grouped in a higher tax segment (one segment higher) than is currently the case. For diesel cars in 2010, this is 51.51% and for petrol-based cars in 2011, this is even equal to 68.91% of the cars. Also interesting to note is that the difference in theoretical and actual tax-segment increased in 2011. This is of course related to the higher spread between theoretical and actual carbon emissions in 2011. It must be noted that being segmented in the same tax-class does not necessarily imply that the same amount of taxes will be paid, since a variable part is present (see Chapter 2.3).

Table 11. Difference in actual and theoretical tax segment ("Bijtelling")

Difference actual and theoretical tax segment	Diesel 2010	Petrol 2010	Diesel 2011	Petrol 2011
-2	0.18%	0.17%	0.20%	0.13%
-1	0.18%	0.28%	0.44%	0.60%
0	69.07%	62.12%	46.52%	60.60%
1	21.32%	32.97%	28.63%	28.53%
2	9.24%	4.47%	24.21%	10.14%
3	-	-	-	-

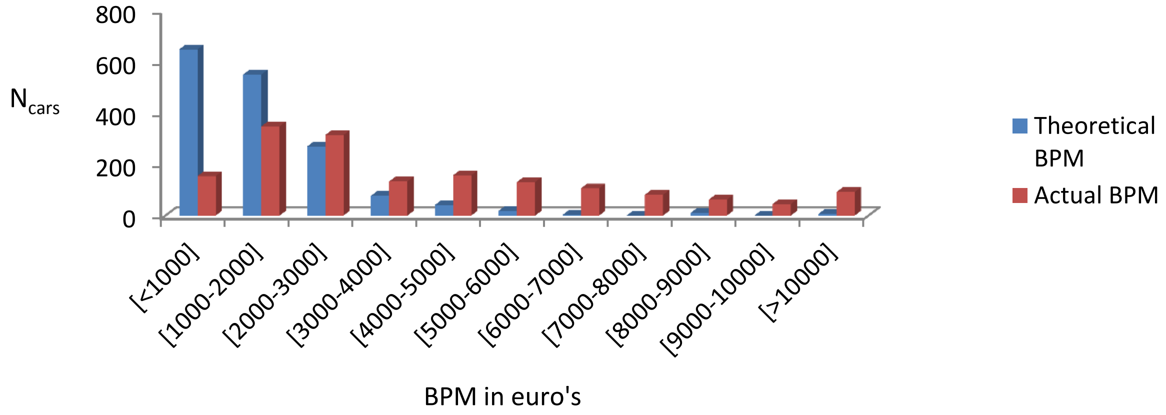
The same effect is present in the "Bijtelling", but in sharp contrast with the BPM, a higher percentage is segmented in the right class if the actual carbon emissions are taken into account. For example, for diesel-based cars in 2010, 69.07% of the cars (in the sample) are grouped in the right tax-segment (i.e., 0%, 14%, 20% or 25%). However, for 21.32% the "Bijtelling" should be one segment higher. This means that cars that initially add 14% of the catalogue price should actually be adding 20% of the catalogue price if the actual carbon emission is used. Also interesting to note, is that the percentages for the 2-segment deviation is much larger than is the case for the BPM. This increases in 2011, mainly again due to the larger discrepancy between theoretical and actual carbon emissions. These two tables already indicate that the loss in tax revenue due to this discrepancy will be significant.

4.1.3 Calculation tax losses

The next step was the calculation of the corresponding taxes and the deviation between the taxes based on theoretical emissions and taxes based on actual emissions. Logically, the corresponding tax-rates (for 2010 and 2011) are hereby used. The tax-rates are, in contrast with the carbon emissions per liter, subject to annual change. The specific BPM and "Bijtelling"-rates are shown in Appendix F. The main results of the analysis are summarized in table 12. For the sake of completeness, the overall distribution of the BPM and "Bijtelling" for petrol cars in 2010 is visualized in figure 14 (see Appendix G for all distributions). Herein, it is clearly visible that while the BPM and Bijtelling based on theoretical consumptions are more concentrated on the right side of the x-as (i.e., 0-14% & lower BPM), the BPM and

Bijtelling based on actual consumptions are either more evenly distributed over the x-as or primarily focused on the left side of the graph.

Figure 14: Distribution of BPM and Bijtelling



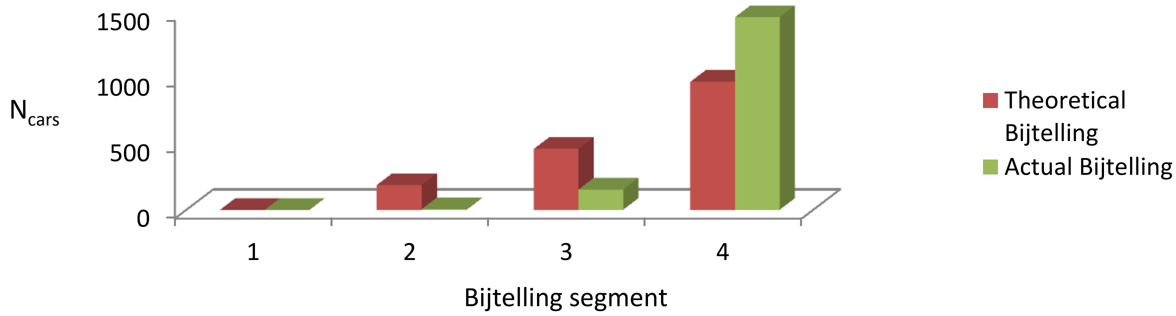


Table 12 illustrates the average BPM that must be paid when the theoretical (=paid BPM) or the actual fuel consumption (=real BPM) is used. As is visible in the row “Average difference”, the discrepancy between these two translates itself into a sizeable difference in taxes. For example, for diesel-based cars in 2010, on average, an additional €2,666.61 of taxes should be levied if the actual fuel consumption was to be used. This spread increases again in 2011, for reasons already extensively discussed in the previous parts. But a main driver of this increase is also the stricter taxation policy of the Dutch government. As mentioned in chapter 2.3, a trend exists in which the government is gradually increasing taxes by implementing either higher tax-rates or more stringent condition (i.e., lower carbon emissions). For instance, the fixed tax rate of segment 4 (i.e., >270 CO_2 per 100 km) increased from €13,720 in 2010 to €22,450 in 2011 (see Appendix F). It is therefore no surprise that the BPM increased significantly in 2011. The same trend is visible at the

"Bijtelling", but this increase is more driven by the earlier mentioned increase in deviation between the theoretical and actual fuel consumption. It is important to note that the "Bijtelling" seems larger than the BPM, but the first is derived as a percentage of the catalogue price, which results generally speaking in higher taxes. Moreover, the average difference seems smaller than the BPM, but this is because the percentages are more or less concentrated around the 20% (i.e., 14%, 20%, and 25%). Additionally, this small difference can amount to impressive figures, since the population of the "Bijtelling" is much larger than that of the BPM, which is only focused on newly acquired and registered company cars. Moreover, this is an annual payment and not a one-time payment as is the case with the BPM. This will be shown in step five. Also noteworthy, is that the difference between the theoretical based "Bijtelling" and the actual based will not instantly represent the loss in taxes. The "Bijtelling" is added on the taxable income and the actual loss in taxes for the government can only be derived after the income tax is subtracted from this figure.

Table.12 BPM and Bijtelling taxes

	Petrol		**Diesel**	
	2010	**2011**	**2010**	**2011**
Average levied BPM	€1,447.48	€2,202.87	€1,166.37	€1,216.77
Average real BPM	€4,111.09	€7,618.71	€3,360.79	€5,819.22
Average difference	€2666.61	€5415.84	€2194.41	€4602.45

	Petrol		**Diesel**	
	2010	**2011**	**2010**	**2011**
Average levied Bijtelling	€6,781.50	€6,856.16	€7,745.19	€6,599.82
Average real Bijtelling	€7,297.16	€7,462.95	€8,231.65	€7,485.96
Average difference before taxation	€515.66	€606.79	€486.46	€886.14
Average difference after taxation	€216.58	€254.85	€204.31	€372.18

4.1.4 Additional revenue through duties

As earlier mentioned, the discrepancy in theoretical and actual fuel consumption will result in the use of more petrol and diesel. Hence, the tax revenue of the government will increase due to duties that are levied on fuel. The VAT on fuel will be ignored, as this is always reimbursed by the companies. The duties and the main results are depicted in table 13.

