REBOUND EFFECTS FOR HOUSEHOLDS’ ENERGY EFFICIENT VEHICLES

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

DİLAN YÜKSEL

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCİENCE
IN
EARTH SYSTEM SCİENCE

SEPTEMBER 2019

Approval of the thesis:

REBOUND EFFECTS FOR HOUSEHOLDS' ENERGY EFFICIENT VEHICLES

submitted by **DİLAN YÜKSEL** in partial fulfillment of the requirements for the degree of **Master of Science in Earth System Science Department, Middle East Technical University** by,

Prof. Dr. Halil Kalıpçılar
Dean, Graduate School of **Natural and Applied Sciences** __________________

Prof. Dr. C.Can Bilgin
Head of Department, **Earth System Science** __________________

Prof. Dr. Ramazan Sarı
Supervisor, **Earth System Science, METU** __________________

Dr. Bora Kat
Co-Supervisor, **TÜBİTAK** __________________

Examining Committee Members:

Prof. Dr. Şenay Açıkgöz
Econometrics, Ankara Hacı Bayram Veli University __________________

Prof. Dr. Ramazan Sarı
Earth System Science, METU __________________

Prof. Dr. Uğur Soytaş
Business Administration, METU __________________

Date: 06.09.2019

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Surname: Dilan Yüksel

Signature:

ABSTRACT

REBOUND EFFECTS FOR HOUSEHOLDS' ENERGY EFFICIENT VEHICLES

Yüksel, Dilan
Master of Science, Earth System Science
Supervisor: Prof. Dr. Ramazan Sarı
Co-Supervisor: Dr. Bora Kat

September 2019, 118 pages

Energy efficiency is one of the most critical dimensions in energy consumption and the technologies improving energy efficiency thus decreasing energy demand as well as greenhouse gases have been becoming widespread in recent years. On the other hand, the fact that the savings owing to the improvements in energy efficiency would not happen as expected indicates a phenomenon which has been being addressed for a long a time in the literature and practice: Rebound Effect. This concept emphasizes that the cost advantage due to an improvement in energy efficiency would offset some of or overall expected gains resulting from this efficiency improvement. This study focuses on the direct rebound effect in personal automotive transport for households in Turkey. A survey with 472 participants was conducted within the study. The rebound effect analyses are performed by the quasi-experimental method and based on the participants from 4^{th} and 5^{th} quintile income groups for whom the data for both the current and the previous cars are available. Besides, the distinct fuel types (gasoline, diesel and LPG) are taken into account in a single framework and the rebound effects are calculated separately according to the unit energy cost criteria and energy intensity criteria. The estimations are 10.08% and 25.40% for in-city and inter-city, respectively, based on the former criteria while it is 16.77% and 31.51% based on the latter criteria. On the other hand, the effect of the fuel price is analyzed by estimation of price elasticity of fuel consumption which is the first attempt for micro level in Turkey. The estimation results of the price elasticity of fuel demand showed that the price elasticity of in-city consumption is -0.25 for gasoline, -0.22 for diesel and -0.28 for LPG; price elasticity of inter-city consumption is -0.29 for gasoline; -0.22 for diesel and -0.19 for LPG.

Keywords: Rebound Effect, Quasi-experimental Study, Vehicle Energy Efficiency, Vehicle Kilometers Traveled (VKT), Household Vehicle Ownership, Turkey, Survey, Fuel Price Elasticity

ÖZ

ENERJİ VERİMLİ ARAÇLARA SAHİP HANEHALKININ GERİ SEKME ETKİSİNİN İNCELENMESİ

Yüksel, Dilan
Yüksek Lisans, Yer Sistem Bilimleri
Tez Danışmanı: Prof. Dr. Ramazan Sarı
Ortak Tez Danışmanı: Dr. Bora Kat

Eylül 2019, 118 sayfa

Enerji verimliliği, enerji tüketimin en kritik boyutlarından birini oluşturmaktadır. Son yıllarda enerji verimliliğini artıracak ve dolayısıyla enerji talebini ve sera gazı salınımını azaltacak teknolojiler hızla yaygınlaşmaktadır. Diğer taraftan, enerji verimliliğindeki artışın her zaman öngörülen kazanımları sağlamadığı literatürde ve pratikte uzun yıllardır değinilen bir fenomene işaret etmektedir: Geri Sekme Etkisi. Bu kavram, enerji verimliliği sağlayan gelişmeler sonucunda ortaya çıkan maliyet avantajının, öngörülen tasarruf potansiyelinin bir kısmını veya tamamını ortadan kaldırabileceğini vurgular. Hane halkının enerji tasarruflu otomobilleri için doğrudan geri sekme etkisinin var olup olmadığını test etmeyi amaçlayan çalışmada, Türkiye genelinde 472 katılımcı ile anket çalışması gerçekleştirilmiştir. Çalışmadaki enerji verimliliğindeki geri sekme etkisinin analizleri, yarı deneysel yöntemle, mevcut ve önceki arabaları için verisi olan dördüncü ve beşinci %20'lik gelir grubundaki katılımcılara dayanılarak yapılmıştır. Ayrıca, farklı yakıt türleri (benzin, dizel, LPG) birlikte ele alınmış ve geri sekme etkisi, birim enerji maliyeti kriterlerine ve enerji yoğunluğu kriterlerine göre iki ayrı şekilde hesaplanmıştır. Geri sekme etkisi tahminleri, ilk kriter için şehir içi ve şehirlerarasında sırasıyla %10.08 ve %25.40, ikinci kriter kapsamında ise %16.77 ve %31.51 olarak hesaplanmıştır. Öte yandan, Türkiye'de hanehalkı düzeyinde daha önce hiç hesaplanmamış olan yakıt fiyat esnekliği de anket kapsamında beyan edilen eğilimler kullanılarak tahmin edilmiş ve şehiriçinde benzin için -0.25; dizel için -0.22 ve LPG için -0.28 olarak; şehirlerarasında ise benzin için -0.29; dizel için -0.22 ve LPG için -0.19 olarak hesaplanmıştır.

Anahtar Kelimeler: Geri Sekme Etkisi, Yarı-deneysel Çalışma, Araç Enerji Verimliliği, Taşıt-Kilometre, Hanehalkı Araç Sahipliği, Türkiye, Anket, Yakıt Fiyat Esnekliği

To my mom and dad..

ACKNOWLEDGEMENTS

I owe my deepest gratitude to my thesis advisor, Prof. Dr. Ramazan Sarı, who gave me a chance to write this thesis and had a continuous support and patience for a long time.

It gives me great pleasure in acknowledging the support and help of my co-advisor, Dr. Bora Kat, who had continuous and deep interest in every detail of my thesis. He encouraged and guided me during my thesis. I would also like to thank him for his goodness, patience, empathy during the research and writing of this thesis. Without his efforts, my work would have undoubtedly been more difficult.

On the other hand, I would like to thank to the Head of Department, Prof. Dr. Can Bilgin for his considerably supports and ex-head of Department Prof. Dr. Ayşen Yılmaz for giving me an opportunity to be a part of this master program.

Furthermore, I would like to thank Prof. Dr. Şenay Açıkgöz and Prof. Dr. Uğur Soytaş for their participation in my thesis committee. I had the opportunity to meet them and their comments and new ideas to push forward this thesis study.

Finally, I would like to offer my special thanks to my mom, my dad, my brother Ferhat and my twin sisters Kübra and Büşra. They are always by my side. I am thankful for their sacrifices, caring, and understanding during my work. I also thank my friends and cousins for their friendship, love, and unyielding support of my work.

TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

LIST OF ABBREVIATIONS

ABBREVIATIONS

ADF: Augmented Dickey Fuller Test

BET: Behavioural Economic Theory

CAFE: Corporate Average Fuel Economy

DOLS: Dynamic Least Squares

CGE: Computable General Equilibrium

GDP: Gross Domestic Product

EMRA: Energy Market Regulatory Board’s

GHG: Greenhouse Gas

ICCT: International Council on Clean Transportation

IEA: International Energy Agency

ILO: International Labor Organization

IPCC: The Intergovernmental Panel on Climate Chang

ISCO: International Standard Classification of Occupations

K-B Postulate: Khazzoom-Brookes Postulate

Ktoe: Kilotonne (Thousand tonnes) of oil equivalent

LA-AIDS: Linear Approximation of the Almost Ideal Demand System

Mtoe: Millions of tonnes of oil equivalent

NHTSA: National Highway Traffic Safety Administration

OLS: Ordinary Least Squares

OECD: Organization for Economic Co-operation and Development

PP Unit Root Tests: Phillips-Perron Unit Root Tests

Pj: Petajoule

SCT: Special Consumption Tax

TPES: Total primary energy supply

TUIK, TurkStat: Turkish Statistical Institute

TFC: Total Final Consumption

UKERC: UK Energy Research Centre

VMT: Vehicle Miles Traveled

VKT: Vehicle Kilometers Traveled

CHAPTER 1

INTRODUCTION

1.1. Background

Energy efficiency has become one of the most critical pillars of energy related sectors due to the rapid increases in energy demand as well as resulting greenhouse gas (GHG) emissions in recent decades. There are many improvements in the technology for providing energy efficiency and thereby reducing energy demand, decreasing energy service cost and GHGs. Savings in energy related activities are closely related to both technological improvements and behavioral changes. Energy savings due to technological improvements mostly arise from improvements in energy efficiency. However, on the other side of the coin, the decrease in the cost of a particular energy service due to an increase in efficiency would trigger more consumption of the given energy service as well as other energy services. This phenomenon is known as the rebound effect in the literature, i.e., consuming more energy due to cost savings from energy efficient improvements. Rebound effect can happen in many energy services such as heating, cooling, household appliances, lighting, transport and so forth. The concept takes its roots from the "Jevon's Paradox" which dates back to mid 1800s, i.e., consumption of a resource increases unexpectedly in case of an energy improvement. The concept was revisited by Brookes (1979) and Khazzoom (1980a) where the former focuses on a macroeconomic framework while the latter focuses on micro and direct effects. These two approaches are then discussed together which is called as "Khazzom-Brookes Postulate" (Saunders, 1992). Moreover, Binswanger (2001) addresses the rebound in a broader framework, i.e., resource efficiency improvements due to technological progress, as the decrease in the potential gains of time-saving technological improvements.

The rebound effect can be classified under three main broad categories, i.e., direct rebound effects, indirect rebound effects and economy-wide rebound effects (Sorrell & Dimitropoulos, 2008). Direct rebound effect occurs in case of a decrease in the cost of a particular energy service resulting from energy efficiency improvement. The decrease in price is accompanied with an increase in the consumption of that energy service which offsets the expected potential savings to an extent. The magnitude of the offset is mostly lower than the savings, then the agents have still positive savings which they can use for consumption of other energy services. In other words, the additional amount of savings is further offset by the increase in the consumption of other services. This is called as the indirect rebound effect.

In addition to direct and indirect rebound effects, an economy is defined by a series of and numerous interactions between economic agents. Then, a decrease in the real price of a service may induce changes in prices and quantities of other final goods as well as intermediate inputs. Therefore, the sequence of complex interactions may also offset the expected savings as well. This overall affect is called as the economy-wide rebound effect.

It is a long-lasting debate whether rebound effect exists and its significance if it really exists. However, it is still an interesting research question in the literature. There are numerous studies showing that there is strong evidence for the existence of rebound effect (Greening, Greene, & Difiglio, 2000a) although there is not a consensus on the magnitude, definition and significance of the concept (Turner, 2013). This may be reasonable since there is a wide range of factors having impact on the magnitude of the rebound effects, e.g., consumer behaviors, sectoral interactions, social and cultural aspects, level of improvements etc.

1.2. The Objective and Scope of the Study

There are numerous studies on rebound effect in the literature. These studies are diverse in terms of energy services, regions, methodological approach, income groups, type of rebound (direct, indirect or economy-wide) and so forth. Among these studies, the studies focusing on personal automotive transport and household heating as the consumer energy services are the leading ones with significantly higher number of studies compared to other consumer energy services.

Similarly, with regard to rebound type, a substantial part of these studies focus on the direct rebound effects. In this study, the objective is to test the hypothesis of existence of direct rebound effect for households' energy efficient cars. When vehicles are produced with higher technologic standards, fuel cost per mile will decrease. In hence, consumers could travel the same distance with a lower amount of fuel. However, the magnitude of energy savings and concomitant emission reductions due to improvement in energy efficiency is disputable, since the consumers tend to travel more as the fuel cost per km decreases.

There is a wide array of factors that affect the demand for personal automotive transport which makes it difficult to distinguish the rebound effect which is originated from energy efficiency improvements. Household income, vehicle brand, vehicle fuel type, engine type, vintage effects, ownership, motorist's age, household size and structure, employment status, population density, fuel price, distance between home and city center/office, marital status, road network density, and so forth are taken into account as the potential factors to affect rebound effects in the literature (Kutucu, 2018; Munyon, Bowen, & Holcombe, 2018; Su, 2012; B. Yu, Zhang, & Fujiwara, 2013; F. Yu & Liu, 2016).

Econometric and empirical approaches are the main methodologies employed to identify the rebound effect in the literature (Greening, Greene, & Difiglio, 2000b; Sorrell, Dimitropoulos, & Sommerville, 2009). As noted in (Kutucu, 2018), the main problem in estimating the rebound effect in personal automotive transport for developing countries is the lack of a consistent and detailed VKT database which is also the case in Turkey. In order to estimate the direct rebound effect for personal automotive transport in Turkey, a survey with 472 participants was conducted within this study and a modified 'before and after' analysis was performed where before and after correspond to inefficient and efficient cars of the same households who are in 4^{th} and 5^{th} quintile income groups.

1.3. Main Findings and Contribution

In this study, direct rebound effects are identified not only for different types of fuel, i.e., gasoline, diesel and LPG, but also in city and intercity travels. Since different fuel types do not contain the same energy content, these fuel types are taken into account by converting them into equivalent energy content they embody. In the calculation of the rebound effect, the current and previous vehicles of the same participants were taken into consideration. Energy cost and energy intensities were calculated as two separate criteria for evaluating the energy efficiency of the same participant's current and the previous vehicle. In regards of the unit energy cost criteria from the survey data, the rebound effects are found to be 10.08% and 25.40% for in-city and inter-city travels, respectively; while with respect to energy intensity criteria the corresponding amounts are 16.77% and 31.51%, respectively. These values are in line with the values summarized in (Sorrell, 2007). Moreover, energy efficiency elasticity values, which are also used as proxy to the rebound effect (Sorrell & Dimitropoulos, 2008), calculated within this study are consistent with the values mentioned above.

Kutucu (2018) estimated the direct rebound effect for personal automotive transport as 12% for the income groups of 4^{th} and 5^{th} quantiles in her MSc thesis where she followed the methodology in (Nässén & Holmberg, 2009) and used the data collected via the household survey she conducted. The results of her comprehensive study are not restricted with the estimation of direct rebound effect, but also includes the calculation of indirect rebound as well as consideration of additional energy efficiency capital costs. However, several aspects have been identified to be improved after a careful analysis. These are:

- A larger sample of households for better representation of the whole country

- The analysis of rebound effect in (Kutucu, 2018) is mainly based on the difference between data of the participants' actual cars and the catalogue specifications of the cars they plan/wish to buy. However, the official and on-road values show a significant divergence especially for fuel consumption and emission values (Tietge, Mock, German, Bandivadekar, & Ligterink, 2017).
- Kutucu (2018) does not take into account the differences due to fuel type, i.e., gasoline, diesel, LPG.
- Fuel price elasticity plays a key role in the methodology introduced by (Nässén & Holmberg, 2009) and may be significantly different across individuals. A single elasticity estimate used for each participant would be an aspect to be improved.

After addressing the issues open for improvement, the study is designed in a way that it can tackle the problem to a larger extent. First of all, in company with the face-to-face interviews, an online version of the survey is prepared in order to reach a larger sample of people. In order to identify the alterations in consumption patterns and to collect on-road statistics of the same consumers, questions related to current and previous cars are added to the survey. These questions also eliminate the need for an estimate of fuel price elasticity. However, it was recognized that there is a gap in the literature about the fuel price elasticity for Turkey. Then, additional questions are asked to the survey participants in order to obtain such an elasticity estimate. Finally, the fuel consumptions are standardized by calculating equivalent energy content of different fuel types. The direct rebound effect obtained after all of these improvements is found to be in line with the results reported in (Kutucu, 2018) which was 12%.

As noted in the previous paragraph, estimates for fuel price elasticity are provided within this thesis. The studies on fuel price elasticity for Turkey are limited (Deniz, 2006; Erdogdu, 2014; Gerçek, 2009; Hasanov, 2015; Yalta & Yalta, 2016) and aggregated macro data with restrictive assumptions are used in all of these studies due to lack of comprehensive VKT statistics. In this study, a regression model, based on the stated preferences of the survey participants, is established. The model showed price elasticity of gasoline is -0.25; -0.22 for diesel and -0.28 for LPG in regards of VKTs in cities. Also the fuel prices effects on intercity VKTs are -0.29 for gasoline, -0.22 for diesel and -0.19 for LPG.

Briefly, this study examines whether switching to more efficient cars will cause higher energy consumption or not and estimates the price elasticity of fuel which have never been calculated for micro level in Turkey.

1.4. Structure of the Thesis

This thesis study consists of six chapters in total, which will be mentioned briefly and outlined in this section. Subsequent to the introduction section, general frameworks of issues related with “rebound effect in energy efficiency” are summarized, for instance the energy supply, demand, efficiency, price issues are handled in world and Turkey level, also under these topics transportation energy (fuel) consumption for the end users are classified in Chapter 2. All rebound studies in Turkey, classification of rebound effect studies in the world, rebound effect studies in transportation sector and also as breakdown in the analysis “direct rebound effect measures aspect by household car” from the literature are analyzed in Chapter 3. Then, in Chapter 4, some main information about cars and fuel consumption statistics are stated. Chapter 5 is dedicated to the methodology and survey applied to the households including calculations and statistical analysis with discussion on the results. In the final chapter, the findings are summarized, suggestions for policy making are presented and the thesis is finalized by making suggestions for future studies.

CHAPTER 2

ISSUES RELATED TO REBOUND EFFECT

2.1. Energy Supply and Demand

Energy directly affects the welfare of communities and plays an important role in the development of countries. Providing safe, sufficient, cheap and clean energy for countries is among the main problems of economic and social life. Therefore, as in the past, the efforts of countries to reach energy sources and ensure security of supply continue to increase significantly (MENR, 2018).

Total primary energy supply is the total amount of primary energy that a country supply in a year which consists of domestic supply, i.e., energy extracted from or generated by natural resources, imported energy and exported energy. Since total primary energy stems from imports and exports both; the net amount of electricity and net secondary fuel trades are also part of the total primary energy supply. Total final consumption of energy, on the other hand, is the total energy consumed by the end-users either in production or consumption activities. The main difference between primary and final energy mainly comes from the conversion sectors, i.e., power generation and oil refining.

As it is seen in Figure 2.1., worlds' energy supply was nearly 14.000.000 mtoe in 2016 and has been on a rising trend to meet the energy needs where significant increases have been observed in shares of coal and renewables in recent years.

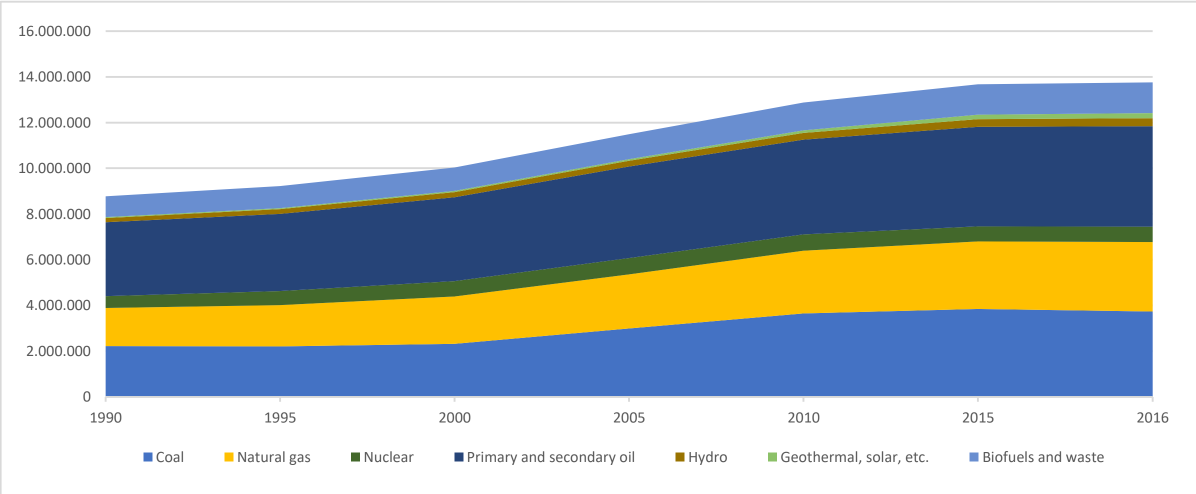


Figure 2.1. Total primary supply by source, World, 1990-2016, mtoe, own graph based on data by IEA.

Turkey’s energy supply has been on a rising trend to meet the increasing energy needs of the rapid growing economy for the last decades. Turkey’s total primary energy supply between 2000 and 2017 can be seen in Figure 2.2.

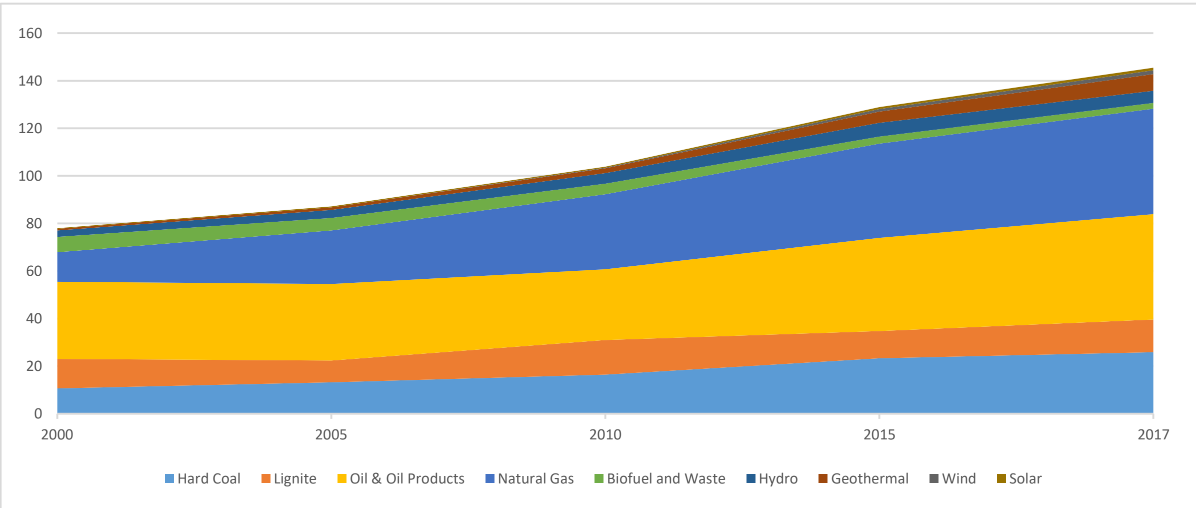


Figure 2.2. Total primary supply by source, Turkey, 2000-2017, mtoe, own graph based on data by GDEA.

In supply side of Turkey, natural gas, petroleum products, hard coal and lignite are the main energy resources with a total share of nearly 90% in 2017. Although there has been a significant increase in the electricity generation by wind and solar in the recent years; the renewable resources sum up to only 10% of the total primary supply. The total energy supply was around 145 mtoe in 2017 where there has been a rising trend in the share of imported energy as illustrated in Figure 2.3., i.e., domestic supply constitutes only one quarter of the total energy supply in 2017.