Table 13. Duties and summary results

		2010	2011
Diesel	Duty per liter	€0.428	€0.430
	Average fuel consumed based on theoretical consumption	1,879.27 liter	1,793.56 liter
	Average fuel consumed based on actual consumption	2,373.25 liter	2,520.13 liter
	Average difference	493.99 liter	726.57 liter
	Average additional duties per car	€211.43	€312.42
Petrol	Duty per liter	0.723	0.724
	Average fuel consumed based on theoretical consumption	1,847.13 liter	1,948.94 liter
	Average fuel consumed based on actual consumption	2,322.38 liter	2,571.09 liter
	Average difference	475.24 liter	622.15 liter
	Average additional duties per car	€343.60	€450.44

As is visible, the level of duties levied remained more or less the same. For diesel based cars in 2010, the average fuel consumed by company cars was 2,373.25 liter, while a consumption of approximately 1,879.27 was expected in the theoretical fuel consumption was taken at face value. The average difference in the same year amounted to 439.99 liter, which corresponded to an average of €211.43 (€0.428 per liter) of additional revenue per company car due to the fact that these are less efficient than claimed by the car manufacturers. For reasons already mentioned in the previous parts (i.e., higher discrepancy), significant difference exists between the additional revenue in 2010 and 2011.

4.1.5 Aggregation to the population

The last step involves the extrapolation of the determined averages to the population level. It is important to highlight again that this study only focuses on the company cars. Hence, the population figures used will seem relatively small if compared with the overall size of the passenger cars in the Netherlands. Each average (i.e., per year and fuel type) will serve as a proxy for their respective population (e.g., diesel 2010 for all diesel company cars in 2010). It is therefore necessary to identify the exact proportions of the respective fuel type. According to VNA (2010), 48% of the company cars in 2010 were diesel driven, whereas 45% of were petrol based. This remained the same in 2011 for the diesel cars, but the proportion of petrol based cars increased to 46%. This results in the following table.

Table 14. Company car fleet characteristics

	Diesel		Petrol	
	2010	2011	2010	2011
Total newly acquired cars	129,700	139,300	129,700	139,300
Total number of cars in the Netherlands	682,400	683,400	682,400	683,400
Fuel type proportions	48%	48%	45%	46%
BPM-population in cars	62,256	66,864	58,365	64,078
Bijtelling-population in cars	327,552	328,032	64,078	314,364
Fuel duties-population in cars	327,552	328,032	64,078	314,364

Source: VNA (2013)

Based on these figures, the averages are used to estimate the effect over the whole company car fleet. This is simply done multiplying the proportions with the overall population, after which this is again multiplied with the respective average. The results derived from the analyses are summarized in table 15. This table indicates that the discrepancy leads, as expected, to significant losses in tax revenue. It also confirms the notion that the current carbon tax policies is founded on unreliable information provided by the car manufacturers. The government missed €425,681,566 of taxes in 2010 alone. The overall taxation loss increased significantly in 2011 to €856,976,999. The increase in missed taxes from 2010 to 2011 is primarily attributable to the rising BPM rates and stricter taxation policy. The BPM loss in diesel alone rose by 126% in 2011, while the petrol-based cars increased by 123%. The "Bijtelling" rates remained the same and the average gross income increased only €500, so the main driver of this increase seems to be the rising discrepancy. Additionally, the income tax-rates also increased in the same period, which can also be held accountable for the increase in missed taxation through the "Bijtelling".

Table 15. Main results

	Diesel	Petrol	Diesel	Petrol
	2010	2010	2011	2011
BPM	-€136,615,329	-€155,636,735	-€307,738,194	-€347,036,019
Bijtelling	-€66,923,199	-€66,506,303	-€122,086,501	-€80,116,285
Total loss	-€203,538,528	-€222,143,038	-€429,824,695	-€427,152,304
Additional duties	+€69,254,319	+€105,513,163	+€102,484,876	+€141,601,775
Net loss	-€134,284,209	-€116,629,875	-€327,339,819	-€285,550,529
Total net loss	**-€250,914,084**		**-€612,890,348**	

But the discrepancy also leads to higher tax revenue due to the fuel duties. This corresponded to €174,767,482 of additional revenue in 2010, which increased to €244,086,651 in 2011. This increase is of course mainly driven by the rising discrepancy in theoretical and actual fuel consumption, which resulted in the use of more fuel. Also noteworthy, is that the average distance of the cars in the sample increased in 2011. For diesel-based cars, the average distance increased from 38,959 km in 2010 to 41,267 km in 2011, whereas petrol-based cars drove on average 29,997 km in 2010 and 32,694 km in 2011. The duties remained more or less the same. Hence, these two factors were the main underlying drivers of this growth in tax revenue. Corrected for additional tax revenue through fuel duties, the discrepancy leads to a net taxation loss of €250,914,084 in 2010 and €612,890,348 in 2011, which posits nevertheless a quite substantial figure.

4.2 Non-financial costs for the government

In addition to the financial losses, the government also incurs non-financial costs due to the discrepancy. As indicated in the introduction, this will be measured by deriving the total amount of carbon emissions emitted by the company cars. More specifically, this research will quantify the extra non-financial burden the discrepancy between theoretical and actual fuel consumption causes. The exact procedure is described in chapter 3.2. This resulted in the following results.

Table 16. Non-financial costs

	Diesel	**Petrol**	**Diesel**	**Petrol**
	2010	2010	2011	2011
Average theoretical carbon emission	4,961	4,876	4,735	4,662
Average actual carbon emission	6,265	6,131	6,653	6,150
Average difference	1,304	1,255	1,918	1,488
Population	327,552	307,080	328,032	314,364
Total emission	427,167,114	385,276,280	629,209,473	467,833,490
Total non-financial costs	**812,443,394**		**1,097,042,963**	

*Note: all variables are depicted in kg CO_2

The table above suggests that huge differences exist in theoretical carbon emissions and actual carbon emissions, which increased substantially in 2011. Aggregating the average difference between the actual and theoretical carbon emissions leads to a total additional

CO_2 of 812,443,394 kg in 2010. This increased with 35% in 2011 to a total carbon emission of 1,097,042,963 kg in 2011. Reasons for this increase are already extensively discussed in the previous paragraphs. This obscure number is hard to interpret, as it offers no reference point about the magnitude of this figure. As such, representing this figure in monetary terms and calculating the relative magnitude can be more insightful. For the first, a value of €20 per ton CO_2 (=1000 kg) will be used (Geurts & Rathmann, 2010). The price was initially much higher (€40), but the economic downturn lead to a lower CO_2 price. It must be noted that different studies argue a much higher price (Tol, 2005). This leads to a total € 16,248,868 in 2010 and € 21,940,859 in 2011. This is rather low, but the global CO_2 emission rights markets are incurring huge drops in value, so this might explain the low value. The second method is however more insightful. According to the CBS (2012), the Netherlands as a whole emitted around 211 billion of CO_2 equivalents (=total effect of 1 kg CO_2) in 2010. This decreased in 2011 to 208 billion of CO_2 equivalents. The above mentioned figures are therefore equal to 0.39% in 2010 and 0.53% in 2011. This seems small, but given the fact that the Netherlands must reduce the total carbon emission with 6% in the period 2008-2012 in order to comply with the guidelines set in the Kyoto protocol, this relative small amount can still be influential. This is especially true if the results in the table are extrapolated over the whole Kyoto-period of 2008-2012, since the total of 2010 and 2011 alone already sums up to almost 1%.

4.3 Financial costs for companies

Also of interest for this research are the financial costs the market incurred due to the discrepancy in fuel consumptions. The deviation in fuel consumption will, as previously mentioned and illustrated, lead to the use of more fuel. Hence, companies incur more fuel costs, since, as mentioned in the introduction, the car lease holders are not liable for the extra costs. In order to calculate these costs, the difference in fuel usage is corrected for the 23% margin, after which these figures are expressed in a monetary value using the recoverable part of the fuel price. The average over the whole dataset is then multiplied by the number of cars in the population. The results are summarized in table 17.