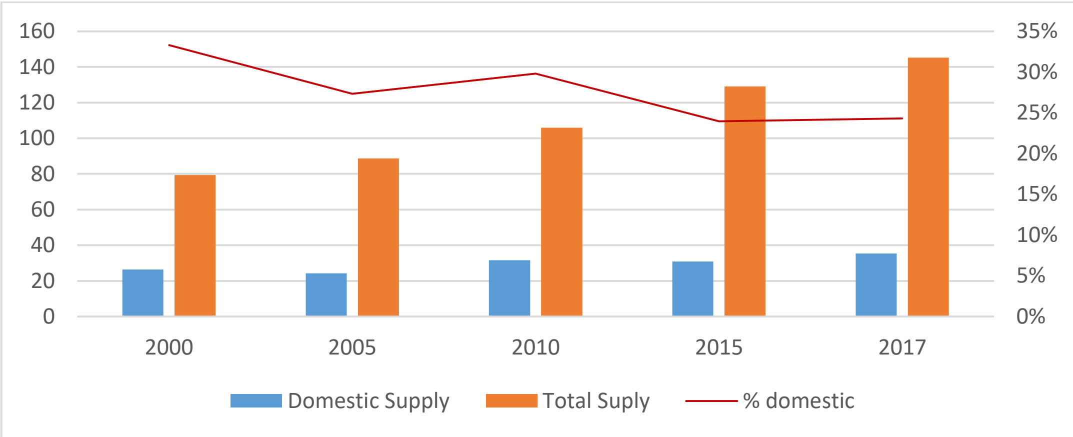


Figure 2.3. Distribution of primary energy supply, Turkey,2000-2017; domestic and total supply in mtoe; % domestic in percent.

Decomposition of total final energy consumption, nearly 105 mtoe including non-energy use of 4.9 mtoe, across resources and end-use groups for year 2017 is illustrated in Figure 2.4.; Figure 2.5., on the other hand, shows the details of the decomposition by fuel type. As seen in these figures, nearly 28% of the final energy consumption belongs to the transport, 32% belongs to industry and 22% belongs to the residential sector. In terms of fuels that forms the total final energy, oil & petroleum products, natural gas, solid fuels and electricity stand for nearly 36%, 25%, 12% and 21% of the total final energy consumption, respectively. Renewable resources, on the other hand, form only 5% of the total final energy consumption.

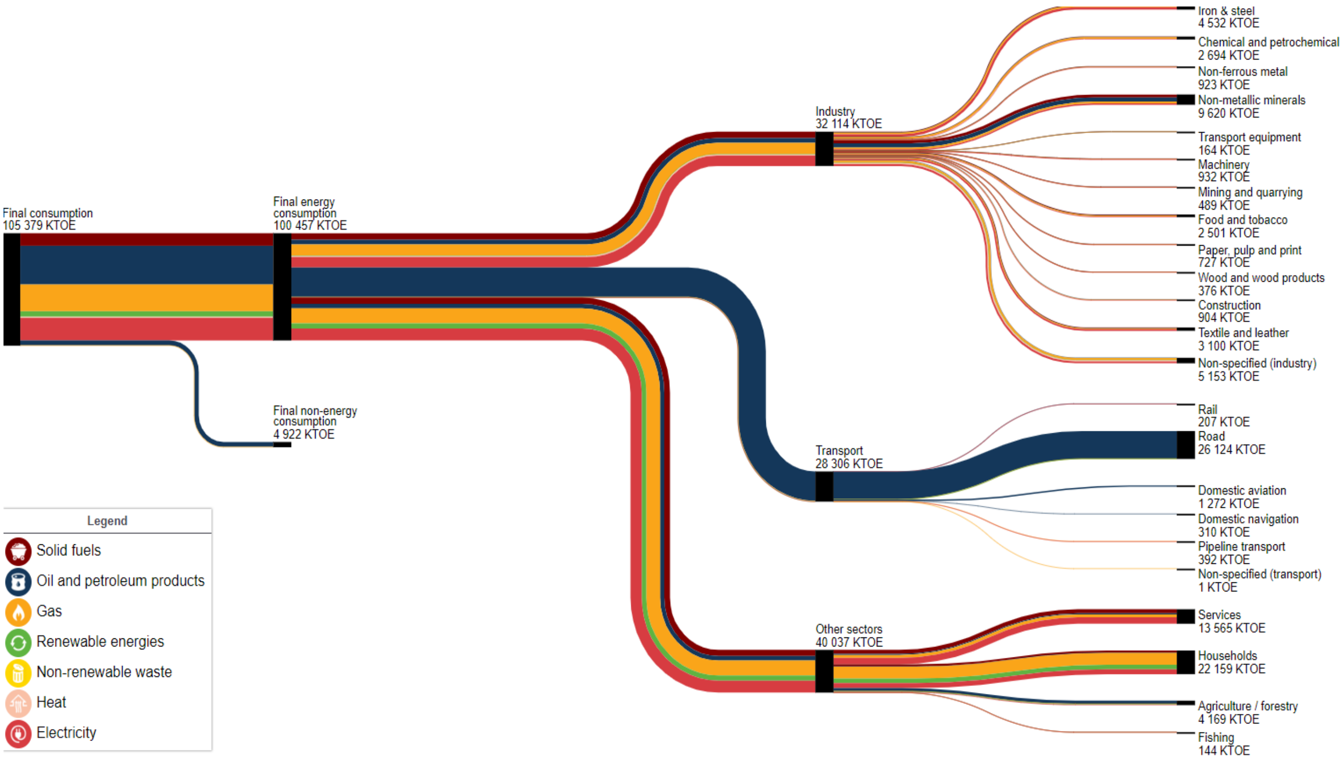


Figure 2.4. Sankey diagram of final energy consumption, Turkey, 2017, ktoe; EuroStat.

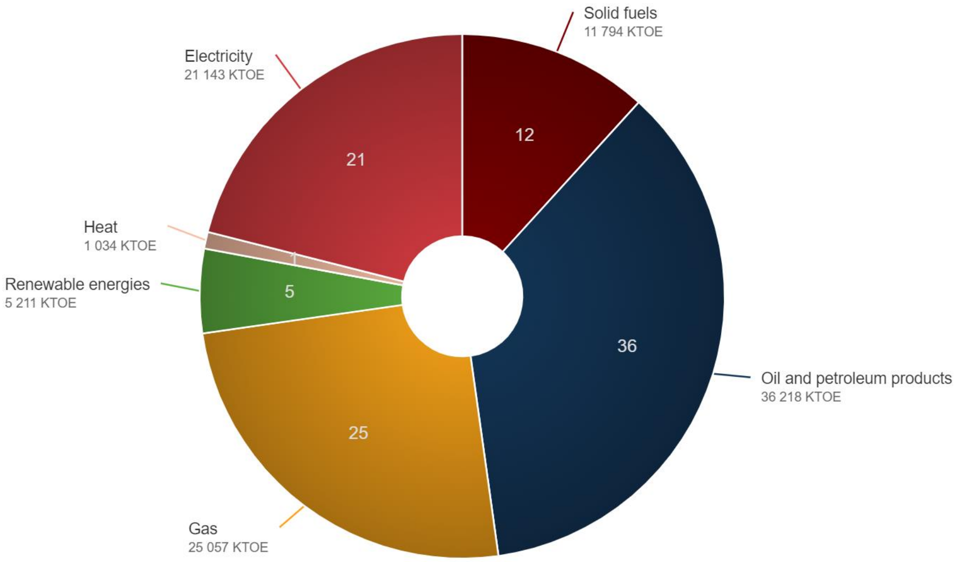


Figure 2.5. Final energy consumption by resource type, Turkey, 2017, ktoe; EuroStat.

2.2. Fuel Prices

Turkey is one of the countries with the highest fuel prices for a long time due to high taxes, i.e., special consumption tax (SCT), value added tax (VAT), especially on the retail prices. Figure 2.6. shows the historical evolution of fuel prices in Turkey. As seen from this figure, there is a significant increasing trend after 2016 with the increases in oil prices as well as the sharp increase of US Dollar against national currency. Moreover, monthly fuel prices from 2015 to 2019 by all cities in Turkey were collected from EMRA and several distributor companies. LPG data is obtained from Energy Market Regulatory Board's (EMRA). Due to the fact that the monthly data of each distributor company could not be reached, the data of different distributor companies were used. Due to the fact that the fuel data were withdrawn from Petrol Ofisi, attention was paid to the fact that the LPG data was also predominantly Petrol Ofisi data. In the diesel and gasoline prices, central district data as of the last day of each month were taken into consideration where Petrol Ofisi data were used for both of them.

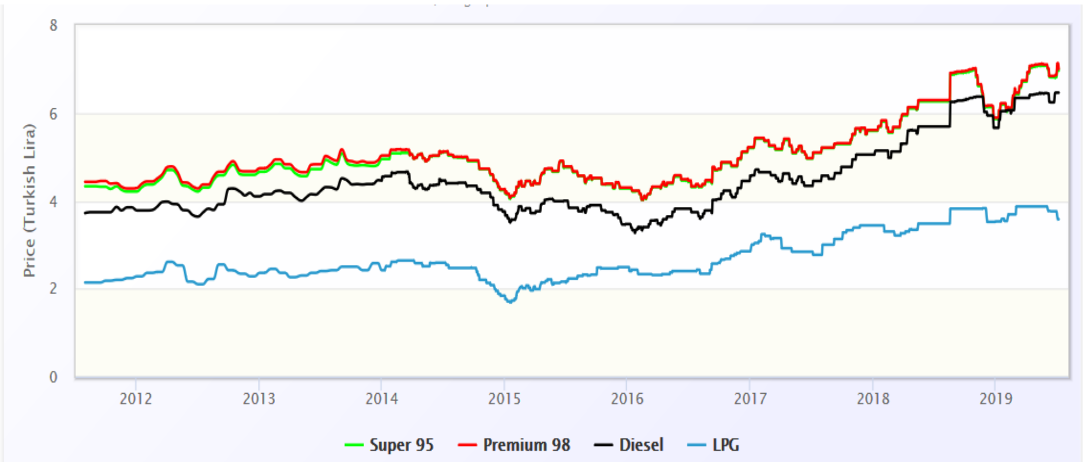


Figure 2.6. The Trend in Gasoline, Diesel and LPS Prices in Turkey, autotraveler.ru.

In this study, since the rebound effect will be based on the data of current and previous cars of the same users, fuel prices would have a significant impact if the changes in overall price index and changes in fuel prices were not close to each other. However, Figure 2.6. and Figure 2.7. indicate that overall consumer price index, fuel prices and price index for transportation services have similar trends. Moreover, the rebound analysis was designed to compare responses of the participants who changed their car not before 2015. Then, it is assumed that no income effect exists unless it was indicated by the survey participant. In other words, it was assumed that, change in annual income of the participants are in line with the annual changes in the fuel prices.

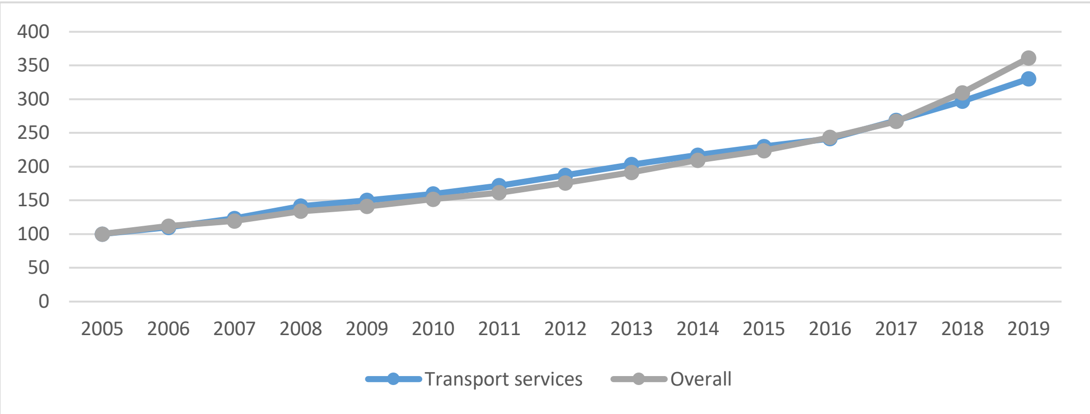


Figure 2.7. Consumer price index for overall economy and transport services, 2005-2019, 2005=100, CBRT.

2.3. Energy Saving, Efficiency and Intensity

Energy saving is related with the reducing of final energy consumption either by utilizing more efficient technologies and processes or by reducing the unnecessary energy service consumption. Policies can include each one or both aspects at the same time.

The energy efficiency of systems (ε), on the other hand, is the rate of useful energy services (S) to energy demand (E). For example, efficiency for a personal car is the distance, km, that can be traveled by unit amount of energy, e.g., per liter of gasoline. The measure of the amount of energy used to produce a unit of output is called as energy intensity. Then, energy intensity can be assumed to be the inverse of the energy efficiency. However, improving in global primary energy intensity is not only stem from energy efficiency improvements. It would also be affected by factors such as the shifting of economic activities from energy-intensive heavy industries to less energy-intensive service sectors.

The energy cost of useful work (P_s) can be described as: $P_S = {}^{P_E}/_{\varepsilon}$. Here P_E refers the energy inputs price. Nevertheless, this component is just one of the all entire cost of giving an energy service (P_G), which also includes capital, maintenance and time costs (Sorrell et al., 2009).

Developments in energy efficiency in the world's leading economies has been offsetting more than one-third of the increase in energy related activities since 2000. The industry and buildings sectors are the most savings were achieved in all the other sectors. Across the world, efficiency gains keep from using 12% more energy in 2017 since 2000 (IEA, 2018) as illustrated in Figure 2.8.

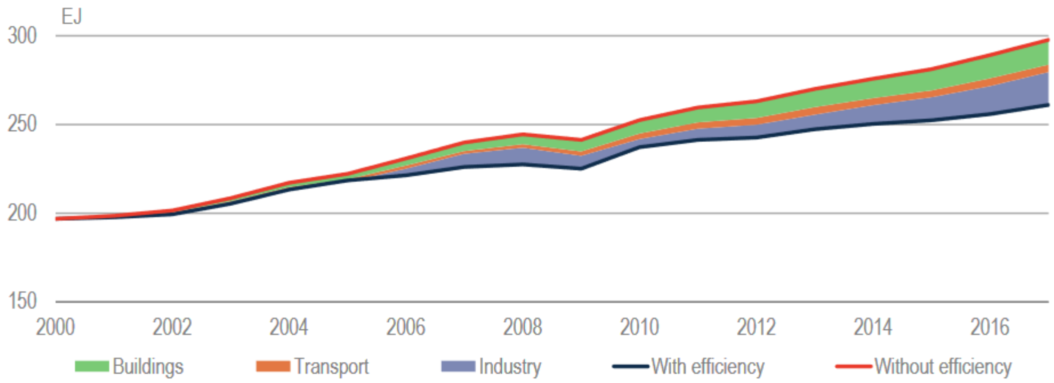


Figure 2.8. Energy Use with or without Energy Savings from Efficiency Improvements, by sector, 2000-2017, (IEA, 2018).

The composition of elevated economic and energy demand growth lead to a global primary energy intensity falling by solely 1.7% in 2017, the slowest rate of drop since

2010 as shown in Figure 2.9. This slow down would have resulted in even higher impacts had it not been for a faster deterioration in China, which accounts for around one-third of the global recession in intensity. Chinese energy intensity slows down to 3.9% in contrast to around 1.2% in the rest of the world. While annual developments in global energy intensity since 2011 have reached nearly 2.2%, almost double the rate of progress between 2001 and 2010, this report hints at global energy intensity being able to improve by closer to 3% per year. The rate 1.7% in 2017 shows that the world has not been capable in maintaining the appropriate energy efficiency potential (IEA, 2018).

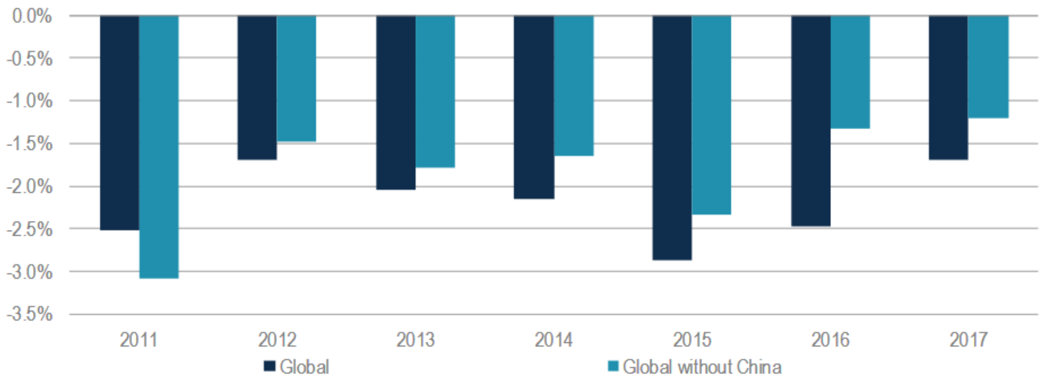


Figure 2.9. Changes in Global Primary Energy Intensity, IEA.

In Turkey side, on the other hand, energy efficiency studies aim to reduce at least 20% of Turkey’s Energy Intensity (energy consumed per GDP) by 2023, compared to 2011. In addition, Turkey's first energy efficiency action plan of the National Energy Efficiency Action Plan (2017-2023) entered into force on 01.02.2018. With the implementation of 55 actions in 6 different sectors, it is expected to save 23.9 million tons of equivalent oil (mtoe) energy cumulatively with an investment of USD 10.9 billion by 2023. This corresponds to a reduction of 14% in Turkey's primary energy consumption by 2023. The savings expected to be provided by 2033 is 30.2 billion Dollars (MENR, 2019).

2.4. Fuel Efficiency

One of the countries with stringent fuel efficiency policies is United States. In the US, the distance that vehicles should make kilometers on a gallon of fuel is set by NHTSA (National Highway Traffic Safety Administration) via the Corporate Average Fuel Economy (CAFE) standards, origins of which date back to 1975. CAFE standards are binding for passenger cars and light trucks. Besides, CAFE includes fuel consumption standards for medium and heavy-duty trucks and engines as well. The CAFE standards are fleet-wide averages that must be accomplished by each automaker for its car and truck fleet for every year, since 1978 and the standards have resulted in significant amount of fuels since then. Figure 2.10. illustrates the historical cumulative fuel savings owing to the CAFE standards as well as projections for future potential (NHTSA, 2019).

In Turkey, vehicle taxes are determined on the basis of motor engine capacity and the age of the vehicle under the 2004 Motor Vehicles Tax Law. Turkey has legal obligations to blend petrol (not diesel) with up to 3% of bioethanol. The legal framework is constituted in the 2008 Regulation on the reduction of the unit fuel consumption and the increase of the efficiency standards (IEA, 2016).

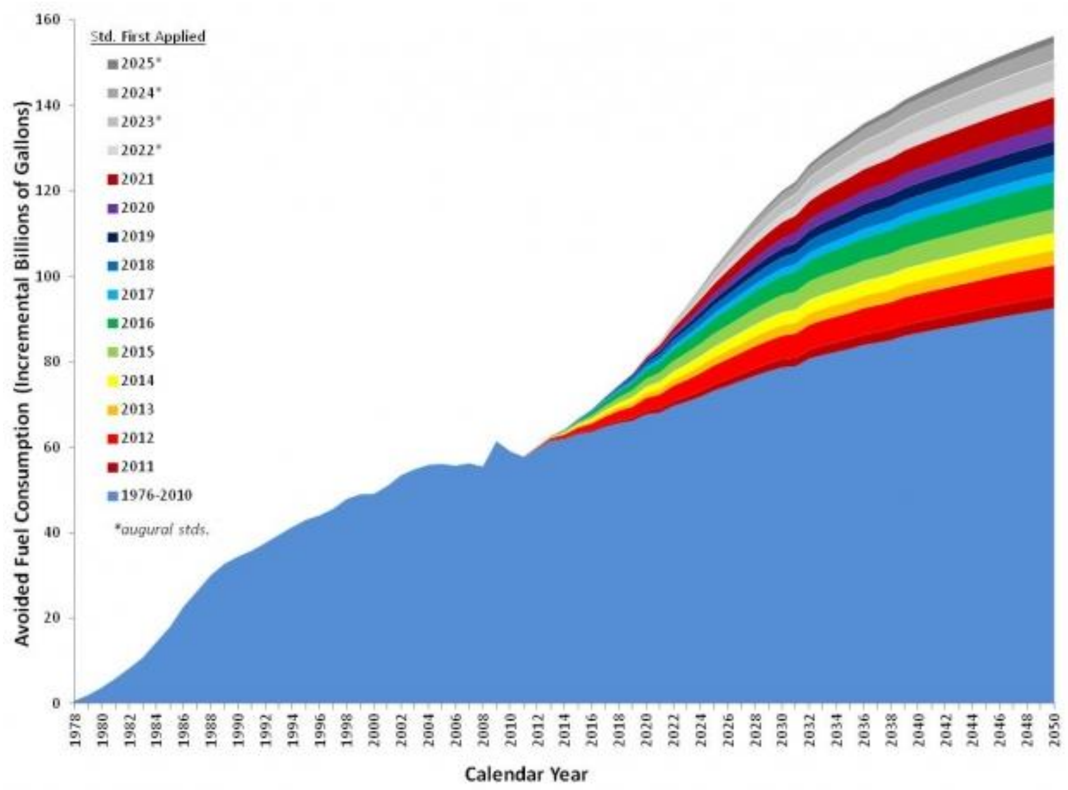


Figure 2.10. Predictions of Fuel Savings

The Ministry of Treasury and Finance supports the buying of low-emission cars through taxation incentives, with the inclusion of a lower special consumption tax applied to electrical vehicles. When buying a vehicle in Turkey for the first time, excise duty (SCT) is applied. This SCT rate is higher for high-speed vehicles.

Most of the vehicle fleet in Turkey consists of passenger cars and light commercial vehicles. These vehicles should be taken into account as regards reducing fuel consumption. Mock (2016) showed that there are not so many differences between the German and European Union in terms of new cars efficiency standards. And also there are not so many differences between Turkey and Germany in terms of some efficiency improvements applied to vehicles.

Three-quarters of the vehicle fleet in Turkey are from passenger cars and light commercial vehicles. Therefore, to reduce fuel consumption and emissions, it should be focused on these two vehicle categories. In International Council on Clean Transportation (ICCT) report, it was found that the level of efficiency for new cars and light commercial vehicles in Turkey is similar to the efficiency of comparable vehicles in the EU. Besides, the level of technologies applied to vehicles in Turkey is a bit lower than the EU (Mock, 2016).

CHAPTER 3

LITERATURE REVIEW

In this chapter, the literature review for rebound effects will be summarized. First, the phenomenon is explained with the emphasis on the Jevons' paradox and Khazzom-Brookes Postulate. Then, the studies on classification of rebound effect, the methodologies used in rebound effect analyses and the studies focusing on transportation sector are given. Finally, the chapter ends with the rebound effect and fuel price elasticity studies in Turkey.

3.1. Rebound Effect Phenomena

The phenomena that forms the basis for the rebound effect is known as the Jevons Paradox. Jevons introduced this phenomena in his study where the impact of efficiency improvements in steam engines on coal consumption is considered (Jevons, 1865). In the early years of industrial revolution and energy intensive production, energy efficiency improvements in steam engine technology reduce coal consumption for a given work. This progress, on the other hand, also had impacts on a series of economic activities in a circular manner where the most important was the decrease in the cost of iron production which triggered the decrease in the cost of steam engines as well as accelerating railway transportation. These inter-connected developments result in more demand for coal which became more available and accessible. As mentioned at the beginning of the thesis, Jevons statements on the production, efficiency, and consumption of coal were systematized with studies by Brookes (1979) and (Khazzoom, 1980) where the former focuses on a macroeconomic framework while the latter focuses on micro and direct effects. These two approaches are then discussed together which is called as "Khazzom-Brookes Postulate" or "K-B

Postulate” (Saunders, 1992). Saunders defined the postulate as “*with fixed real energy prices, energy-efficiency gains will increase energy consumption above what it would be without these gains*”. However, in course of time, the postulate has been shown to be theoretically valid only under special circumstances and have not been sufficiently supported with empirical studies. Sorrell and Dimitropoulos (2007) argue that it would be better to discuss the postulate considering the characteristics of energy efficiency improvement. More precisely, the dynamics of the energy consumption would change depending on whether the efficiency improvement is in the production side or in the final consumption side. For example, stem engines (the case tackled by Jevons) or electric motors would provide results in line with the K-B postulate. However, for the efficiency improvement in the final consumption side, e.g., thermal insulation, the postulate seems less likely to be satisfied.