It comes as no surprise that 2011 is characterized by higher costs on average, since the deviation between the theoretical and actual consumption was larger. The latter is of course also visible when looking at the average extra fuel that is consumed. Consequently, the financial costs in 2011 are much higher than in 2010. More precisely, the costs increased with over 62% from €265,486,218 in 2010 and €430,972,269 in 2011. Another contributing factor was the increased average fuel price (excluding taxes). This resulted in higher costs per liter, and thus to higher financial costs. It is important to note that it is of course nearly impossible to save the totality of these costs. However, given the fact that the results above is corrected for non-driving behavior factors, it is more than conceivable that promoting eco-friendly driving can save significant amount of money for the market.

Table 17. Financial costs for the market

	Diesel	**Petrol**	**Diesel**	**Petrol**
	2010	2010	2011	2011
Average extra fuel	380.37 liter	365.94 liter	559.46 liter	479.06 liter
Average extra costs	€384.14	€447.58	€677.21	€664.28
Duties	€0.43	€0.72	€0.43	€0.72
VAT	€0.19	€0.23	€0.23	€0.22
Fuel price excluding taxes	€0.58	€0.50	€0.78	€0.66
Total recoverable per liter	€1.01	€1.22	€1.21	€1.39
Population	327,552 cars	307,080 cars	328,032 cars	314,364 cars
Total extra financial costs	€128,043,352	€137,442,866	€222,146,551	€208,825,718
	€265,486,218		**€430,972,269**	

5 Implications & Discussion

In this chapter, the overall implications of this research will be discussed. In addition to this, the limitations of this research will be further elaborated upon. Lastly, some suggestions for future research will be presented.

5.1 General Implications

The results of this research lead to several implications. Firstly, this research showed that huge shortcomings exist in the current procedures to derive fuel consumptions. The procedures are basically a form of forecasting, and as the saying goes: “The only right thing about a forecast is that it is wrong”. Deviations of the actual fuel consumption are therefore to be expected, but the involved magnitudes are much greater than are warranted by test procedures. This research showed, in line with the results of the TNO (2013) and findings provided by Lighterink and Bos (2010), that the average deviation in 2010 was approximately 30% for both diesel-based (30.37%) as petrol-based cars (28.29%). This increased even more in 2011. For petrol-based cars, the deviation between the actual and theoretical consumption increased (with 19.79%) to 33.89%, while deviation for diesel based cars rose (with 46.89%) to 44.61%. It is of course difficult to conclude any trends based on two points in time, but it can nevertheless provide some valuable insights. The increased deviation is attributable to the lower theoretical fuel consumptions in 2011, at least according to the car manufacturers (Romaszweski, 2012). This research showed that, despite these claims, no lower fuel consumptions were achieved and thus the deviation increased in 2011.

This also presents another dilemma, namely the conflict of interests in the current taxation policies. On the one hand, the car manufacturers provides the necessary specifics that is used as an input to calculate the taxation, but on the other hand, these car manufacturers might profit from these policies, since it will be more attractive for consumers to acquire these cars as more tax benefits are available. Consequently, these car manufacturers have a strong stimulus to report even lower theoretical consumptions by using a lot of latitude provided by current legislation. This in order to promote the sales of their cars, despite the obvious problems related to the actual fuel consumption. Consumers are hereby the sole bearer of additional costs these larger deviations amount to. Hence, it is necessary implement new legislation for the car manufacturers. Given the international scope of the industry, this must be realized on the European Union level. The goal of this legislation would be to regulate the testing procedures and to provide more realistic guidelines to car manufacturers. An example of this is already presented in chapter 2 (see CADC). But this alone would not be enough to address the total deviation, as the behavior of the driver also has a substantial influence on the size of the discrepancy. With this in mind, the EU can implement regulations that make the installation of fuel efficiency improvement tools mandatory for car manufacturers. Examples could include a smart system in cars that advices the driver (e.g., when to break and in which gear) or the incorporation of feedback mechanisms, which increases the push back force in the pedal. This can all be promoted through the use of subsidies or even, in an extreme case, making it mandatory for cars.

5.2 Implications for the government

Additionally, this study argued that the current taxation schemes are based on the wrong information and consequently fails to fully realize the goals of these schemes. The results presented in chapter 4 supports this notion and indicate that sizeable opportunity costs for the government exists. This means that the earlier mentioned principle of the 'vervuiler betaalt' (polluter pays) is not fully grasped by the current BPM and Bijtelling scheme, and that the 'vervuilers' are not fully held responsible for the emission they emit. This is the case because the theoretical fuel consumption is used, which gives a false representation of the reality. Cars with a lower consumption are expected to emit less carbon emissions and consequently fewer taxes are levied on these cars. But these cars emit much more than expected and this is especially the case for cars with lower consumptions. These cars should consequently be segmented in a higher tax-class (with higher tax rates), resulting in the payment of more taxes. This was illustrated by demonstrating that, for BPM, 51.51% of the diesel cars in 2010 should be segmented should actually be segmented in one class higher, while for petrol cars this is equal to 56.65%. This increased in 2011 even to 67.75% and 68.91% respectively. For the 'bijtelling' this is a bit lower, namely around 30% for both 2010 and 2011, but it still represents a sizeable portion of the cars. 24.21% of the diesel cars in 2011 are even classed two segments lower than should be the case if the actual consumption is taken into account.

Using the dataset of Athlon, this research also illustrated that the total net losses in taxation in 2010 alone equaled €250,914,084 (€134,284,209 for diesel cars and €116,629,875 for petrol cars). This is even corrected for the increased income of €174,767,482 through fuel duties (more fuel usage at lower efficiency), so the initial taxation loss was much higher (i.e., a substantial amount of €425,681,566). This taxation loss increased even substantially in 2011 (with 144%) to over €612,890,348 (€327,339,819 for diesel cars and €285,550,529 for petrol cars). This was also corrected for the increased fuel duties of €244,086,651, so the initial loss was €856,976,999. In addition to these financial costs, the government (and society as a whole) also incurred non-financial costs in the form of carbon emissions. This study showed that in 2010 alone an additional 812,433,394 kg CO_2 was emitted due to the discrepancy in fuel consumptions. This increased to 1,097,042,963 kg CO_2 in 2011.

In order to address these issues, the government can implement or adjust several policies. First of all, the government can internalize the costs to society by adjusting the current taxation scheme by the magnitude of these losses. This can, for example, be realized by raising the fuel duties to a level whereby the taxation losses are accounted for. The exact amount needs to be determinant, but a simple analysis can give some insight in the approximate amount. According to the VNPI ("Vereniging Nederlandse Petroleum Industrie") the total amount of fuel used in the Netherlands equaled to approximately 14.02 billion of liter in 2010 and 2011. This means that the fuel duties should be increased with 2 cent per liter in 2010 and 4 cent in 2011 to account for the respective taxation losses. This was derived by dividing the losses by the total liter. Thus, the effect could be rather small, but more research is needed is of course needed to calculate the right amount. However, gathering political support for such a policy would prove to be difficult.

Another possibility would be to improve the current taxation scheme such that the actual emissions are reflected in a more accurate way. This can for instance be achieved by using the actual fuel consumption instead of the theoretical. One way to realize this would be add a fixed percentage on the theoretical consumption provided by the car manufacturers. It is also possible to levy a delayed form of taxes by issuing a period in which the actual emissions are derived. So the actual consumption of a newly registered or acquired cars would be investigated for a certain fixed period (say 1 year), after which the consumption is derived using tank cards (or electronic boxes in cars). This would then be used as an input to calculate the actual taxes. Another method is incorporating the road tax into the fuel price (a form of the earlier proposed 'kilometerheffing'). This will however be challenging, since companies are responsible for the fuel payments. In order to address this issue, companies can transfer excessive discrepancies in fuel usage to their employees. This is necessary in order to provide them with a financial incentive to drive more efficiently. Thus, drivers would be susceptible to the effect of extra fuel consumption and consequently on the emissions of the car. This will transfer the larger share of the tax burden on the polluters, which would be in line with the 'vervuiler betaalt' principle. This can present a strong stimulus for drivers to drive more efficient (Boriboonsomsin, Vu, & Barth, 2010). This would also influence the decision making process of employees, as the opportunity rises, making alternative transportation methods more attractive. This policy would however not without challenges, as it would introduce a lot of variability in the taxation revenue. Additionally, the political support for such a solution may be missing. It must be noted that the tax losses will be much higher in 2012 onwards. The main reason for this, is the more stringent tax policies introduced by the government. The government is increasingly lowering the threshold (so lower emissions in order to be eligible for lower tax rates). As a consequence, a small deviation would be sufficient to put a car in a higher tax segment, making the losses much higher.

The last possibility worth mentioning is the improvement of transportation infrastructure (Barth & Boriboonsomsin, 2009). The aim of this improvement is to reduce congestion, which has been widely acknowledged as one of the drivers of the fuel consumption discrepancies and thus higher emissions (Treiber, Kesting & Thiemann, 2007). This can be realized by increasing road capacity or implementing smart road grids that provide real-time information about the current state of highways. The latter is especially attractive, since, as mentioned in chapter 2.4, car manufacturers have increasingly focused solely on urban driving conditions and not on highway-driving. In theory, these practices seem attractive and feasible, but the use and implementation of these kinds of practices prove to be more challenging in practice. For example, the diversion of traffic to less congested areas can result in the mere reallocation of congestions.

5.3 Implications for companies

This research also asserted that, in addition to the government, companies also incur a lot of costs. This is the case, as these companies are ultimately responsible for paying the costs of fuel. As such, this study demonstrated that the total financial costs in 2010 equaled to €265,486,218, which increased with 62% to €430,972,269 in 2011. The underlying drivers of this increase are already discussed extensively in the previous parts. This study showed thus that an impressive amount of money can be saved if more efficient driving behaviors are stimulated. But, maybe more important than the monetary savings, is the possibility to reduce the carbon footprint of companies. Nowadays sustainability is increasingly becoming a matter of concern, not only for customers and governments, but also for companies themselves. Demanding customers, stricter government policies, coupled with an increasing competitive market, forces companies to incorporate sustainability practices into their business model. This research showed that in 2010 alone these companies incurred an additional carbon footprint of 812,433,394 kg CO_2, which increased to 1,097,042,963 kg CO_2 (an increase of 35% when compared with 2010).

Several policies could be implemented by the companies in order to reduce these costs and carbon emissions. Firstly, companies could implement more flexible working hours. It is not surprising that congestion is one of the key drivers of the discrepancy between the theoretical and actual fuel consumption. Treiber, Kesting and Thiemann (2007) argued even that during congestion fuel consumption increases with 80%. Since congestion is essentially a peak problem (i.e., too much traffic at once), spreading the working hours of employees can reduce the magnitude of this peak, resulting in less congestion and therefore lower deviations. However, it must be noted that Saleh and Farrell (2005) demonstrated that, due to non-work commitments (e.g., child care), the timing of employees' work trips may not be that flexible. So, the effect of this policy alone must not be overestimated. Furthermore, sometimes it is simply not possible to offer flexible working hours.

A second policy that could prove to be beneficial is encouraging employees to drive more efficiently. As mentioned in chapter 2.5, the provision of information to optimize work trips can influence driving behavior such that fuel consumption can be reduced. This policy can be orchestrated in coordination with the government, as one of the main aims of government policy is the reduction of carbon emissions. Especially in light of the government objectives introduced by the Kyoto protocol. Ideally, such a program should be augmented by an incentive system. This is especially necessary since information alone is not enough to influence the driving behavior. For example, the fuel consumptions of employees could be tracked and by encouraging competition among employees and rewarding the winner with a price (e.g., holiday or some electronics), the driving behavior can be positively influenced. It is also possible to penalize employees when excessive fuel is used. This can perhaps even have a larger effect, as employees incur more costs if more fuel is consumed. This would of course be more difficult to sell to employees.

6 Conclusion

The aim of this research was threefold. First, it examined the fiscal consequences of the discrepancy in theoretical and actual fuel consumption in company cars in the Netherlands. Second, it investigated the related non-financial costs, as measured by the total carbon emissions, for the Dutch government. And lastly, it provided some insight about the financial costs for the companies providing these company cars. In order to achieve these goals, this research utilized an extensive dataset provided by Athlon, one of the largest car lease companies in the Netherlands. Reviewing past literature, tax frameworks, and characteristics of the company car industry ensured robust and holistic analyses. Based on these reviews, it was illustrated that the deviation in theoretical and actual consumption is basically driven by two main factors, namely inadequate test procedures on the side of the car manufacturers, and inefficient driving behaviors of car users. In accordance with literature, the average deviation equaled approximately 30% in 2010. This increased further in 2011, due to alleged lower theoretical consumptions in that year. Empirical support for this lower consumption was however not found and more interestingly, it increased for petrol cars. This supports the notion that governments base their taxation schemes on wrong information. Using the sample to derive averages that represent population characteristics, such as average loss in BPM per car, it was demonstrated that the use of this biased information leads to a total fiscal loss (i.e., missed BPM and Bijtelling) in 2010 of €250,914,084, which rose to €612,890,348 in 2011. Both were corrected for additional tax revenues from fuel duties (€174,767,482 in 2010 and €244,086,651 in 2011). Moreover, the Dutch government incurred significant non-financial costs in the form of 812,433,394 kg of carbon emissions in 2010 and 1,097,042,963 kg CO_2 in 2011. Lastly, the discrepancy led in 2010 alone to additional financial costs of €265,486,218, which increased to €430,972,269 in 2011. All these results indicate that the consequences of fuel consumption discrepancies are huge and consequently this should be addressed accordingly. First of all, great headway can be made through the use of tools that support more eco-friendly driving and other programs, such as incentive systems and flexible working arrangements. Secondly, new regulations on a transnational level are needed to ensure adequate guidelines for test procedures. Thirdly, the Dutch government can correct for this by using either actual emissions (based on past data) or correct for the discrepancy by a mark-up percentage.

6.1 Limitations

The first limitation of this study is the extensive use of averages. It is implicitly assumed in this research that the average of the sample can be used to proximate population characteristics. Albeit good reasons exists that the method followed in this research is more or less adequate, several alternative methods can be used that are more sophisticated and reliable than the current method. It is, for example, conceivable that different deviations exist per brand and even per model. As such, one could take this into account by segmenting the overall population into distinct sub-groups and proximate the characteristics of these groups by the sample. In other words, by making use of multiple averages instead of one average. This would make the aggregation to the population level more reliable. However, given time constraints and more importantly lack of the necessary data (about the population) made the use of this method infeasible. Consequently, this research was forced to express all the deviations into one number and aggregate this to the population.

A second limitation involves the data, as it is not entirely known if the sample data is correct. Especially the mileage data is a source for concern, since negligence and mistakes can occur in wrong insertions. As mentioned in chapter 3.2, attempts were made to account for these mistakes, but there is of course no guarantee that this was successful. Since the mileages were of paramount importance for this research, the results can be biased. Another example of the less than optimal data is the gross income that is used to calculate the missed Bijtelling. Ideally, the corresponding incomes would be used as an input, but these were not present in the dataset. Company cars, often considered as a status symbol, are also provided to employees with higher salaries. As such, it is conceivable that the loss in taxation revenue will be much larger, but this could be ascertained since the data was not available. Moreover, it was not possible to make a distinction between different subgroups. For example, it was not known which of the employees was responsible for paying their own fuel consumption. Since this, as illustrated in chapter 2.2, can influence the driving behavior and hence fuel consumption, the results are not so easy generalizable to the population level.