The magnitude of the rebound effect would be classified in several forms:

- When rebound effect is larger than 100%, i.e., the energy offset is more than the expected saving potential, it is called ‘backfire effect’ (Saunders, 2000a, 2000b).
- When rebound effect is negative, i.e., actual energy saving is more than expected, it is called as “super-conservation”.

Besides the definitions given above, the size of the rebound effect also varies with the time period considered, i.e., short-term and long-term rebound effects, where the latter are observed to be significantly larger than the former as obviously expected.

The total rebound effects because of energy efficiency improvements seem to be in the range between 5% and 15% in most cases, but these results can change according to assumptions of energy service price elasticities. In addition, low or negative capital costs of energy efficiency improvements could result in high rebound effects because the income effects get more important. Energy conserving behavior affecting direct energy use cause to rebound effects around 10–20%, depending on the household consumption per primary energy for different fuels and energy tools (Nässén & Holmberg, 2009).

As in the studies on long-term rebound effect calculation from the last third of the 20th century in the USA, Small et al. (2007) showed that elasticity, which expresses the effect of changes in fuel efficiency on driving amount, is 20-25%. What is new here is that the rebound effect is reduced by revenue and possibly increased by fuel cost. As revenues increased and actual fuel costs decreased, the rebound effect declined significantly over time. (Small, Dender, & Van Dender, 2001)

Because of the rebound effect and the price elasticity are connected too much, estimations of price elasticities provide the closest possible empirical results for the size of the rebound effect (Berkhout, Muskens, & Velthuijsen, 2000). The energy price magnitudes affect the energy price elasticity, which an increasingly upward sloping function of the price. At the low energy price level, it is possible when price increase a small proportion, energy demand will decrease by a small amount. But in the case of the relatively high price level, energy demand will be more elastic (Berkhout et al., 2000).

3.2. Rebound Effect Studies

After Khazooms' study (Khazzoom, 1980), rebound effect concept has been handled by different aspects of economic activity as production and consumption; economic sectors as heating, transportation, lighting, etc.; economic groups units as household level or economy-wide level. In this section, classification of rebound effect, estimation of direct rebound effect and estimation of direct rebound effect in transportation sector will be presented respectively and separately.

3.2.1. Rebound Effect Classification

As mentioned in introduction, the rebound effect studies are mainly categorized under three main headings: direct rebound, indirect rebound and economy-wide rebound where the vast of the studies focus on the first one. The schematic representation of the rebound effect and its sub-categories can be seen in Figure 3.1.

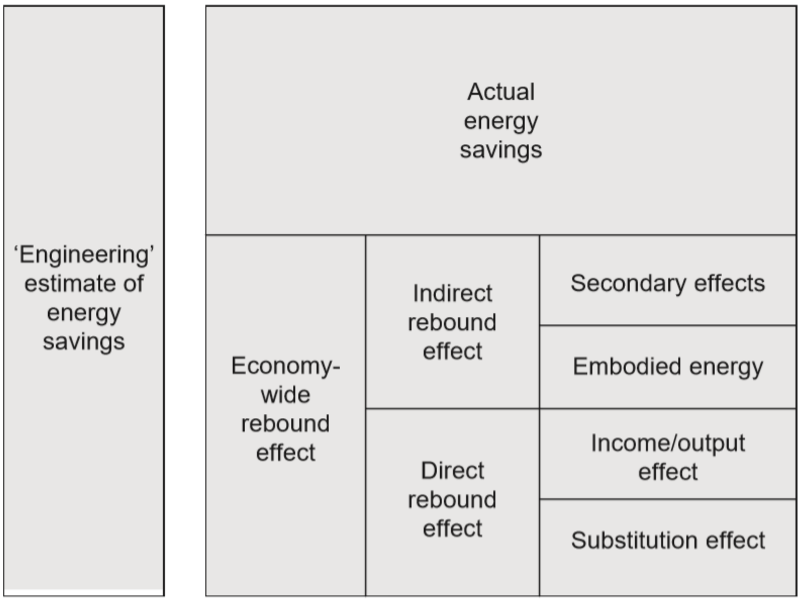


Figure 3.1. Classification Scheme for Rebound Effects (Sorrell, 2007).

Moreover, the studies tackle a wide range of energy services. In their survey paper on the rebound effect, Greening et al. (2000) classify the subject areas for the consumption side as follows:

- Space heating
- Space cooling
- Water heating
- Residential lighting
- Home Appliances
- Automotive transport

Among these areas, most of the studies are on the space heating and personal automotive transport. As summarized in Section 2.3., the energy efficiency of a system is the rate of useful energy services to energy inputs, $\varepsilon = S/_E$ and the energy cost of energy services can be described as $P_S = {P_E}/_{\varepsilon}$. However, measurement of useful energy service is challenging for most of the cases that is why the rebound effect studies mostly focus on the personal automotive transport and space heating (Sorrell, 2007). Moreover, as pointed out in the previous chapter, the price of energy inputs constitute only a part of the overall cost corresponding energy service, P_G, which also includes annualized capital costs, maintenance costs and time value of the service.

The energy efficiency improvements have also required energy consumption. For instance, producing and installing thermal insulation also requires the energy. This concept is called "embodied energy" (Herring & Sorrell, 2009). Consumers may perform both direct and indirect rebound effects due to energy efficiency improvements, such as the buying a more fuel-efficient car. The illustration of rebound effects for consumer is shown at below (Herring & Sorrell, 2009).

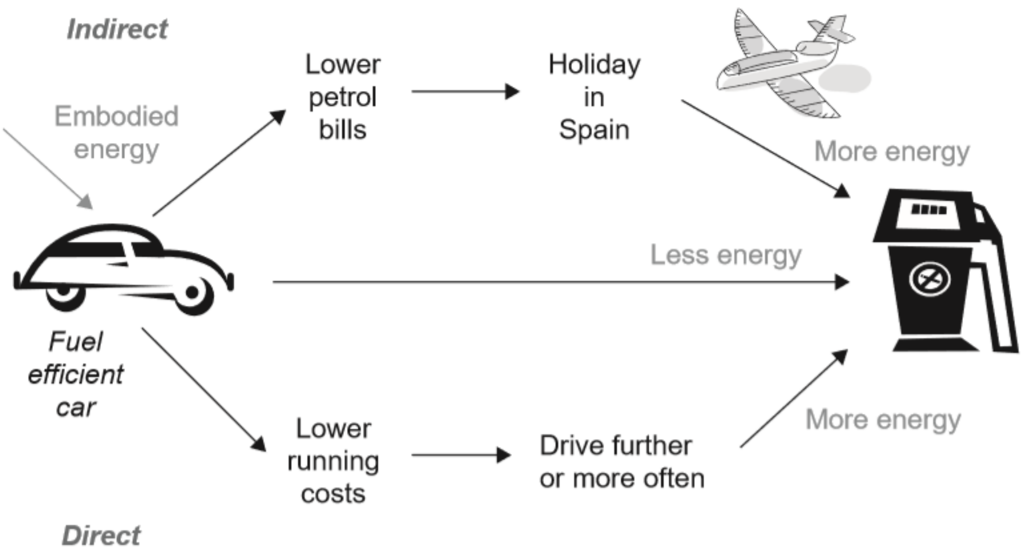


Figure 3.2. Illustration of Rebound Effects for Consumers, (Herring & Sorrell, 2009).

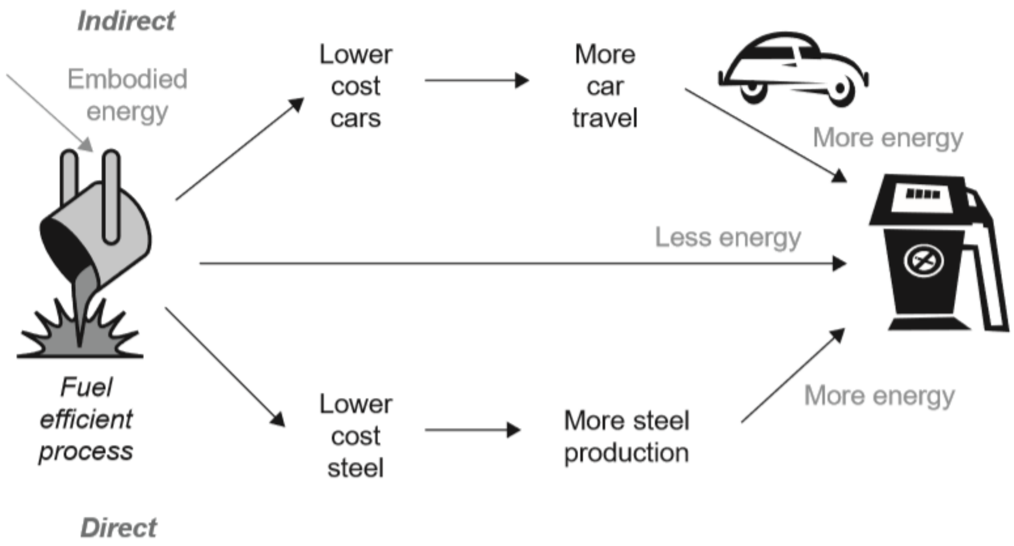


Figure 3.3. Illustration of Rebound Effects for Producers, (Herring & Sorrell, 2009).

On the other hand, producers may apply energy efficiency developments and hence both direct and indirect rebound effects may occur, such as the adoption of technological processes for energy efficiency. In regards of producers, direct rebound effect can be distinguished in two groups. Firstly, when energy service price reduce it could be substituted for the use of capital, labour and materials in producing a same amount of output. This mechanism is called as "substitution effect". Secondly, when the energy efficiency improvement results in cost savings, production level may rise therefore it means increase in all the inputs, including the energy service. This mechanism is called as "output effect" (Herring & Sorrell, 2009). For the production side, the specific areas of the rebound concept are indicated as process-use and lighting (Greening et al., 2000b). Figure 3.2. and Figure 3.3. illustrate how the rebound effect in the consumption and production side happens, respectively, where the dynamics of direct and indirect components will be explained in the following two sections.

3.2.1.1. Direct Rebound Effect

Direct rebound effect is observed when a decrease in the cost of a particular energy service resulting from energy efficiency improvement occurs (Berkhout et al., 2000; Greening et al., 2000b; Khazzoom, 1980; Sorrell & Dimitropoulos, 2008). The decrease in price is accompanied with an increase in the consumption of that energy service which offsets the expected potential savings to an extent. As shown in Figure 3.1., the direct rebound effect has two main triggers, i.e. the substitution effect and income effect. Economic theory implies that a rational consumer tends to consume more when the relative price of the corresponding normal good declines compared to other goods in her consumption bundle. Moreover, the decrease in the price of a good increases the real income of the consumer. Then, the increase in consumption of the corresponding good stems from these two effects. As stated earlier, the literature on the rebound mostly focus on direct rebound effect and there are substantial empirical studies on this aspect. These studies employ efficiency elasticities, energy price elasticities and energy service price elasticities as estimation tools (Sorrell & Dimitropoulos, 2008) as well as a variety of theoretical frameworks (Sorrell, 2007). These methodologies will be scrutinized in Section 3.2.2.

Table 3.1. summarizes the empirical evidences for the direct rebound effect for several household energy services. As seen from this table, the degrees of confidence are medium or high for the personal automotive transport and space heating while it is low for space cooling and the other household energy services. Besides, best guess values are below 30% where it is 10%-30% for personal automotive transport.

Table 3.1. Econometric estimates of the long-run direct rebound effect for household energy services in the OECD, (Sorrell et al., 2009).

End-use	Range of values in evidence base (%)	Best guess (%)	No.of studies	Degree of confidence
Personal automotive transport	3–87	10–30	17	High
Space heating	0.6–60	10–30	9	Medium
Space cooling	1–26	1–26	2	Low
Other consumer energy services	0–41	< 20	3	Low

The total demand for an energy service in the future have two main components, i.e., the demand of existing consumers and the demand of the prospective ones who are currently unable to benefit from the service. Improvements in the energy efficiency may increase the size of these prospective consumers (or “marginal consumers”, Wirl, 1997) especially in the developing countries for which the corresponding market is far from satiation. Then, the savings resulting from the current consumers would be offset to a large extent by these prospective consumers, i.e., larger direct rebound effects (Roy, 2000; Wang, Zhou, & Zhou, 2012). Similarly, the direct rebound effect would be larger for the low income households in the developed countries in the same manner (M Frondel, Ritter, & Vance, 2010; Small & Van Dender, 2007).

3.2.1.2. Indirect Rebound Effect

As mentioned in the beginning of this section, the decrease in the cost of an energy service creates a real income effect where the savings can be reallocated to other goods as well. Main component of the indirect rebound effect is the energy savings offset due to this reallocation (Berkhout et al., 2000; Binswanger, 2001). There may be indirect rebound effect even if there is no direct rebound effect for the energy service in question. It is possible the total decrease in energy consumption due to energy efficiency may be less than simple calculations suggest. For instance, the money saved from less fuel consumption may be spent on other goods and services that also need energy – like an overseas holiday (Herring & Sorrell, 2009) as illustrated in Figure 3.2. Moreover, the improvement itself may require some "embodied energy", e.g., the energy needed to produce and install thermal insulation, which forms another component of the indirect rebound effect (Herring & Sorrell, 2009). In addition to these two components, the efficiency improvement may result in a series of mutual effects in the economy. In other words, producers may increase their output due to the cost savings, the improvements may induce the overall productivity in the economy and result in economic growth, significant improvements may lower energy prices and thereby increase energy consumption and so forth.

The studies in the literature generally employ a system of demand models for energy services and other goods in order to assess the indirect rebound effect. The most acknowledged demand model is the Almost Ideal Demand System (AIDS) (Deaton & Muellbauer, 1980). AIDS can measure the degree of complementarity and substitution between the energy service in focus and the other goods as well as the marginal changes in spending patterns with respect to income and price effects. AIDS and its extensions were employed in a significant number of studies (e.g., Brännlund, Ghalwash, & Nordström, 2007; Lin & Liu, 2013; Mizobuchi, 2008; Wang et al., 2012).

3.2.1.3. Economy Wide Rebound Effect

An improvement in energy efficiency may accompany changes in commodity and factor prices in the whole economy. The economy then returns to equilibrium after this shock while this progress induces changes in energy consumption throughout the economy (Greening et al., 2000b; Sorrell, 2007). The economy-wide or overall rebound effect due to the energy-efficiency developments comprise of the sum of the direct and indirect effects as well as macro-economic effects.

Although there are significant amount of studies using macro econometric models (Meyer, Distelkamp, & Wolter, 2007), models utilizing Impact Population Affluence Technology (IPAT) identity (Du & Lin, 2015; Shao, Huang, & Yang, 2014) and Input-Output (I-O) analysis (Li & Jiang, 2016; Pfaff & Sartorius, 2015; Thomas & Azevedo, 2013); computable general equilibrium (CGE) models (Guerra & Sancho, 2010; Somuncu & Hannum, 2016; B. Yu et al., 2013) are mostly used to assess the economy-wide rebound effects.

Allan et al. (2007) summarizes CGE modelling studies on the evidence for the rebound effect where the results indicate that the rebound effect is more than 37% and backfire is observed in nearly half of the studies. Allan et al. (2007) also scrutinizes the ways how energy, non-energy, labour and capital are treated in production functions used in the CGE models. Moreover, Böhringer & Rivers (2018) proposed a stylized general equilibrium model to decompose the rebound effect of energy efficiency improvements into its partial and general equilibrium components.

The economy-wide rebound effect can be analyzed either for a single region/country, e.g., (Semboja, 1994) for Kenya and (Somuncu & Hannum, 2016) for Turkey, or for a broader group of countries, e.g., (Wood et al., 2018) for European Union, or in a global scale (e.g., Wei & Liu, 2017).

3.2.2. Approaches for Estimating Direct Rebound Effect

There are two main approaches in estimating the direct rebound effect, i.e., quasi-experimental and econometric approaches. However, the concepts and definitions in rebound effect studies may be inconsistent in different studies. Then Sorrell & Dimitropoulos, clarified basic definitions and issues in their seminal paper (Sorrell &

Dimitropoulos, 2008). In this section, first these clarifications will be summarized and then the two approaches will be explained in detail.

3.2.2.1. Basic Definitions and Key Conceptual Issues about Direct Rebound Effect

Let S denote useful energy service, E the energy input required for one unit of useful work and $\varepsilon = {}^{S}/_{E}$ is the energy efficiency of the energy system. S can be measured in terms of a variety of ways, e.g., vehicle kilometers for personal automotive transport. The two key concept in rebound effect analysis are:

- efficiency elasticity of the demand for useful work, $n_{\varepsilon}(S) = \frac{\partial S}{\partial \varepsilon}\frac{\varepsilon}{S}$
- efficiency elasticity of the demand for energy, $n_{\varepsilon}(E) = \frac{\partial E}{\partial \varepsilon}\frac{\varepsilon}{E}$

where the former measures the rate of change in useful work with respect to the rate of change in the energy efficiency while the latter measures the rate of change in energy input with respect to the rate of change in the energy efficiency.

Note that, the two indicators can be related using the equality $S = \varepsilon E$:

$$n_{\varepsilon}(E) = \frac{\partial\left(\frac{S}{E}\right)}{\partial \varepsilon}\frac{\varepsilon}{\left(\frac{S}{E}\right)}$$ *Eqn. 3.1*

$$n_{\varepsilon}(E) = \left(\frac{\varepsilon^2}{S}\right)\left[-\frac{S}{\varepsilon^2} + \frac{1}{\varepsilon}\left(\frac{\partial S}{\partial \varepsilon}\right)\right] = \left(\frac{\partial S}{\partial \varepsilon}\right)\frac{\varepsilon}{S} - 1$$ *Eqn. 3.2*

$$n_{\varepsilon}(E) = n_{\varepsilon}(S) - 1$$ *Eqn. 3.3*

$n_\varepsilon(S)$ is commonly used as an estimator for the direct rebound effect (Berkhout et al., 2000). It measures the change in demand for useful work with respect to the change in efficiency. The conditions based on the value of $n_\varepsilon(S)$ can be summarized as follows:

- If $0 < n_\varepsilon(S) < 1$ then there exists a positive rebound effect and the actual savings are less than the potential savings.
- If $n_\varepsilon(S) = 0$ then there is no rebound effect and the actual savings are exactly equal to the potential savings.
- If $n_\varepsilon(S) > 1$ then backfire happens.
- If $n_\varepsilon(S) < 0$ super conservation happens.

The energy cost of energy services P_s and $1/_\varepsilon$ are linearly correlated, e.g., if ε doubles then the P_s decreases reduces by half. Then Eqn. 3.23.3 can be rearranged as follows:

$$n_\varepsilon(E) = -n_{P_S}(S) - 1$$ *Eqn. 3.4*

Negative of $n_{P_S}(S)$ in this equation can also be used as a proxy for the direct rebound effect.

Another equality given in (Sorrell & Dimitropoulos, 2008) relates $n_\varepsilon(E)$ and $n_{P_E}(E)$ under certain circumstances, i.e., the energy demand emphasized serves only for a single energy service.

$$n_\varepsilon(E) = -n_{P_E}(E) - 1$$ *Eqn. 3.5*

For the energy demand which serves for a group of energy services, e.g., household electricity demand, the own-price elasticity of energy demand ($n_{P_E}(E)$) is an upper bound on the weighted average of individual rebound effects for those services.

3.2.2.2. The Quasi- Experimental Approach

The quasi-experimental approach is the one of the two common methodologies to estimate the direct rebound effect in which the demand for useful work before and after an energy efficiency improvement (Coyne, Lyons, & McCoy, 2018; Hens, Parijs, & Deurinck, 2010; Sunikka-Blank & Galvin, 2012) are taken into account. Most of the time, it may be very difficult to measure the demand for useful work, thereby, it is the energy consumption measured in most of the quasi-experimental studies. A quasi-experimental method (or sometimes called as evaluation study) is the most useful estimation method to measure the causal effect of a behavior on any outcome variable for such before-after analysis.

For estimation of direct rebound effects, comparing with a counterfactual prediction of energy consumption which holds minimum two sources of error is needed. For instance, (a) the energy consumption that may be occurred without energy efficiency development; and (b) the energy consumption that may be occurred following the energy efficiency development had no behavioral change (Sorrell et al., 2009).

To show rebound effect process mathematically, the energy rebound figure could be drawn as below (Lin & Liu, 2013):

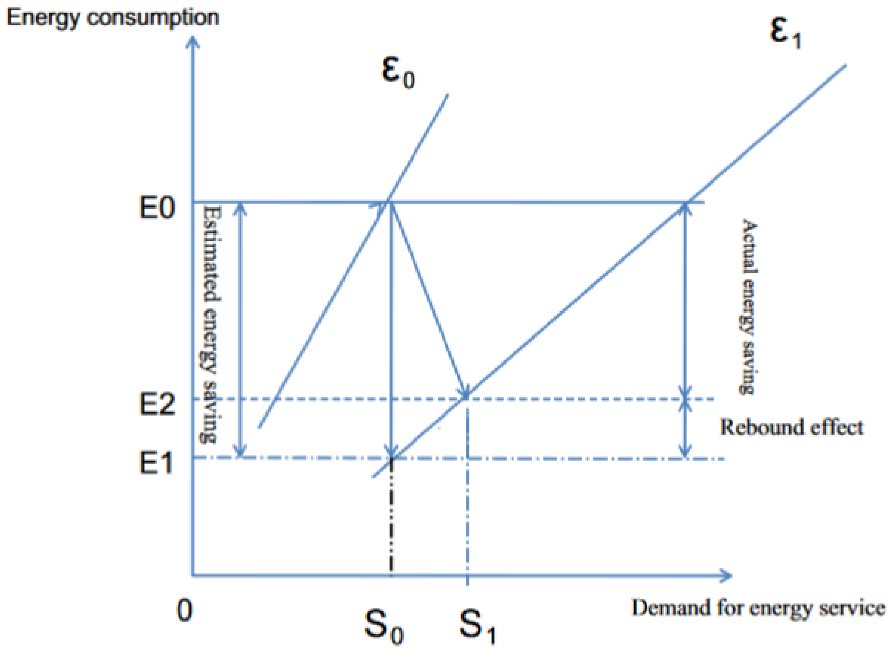


Figure 3.4. Energy Rebound, (Mizobuchi, 2008).

ε_0 and ε_1 ($\varepsilon_0 < \varepsilon_1$) show that two particular energy efficiency levels for one type of energy service. If the demand for energy services (S_0) is same as before, and before and after energy consumptions are E_0 and E_1 respectively, and energy conservation can be calculated as ($E_0 - E_1$). But it is different in real life. When energy efficiency develops, demand for energy services increases to S_1, and the corresponding energy consumption increases to E_2, and the actual energy saving become ($E_0 - E_2$). It is clear that ($E_2 - E_1$) is the amount of rebound, the difference between real and expected energy savings (Lin & Liu, 2013).

$$RE = \frac{E_2 - E_1}{E_0 - E_1} \times 100\% = 1 - \frac{E_0 - E_2}{E_0 - E_1} \times 100\% \qquad \textit{Eqn. 3.6}$$

3.2.2.3. Econometric Methods

Another and more common approach in estimating direct rebound effect is through econometric models. In these models, the secondary data, i.e., the data collected for another purpose, is used for rebound effect estimation. Econometric models developed for assessing the rebound effect may have various attributes such as level of aggregation, dynamicity, type of data, model structure and estimation technique (Herring & Sorrell, 2009) as summarized in Figure 3.5.