The third limitation concerns the sample size. This research implicitly assumed that the sample was of a size that it is representative for the whole population. No clear rules exist about the exact sample size for aggregation-like studies, but an argument could be made for the insufficient size of the sample. A small sample will be problematic, as it will be unable to cover all variation in the population. For instance, chapter 2.4 indicated that the driving behavior of employees significantly influences the discrepancy in fuel consumptions. Moreover, Romaszewski (2012) illustrated that differences in driving behavior exists between different economic sectors. Also, some car users reside in urban areas and are therefore less efficient than users living in more rural areas. A small sample size would not sufficiently cover such characteristics. Another limitation related to the sample, is that only two points in time are used. Consequently, no reliable conclusions could be made about the development of the total welfare costs over time.

Another major limitation of this study is that this study only took the years 2010 and 2011 into consideration. An argument could be raised about the actuality of this research and the applicability of its findings. However, given the continuing use of the carbon-based taxation schemes and given the even stringent criterions, the results of this research will still provide valuable insights. Especially since this problem has not been sufficiently addressed by previous researches.

6.2 Future research

Given the shortcomings described above, a number of recommendations for future research can be made. Firstly, it would be very insightful if future research can extend this research by looking at more recent years (i.e., 2012, 2013 and 2014). This can shed some light in the amount of taxation losses in these years and it would also be possible to identify certain trends in these losses. For example, as mentioned repeatedly, the current taxation scheme is becoming more stringent with the year. Hence, it was asserted that this will translate itself into larger taxation losses. This claim can be investigated by looking at all years of implementation. In other words, by taking a more longitudinal approach to the topic. Secondly, improving the dataset and enlarging it could provide valuable insight. For example, adding the corresponding taxable income of the car users can result is more accurate and reliable results in terms of missed tax revenues from Bijtelling. Additionally, enlarging the dataset ensures that the aggregation process will be more robust. A large sample would encompass more variation (e.g., in driver behaviors and economic sectors), which results in more reliable averages and thus to more accurate aggregations. Thirdly, future research can use more sophisticated methods. It would also be very beneficial is a distinction is made between the different car brands and models. This would provide more accurate results. Fourthly, future research can also investigate the effect of support tools. Such a study would involve cars with and without support tools, whereby tank cards are used to conclude if the discrepancy between the actual and theoretical fuel consumption decreased. This would be especially attractive for companies that consider the implementation of carbon reduction programs, which currently seems to gain tract among companies as customers become more demanding. Lastly, more research is needed in the field of fuel consumption. Explanatory models could be extended to encompass a wider variety of variables that are not only related to the technical characteristics of cars, but also incorporate more soft factors.

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Appendix

Appendix A: Development of "Bijtelling" rates

Bijtelling lease auto op benzine	2012 1 juli	2013 1 januari	2014 1 januari	2015 1 januari
0 %	minder dan 51 g			
7 %		minder dan 51 g	minder dan 51 g	minder dan 51 g
14 %	51 - 102 g	51 - 95 g	51 - 88 g	51 - 82 g
20 %	103 - 132 g	96 - 124 g	89 - 117 g	89 - 110 g
25 %	meer dan 132 g	meer dan 124 g	meer dan 117 g	meer dan 110 g

Bijtelling lease auto op diesel	2012 1 juli	2013 1 januari	2014 1 januari	2015 1 januari
0 %	minder dan 51 g			
7 %		minder dan 51 g	minder dan 51 g	minder dan 51 g
14 %	51 - 91 g	51 - 88 g	51- 85 g	51- 82 g
20 %	92 - 114 g	89 - 112 g	86 - 111 g	83 - 110 g
25 %	meer dan 114 g	meer dan 112 g	meer dan 111 g	meer dan 110 g

Appendix B: Development BPM rates

BPM voor benzine auto	tot 1-7-2012	vanaf 1-7-2012	2013	2014	2015
vrijgesteld	< 111	< 103	< 96	< 89	< 83
1e schijf	111-180	103-159	96-140	89-124	83-110
2e schijf	181-270	160-237	141-208	125-182	111-160
3e schijf	> 270	238-242	209-229	183-203	161-180
4e schijf	nvt	>242	>229	>203	>180

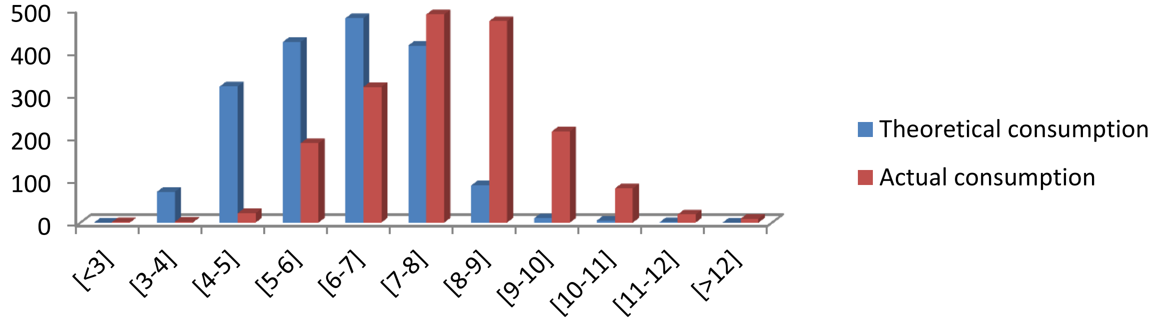
BPM voor diesel auto	tot 1-7-2012	vanaf 1-7-2012	2013	2014	2015
vrijgesteld	< 96	< 92	< 89	< 86	< 83
1e schijf	96-155	92-143	89-131	86-120	83-110
2e schijf	156-232	144-211	132-192	121-175	111-160
3e schijf	> 232	212-225	193-215	176-197	161-180
4e schijf	nvt	>225	>215	>197	>180

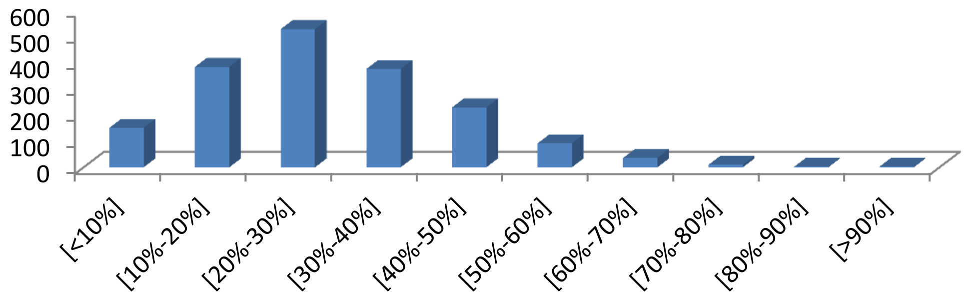
Appendix C: Buildup dataset

Year	N_{cars}	$\%_{cars}$	N_{cars}	$\%_{cars}$
2006	20	0.28	19	0.26
2007	141	1.99	115	1.58
2008	964	13.61	641	8.81
2009	1799	25.40	1447	19.88
2010	1811	25.57	1623	22.30
2010	2348	33.15	3433	47.17
Total	7083		7278	

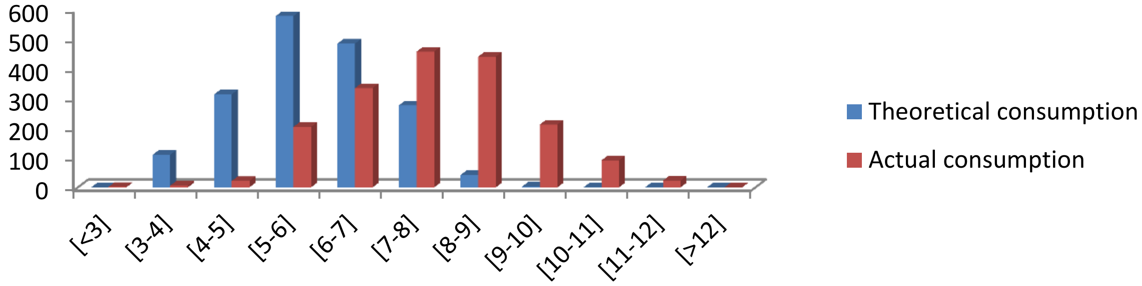
Appendix D: Difference between the theoretical and actual fuel consumption

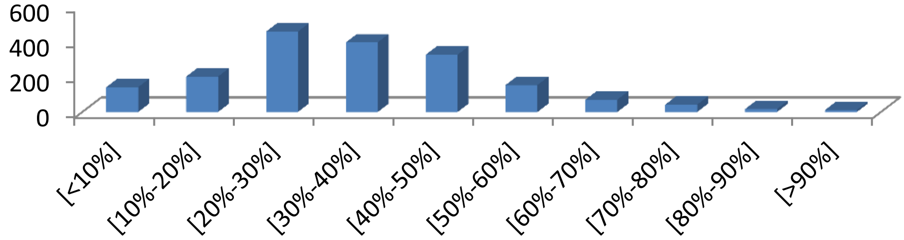
Petrol 2010: Difference (y-axis: number of cars, x-axis: liter/100km) and deviation frequencies (x-axis: % of deviation between theoretical and actual fuel consumption).



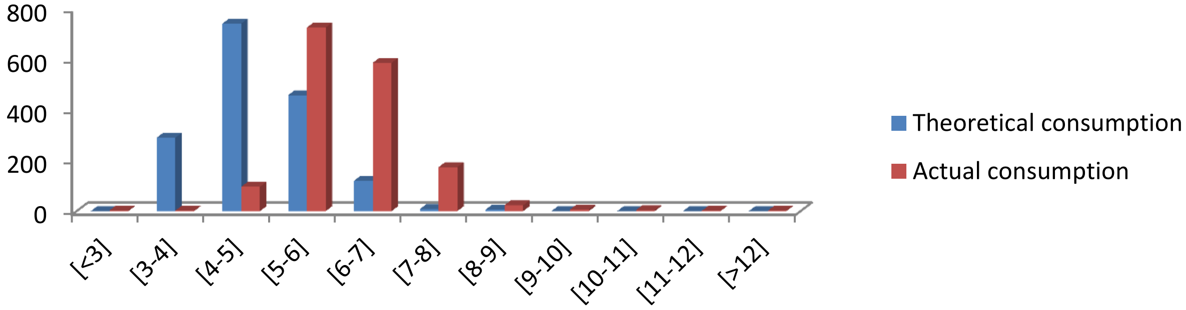


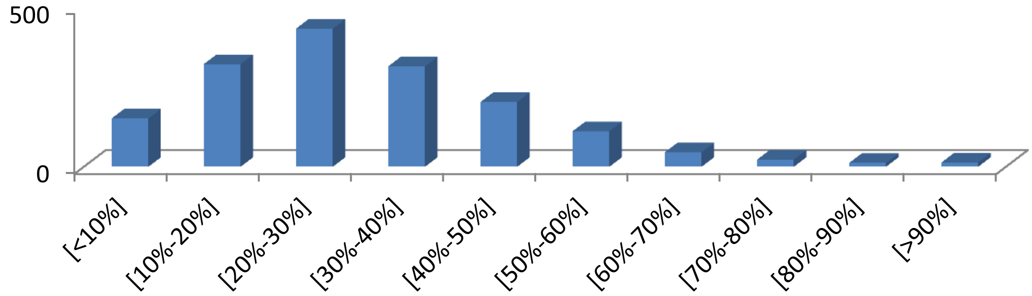
Petrol 2011: Difference (y-axis: number of cars, x-axis: liter/100km) and deviation frequencies (x-axis: % of deviation between theoretical and actual fuel consumption).



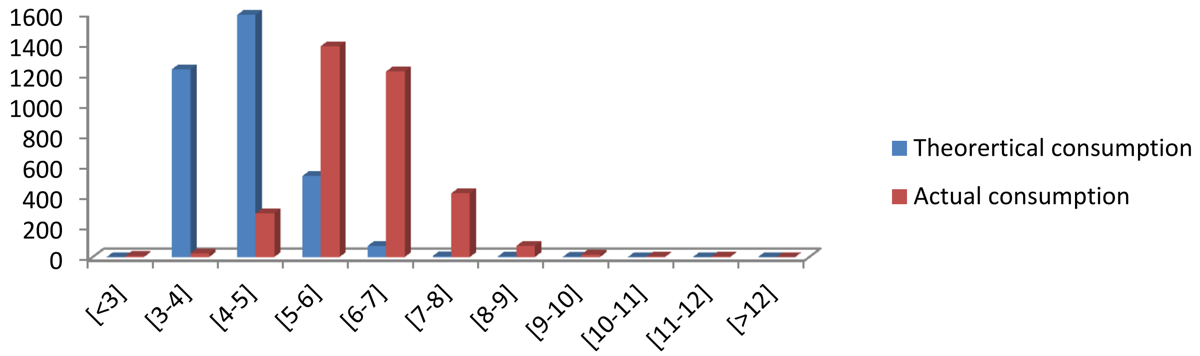


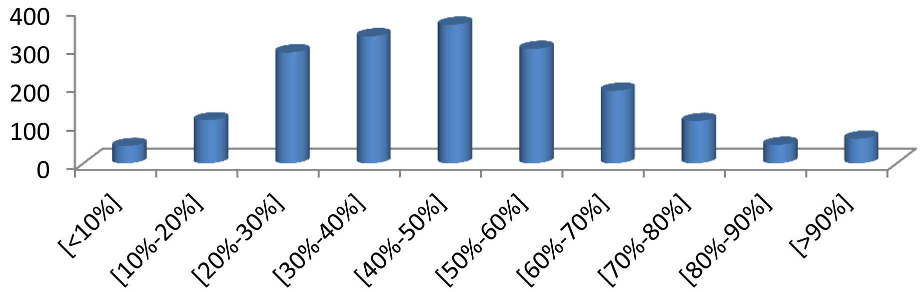
Diesel 2010: Difference (y-axis: number of cars, x-axis: liter/100km) and deviation frequencies (x-axis: % of deviation between theoretical and actual fuel consumption).





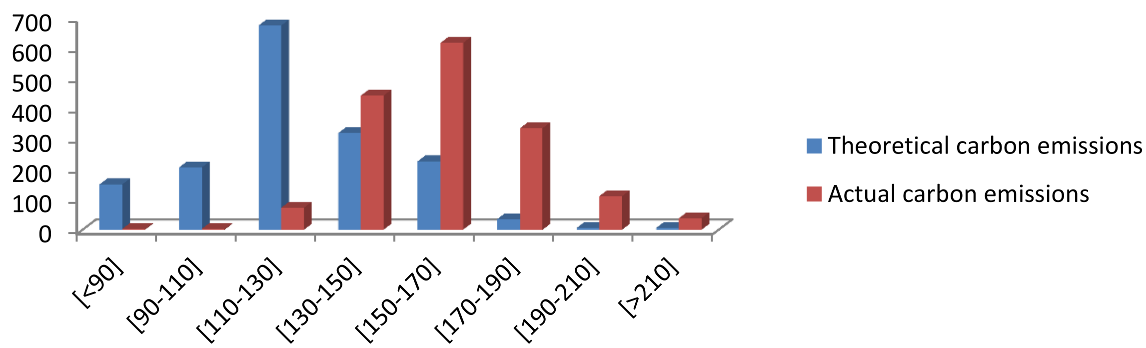
Diesel 2011: Difference (y-axis: number of cars, x-axis: liter/100km) and deviation frequencies (x-axis: % of deviation between theoretical and actual fuel consumption).