The most common and straightforward approaches to estimate rebound effects are single equation models with aggregate cross-sectional or time-series data. However, they can cause biased estimates if there are endogenous explanatory variables. In addition to that, they won't be able to differentiate the relative impact of differences in number capacity and/or equipment use. From this point of view, better performance exists in multi equation models. But also, these models will need more data. Especially exhausting models are discrete/continuous and household production models. As a result, they are limited to separate studies into its parts with comprehensive household survey data.

Short-term and long-term direct rebound effects may be estimated by using some model structures. Because of the time-varying direct rebound effect and multiple repercussions within sectors, the robust estimates are likely to be provided by the studies with pooled cross-section or panel data. Nevertheless, these data sets are less commonly applicable.

Category	Choices available
Level of aggregation	Aggregate (country or regional level) Disaggregate (household level)
Static versus dynamic	Static (provides only single elasticity estimates) Dynamic (allows short- and long-run elasticities to be identified)
Type of data	Cross-section (XS) Time-series (TS) Pooled cross-section Panel
Model structure	Single equation Multi-equation Recursive Simultaneous equation Discrete/continuous Household production
Functional form	Linear Log-linear Double log Translog
Estimation technique	Ordinary least squares (OLS) Feasible generalised least squares (FGLS) Instrumental variables (IV) Two-stage least squares (2SLS) Three-stage least squares (3SLS) Fixed effects (FE) and random effects (RE) Error correction (ECM) Logit/probit/tobit Maximum likelihood (ML)

Figure 3.5. Classifying Econometric Studies of the Direct Rebound Effect, Sorrell et al. (2009).

In the most general approach to predicting direct rebound effect is by way of the econometric analysis of secondary data sources which have information on the relevant energy, the energy demand and/or energy efficiency of the related service. Generally, this kind of studies predict elasticities, which means the percentage change in one variable following a percentage change in another, holding the other gauged variables constant. If time-series data exists, a prediction may be made of short-term elasticities, where the stock of conversion devices is supposed to be fixed, along with long-term elasticities where it is variable. Cross-sectional data are generally supposed to enable prediction of long-term elasticities (Sorrell et al., 2009).

In most of the econometric models, the definitions and indicators introduced and explained in 3.2.1.1. and recalled below are estimated as a proxy for the direct rebound effect. It is the data on hand or available data that specify which elasticity to use.

- efficiency elasticity of the demand for useful work, $n_{\varepsilon}(S)$
- negative of the service cost elasticity of the demand for energy, $n_{P_S}(S)$
- negative of the own price elasticity of fuel demand, $n_{P_E}(E)$

The studies that employ econometric models mostly focus on personal automotive transport and space heating for which the data is more available or accurate compared to other energy services. Besides, accessing to more accurate data on energy use and energy prices are easier compared to the data on useful work and efficiency.

3.2.3. Direct Rebound Effects in Transportation Sector

Evaluation and econometric methods are the two techniques usually used in calculating the size of this effect. Evaluation methods depend on quasi-experimental studies and measure the 'before and after' changes to energy consumption from the enforcement of energy efficiency in technology. Econometric methods use elasticity values to calculate the possible effects of changes in the real price of energy services (Murray, 2009). Empirical evidences show that the long term rebound effect, as expected, is lower than short term rebound effect, and the rebound effect in regions where public transportation alternatives are more widespread are larger compared to those with prevalent alternatives, e.g., Europe vs US, (Ficano & Thompson, 2014). Several empirical studies as well as some theoretical arguments indicate that the rebound effect declines with income (Hymel & Small, 2015; Small & Van Dender, 2007). In addition to these, the magnitude is higher when the gasoline prices are rising compared to when they are falling (Hymel & Small, 2015).

Econometric estimates of the direct rebound effect for personal automotive transport can be conducted in several ways in terms of the data (i.e., aggregate panel data, time-series or cross-section data, household survey data) used in these studies. There are numerous studies including each data type in the literature while those using household survey data is summarized as below (Sorrell et al., 2009).

Author/year	Short-run rebound effect	Long-run rebound effect	Country	Data	Model structure	Functional form	Estimation technique	Comments
Goldberg (1996)	0%		US	Rotating panel 1984–1990 (CES)	Discrete/ continuous	Double log (utilisation equation)	Nested logit (discrete) and instrumental variables (utilisation)	Very detailed model, but estimates utilisation of new cars only. If endogeneity bias ignored, RE estimated to be 22%.
Puller and Greening (1999)	49%		US	Rotating panel 1980–1990 (CES)	Simultaneous equation (dynamic—single year)	Double log	2SLS	Confined to non-business travel. Find $\eta_{P_E}(\varepsilon)<0$ reflecting only short-term changes in driving habits. Partly explains high estimate of RE. Omission of vehicle age may lead to bias.
Greene et al. (1999)		23%	US	Pooled cross-section (travel survey)	Simultaneous equation	Double log	3SLS	RE estimated from $\eta_{\varepsilon}(S)$ for households owning 1 to 5 vehicles—quoted figure is weighted average and relates solely to utilisation. Find
West (2004)	87%		US	Cross-section (CES-1997)	Discrete/ continuous	Double Log (utilisation equation)	Nested logit (discrete) ad instrumental variables (utilisation)	S is the distance travelled by household. RE estimated from $\eta_{P_G}(S)$—represents an upper bound since $P_S \leqslant P_G$.
Frondel et al. (2008)		56–66%	Germany	Panel	Single equation	Double log	Fixed/between/ random effects	RE estimated from $\eta_{P_E}(S)$, $\eta_{\varepsilon}(S)$ and $\eta_{P_E}(E)$. Results insensitive to elasticity measure and estimation method.

Figure 3.6. Econometric Estimates of the Direct Rebound Effect for Personal Automotive Transport Using Household Survey Data

The studies including (Greene David L, 1992; Greening et al., 2000b; Small & Van Dender, 2007; Su, 2012; Wang et al., 2012) employs aggregate national or sub-national vehicle miles traveled data to estimate responsiveness to fuel price, fuel efficiency or service price. Ficano & Thompson (2018) points out that the estimation of rebound effects in these studies is ranging from 5% to over 40 % and propose two econometric models (OLS and IV) in order to estimate rebound effects in the US, based on the micro-data of individual households, i.e., 2009 National Household

Travel Survey (NHTS) data, instead of the aggregate approach used in the aforementioned studies where they followed the methodology used in (Manuel Frondel, Ritter, & Vance, 2012). Their estimates are 56% and 78% by the models OLS and IV, respectively and no evidence is found about the impact of the income on the rebound effect. Their compare their results with those of the studies which also use the US micro data in their studies, e.g., gasoline price elasticity of 2% to 48% for different groups of households in (Wadud, Noland, & Graham, 2010).

The study by Yu et al. (2013) offers a simple way of understanding the rebound effects due to more fuel efficient technologies and with deciding the distribution of the rebound effects in a household sector which includes residential and transport sectors via an SP-off RP study in Japan in 2012. The aim of the study is to investigate the priority of the people for the reallocation actions when they know their operating cost saving annually due to vehicle efficiency improvement. People are prone to spend their money on residence requirements or transport when saving money due to relocation. With the information of rebound effects distribution, it can be assumed that household appliances will be affected more than vehicles (B. Yu et al., 2013).

Yu and Liu (2016) investigate the direct rebound effect of households' cars in 2014, predict the direct rebound effect in regards of Chinese policy and also scrutinize lthe factors which could affect the possibility of rebound effect less than or equal to 0 by the binary logistic model. They find the direct rebound effect approximately -25.47% for year 2014. According to the baseline scenario in (F. Yu & Liu, 2016), the direct rebound effect is estimated nearly 13.98%. On the other hand, it is found that 55.31% of the rebound effect is less than or equal 0 under a scenario achieving fuel consumption as 5.0L/100km.

In the study by Lin & Liu (2013), rebound effect for passenger transportation is estimated in regards of energy efficiency developments and energy cost of transport sector. They studied the linear approximation of AIDS (LA-AIDS) model to predict the demand function of Chinese passengers and calculated resulting rebound effect.

The rebound effect they found is 107.2%, which shows the existence of the 'backfire effect'. The reason why the rebound effect higher is indicated as the fuel pricing mechanisms, which is strict and not market-oriented, in China.

Remember the Table 3.1 which summarizes the long-run rebound effects for various energy services and indicates that the best guess for personal automotive transport is 10-30%. In a more recent study, Dimitropoulos et al. (2018) performed a meta-analysis of rebound effect in road transport in which 74 studies are included. The results showed that the short-run rebound effect is 10-12% while it is 26-29% for the long-run. Dimitropoulos et al. also analyzed the distribution of elasticities based on 255 estimates provided in the 74 primary studies based on the elasticity measure used, i.e., with respect to fuel efficiency, fuel costs and fuel price, as illustrated in Figure 3.7. Among 255 estimates, 57 of them represent elasticity with respect to fuel efficiency; 116 of them, fuel costs and 82 of them, fuel price.

In addition to the analyses summarized above, Dimitropoulos et al. (2018) proposed a fixed effects model to predict long-run rebound effects for different levels of GDP per capita, fuel price and population density.

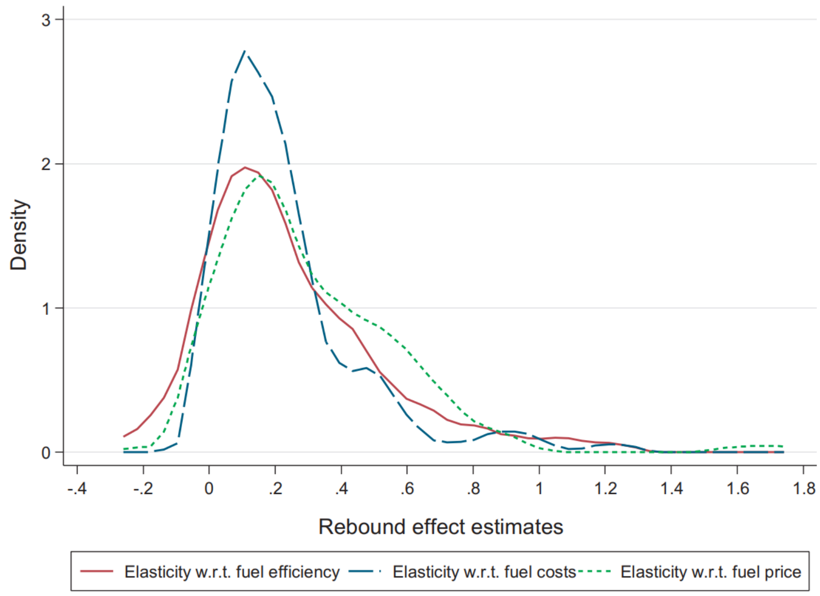


Figure 3.7. Distribution of 255 estimates of the rebound effect by elasticity measure (Dimitropoulos et al., 2018).

3.3. Rebound Effect Studies in Turkey

Although there is a large number of studies considering the rebound effect in diverse aspects and provide evidence for the developed countries especially for the US, the literature for developing countries is still very weak. One of the underlying reasons is the lack of a systematic approach or policy to maintain a consistent and detailed VKT database as mentioned at the outset and also noted in (Kutucu, 2018).

There are numerous studies on rebound effect in the literature but the studies in Turkey are highly new. Generally economy wide rebound effect has been studied in Turkey. These studies are summarized at below.

Table 3.2. Rebound Effect Studies in Turkey

Title	**Authors**	**Year**	**Estimation Technique**	**Rebound Effect Type**	**Long Run Rebound Effect**
Rebound Effect For Energy Consumption: The Case Of Turkey	Ulucak, R. Koçak, E.	2018	Total factor productivity	Economy-wide	+*
Jevons Paradoksu: Enerji Etkinliği Ve Rebound Etkisi Üzerine Ekonometrik Bir Analiz	Akıncı, M. Sevinç, H. Yılmaz, Ö.	2018	VEC Analysis	Economy-wide	+*
The Rebound Effect: Empirical Evidence From Turkey	Topallı, N. Buluş, A.	2012	ARDL method	Economy-wide	%18
Enerji Verimli Araç Kullanımının Geri Sekme Etkisinin (Rebound Effect) Gelir Gruplarına Göre Karşılaştırılması	Kutucu, M.	2018	Nassen ve Holmber (2009)	Direct&Indirect Rebound Effect	DRE: %12 IRE: %32
Can energy efficiency save energy? An economy-wide rebound effect simulation for Turkey.	Somuncu, T.	2016	CGE Model	Economy-wide	%18-19
Enerji Rebound Etkisinin Panel Veri Yöntemi ile Analizi	Kılıçarslan, Z. Dumrul, Y.	2019	Panel co-integration test	Economy-wide	-**
Energy Efficiency and Rebound Effects for Household Gas Consumption: Evidence from Ankara.	Yılmaz, Z.I.	2019	OLS,2SLS	Direct Rebound Effect	%70 and %50

*The rebound effect may exist in long-term economic relationships with various economic indicators. It is possible to say that at least one-way causality relationship can be expected among the related variables.

**The energy rebound effect, which indicates that energy efficiency increases will increase energy consumption, is not valid.

Ulucak et.al. (2018) studied on literature review briefly, and they pointed out the relationship between total factor productivity due to improved technology and primary energy consumption period from 1965 to 2014 in Turkey. They stated that primary energy consumption increases with total factor productivity at the same time. The increase in energy consumption found as a result of the statistical method was accepted as a direct rebound effect. In other words, the results obtained support the hypothesis of the rebound effect for Turkey. Johansen and Jusellius test was used as co-integration analyze, and Dynamic Least Squares (DOLS) method was used for robustness control (Ulucak & Kocak, 2018).

Through the time-series analysis by Akıncı et. al (2018), the rebound effect in Turkey's economy, energy production, savings and imports as well as economic growth, inflation and the current account deficit and its impact on the environment were investigated with the aid of time series analysis. The authors state that the models findings show Jevons paradox is valid and rebound effect is significant for Turkey. In their study, the rebound effect is investigated using time series analysis from 1967 to 2015 in the Turkish economy.

Topallı and Buluş (2012) study, rebound effect of Turkey’s domestic electricity consumptions from 1964 to 2009 was calculated and Autoregressive Distributed Lag (ARDL) co-integration method was used when time series data analyzed. In their study, it is stated that long term electricity price is inelastic and its value is -0.18, and as claimed by study rebound effect in the housing sector in Turkey, is %18 (Topallı & Buluş, 2012).

Somuncu developed a computable general equilibrium (CGE) model for Turkey based on Social Accounting Matrix (SAM) constructed on 2002 I-O tables to estimate the economy-wide rebound effect (Somuncu, 2016). The CGE model is arranged in the manner that it represents the informal economy (or “shadow economy” as stated in her thesis) in Turkey. Then the model is run under the scenario in which there exist two types of energy efficiency improvements. The model results imply that the economy-wide rebound effect is 18-19%. Somuncu and Hannum (2018) developed an extended and updated CGE model for Turkey based on two SAMs constructed on 2011 I-O tables taken from the World Input Output Database (WIOD). This model also incorporates informal economy and put emphasis on energy theft and is run under the efficiency scenario in which 42% and 48% energy efficiency improvements are introduced for service sector and households, respectively. The results show that the rebound effects are -1.4% and 3.1% for the service sector and between 0.4% and 2.1% for households without energy theft while the same figures are -7.9% to -19.7% and 10.4% to 40.7% with energy theft.

In the thesis of Kutucu (Kutucu, 2018), the rebound effect is calculated when the households replace their existing vehicles with energy efficient vehicles, and the results are compared for two different income groups. In the study, the estimation was carried out by applying a survey to 104 households. Concerning the results of Kutucu’s (2018) study, the direct rebound effect of the fourth and fifth quantile income groups is both % 12. The indirect rebound effect amount for the fourth quantile is % 18, and for the fifth quantile, income group is % 32.

In the study of Kutucu (2018), the direct rebound effect is calculated based on the energy saving rate β and energy service price elasticity α parameters. The price elasticity of energy services varies depending on the development levels of the countries and fuel prices. Therefore, it is seen that the results in the literature are in a wide range. The indirect and total rebound effect results were obtained in a wider range in (Kutucu, 2018). The main reason for this situation is the change in the q/qBE ratio, which is expressed as a parameter indicating how long the savings per kilometer can be achieved by the new vehicle. Also another situation that may affect the results of the study is that the value used for energy service price elasticity is taken as a reference from a 2009 study. It is stated that in order to calculate the price elasticity, detailed vehicle-km data bases are required on a national basis (Kutucu, 2018).

In Kutucu's (2018) study, direct rebound effect is handled by the aspect of price effect and is estimated following the methodology and equations introduced in (Nässén & Holmberg, 2009):

$$R_{price} = 1 - \frac{1}{\beta}\left[1 - (1-\beta)^{\alpha+1}\right] \qquad \textit{Eqn. 3.7}$$

$$R_{total} = 1 - \frac{1}{\beta}\left[1 - (1-\beta)^{\alpha+1} - \frac{1}{e_A}\sum_{i=1}^{N} \gamma_i e_i \left(1 - (1-\beta)^{\alpha+1} - \beta\frac{q}{q_{BE}}\right)\right] \quad \textit{Eqn. 3.8}$$

where e_A is the energy intensity of the service of interest and e_i denotes the intensity of ith good. q and q_{BE}, on the other hand, are the additional capital cost for energy efficient good and break-even investment, respectively, and γ_i denotes the marginal consumption factor for the ith good.

In the study of (Kılıçarslan & Dumrul, 2019), the panel co-integration method was used from 2000 to 2015 for Turkey and 23 European Union countries. According to this study, energy efficiency improvements result in reductions in energy consumption. Hence, they state that there is no rebound effect for the selected European countries and Turkey in those years. However, the results seem to indicate a positive rebound effect, since the reference value should be the expected energy demand after an efficiency improvement instead if the initial energy demand.

3.4. Fuel Price Elasticity Studies in Turkey

Future fuel demand may be predicted by trusted fuel price elasticity estimations. Revealed preference (RP) data may be used for such predictions. But RP estimations of fuel price elasticity do not lead to trusted results in lack of structural discontinuities or in sufficiently stable environments. For overcoming this potential limitation, it is used a situational stated preference (SP) survey to estimate the response to theoretical fuel price changes. It is stated that applying a situational approach is especially helpful, when behavioral predictions for non-financial policy interventions go beyond of standard RP approaches. Moreover, the situational approach tries to consider extra behavioral constraints and ask more specifically ‘‘What would you have done in this specific situation if...”. When respondents remind their own recent past, it helps them consider personal constraints when think about their answers to a fuel price increase. It is found that the situational approach generally predicts the actual aggregate responses to previously fuel price changes very well. It is suggested that the situational SP approach is especially helpful for estimating demand responses to a sharp and persistent price increase, such as demand and supply shocks. Briefly, it is stated that both RP and SP approaches can take into account for estimations (Hössinger, Link, Sonntag, & Stark, 2017)

There is a great deal of international research showing that fuel prices affect travel behavior. As generally measured, automobile travel is not flexible with respect to fuel price. For example, a 10% increase in fuel prices leads to a 1% decrease in automobile use and a 3% decrease in the medium term. Even a price increase of 50%, which is too high for consumers, usually leads to a reduction of only 5% in the short term in terms of vehicle-km. This change is too small for most people to notice. However, this rate increases in the long term. Because, for example consumers can take major actions in their long-term on their place of residence as well as place of their work (Gerçek, 2009).

The main purpose of Deniz (2006) is to present Turkey's oil demand function through an econometric model. The log-log demand model is used to empirically investigate the relationship between oil consumption, oil prices and income levels in Turkey. Quarterly data between 1992 and 2004 were used. The reason for using the double-log functional form instead of the linear form is that the estimated coefficients in the price and revenue series directly give price and income elasticities of oil demand. It is estimated that short-term income elasticity is 0.58 while short-term price elasticity was calculated as -0.15. However, the latter was statistically insignificant. In the long run, price elasticity was estimated as -0.38.

Elasticity estimates for the gasoline and diesel in Turkey are cataloged as shown at the below table which was presented in (Hasanov, 2015). In addition to Hasanov's study, several new estimates are also added to the catalog. Although in the study of Gerçek (2009) it is stated that fuel price is a weak indicator of elasticity for automobile use and in the long run higher fuel efficient vehicles are preferred by consumers, the elasticity of total annual VKT per capita relative to fuel cost per kilometer is calculated as -0.14 by using General Directorate of Highways data; when predicted values ın (Soruşbay, 2009) are used, the elasticity was estimated as -0.34.

Table 3.3. Price elasticity estimates of previous studies for Turkey, (Hasanov, 2015).

	Author	Period & frequency	Model & method	Price elasticity	
				Short Run	Long Run
Gasoline Demand	Baltagi and Griffin (1983)	1960-1978 annual	Static, OLS		-0,26
	Sterner et al. (1992)	1960–1985 annual	PAM, OLS	-0.31*	-0.61
			DL, OLS		-1,1
			INV, OLS		-0,5
	Birol and Guerer (1993)	1970–1990 annual	PAM, OLS	−0.18*	-0,75
	Franzen (1994)	1955–1984 annual	ARDL, OLS	−0.493*	
		1959–1984 annual	Static, OLS		−0.565*
		1961–1984 annual	VAR, MLE		−0.448
	Baltagi and Griffin (1997)	1960–1990 annual	ARDL, shrinkage OLS	−0.28*	-0.88*
			ARDL, shrinkage 2SLS	-0,28*	−0.72
	Erdoğdu (2014)	2006–2010 annual	PAM, OLS	−0.213	−0.481
	Yalta (2015)	2003-2012 monthly	ARDL	-0.19	-0.18
	Hasanov (2015)	2003-2014 quarterly	PAM	inelastic	inelastic
Diesel demand	Birol and Guerer (1993)	1970–1990 annual	PAM, OLS	0.06	0.15
	Erdogdu (2014)	2006–2010 quarterly	PAM, OLS	0.067	0.155
	Yalta (2015)	2003-2012 monthly	ARDL	-0.28	-0.14
	Hasanov (2015)	2003-2014 quarterly	PAM	inelastic	-0.28
LPG	Erdoğdu (2014)	2006–2010 annual	PAM, OLS	0.279	0.949

(*) denotes that estimated elasticity is statistically significant.
PAM = partial adjustment model, DL = distributed lag model, INV = inverted-lag model, VAR = vector autoregressive model, ARDL = autoregressive distributed lag model, OLS = ordinary least squares, 2SLS = two stage least squares, MLE = maximum likelihood estimator, Q = fuel demand, Y = income, N = population, PF=fuel price, PGDP=GDP deflator, CPI = consumer price index, C = car stock.

CHAPTER 4

AN OVERVIEW OF HOUSEHOLDS' VEHICLES USAGE IN TURKEY

In Turkey, most of the road motor vehicles comprise of cars. According to TurkStat, there are 12.398.190 cars in 2018 in Turkey while 5.772.745 were in 2005.

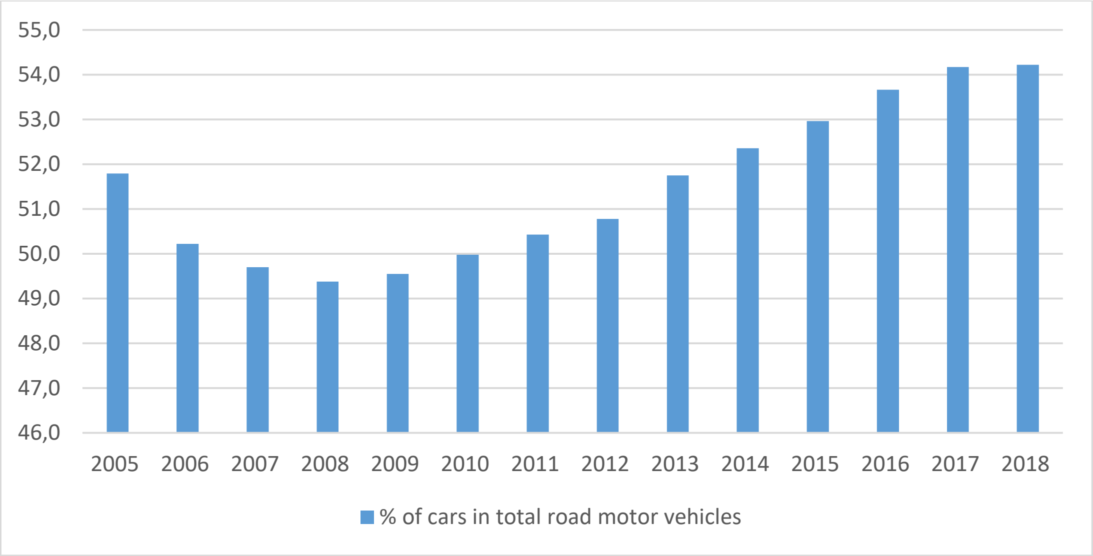


Figure 4.1. Percentages of Cars in Total Road Motor Vehicles, TurkStat, Road Motor Vehicle Statistics

The brands of registered cars can be seen below. It is seen that Renault is the most commonly used trademark in Turkey with a total number 1.193.938 cars. Volkswagen follows it with a number of 855.282 cars.

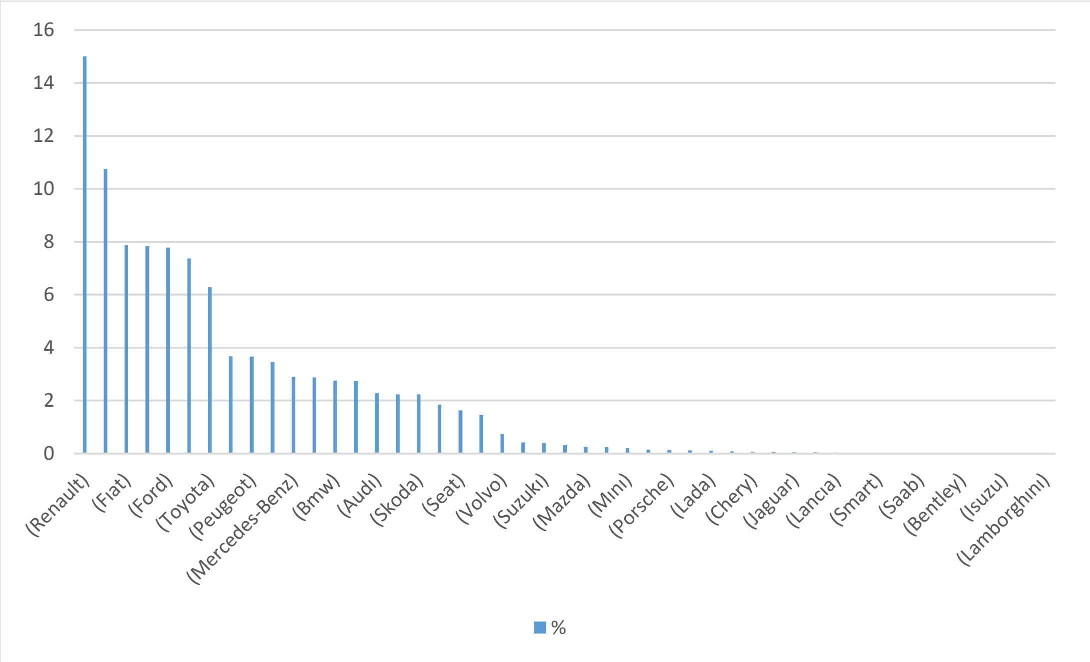


Figure 4.2. Percentages of cars registered to traffic by trademarks, TurkStat, Road Motor Vehicle Statistics, 2019.

4.1. Cars by Fuel Type

The Gasoline cars comprise of 24.9% of total cars in 2018 in Turkey while they were 75.2% of total cars in 2004. According to General Directorate of Public Security there are 7,903 gasoline-electric, diesel-electric and electric cars in Turkey by the end of April, 2019. On the other hand, there are 38.512 unknown cars for which the type of fuel field in the license is filled incorrectly or left blank.

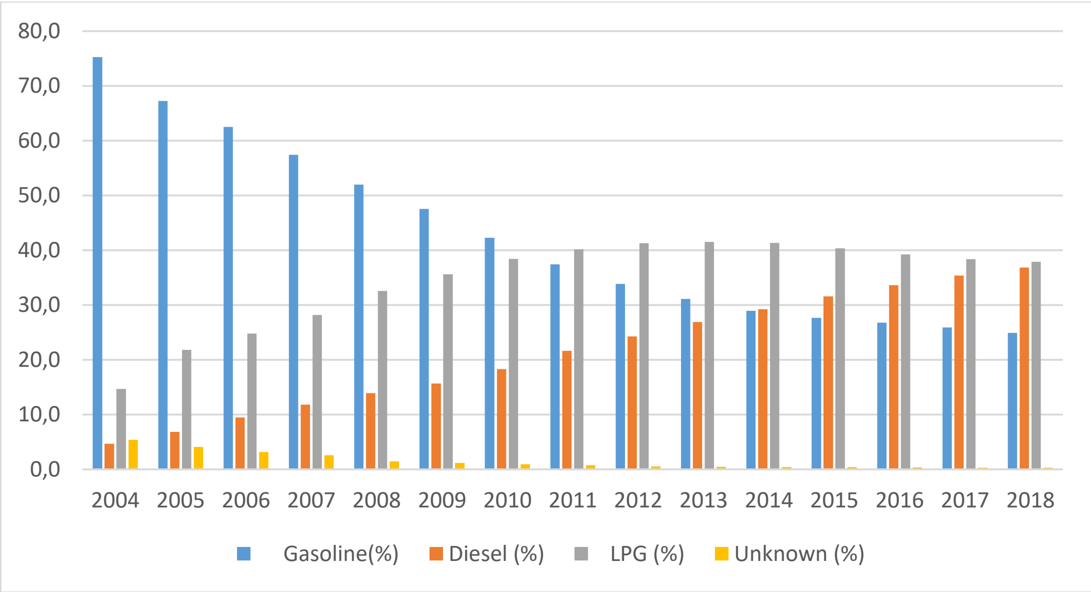


Figure 4.3. Distribution of cars registered to the traffic according to fuel type, General Directorate of Public Security

As of the year 2017, the distribution of the registered cars by fuel type shows that, 38.4% of the 12,035,978 registered cars use LPG, 35.4% diesel and 25.9% gasoline. The ratio of cars with unknown fuel type is 0.4%. According to data from the 2016 rate of LPG cars, Poland has highest proportion with 16% in the Europe. And the proportion of LPG car in Turkey is very high compared to European countries.

As of 2016, 16 out of the 24 EU countries for which data is available, the majority of cars have gasoline engines. In 2016, an average of 42% of the EU-28 automobile fleet was diesel-powered. In 2017, approximately 3% of total EU passenger cars are composed of alternative fuel and electric vehicles. The detailed data is shown in the chart and table below:

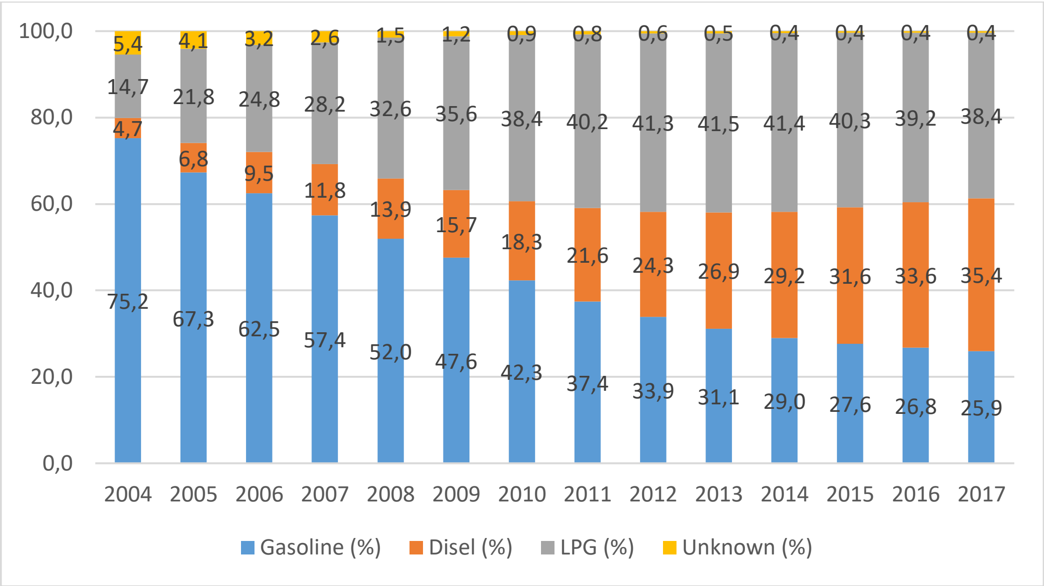


Figure 4.4. Percentages distribution of registered cars by fuel type

Table 4.1. Numbers of registered cars by fuel type

	Gasoline	Disel	LPG	Unknown[1]	Total
2004	4.062.486	252.629	793.081	292.244	5.400.440
2005	3.883.101	394.617	1.259.327	235.700	5.772.745
2006	3.838.598	583.794	1.522.790	195.810	6.140.992
2007	3.714.973	763.946	1.826.126	167.111	6.472.156
2008	3.531.763	947.727	2.214.661	102.478	6.796.629
2009	3.373.875	1.111.822	2.525.449	82.818	7.093.964
2010	3.191.964	1.381.631	2.900.034	71.242	7.544.871
2011	3.036.129	1.756.034	3.259.288	61.660	8.113.111
2012	2.929.216	2.101.206	3.569.143	49.310	8.648.875
2013	2.888.610	2.497.209	3.852.336	45.768	9.283.923
2014	2.855.078	2.882.885	4.076.730	43.222	9.857.915
2015	2.927.720	3.345.951	4.272.044	43.622	10.589.337
2016	3.031.744	3.803.772	4.439.631	42.851	11.317.998
2017	3.120.407	4.256.305	4.616.842	42.424	12.035.978

(1) Unknown fuel typed vehicles includes electrical vehicles and other vehicles whose license type is left empty or where data is incorrectly entered.

4.2. Consumption Expenditure on Transportation

As it can be seen from the chart below, household consumption expenditure on transportation by quintiles ordered by income increase between the years 2002 and 2017. The largest percentage increase in transportation is seen in the third quintile. The consumption percentages at fourth and fifth quantiles are above the mean percentages with 14.7% and 18.8%, respectively.

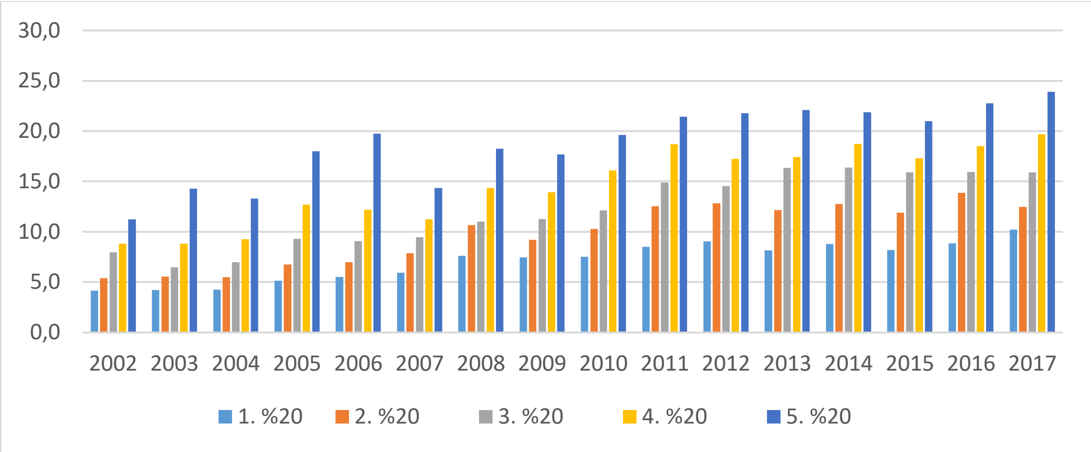


Figure 4.5. Consumption of Transportation, Quintiles ordered by income, TurkStat, Household Budget Survey

4.2.1. Fuel Demand and Consumption in Turkey

Compared with Turkey and EU about an average of fuel consumption and CO^2 emissions levels, the EU average is few higher than Turkey average for new cars and light commercial vehicles. For all that, it has been preferred having less engine power and a little bit lighter and smaller vehicles in Turkey when compared with the EU average. And also Turkey and the EU-28 have nearly the same energy efficiency of vehicles. It is also applied when individual vehicle segments and models are analyzed. By the way, as being stop-start technology, some vehicle models being applied slightly lower technology in Turkey than the German/EU market (Mock, 2016).

Diesel fuel consumption is increasing too much in the business-as-usual scenario for Turkey, because of the expected growth in truck and bus traffic. On the other hand, 60% of new cars in Turkey are switching to diesel, and the number of diesel vehicles will increase expected for future years. In the baseline scenario, fuel consumption from the road transport sector is calculated almost double for Turkey from 2010 to 2030. Because of Turkey's entire oil consumption is imported, it also means there will be a doubling in crude oil imports in the next 20 years (Mock, 2016).

The baseline scenario modeling results are showed in terms of fuel consumption (expressed in barrels oil equivalent per day) in Figure 4.6. Here are the baseline scenario assumptions (Mock, 2016):

- For future years a 1% per year CO^2 reduction,
- No uptake of electrified vehicles,
- No fuel shift,
- Fuel consumption from the road transport sector is estimated to almost double in Turkey in the 2010-2030 time period,
- NOx emissions from passenger cars would not decrease or even slightly increase in future years.

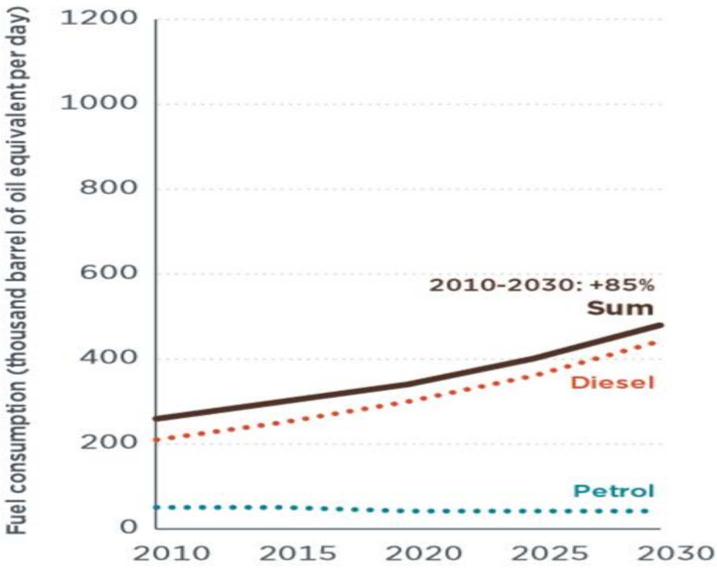


Figure 4.6. Estimated total road transport fuel demand in Turkey (2010-2030) in a business-as-usual scenario, (Mock, 2016).

According to the business-as-usual scenario, the estimated fuel consumption of road transport will be double in Turkey by 2030. Because of imports, nearly whole oil from abroad, Turkey's national energy security is affected negatively. Since there is a link between direct fuel consumption and CO^2 emissions, CO^2 emissions are expected to double by 2030 approximately. The most important reason for this increase would be heavy-duty vehicles. Although the number of trucks and buses is relatively small compared to passenger cars, fuel consumption, and CO^2 emissions have a significant impact (Mock, 2016).

CHAPTER 5

DATA AND METHODOLOGY

5.1. Survey and Data

To determine the fuel consumption trends of vehicle kilometers traveled (VKT) by private cars and to measure the behavioral aspects and responses to fuel price changes, a survey was designed (See appendix A).

First, a pilot study was carried out with 23 people which were selected by different car service units in Ankara in April 2019. In this phase, 8 different car service companies were interviewed randomly and the survey was applied to the customers who bring their vehicles to the services. Then, the online version of the survey was delivered to randomly selected people all around Turkey. This online version of the survey was conducted in May 2019 and 449 people submitted their forms which made a total of 472 individual data from 51 different cities as shown in Figure 5.1., i.e., 23 face-to-face interviews plus 449 online responses.

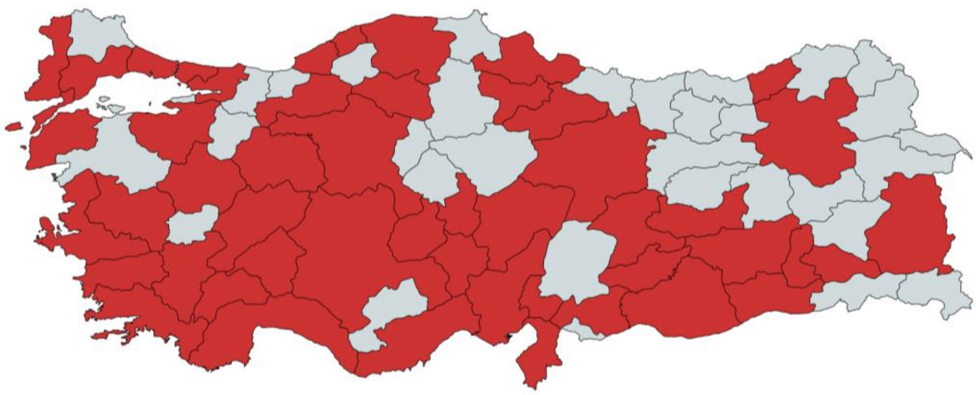


Figure 5.1. The cities from which responses are received are illustrated in red on the map.

Following the pilot study, special attention was paid to ensure that online surveys are not distributed to people from the same environment. Surveys were conducted online, via e-mail and through different groups of Whats App i.e. the group consisting of a large number of soldiers. The participants to whom the questionnaires were submitted were asked to forward the questionnaire to other people they can access.

The questions in the questionnaire were prepared for those who already have a car and have used this car for at least 1 year or who have covered at least 10.000 km with this car.

In addition, the questionnaire was designed to allow people to ask their previous vehicles only if they sold their previous vehicles after 2015. According to TURKSTAT data, 2,760,606 vehicles were registered after 2015 and it should be noted that the sample was selected from this population. When the survey results are examined, it is seen that 95% of the sample is the 4th and 5th income level according to data in 2017 by TURKSTAT as in Kutucu's (2018) study.

The questions in the questionnaire were prepared to determine the fuel consumption trends of the automobile users and to fill the fuel consumption information as much as possible by the users trying to follow, in the section where general information about the questionnaire was given to the participants.

The survey consists of the following main categories:

- Demographic questions (i.e., survey items between 1-12)
- Behavioral questions related to transportation demand and car ownership as well as environmental aspects (i.e., survey items 13,27, 43, 44 and 45)
- Questions related to technical and economic aspects of private cars those the respondents currently have as well as their VKTs (i.e., survey items between 14-26)
- Questions related to technical and economic aspects of private cars those the respondents previously had as well as their VKTs (i.e., survey items between 27-42)

- Questions to obtain stated preferences about VKTs with respect to changes in fuel prices (i.e., survey items between 46-136)

5.1.1. Descriptive Statistics

In this part, detailed graphics and figures will be given about demographic statistics and the behavioral attributes related to personal transportation, energy consumption and environmental awareness.

- The survey was completed by 472 participants, 67.9% were male and 32.1% were female.

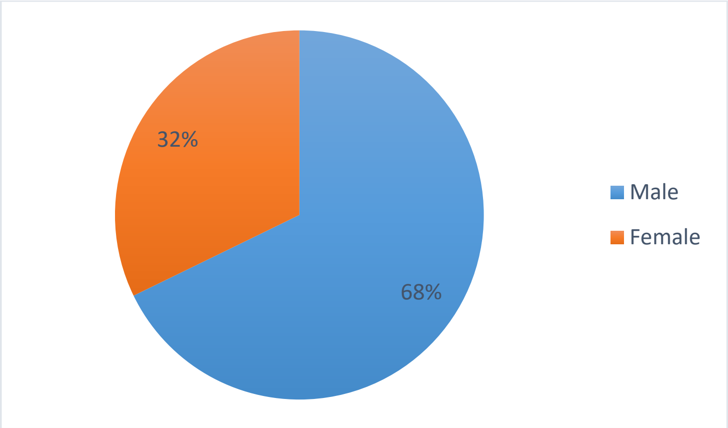


Figure 5.2. Gender of Participants

- The age of the participants ranged from 20 to 67, and the age range of the 28- to 40-year-olds was 70%, representing the majority of the questionnaire.

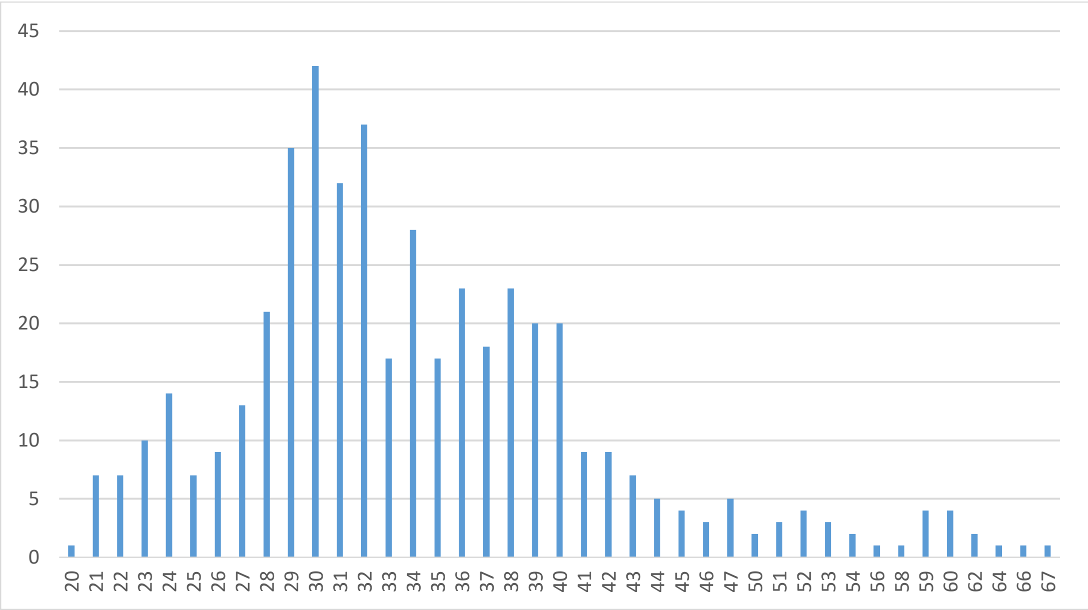


Figure 5.3. Number of participants in each age category

- Approximately 64% of the survey participants were university graduates, 20% graduate students, 8% doctorate and above education and the remaining 8.5% participants stated that they are graduates of either open education, high school, secondary school or primary school.