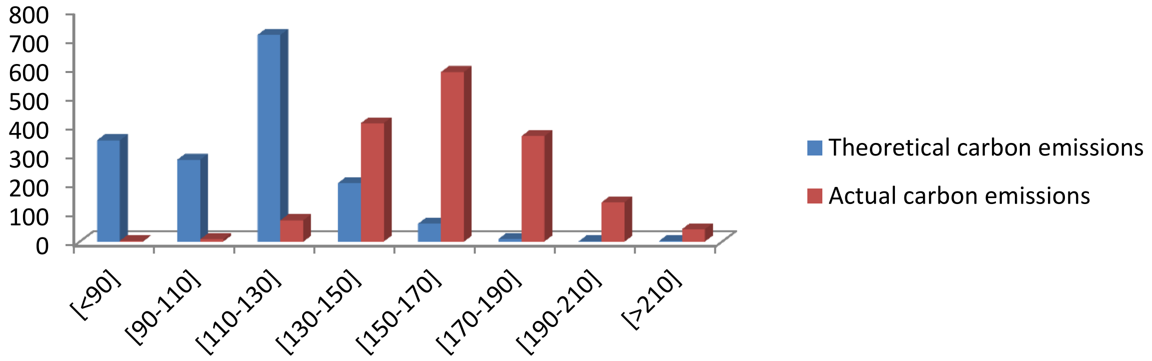


Appendix E: Difference theoretical and actual carbon emissions

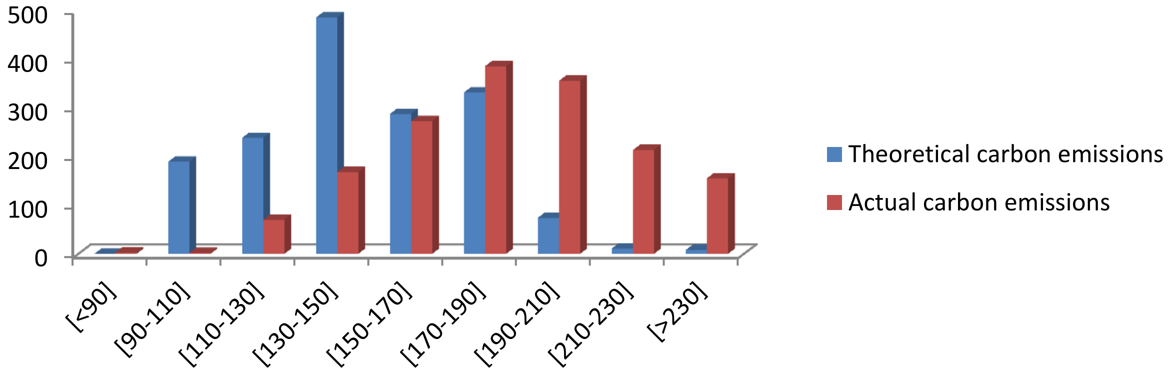
Diesel 2010 (y-axis: number of cars, x-axis: carbon emission in gram per km).



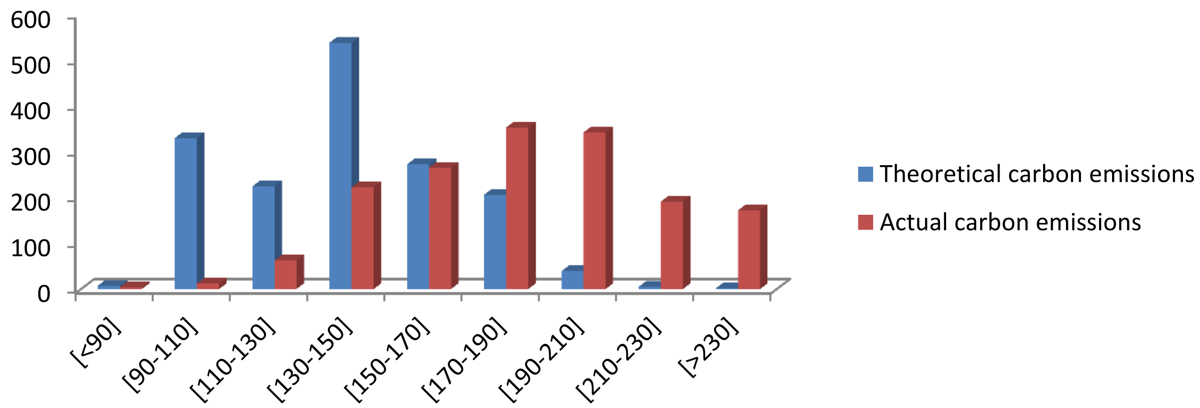
Diesel 2011 (y-axis: number of cars, x-axis: carbon emission in gram per km).



Petrol 2010 (y-axis: number of cars, x-axis: carbon emission in gram per km).



Petrol 2011 (y-axis: number of cars, x-axis: carbon emission in gram per km).



Appendix F: BPM and "Bijtelling" rates

BPM 2010:

BPM for petrol or other

CO_2 emission from g/km	CO_2 emission up to g/km	Fixed	Variable
-	110	0	0
110	180	0	€34
180	270	€2.380	€126
270	-	€13.720	€288

Diesel

CO_2 emission from g/km	CO_2 emission up to g/km	Fixed	Variable
-	95	0	0
95	155	0	€34
155	232	€2.040	€126
232	-	€11.742	€288

BPM 2011:

BPM for petrol or other

CO_2 emission from g/km	CO_2 emission up to g/km	Fixed	Variable
-	110	0	0
110	180	0	€61
180	270	€4.270	€202
270	-	€22.450	€471

Diesel

CO_2 emission from g/km	CO_2 emission up to g/km	Fixed	Variable
-	95	0	0
95	155	0	€61
155	232	€3.660	€202
232	-	€19.214	€471

Bijtelling 2010

Bijtelling

% of catalogue price	Fuel type	CO_2 emissions (gram/km)
0%	-	0
14%	Diesel	≤95
	Petrol or other	≤110
20%	Diesel	≤116
	Petrol or other	≤140
25%	Diesel	≥117
	Petrol or other	≥141

Bijtelling 2011

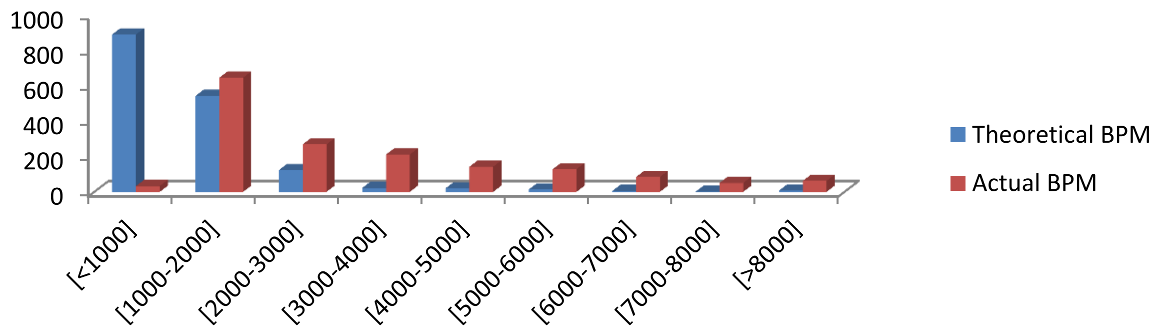
Bijtelling

% of catalogue price	Fuel type	CO_2 emissions (gram/km)
0%	-	0
14%	Diesel	≤95
	Petrol or other	≤110
20%	Diesel	≤116
	Petrol or other	≤140
25%	Diesel	≥117
	Petrol or other	≥141

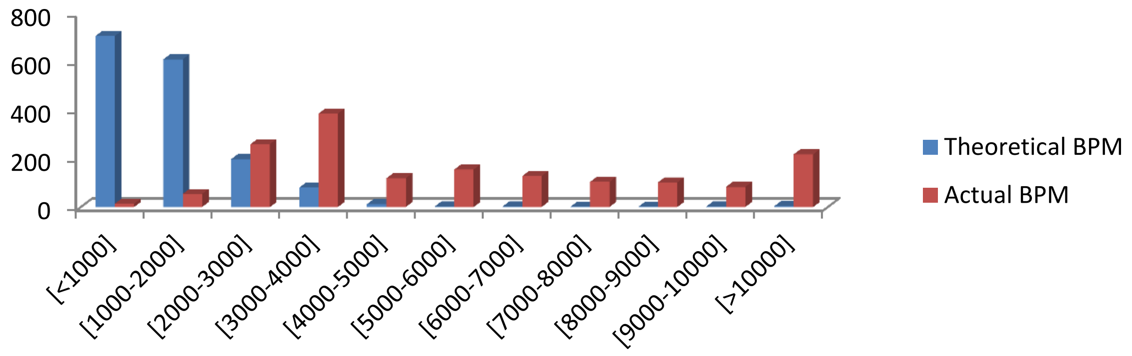
Appendix G: Distribution of BPM taxes and "Bijtelling"