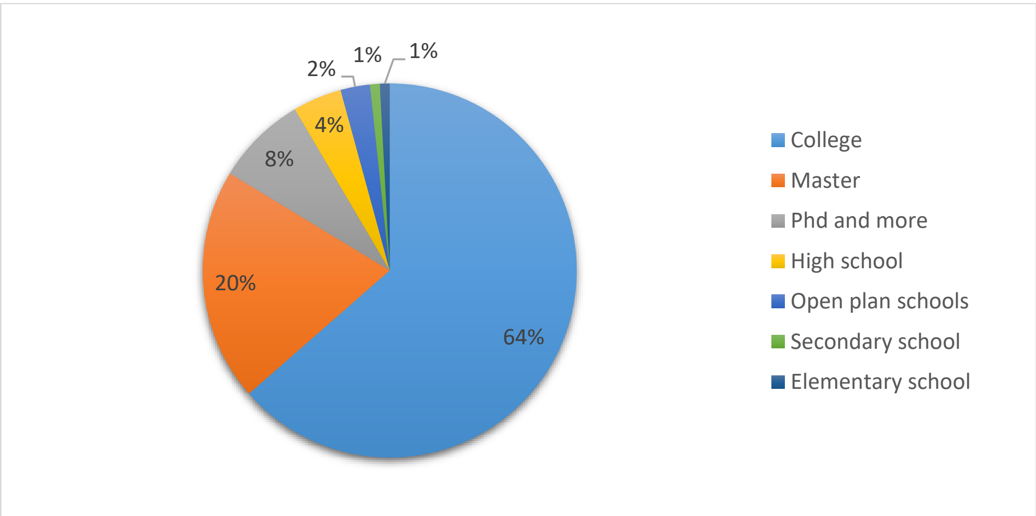


Figure 5.4. Educational level of Participants

- The question of the profession has been answered by 180 public employees, 220 private sector service and production sector employees, 21 academicians, 20 students, 10 retirees, 5 housewives and 3 unemployed. It was paid attention to fill in the questionnaires of people working in different professions and who work in different cities.

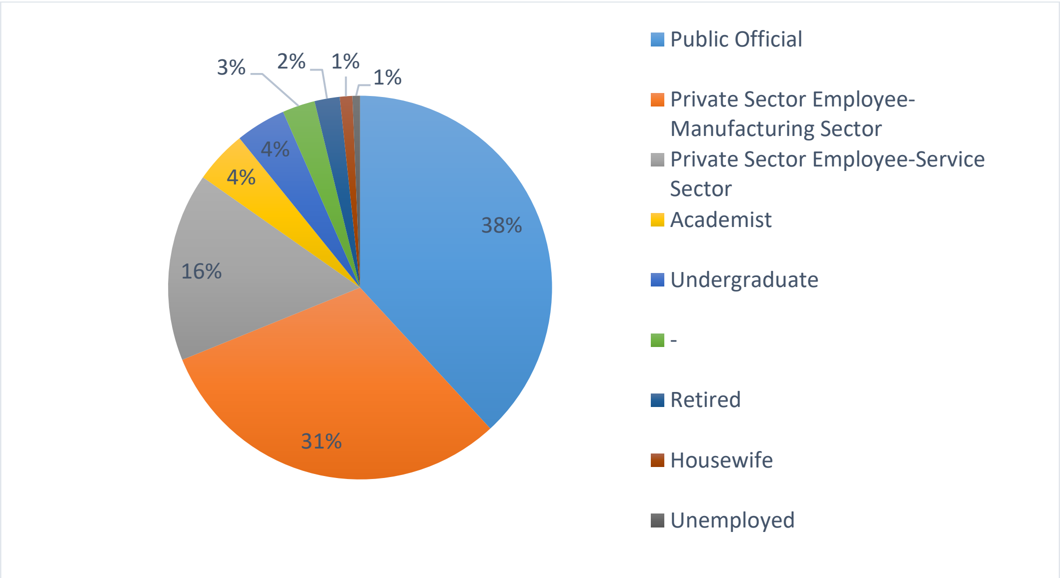


Figure 5.5. Profession of Participants

- The main occupational group included in the ISCO-08 (International Standard Classification of Occupations), which was prepared by the International Labor Organization (ILO) and which enables the international comparison of occupational information, was classified according to the answers of the survey participants. Within the scope of the ISCO-08 main occupational branches of the respondents in the survey, 81% were Professionals, 6% were Technicians and Associate Professionals, 4% were Managers, 3% were Services and Sales Workers, and the remaining 3% were Clerical Support Workers, Skilled Agricultural, Forestry and Fishery Workers, Craft and Related Trades Workers, Technicians and Associate Professionals.

- 64.5% of the participants are married and 48.6% of them have children. In order to take into consideration, the effects of the children and their numbers on the fuel consumption, age ranges in the response options were determined and asked within the age groups of the Turkish education system. The participants have 176 children in the 0-6 age group and 99 children in the 6-13 age group. The participants also had 27 children aged 13-17 years and 57 children over 17 years of age.

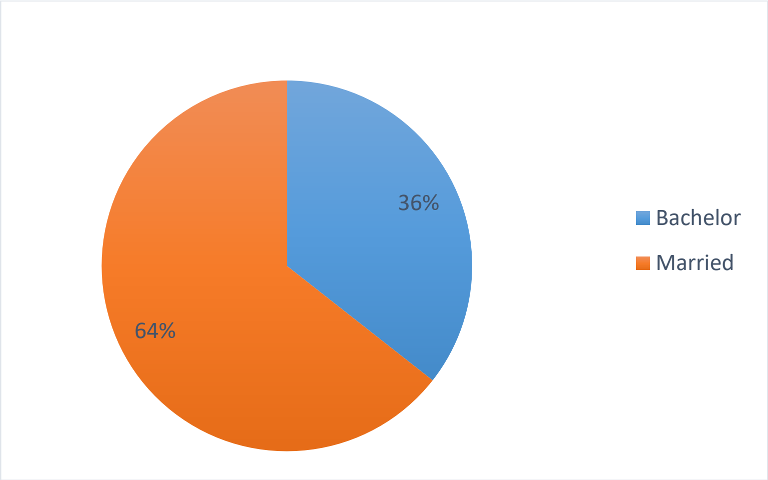


Figure 5.6. Marital Status of Participants

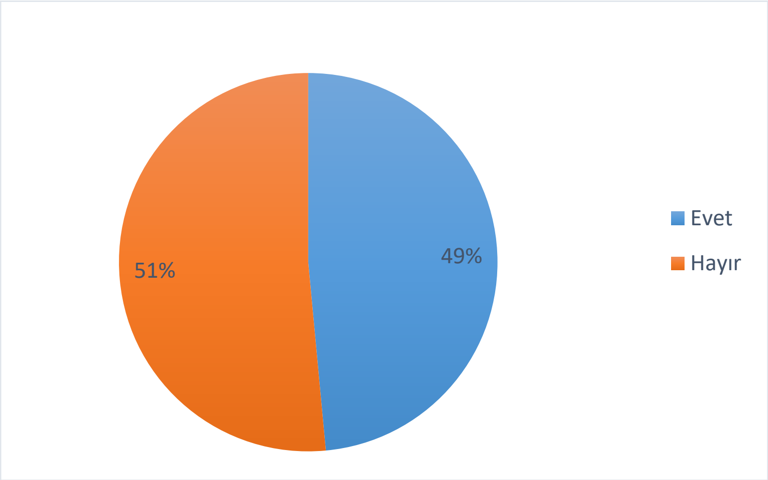


Figure 5.7. Participants with Children

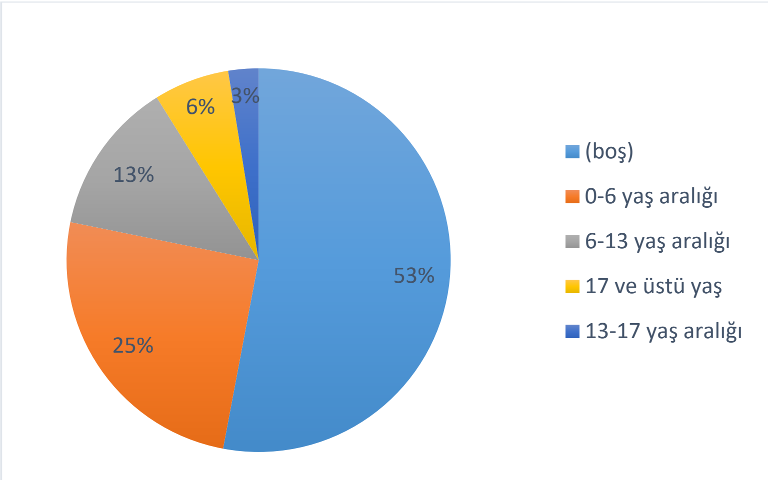


Figure 5.8. Ages of Children

- According to the survey results, it is understood that participation in the survey provided from 49 different provinces in Turkey. The highest number of participants was from Ankara with 252 participants followed by Istanbul with 37 participants (See appendix B).

- The question of the town where the participants dwelled was asked only for the participants living in the province of Ankara and it was understood that the 11 districts, which constitute the majority of the 25 districts, were within the given answers. The majority of the participants were Çankaya with 103 participants, Yenimahalle with 47 participants, Etimesgut with 34 participants and Keçiören with 25 participants. In addition, Mamak, Gölbaşı, Altındağ, Ayaş, Sincan, Pursaklar and Çubuk towns participated in the survey (See appendix C.)

- In the questionnaire, participants were asked to answer the question about total income level. The answers were for 100 people between 10.000 TL-15.000 TL, 98 people between 4.000 TL-6.000 TL, 86 people between 8.000 TL-10.000 TL, 86 people between 6.000 TL-8.000 TL, 50 people between 2.000

TL- 4.000 TL, 27 people stated TL 15.000 to TL 20.000, 20 people over 20.000 TL and 5 people less than 2.000 TL.

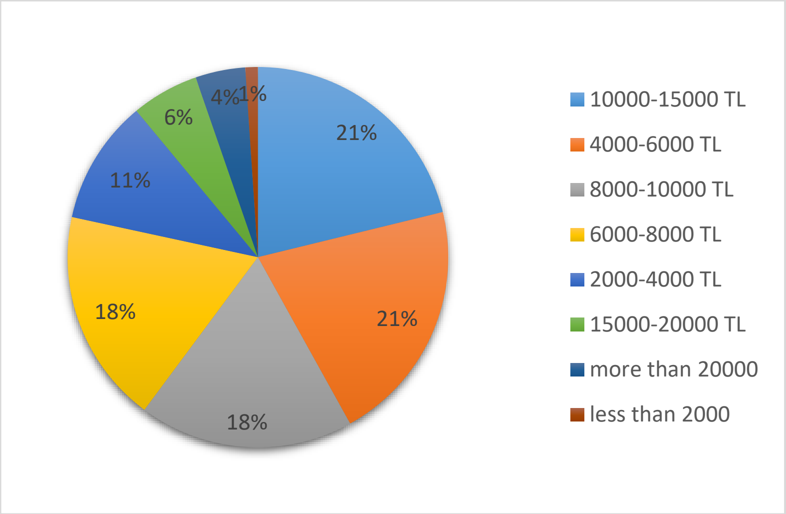


Figure 5.9. Participants' Income Groups

- Because it is thought to have an impact on fuel consumption, the distance between the house and the workplace / school is asked the participants. The percentage of participants who stated that the distance between the house and the workplace / school is 1-5 km is approximately 25%. The percentage of participants indicating that the distance between 5-10 km is 24% and between 10-20 km is approximately 23%. Total rate of the participants were calculated to be 27% for the remaining 0-1 km, 20-30 km and 30 km above.

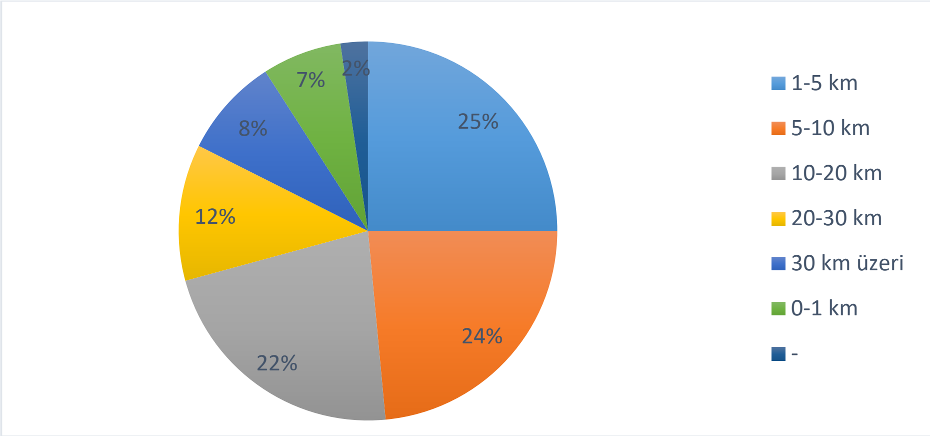


Figure 5.10. Participants' Home and Work/School Distance

- In addition, the distance between the houses and the nearest public transportation vehicle within the walking distance is 100-500 meters with a ratio of 42%, the distance between 0-100 meters with a ratio of 38%, the distance between 500-1000 meters with a rate of 14.5% and it is stated that there is a distance of more than 1000 meters with a ratio of 6%.

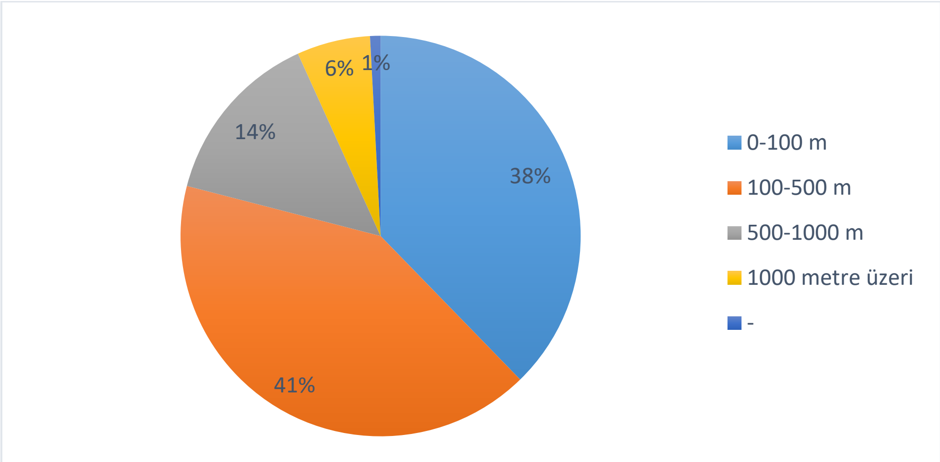


Figure 5.11. Participants Homes' Distance to Nearest Public Transportation Vehicle

- The question in the survey that asked the reasons for preferring public transportation is stated by participants as shown. The option for "Environmental concerns" have the lowest reason rate.

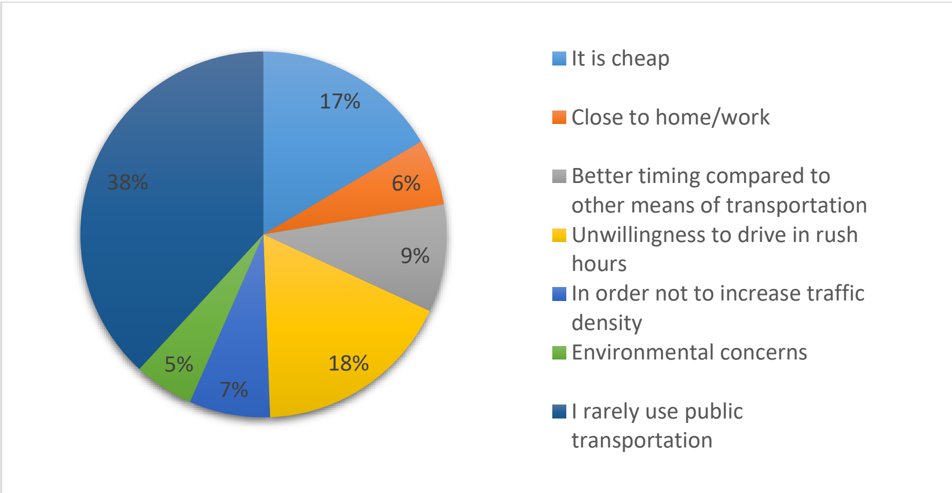


Figure 5.12. Reasons for preferring public transportation

On the other hand, when the fuel types of the vehicles of the participants are compared with the TURKSTAT data, it is seen that preference is made at a similar rate.

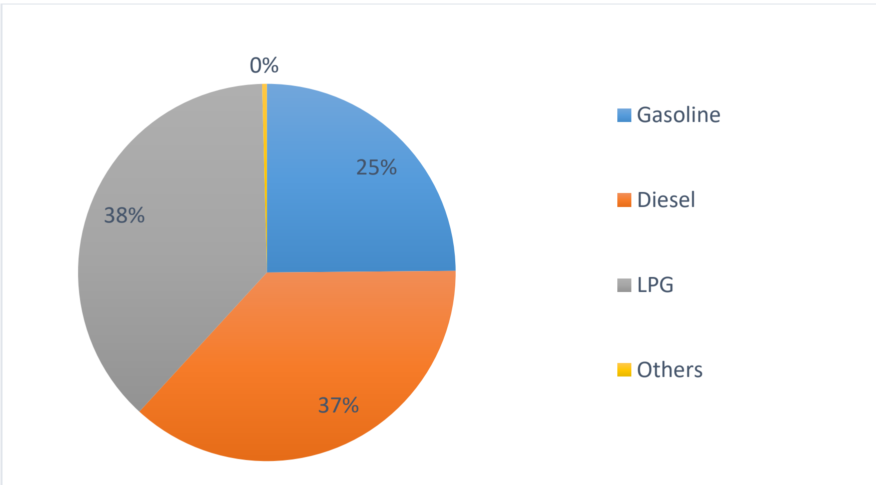


Figure 5.13. Distribution of cars registered to the traffic according to fuel type, 2019

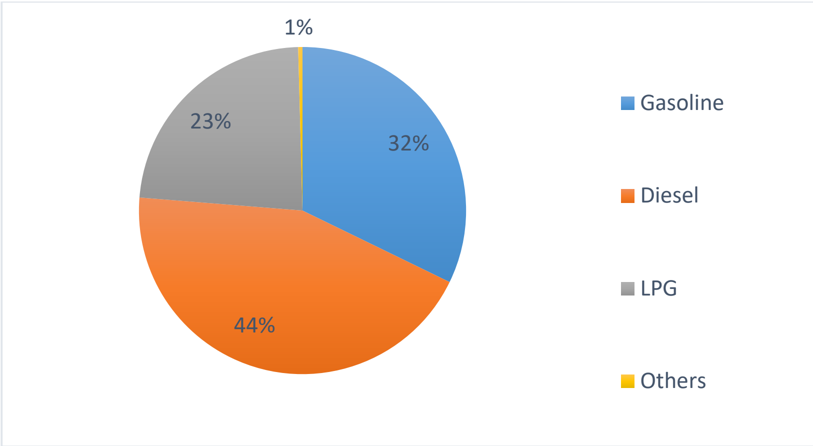


Figure 5.14. Distribution of cars data obtained by Survey according to fuel type.

In addition, when the car brands of the vehicles of the participants are compared with the TURKSTAT data, it is seen that the first six brands are the same in Turkey statistics and the Survey. It shows that participants' responses are consistent with Turkey statistics.

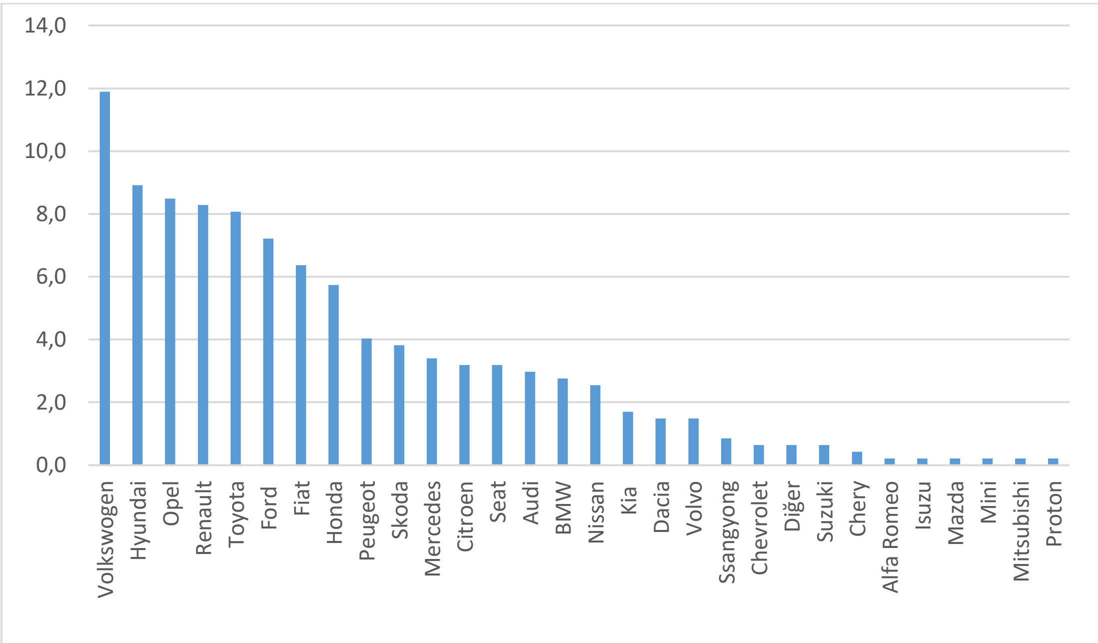


Figure 5.15. Car brands according to data obtained by Survey.

5.2. Analysis and Results

The data collected is utilized in three groups of analysis:

- The behavioral inferences and descriptive statistics from the whole sample
- Before-after analysis to estimate the direct energy rebound effect from the sub-sample in which the data for the previous car ownership is also available
- Price elasticity of fuel demand from the whole sample

First, reliability analysis which measures consistency of the questionnaire responses is applied. Only the consistency of the answers of the questions containing ordinal scale answers is analyzed. The reliability analysis is not performed for the questionnaire with gender, income or yes / no answers. However, with the 5-point Likert scale responses such as I strongly disagree (1) and strongly agree (5) can be subjected to reliability analysis. The main analysis used for reliability analysis is to find the Cronbach Alpha (α) value. Each item can have a single α value, or all questions can have an average α value. The α value obtained for all questions indicates the total reliability of that questionnaire and is expected to be greater than 0.7, lower α values indicate a poor reliability of the questionnaire, and $\alpha > 0.8$ indicates a high reliability of the questionnaire (Salihova & Memmedova, 2017).

Survey items between 46 and 136 include stated preferences about VKTs concerning changes in fuel prices. In this concept, these responses are analyzed by using Cronbach Alpha analysis for the reliability analysis via SPSS. Firstly, the Cronbach Alpha coefficient has been calculated for every fuel price change of each fuel type according to all participants' responses. Secondly, the average amount of separate coefficients has been calculated as 0,82 which indicates a high reliability of the questionnaire.

Since some of the questions in the survey need the respondents have conscious knowledge on the technical and economic features about their cars as well as the VKTs they make, the survey was designed in a way that the answers of the respondents can be crosschecked. For this purpose, the following checks are performed:

i) Whether the declared expenditures on private car use are consistent with the calculated expenditures based on VKTs, fuel prices and fuel efficiency of the cars.
ii) Their declarations whether there had been a significant factor (job change/address change/changes in children's school, change in income etc.) affecting their car use after they changed their cars and the VKTs they make after changing their cars.

The summary of the size of the initial and final data sets are shown in Table 5.1. Note that, the samples sizes for the data used in order to estimate the price elasticity of fuel demand are calculated by multiplying the individual responses by 7 x 2 since the stated preferences are asked for 6 different price levels (plus the actual values) and for both in-city and inter-city VKTs.

Table 5.1. Sample sizes for each type of analysis

Purpose	Data	Sample Size
Data for descriptive & behavioral statistics	Initial Data	472
	Data after consistency check (i)	316
Data for price elasticity of fuel demand	Initial Data	472 * 7 * 2 = 6608
	Data after consistency check (i)	316 * 7 * 2 = 4424
	Data excluding outliers and missing values	4028
Data used in rebound effect (before-after analysis)	Initial Data	150
	Data after consistency check (i)	106
	Data after consistency check (ii)	93
	Data excluding outliers	87

5.2.1. Quasi-experimental analysis (before-after analysis) to estimate the direct energy rebound effect

In this section, the analyses are performed based on the respondents for whom we have data for both their current and previous cars. The survey was designed in a way that the questions related to previous cars are asked only if the respondent sold her previous car after 2015. The sample size corresponding to before-after analysis is 87. An important point to note here is that the "before" and "after" assignments are not based on whether the cars are the older ones or the actual ones. Since the research question is to assess the rebound effect (if exists) when the fuel efficiency changes, the cars are labeled as "before" and "after" based on their efficiencies. In other words, for some of the users, new cars are more efficient compared to the previous ones then these cars are labeled as "after", while new cars are labeled as "before" if their efficiency levels are worse than the previous ones.

Since before and after values belong to the same user and the final sample satisfies the assumption that the only factor that affects the VKTs is the change in fuel efficiency, paired tests are employed to examine whether there exist statistically significant differences between the before and after values of the following variables:

- Annual energy equivalent of fuel consumptions
- Unit cost of fuel
- Annual VKTs

First, paired t-tests are performed for each of the indicators. Table 5.2, Table 5.3 and Table 5.4 summarize these tests for annual energy consumption (MJ/year), unit fuel cost (TL/km) and VKTs (km/year), respectively. The test criteria is taken as "P(T<=t) one-tail" since our null hypotheses state that efficient cars have better indicators based on expectations. The results for the former two variables imply that there are significant differences between before and after values while the same argument is not valid for annual VKTs. However, we do not have enough evidence to reject null hypothesis if the statistical significance is taken as 0.10 instead of 0.05. Moreover, the variances are not close according to results of the before-after analysis for the energy consumption and average fuel price.

Table 5.2. t-Test: Paired Two Sample for Means - before and after annual energy consumption (MJ).

	After	*Before*
Mean	2868.708764	3247.626006
Variance	2669609.896	4054187.981
Observations	87	87
Pearson Correlation	0.862871296	
Hypothesized Mean Difference	0	
df	86	
t Stat	-3.455110883	
P(T<=t) one-tail	0.000428247	
t Critical one-tail	1.662765449	
P(T<=t) two-tail	0.000856495	
t Critical two-tail	1.987934206	

Table 5.3. t-Test: Paired Two Sample for Means - before and after average fuel price (TL/km).

	After	*Before*
Mean	0.313783764	0.425114943
Variance	0.010287397	0.017251164
Observations	87	87
Pearson Correlation	0.716233177	
Hypothesized Mean Difference	0	
df	86	
t Stat	-11.29288538	
P(T<=t) one-tail	5.72558E-19	
t Critical one-tail	1.662765449	
P(T<=t) two-tail	1.14512E-18	
t Critical two-tail	1.987934206	

Table 5.4. t-Test: Paired Two Sample for Means - before and after annual VKTs (km/year)

	After	*Before*
Mean	16636.78161	16102.96552
Variance	63060026.73	66545439.52
Observations	87	87
Pearson Correlation	0.897327455	
Hypothesized Mean Difference	0	
df	86	
t Stat	1.362784457	
P(T<=t) one-tail	0.088254166	
t Critical one-tail	1.662765449	
P(T<=t) two-tail	0.176508331	
t Critical two-tail	1.987934206	

An uncertain fact about performing paired-t tests was the normality assumption for the differences between before and after values. The analysis showed that these differences do not strictly satisfy normality assumption. Then, the Wilcoxon signed-rank tests which are nonparametric equivalent of paired-t tests are employed. Table 5.5, Table 5.6 and Table 5.7 summarize the Wilcoxon signed-rank tests for annual energy consumption (MJ/year), unit fuel cost (TL/km) and VKTs (km/year), respectively. The test criteria is again taken as "P(T<=t) one-tail" since our null hypotheses state that efficient cars have better indicators based on expectations. The results are exactly consistent with the paired t-test results.

Table 5.5. The Wilcoxon signed-rank tests for paired means - before and after annual energy consumption (MJ).

		N	Mean Rank	Sum of Ranks
Before - After	Negative Ranks	34[a]	31.94	1086
	Positive Ranks	51[b]	50.37	2569
	Ties	2[c]		
	Total	87		

a. Before < After

b. Before > After

c. Before = After

Test Statistics[a]	
	Before - After
Z	-3.249[b]
Asymp. Sig. (2-tailed)	0.001

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Table 5.6. The Wilcoxon signed-rank tests for paired means - before and after energy average fuel price (TL/km).

		N	Mean Rank	Sum of Ranks
Before - After	Negative Ranks	0[a]	0	0
	Positive Ranks	85[b]	43	3655
	Ties	2[c]		
	Total	87		

a. Before < After

b. Before > After

c. Before = After

Test Statistics[a]	
	Before - After
Z	-8.008[b]
Asymp. Sig. (2-tailed)	0.000

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Table 5.7. The Wilcoxon signed-rank tests for paired means - before and after annual VKTs (km/year)

		N	Mean Rank	Sum of Ranks
Before - After	Negative Ranks	33[a]	27.64	912
	Positive Ranks	21[b]	27.29	573
	Ties	33[c]		
	Total	87		

a. Before < After

b. Before > After

c. Before = After

Test Statistics[a]	
	Before - After
Z	-1.460[b]
Asymp. Sig. (2-tailed)	0.144
Asymp. Sig. (1-tailed)	0.072

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

In this study, as regards of estimation of rebound effect amount, not only different types of fuel but also in-city and inter-city VKTs are taken into consideration separately. Since different fuel types do not contain the same energy content, these fuel types are taken into consideration by converting them into mega-joules with coefficients[1] based on their energy contents. Energy cost and energy intensities were calculated as two separate criteria for evaluating the energy efficiency of the same participant's current and the previous vehicle. In the calculation of energy efficiency according to cost criterion, the vehicle with low unit cost was considered as efficient vehicle. In the intensity calculation of energy efficiency, the vehicle that uses less fuel for unit km is considered as energy efficient vehicle.

[1] http://w.astro.berkeley.edu/~wright/fuel_energy.html; https://afdc.energy.gov/fuels/fuel_comparison_chart.pdf

Calculation for rebound effect as regards of cost and energy content criteria for in and inter-city are calculated based on the equation below, which is derived from the one introduced in Section 3.2.2.2:

$$RE = \frac{\sum(E_2 - E_1)}{\sum(E_0 - E_1)} \times 100\% \qquad \textit{Eqn. 5.1}$$

Then, the procedure -which is performed for in-city, inter-city and total VKTs- is as follows:

1. Energy efficient vehicles are identified in terms of cost criteria.
2. Efficient and inefficient vehicles' total energy demand are calculated for each participant, E_2 and E_0, respectively.
3. The energy demand of the efficient car is calculated as if it makes the same VKT of the inefficient vehicle, E_1
4. Potential (expected) savings are calculated, $E_1 - E_0$.
5. Rebound effect is calculated using Eqn. 5.1.

The rebound effects calculated according to the procedure presented above are summarized in the Table 5.8. These values are in line with those reported in the literature as well as a recent study for Turkey (Kutucu, 2018).

Table 5.8. Rebound Effect Calculation Results

Criteria	In-City (%)	Inter-City (%)	Overall (%)
Unit Energy Cost	10.08	25.40	19.47
Energy Intensity	16.77	31.51	15.82

On the other hand, rebound estimations with one survey data is shown as an example at below.

2. a) Determination of the new or old cars' efficiencies according to cost criteria: the vehicle with low unit cost was considered as efficient vehicle.

$$unit\ cost = fuel\ price * \frac{\text{incity}\left(\frac{\text{lt}}{\text{100km}}\right) + \text{intercity}\left(\frac{\text{lt}}{\text{100km}}\right)}{2} * 100$$

Unit cost of a new car is calculated at below:

Unit cost=3,9∗([3,75+3,25]/2)/100=0,14 (TL/km)

Unit cost of old car is calculated by same way as 0.15 (TL/km)

b) Determination of new or old cars' efficiencies according to energy intensity criteria: the vehicle with low intensity was considered as efficient vehicle.

$$energy\ intensity = energy\ coefficient * [incity\left(\frac{lt}{100km}\right) * \frac{incity(km)}{incity(km) + \frac{intercity(km)}{12}} + intercity\left(\frac{lt}{100km}\right) * \frac{\frac{intercity(km)}{12}}{incity(km) + \frac{intercity(km)}{12}}]$$

Energy intensity of new car is calculated at below:

Energy intensity=

25,7∗[3,75∗500/(500+10.000/12)+3,25∗(10.000/12)/(500+10.000/12)]

/100=0,88 (MJ/km)

Energy intensity of old car is calculated by same way as 1.05 (MJ/km).

3. Calculate Total Energy Consumption of new and old car seperately.

$$Total\ energy = energy\ coefficient * \frac{\left[incity\left(\frac{lt}{100km}\right) * incity\ (km) + intercity\left(\frac{lt}{100km}\right) * \frac{intercity(km)}{12}\right]}{100}$$

Total energy=25,7∗(3,75∗500+3,25∗10.000/12)/100=1.177,91 lt

Total energy consumption of old car is calculated by same way as 1.352,46 lt

If there was no behavioral change total energy consumption would be:

$$Total\ energy = energy\ coefficient * \frac{\left[incity\left(\frac{lt}{100km}\right)*old\ incity\ (km)+intercity\left(\frac{lt}{100km}\right)*\frac{old\ intercity(km)}{12}\right]}{100}$$

Total energy=25,7∗(3,75∗450+3,25∗10.000/12)/100=1.129,73 lt

4. a) Calculation of the Rebound Effect according to cost criteria.

$$Potential\ Saving = Fuel\ use\ with\ inefficient\ car - Fuel\ use\ if\ there\ were\ no\ behavioral\ change$$

$$Rebound\ Effect = 100 * \frac{Potential\ Saving}{Fuel\ use\ with\ inefficient\ car - Fuel\ use\ if\ there\ were\ no\ behavioral\ change}$$

Fuel use with Efficient car (Lt)	Fuel use with Inefficient car (Lt)	Fuel use if there were no behavioral change (Lt)	Potential Saving (Lt)	Rebound Effect (%)
1177.91	1352.46	1129.73	222.73	21.6

b) Calculation of the Rebound Effect according to energy criteria.

$$Potential\ Saving = Fuel\ use\ with\ inefficient\ car - Fuel\ use\ if\ there\ were\ no\ behavioral\ change$$

$$Rebound\ Effect = 100 * \frac{Potential\ Saving}{Fuel\ use\ with\ inefficient\ car - Fuel\ use\ if\ there\ were\ no\ behavioral\ change}$$

Fuel use with Efficient car (Lt)	Fuel use with Inefficient car (Lt)	Fuel use if there were no behavioral change (Lt)	Potential Saving (Lt)	Rebound Effect (%)
891.47	1391.21	840.6	550.6	9.2

Rebound effect could also be estimated as an energy efficiency elasticity in the literature (Sorrell & Dimitropoulos, 2008). As an efficiency elasticity rebound effect can be obtained by the equation $\eta_\varepsilon(E) = \eta_\varepsilon(S) - 1$ as explained in Section 3.2.2.1.

In this equation, $\eta_\varepsilon(S)$ is the efficiency elasticity of the demand for useful work and $\eta_\varepsilon(E)$ is the efficiency elasticity of the demand for energy. $\eta_\varepsilon(S)$ can be used as a proxy for rebound effect. Our calculations of $\eta_\varepsilon(S)$ and $\eta_\varepsilon(E)$ values show that the results are consistent with the theory and the rebound effects summarized in Table 5.4. Note that, the relationship $\eta_\varepsilon(E) = \eta_\varepsilon(S) - 1$ is exact only for the continuous functions. Then, mid-point elasticities –which gives the best approximation to the constinuous case- are calculated for all of the before-after analysis in this study study since our data consists discrete changes in the indicators.

5.2.2. Price Elasticity Estimation

In order to estimate the price elasticity of fuel demand, the below approach is employed:

- Percentage changes in average VKTs are divided by percentage changes in prices. Then, simple least-square power curves are estimated based on price-quantity pairs for each price level. The power of price in the least-squares formula gives the price elasticity of fuel demand.

In the survey, the regression model was established to evaluate the answers received within the scope of the questions asked to show how the amount of usage in and inter-city can change if the current fuel prices change. The model showed that the R square value is very close to 1 and price elasticity of gasoline is -0.25; -0.22 for diesel and -0.28 for LPG. The analysis was performed with the sum of the answers given by all users at each price level. For example, if the price for gasoline is 4, it is stated that a total distance of 70.370 km will be more traveled by all users. Current fuel prices and usage levels have been accepted as reference values so users' responses to hypothetical situations have been normalized in this context. These graphs are as follows:

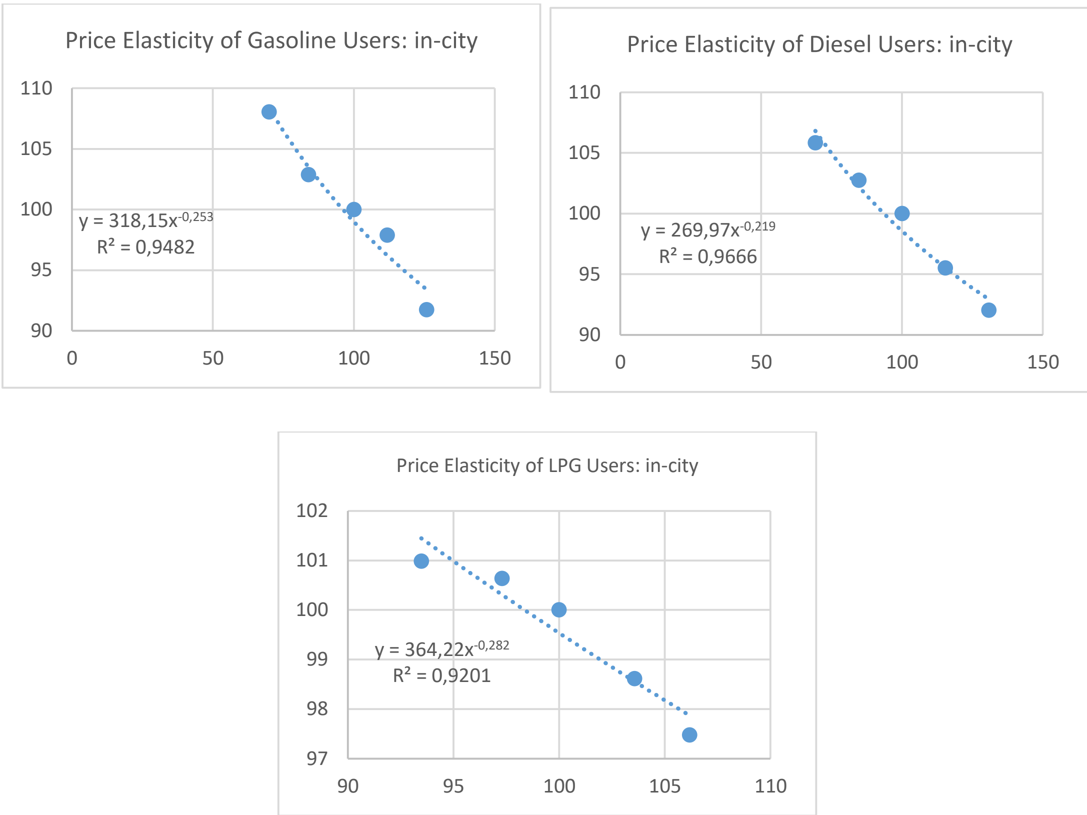


Figure 5.16. Price elasticity of fuel (gasoline, diesel, LPG) demand: in-city

On the other hand, the tables which are obtained by the model established to show the fuel prices effects on intercity road consumption are shown below. As can be seen from the tables, the price elasticity for gasoline is -0.30; It was calculated as -0.22 for diesel and -0.19 for LPG.

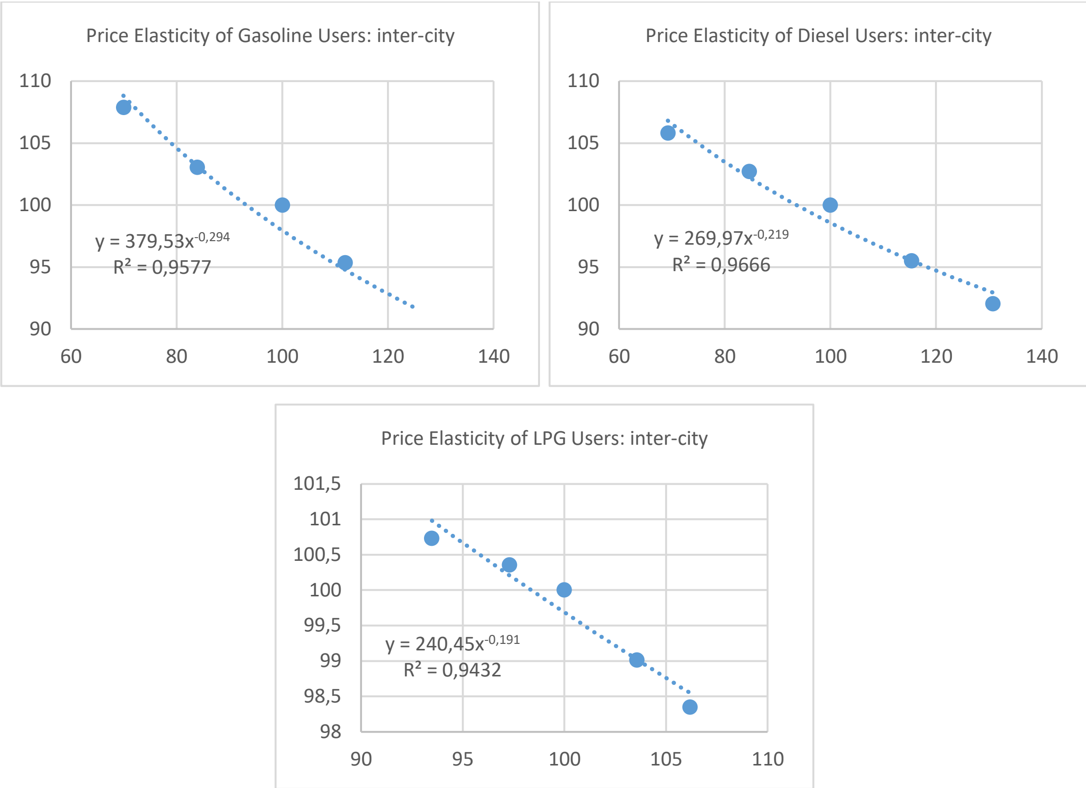


Figure 5.17. Price elasticity of fuel (gasoline, diesel, LPG) demand: inter-city

The effect of fuel prices on fuel use will be examined with a more comprehensive regression model for the future study. The data collected within this study, in fact, make it possible to conduct more comprehensive econometric analysis such as Yılmaz (2019) in which she investigated the rebound effect in residential heating using OLS and 2SLS models (Yılmaz, 2019). Preliminary analysis of the data, e.g., normality test for independent variables, support the feasibility of such a study. Then, this kind of an analysis is proposed as an extension and future work of current study.

CHAPTER 6

CONCLUSION

6.1. Main Findings

As Turkey is greatly dependent on energy imports it is very important to forecast demand of fuel consumption. In this context, the Rebound effect, which may affect the determination of energy demand forecasting, needs to be well understood. In addition, examining how fuel consumption responds to price and revenue changes can provide important insights and conclusions for forecasting macroeconomic indicators. In this study, price elasticity of fuel demand was determined at micro level by estimated responses to possible price changes.

As regards of estimation of rebound effect, not only different types of fuel but also in-city and intercity VKTs are taken into consideration separately. Since different fuel types do not contain the same energy content, these fuel types are taken into consideration by converting them into joule values with certain coefficients which differs this study from the other studies in Turkey.

In this study, the direct rebound effect ratio was calculated by using the before and after calculation of the VKTs performed by the same survey participants having current and previous fuel consumption knowledge. These calculations differ according to the unit energy cost and energy intensity criteria. According to the unit cost criteria, the rebound effect ratio was found to be 10.08% for in-city roads and 25.40% for intercity VKTs. According to the energy intensity criterion, the rebound effect rate in-city roads was found to be 16.77% and 31.51% for intercity VKTs. The reason for the higher rebound effect for intercity VKTs may stem from the energy efficiency of the vehicles in the long distance is more effective. On the other hand, it was reasonable to have a lower rebound effect due to the fact that for in city VKTs are more obligatory, i.e. less flexible.

As a result of the study of seventeen econometric studies on personal car transportation, Sorrell & Dimitropoulos (2007) concluded that the long-term direct rebound effect rate could be between 10 and 30 percent. It is seen that the obtained results from this study are in this range. Besides, the results are close to the estimates obtained from the meta-analysis of a comprehensive set of studies (Dimitropoulos et al., 2018). On the other hand, these values are in line with a recent study for Turkey which finds the size of direct rebound effect is %12 (Kutucu, 2018).

According to the results of the survey which is carried out at micro level, it is seen that energy efficient vehicles may lead to the direct rebound effect.

In the rebound literature (e.g., Sorrell & Dimitropoulos, 2008), rebound effect could be estimated as an energy efficiency elasticity. When the collected data from the survey are placed into elasticity formulas, it is seen that the equations provide very close the rebound effect values which are found from before and after calculations.

In the rebound effect literature it is stated that price elasticity may determines upper bound of a rebound effect. Hence, another contribution of the study is to estimate the price elasticity of fuel demand based on the stated preferences which will be the first time in the literature for Turkey at micro level. A regression model, established as the first approach, was developed to find price elasticity of fuel demand. The model showed price elasticity of gasoline is -0.25; -0.22 for diesel and -0.28 for LPG in regards of VKTs in cities. Also the fuel prices effects on intercity VKTs are -0.29 for gasoline, -0.22 for diesel and -0.19 for LPG.

Similar to this study, the rebound effect was estimated from consumers' reactions to changes in energy efficiency in the study conducted in Switzerland for personal automotive car users in 2015. Contrary to the general of the rebound literature, it was not assumed that the rebound effect is calculated by price elasticity of fuel demand (Weber & Farsi, 2018). Such an assumption is a clear lack of a balance between price elasticity and the rebound effect as long as energy efficiency is constant (Sorrell & Dimitropoulos, 2008). In the study of Sorrell et. al. (2009) it is stated that rational consumers must respond to the decline in energy prices, as well as to an improvement in energy efficiency (and vice versa), since it should have a similar effect on energy costs of energy services. However, this is a serious warning that most of the literature is based on. In fact, there is evidence that consumers' responses depend on the source of cost change (Herring & Sorrell, 2009). For example, Li et al. (2012) state that consumers are responding more strongly to gasoline tax changes than to equal amount of changes in tax-inclusive, and Baranzini and Weber (2013) find that oil shocks and gasoline tax increases are even more effective. Another reason for behaving price and productivity changes differently is emphasized by Linn (2013), as price changes are temporary, while productivity improvements are not possible to be reversed at one time (Weber & Farsi, 2018).

As noted in the previous section, an immediate extension of this study will be a comprehensive econometric model in which the detailed information about participant (e.g., age, income level, marital status, household size, education level, etc.) can be further utilized.

6.2. Contributions

First of all, as far as we know, this study is the first attempt in which the household-level data is utilized to analyze the rebound effect in a quasi-experimental framework for a developing country. Moreover, different fuel types, i.e., gasoline, diesel and LPG, and distinct travel modes, i.e., in-city and inter-city, are taken into account in a single framework. Another important contribution is that the study distinguishes the cost criteria and energy intensity criteria in analyzing the rebound effect and opens this difference into discussion. Besides, with the larger sample of households for better representation of the whole country, this study analyzed the price elasticity of fuel consumption for households' level in Turkey at the first time.

6.3. Further Studies

The data collected within this study make it possible to conduct more comprehensive econometric analysis such as Yılmaz's study in which she investigated the rebound effect in residential heating using OLS and 2SLS models (Yılmaz, 2019). Preliminary analysis of the data, e.g., normality test for independent variables, support the feasibility of such a study. Then, this kind of an analysis is proposed as an extension and future work of current study.

As noted in the previous section, an immediate extension of this study will be a comprehensive econometric model in which the detailed information about participant (e.g., age, income level, marital status, household size, education level, etc.) can be further utilized.