BPM

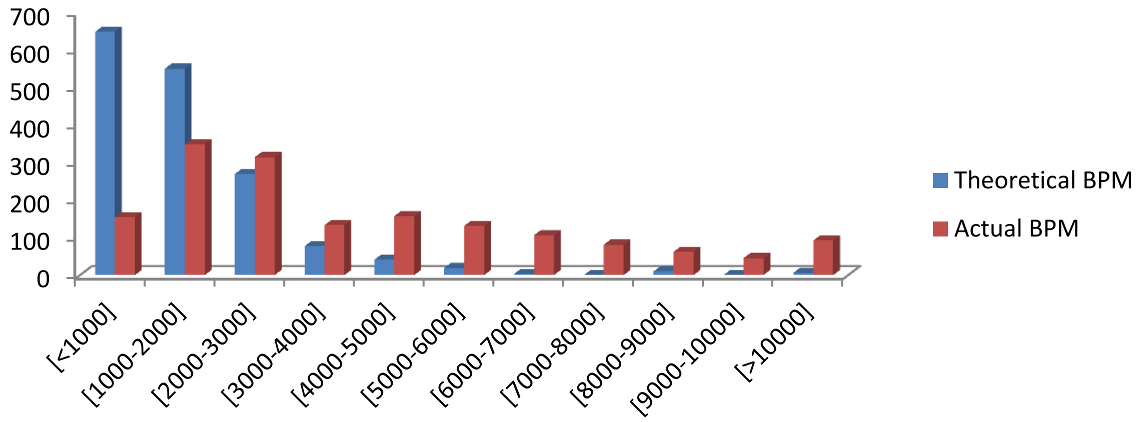
Diesel 2010 (y-axis: number of cars, x-axis: taxes in euro's).



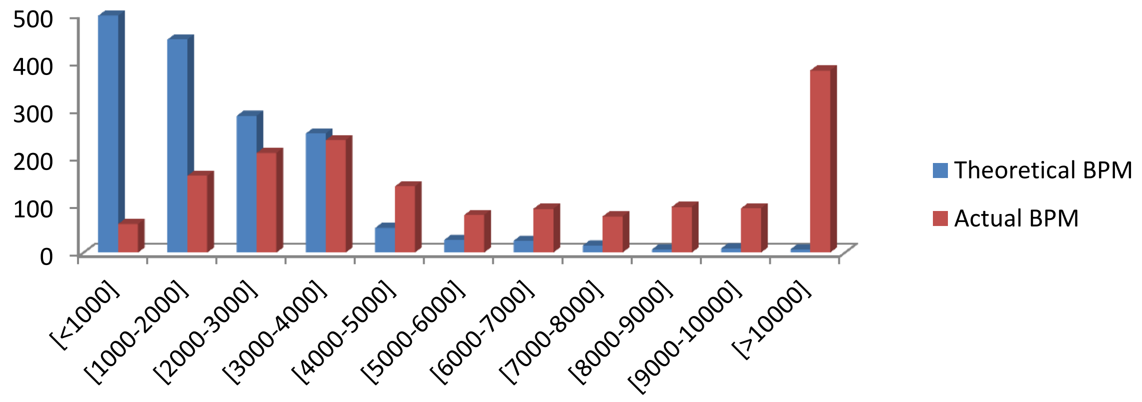
Diesel 2011 (y-axis: number of cars, x-axis: taxes in euro's).



Petrol 2010 (y-axis: number of cars, x-axis: taxes in euro's).

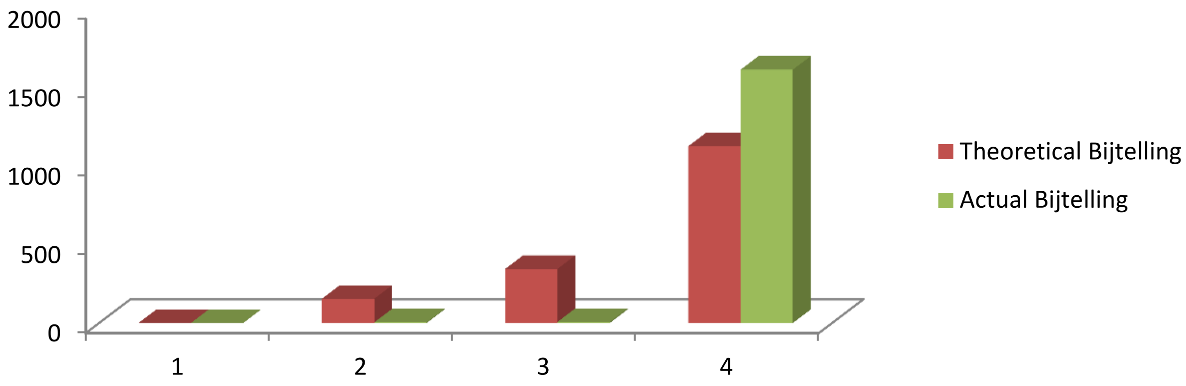


Petrol 2011(y-axis: number of cars, x-axis: taxes in euro's).

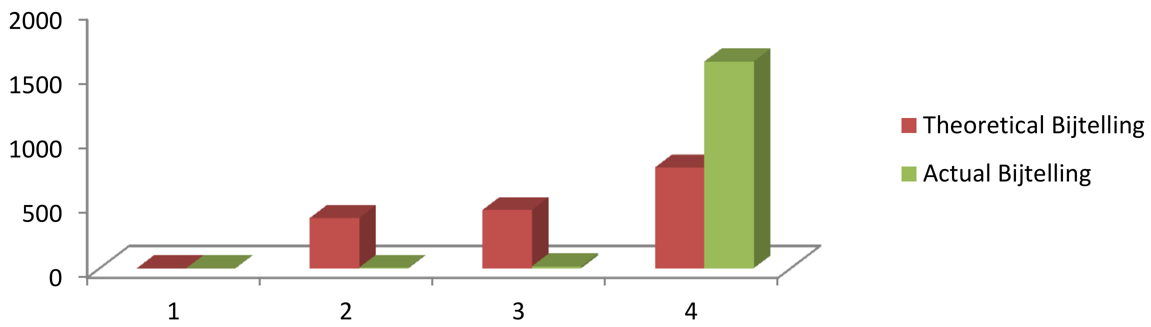


Bijtelling

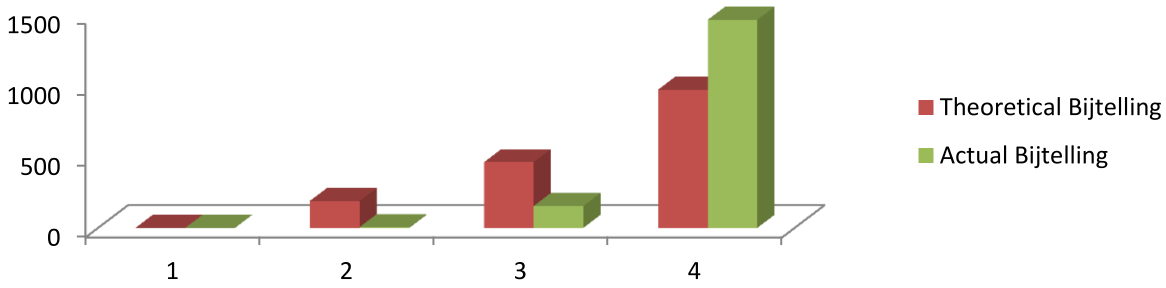
Diesel 2010 (y-axis: number of cars, x-axis: tax segment). 0, 1, 2 and 3 correspond to 0%, 14%, 20%, and 25% respectively.



Diesel 2011 (y-axis: number of cars, x-axis: tax segment). 0, 1, 2 and 3 correspond to 0%, 14%, 20%, and 25% respectively.



Petrol 2010 (y-axis: number of cars, x-axis: tax segment). 0, 1, 2 and 3 correspond to 0%, 14%, 20%, and 25% respectively.



Petrol 2011(y-axis: number of cars, x-axis: tax segment). 0, 1, 2 and 3 correspond to 0%, 14%, 20%, and 25% respectively.