6.4. Policy Issues

Because Turkey is highly dependent on energy imports, rebound effect subject should be considered while energy demand forecasts. Also the issue of learning and awareness should be the focus of designing effective policy. Moreover, the price elasticity estimations for different fuel types based on households' stated preferences would play a significant role in predicting the outcomes of possible fuel pricing policies.

REFERENCES

Akıncı, M., Sevinç, H., & Yılmaz, Ö. (2018). Jevons Paradox:An Econometric Analysis on Energy Efficiency and Rebound Effect. *Fiscaoeconomia*, *2*(1), 23–24. https://doi.org/10.25295/fsecon.2018.01.004

Allan, G., Gilmartin, M., Turner, K., McGregor, P., & Swales, K. (2007). *UKERC Review of Evidence for the Rebound Effect - Technical Report 4: Computable general equilibrium modelling studies*.

Berkhout, P. H. G., Muskens, J. C., & Velthuijsen, J. W. (2000). Defining the rebound effect. *Energy*, *28*.

Binswanger, M. (2001). Technological progress and sustainable development: what about the rebound effect? *Ecological Economics*, *36*(1), 119–132. Retrieved from https://www.sciencedirect.com/science/article/pii/S0921800900002147

Böhringer, C., & Rivers, N. (2018). *The energy efficiency rebound effect in general equilibrium*. Retrieved from https://ssrn.com/abstract=3235208

Brännlund, R., Ghalwash, T., & Nordström, J. (2007). Increased energy efficiency and the rebound effect: Effects on consumption and emissions. *Energy Economics*, *29*(1), 1–17. https://doi.org/10.1016/J.ENECO.2005.09.003

Brookes, L. (1979). A Low Energy Strategy for the UK. *Atom*, (269), 3–8.

Coyne, B., Lyons, S., & McCoy, D. (2018). The effects of home energy efficiency upgrades on social housing tenants: evidence from Ireland. *Energy Efficiency*, *11*(8), 2077–2100. https://doi.org/10.1007/s12053-018-9688-7

Deaton, A., & Muellbauer, J. (1980). An Almost Ideal Demand System. *The American Economic Review*, *70*(3), 312–326.

Deniz, Z. (2006). *An analysis of oil demand in Turkey* (Bilgi University). Retrieved from http://openaccess.bilgi.edu.tr:8080/xmlui/handle/11411/308

Dimitropoulos, A., Oueslati, W., & Sintek, C. (2018). The rebound effect in road transport: A meta-analysis of empirical studies. *Energy Economics*. https://doi.org/10.1016/j.eneco.2018.07.021

Du, K., & Lin, B. (2015). Comments on "Using latent variable approach to estimate China's economy-wide energy rebound effect over 1954-2010" by Shuai Shao, Tao Huang and Lili Yang. *Energy Policy*, *86*, 219–221. https://doi.org/10.1016/J.ENPOL.2015.07.006

Erdogdu, E. (2014). Motor fuel prices in Turkey. *Energy Policy*, *69*, 143–153. https://doi.org/10.1016/J.ENPOL.2013.10.075

Ficano, C. C., & Thompson, P. (2014). Estimating Rebound Effects in Personal Automotive Transport: Gas Price and The Presence Of Hybrids. *The American Economist*, *59*(2), 167–175.

Ficano, C. C., & Thompson, P. (2018). Estimating Rebound Effects in Personal Automotive Transport: Gas Price and The Presence Of Hybrids. *The American Economist*, *59*(2), 167–175.

Frondel, M, Ritter, N., & Vance, C. (2010). Heterogeneity in the rebound effect: Further evidence for Germany. In *Ruhr Economic Papers*.

Frondel, Manuel, Ritter, N., & Vance, C. (2012). Heterogeneity in the rebound effect: Further evidence for Germany. *Energy Economics*, *34*(2), 461–467. https://doi.org/10.1016/J.ENECO.2011.10.016

Gerçek, H. (2009). Türkiye'de Kentlerarası Karayolu Trafiğinin Ekonomik Gelişme ve Akaryakıt Fiyatına Göre Esneklikleri. *8. Ulaştırma Kongresii*, s.255-270.

Greene David L. (1992). Vehicle Use and Fuel Economy: How Big is the "Rebound" Effect? *The Energy Journal*, *3*(1), 117–143.

Greening, L. A., Greene, D. L., & Difiglio, C. (2000a). Energy efficiency and consumption - the rebound effect - a survey. *Energy Policy*, *28*(6–7), 389–401.

Greening, L. A., Greene, D. L., & Difiglio, C. (2000b). Energy efficiency and consumption - the rebound effect - a survey. *Energy Policy*, *28*(6–7), 389–401. Retrieved from https://econpapers.repec.org/article/eeeenepol/v_3a28_3ay_3a2000_3ai_3a6-7_3ap_3a389-401.htm

Guerra, A.-I., & Sancho, F. (2010). Rethinking economy-wide rebound measures: An unbiased proposal. *Energy Policy*, *38*(11), 6684–6694. https://doi.org/10.1016/J.ENPOL.2010.06.038

Hasanov, M. (2015). The demand for transport fuels in Turkey. *Energy Economics*, *51*, 125–134. Retrieved from https://www.sciencedirect.com/science/article/pii/S014098831500184X

Hens, H., Parijs, W., & Deurinck, M. (2010). Energy consumption for heating and rebound effects. *Energy and Buildings*, *42*(1), 105–110. https://doi.org/10.1016/J.ENBUILD.2009.07.017

Herring, H., & Sorrell, S. (2009). *Energy Efficiency and Sustainable Consumption* (H. Herring & S. Sorrell, Eds.). https://doi.org/10.1057/9780230583108

Hössinger, R., Link, C., Sonntag, A., & Stark, J. (2017). Estimating the price elasticity of fuel demand with stated preferences derived from a situational approach. *Transportation Research Part A: Policy and Practice*, *103*, 154–171. https://doi.org/10.1016/j.tra.2017.06.001

Hymel, K. M., & Small, K. A. (2015). The rebound effect for automobile travel: Asymmetric response to price changes and novel features of the 2000s. *Energy Economics*, *49*, 93–103. https://doi.org/10.1016/j.eneco.2014.12.016

IEA. (2016). *Energy Policies of IEA Countries: Turkey*. Retrieved from https://www.iea.org/publications/freepublications/publication/EnergyPoliciesofIEACountriesTurkey.pdf

IEA. (2018). *Energy Efficiency 2018: Analysis and outlooks to 2040*. Retrieved from http://indiasmartgrid.org/reports/IEA - Energy Efficiency 2018 Report.pdf

Jevons, W. (1865). 'The Coal Question: Can Britain Survive? In A. Flux (Ed.), *The Coal Question: An Inquiry Concerning the Progress of the Nation, and the Probable Exhaustion of Our Coal-mines*. New York: Augustus M. Kelley.

Khazzoom, J. D. (1980). Economic Implications of Mandated Efficiency in Standards for Household Appliances. *Source: The Energy Journal*, *1*(4), 21–40. https://doi.org/10.5547/ISSN0195-6574-EJ-Vol3-No1-8

Kılıçarslan, Z., & Dumrul, Y. (2019). Enerji Rebound Etkisinin Panel Veri Yöntemi ile Analizi. *Int. Journal of Management Economics and Business*, *15*(1), 1–13.

Kutucu, M. (2018). *Enerji Verimli Araç Kullanımının Geri Sekme Etkisinin (Rebound Effect) Gelir Gruplarına Göre Karşılaştırılması*. Hacettepe Üniversitesi.

Li, K., & Jiang, Z. (2016). The impacts of removing energy subsidies on economy-wide rebound effects in China: An input-output analysis. *Energy Policy*, *98*, 62–72. https://doi.org/10.1016/J.ENPOL.2016.08.015

Lin, B., & Liu, X. (2013). Reform of refined oil product pricing mechanism and energy rebound effect for passenger transportation in China. *Energy Policy*, *57*(2013), 329–337. https://doi.org/10.1016/j.enpol.2013.02.002

MENR. (2018). *Annual Report 2018*.

MENR. (2019). T.C. Enerji ve Tabii Kaynaklar Bakanlığı - Enerji Verimliliği. Retrieved July 17, 2019, from https://www.enerji.gov.tr/tr-TR/Sayfalar/Enerji-Verimliligi

Meyer, B., Distelkamp, M., & Wolter, M. (2007). Material efficiency and economic-environmental sustainability. Results of simulations for Germany with the model PANTA RHEI. *Ecological Economics*, *63*(1), 192–200. https://doi.org/10.1016/J.ECOLECON.2006.10.017

Mizobuchi, K. (2008). An empirical study on the rebound effect considering capital costs. *Energy Economics*, *30*(5), 2486–2516. https://doi.org/10.1016/J.ENECO.2008.01.001

Mock, P. (2016). *The Automotive Sector in Turkey-A Baseline Analysis of Vehicle Fleet Structure,Fuel Consumption and Emissions*.

Munyon, V. V., Bowen, W. M., & Holcombe, J. (2018). Vehicle fuel economy and vehicle miles traveled: An empirical investigation of Jevon's Paradox. *Energy Research & Social Science*, *38*, 19–27. https://doi.org/10.1016/J.ERSS.2018.01.007

Murray, C. (2009). New insights into rebound effects: Theory and empirical evidence. Retrieved from http://eprints.qut.edu.au/27655/1/Cameron_Murray_Thesis.pdf

Nässén, J., & Holmberg, J. (2009). Quantifying the rebound effects of energy efficiency improvements and energy conserving behaviour in Sweden. *Energy Efficiency*, *2*(3), 221–231. https://doi.org/10.1007/s12053-009-9046-x

NHTSA. (2019). Corporate Average Fuel Economy (CAFE) Standards. Retrieved July 17, 2019, from https://www.transportation.gov/mission/sustainability/corporate-average-fuel-economy-cafe-standards

Pfaff, M., & Sartorius, C. (2015). Economy-wide rebound effects for non-energetic raw materials. *Ecological Economics*, *118*, 132–139. https://doi.org/10.1016/J.ECOLECON.2015.07.016

Roy, J. (2000). The rebound effect: some empirical evidence from India. *Energy Policy*, *28*(6–7), 433–438. https://doi.org/10.1016/S0301-4215(00)00027-6

Salihova, S., & Memmedova, V. (2017). Öğrencilerin İstatistik Dersine Yönelik Tutumları: Geçerlilik ve Güvenirlik Çalışması. *Akademik Bakış Dergisi*, *59*, 116–127.

Saunders, H. (1992). The Khazzoom-Brookes Postulate and Neoclassical Growth. *The Energy Journal*, *Volume 13*(Number 4), 131–148. Retrieved from https://econpapers.repec.org/article/aenjournl/1992v13-04-a07.htm

Saunders, H. (2000a). A view from the macro side: rebound, backfire, and Khazzoom–Brookes. *Energy Policy*, *28*, 439–449. Retrieved from https://www.sciencedirect.com/science/article/pii/S0301421500000240

Saunders, H. (2000b). Does predicted rebound depend on distinguishing between energy and energy services? *Energy Policy*, *38*, 497–500. Retrieved from https://www.osti.gov/etdeweb/biblio/20149056

Semboja, H. H. H. (1994). The effects of an increase in energy efficiency on the Kenya economy. *Energy Policy*, *22*(3), 217–225. https://doi.org/10.1016/0301-4215(94)90160-0

Shao, S., Huang, T., & Yang, L. (2014). Using latent variable approach to estimate China′s economy-wide energy rebound effect over 1954–2010. *Energy Policy*, *72*, 235–248. https://doi.org/10.1016/J.ENPOL.2014.04.041

Small, K. A., Dender, K. Van, & Van Dender, K. (2001). Fuel Efficiency and Motor

Vehicle Travel : The Declining Rebound Effect. *Energy*, *28*(1), 25–52. https://doi.org/10.5547/ISSN0195-6574-EJ-Vol28-No1-2

Small, K. A., & Van Dender, K. (2007). Fuel Efficiency and Motor Vehicle Travel : The Declining Rebound Effect. *The Energy Journal*, *28*(1), 25–52. https://doi.org/10.5547/ISSN0195-6574-EJ-Vol28-No1-2

Somuncu, T. (2016). *Can energy efficiency save energy? An economy-wide rebound effect simulation for Turkey*. Istanbul Technical University.

Somuncu, T., & Hannum, C. (2016). Can energy efficiency save energy? An economy-wide rebound effect simulation for Turkey. *Enerday 2016*. Retrieved from https://tu-dresden.de/bu/wirtschaft/ee2/ressourcen/dateien/lehrstuhlseiten/ordner_enerday/ordner_pacp/ordner_fpap/presentations_2016/Somuncu.pdf?lang=en

Somuncu, T., & Hannum, C. (2018). The Rebound Effect of Energy Efficiency Policy in the Presence of Energy Theft. *Energies*, *11*(12), 3379. https://doi.org/10.3390/en11123379

Sorrell, S. (2007). *The Rebound Effect: an assessment of the evidence for economy-wide energy savings from improved energy efficiency*. Retrieved from https://pdfs.semanticscholar.org/8e52/60a35163402b6ada126baddc023966252618.pdf

Sorrell, S., & Dimitropoulos, J. (2007). UKERC Review of Evidence for the Rebound Effect. In *Technical Report 2 : Econometric studies*.

Sorrell, S., & Dimitropoulos, J. (2008). The rebound effect: Microeconomic definitions, limitations and extensions. *Ecological Economics*. https://doi.org/10.1016/j.ecolecon.2007.08.013

Sorrell, S., Dimitropoulos, J., & Sommerville, M. (2009). Empirical estimates of the direct rebound effect: A review. *Energy Policy*, *37*(4), 1356–1371. https://doi.org/10.1016/j.enpol.2008.11.026

Soruşbay, C. (2009). *Ulaştırma Sektöründe Sera Gazı Azaltımı*.

Su, Q. (2012). A quantile regression analysis of the rebound effect: Evidence from the 2009 National Household Transportation Survey in the United States. *Energy Policy*, *45*, 368–377. https://doi.org/10.1016/j.enpol.2012.02.045

Sunikka-Blank, M., & Galvin, R. (2012). Introducing the prebound effect: the gap between performance and actual energy consumption. *Building Research & Information*, *40*(3), 260–273. https://doi.org/10.1080/09613218.2012.690952

Thomas, B. A., & Azevedo, I. L. (2013). Estimating direct and indirect rebound effects for U.S. households with input–output analysis Part 1: Theoretical framework. *Ecological Economics*, *86*, 199–210.

https://doi.org/10.1016/J.ECOLECON.2012.12.003

Tietge, U., Mock, P., German, J., Bandivadekar, A., & Ligterink, N. (2017). *From laboratory to road: A 2017 update of official and "real-world" fuel consumption and CO2 values for passenger cars in Europe*. Retrieved from https://theicct.org/publications/laboratory-road-2017-update

Topallı, N., & Buluş, A. (2012). The Rebound Effect : Empirical Evidence from Turkey. *Anadolu University Journal of Social Sciences*, *16*, 29–38.

Turner, K. (2013). "Rebound" effects from increased energy efficiency: A time to pause and reflect. *Energy Journal*. https://doi.org/10.5547/01956574.34.4.2

Ulucak, R., & Kocak, E. (2018). *Rebound Effect for Energy Consumption: The Case of Turkey*. 1–10. Amsterdam.

Wadud, Z., Noland, R. B., & Graham, D. J. (2010). A semiparametric model of household gasoline demand. *Energy Economics*, *32*(1), 93–101. https://doi.org/10.1016/J.ENECO.2009.06.009

Wang, H., Zhou, P., & Zhou, D. Q. (2012). An empirical study of direct rebound effect for passenger transport in urban China. *Energy Economics*, *34*(2), 452–460. https://doi.org/10.1016/J.ENECO.2011.09.010

Weber, S., & Farsi, M. (2018). *Travel distance, fuel efficiency, and vehicle weight: An estimation of the rebound effect using individual data in Switzerland*. Retrieved from ftp://sitelftp.unine.ch/RePEc/irn/pdfs/wp14-03.pdf

Wei, T., & Liu, Y. (2017). Estimation of global rebound effect caused by energy efficiency improvement. *Energy Economics*, *66*, 27–34. https://doi.org/10.1016/J.ENECO.2017.05.030

Wirl, F. (1997). *The Economics of Conservation Programs*. https://doi.org/10.1007/978-1-4615-6301-3_1

Wood, R., Moran, D., Stadler, K., Ivanova, D., Steen-Olsen, K., Tisserant, A., & Hertwich, E. (2018). Prioritizing Consumption-Based Carbon Policy Based on the Evaluation of Mitigation Potential Using Input-Output Methods. *Journal of Industrial Ecology*, *22*(3), 540–552. https://doi.org/10.1111/jiec.12702

Yalta, A., & Yalta, A. (2016). The dynamics of fuel demand and illegal fuel activity in Turkey. *Energy Economics*, *54*, 144–158. Retrieved from https://www.sciencedirect.com/science/article/pii/S0140988315003564

Yılmaz, Z. İ. (2019). *Energy Efficiency and Rebound Effects for Household Gas Consumption: Evidence from Ankara*. METU.

Yu, B., Zhang, J., & Fujiwara, A. (2013). Rebound effects caused by the improvement of vehicle energy efficiency: An analysis based on a SP-off-RP survey. *Transportation Research Part D: Transport and Environment*, *24*, 62–68.

https://doi.org/10.1016/j.trd.2013.06.001

Yu, F., & Liu, Z. (2016). Direct Energy Rebound Effect of Family Cars: An Analysis Based on a Survey in Chang-Zhu-Tan City Group. *Energy Procedia*, *104*, 197–202. https://doi.org/10.1016/j.egypro.2016.12.034

APPENDICES

A. Survey

Hanehalkı Araç Kullanımında Geri Sekme Etkisinin (Rebound Effect) Araştırılması

Bu anket, Dilan Yüksel'in ODTÜ Fen Bilimleri Enstitüsü Yer Sistem Bilimleri Programı'nda yapmakta olduğu Yüksek Lisans tezinde kullanılmak üzere hazırlanmıştır.

Anketteki sorular, otomobili olan ve bu otomobili en az 1 yıldır kullanan veya bu otomobil ile en az 10.000 km yapmış kişilere yönelik hazırlanmıştır.

Anketteki sorular, otomobil kullanıcılarının yakıt tüketimi eğilimleri belirlemeye yöneliktir. Bu nedenle, yakıt tüketim bilgilerini mümkün olduğunca takip etmeye çalışan kullanıcılar tarafından doldurulması analizlerin tutarlılığı açısından önem taşımaktadır. Anket, ortalama 7-8 dakikanızı alacaktır.

Toplanan bilgiler sadece akademik amaçlı kullanılacak olup, sorular anonim bir kişi tarafından doldurulacak şekilde hazırlanmıştır.

Sorularınız ve daha detaylı bilgi için rebound.dy.info@gmail.com adresine e-posta gönderebilirsiniz.

İlginiz ve katkınız için şimdiden teşekkür ederiz.

1. **Cinsiyetiniz**:
   - ☐ Kadın
   - ☐ Erkek
2. **Yaşınız:**
3. **Eğitim durumunuz:**
   - ☐ İlkokul
   - ☐ Ortaokul
   - ☐ Lise
   - ☐ Açık Öğretim

- ☐ Üniversite
- ☐ Yüksek Lisans
- ☐ Doktora ve Üst

4. Mesleğiniz

5. Medeni durumunuz
- ☐ Evli
- ☐ Bekar

6. Çocuğunuz var mı?
- ☐ Evli
- ☐ Bekar

7. Çocuklarınızın yaş aralıkları:
- ☐ 0-6 yaş aralığı
- ☐ 6-13 yaş aralığı
- ☐ 13-17 yaş aralığı
- ☐ 17 ve üstü yaş

8. İkamet ettiğiniz ilçe:
- ☐ Akyurt
- ☐ Altındağ
- ☐ Ayaş
- ☐ Bala
- ☐ Beypazarı
- ☐ Çamlıdere
- ☐ Çankaya
- ☐ Çubuk
- ☐ Elmadağ
- ☐ Etimesgut
- ☐ Evren
- ☐ Gölbaşı
- ☐ Güdül
- ☐ Haymana
- ☐ Kahramankazan
- ☐ Kalecik
- ☐ Keçiören
- ☐ Kızılcahamam
- ☐ Mamak
- ☐ Nallıhan
- ☐ Polatlı
- ☐ Pursaklar
- ☐ Sincan

- ☐ Şereflikoçhisar
- ☐ Yenimahalle

9. İkamet ettiğiniz il:
- ☐ 01 Adana
- ☐ 02 Adıyaman
- ☐ 03 Afyon
- ☐ …
- ☐ 79 Kilis
- ☐ 80 Osmaniye
- ☐ 81 Düzce

10. Hane olarak toplam aylık geliriniz hangi aralıkta yer almaktadır?
- ☐ 2.000 TL'den az
- ☐ 2.000 TL – 4.000 TL arasında
- ☐ 4.000 TL – 6.000 TL arasında
- ☐ 6.000 TL – 8.000 TL arasında
- ☐ 8.000 TL – 10.000 TL arasında
- ☐ 10.000 TL – 15.000 TL arasında
- ☐ 15.000 TL – 20.000 TL arasında
- ☐ 20.000 TL üzeri

11. Eviniz ile işiniz/okulunuz arasındaki mesafe
- ☐ 0-1 km
- ☐ 1-5 km
- ☐ 5-10 km
- ☐ 10-20 km
- ☐ 20-30 km
- ☐ 30 km üzeri

12. Evinize en yakın toplu taşıma aracına yürüme mesafeniz
- ☐ 0-100 metre
- ☐ 100-500 metre
- ☐ 500-1000 metre
- ☐ 1000 metre üzeri

13. Toplu taşımayı tercih ediyorsanız sebepleriniz nelerdir? Birden fazla seçenek işaretleyebilirsiniz. Uygun olanların tümünü işaretleyin
- ☐ Ekonomik olması
- ☐ Evime/işime yakın olması
- ☐ Zamanın daha iyi kullanılması
- ☐ Trafiğin yoğun olduğu zamanlarda araç kullanmayı istememek
- ☐ Trafik yoğunluğunu arttırmak istememek

- ☐ Hava kirliliğini arttırmak istememek
- ☐ Nadir durumlar dışında toplu taşıma kullanmıyorum.

Mevcut Otomobil Bilgileri

Birden fazla otomobiliniz varsa, anketteki soruları en çok kullandığınız otomobile yönelik doldurmanız beklenmektedir.

Genel Bilgiler

14. Mevcut otomobilinizin markası:

- ☐ Alfa Romeo
- ☐ Audi
- ☐ BMW
- ☐ Chery
- ☐ Chevrolet
- ☐ Citroen
- ☐ Dacia
- ☐ Fiat
- ☐ Ford
- ☐ Honda
- ☐ Hyundai
- ☐ Kia
- ☐ Lancia
- ☐ Mercedes
- ☐ Nissan
- ☐ Opel
- ☐ Peugeot
- ☐ Renault
- ☐ SAAB
- ☐ Seat
- ☐ Skoda
- ☐ Suzuki
- ☐ Toyota
- ☐ Volkswagen
- ☐ Volvo
- ☐ Diğer

15. Modeli (örneğin Polo, Astra Sedan, A180 vb.)

16. Model Yılı:

- ☐ 2018
- ☐ …

- ☐ 2000
- ☐ 2000 öncesi

17. Motor hacmi (cc): *

- ☐ 0-1300
- ☐ 1301-1600
- ☐ 1601-1800
- ☐ 1801-2000
- ☐ 2001-2500
- ☐ 2501-3000
- ☐ 3001-3500
- ☐ 3501-4000
- ☐ 4001 ve üzeri

18. Vites (Şanzıman) tipi:

- ☐ Düz Vites (Manuel)
- ☐ Otomatik Vites

19. Mevcut otomobilinizi ne zaman aldınız?

- ☐ 2018-Mayıs veya sonrası
- ☐ 2018-Nisan
- ☐ 2018-Mart
- ☐ 2018-Şubat
- ☐ 2018-Ocak
- ☐ 2017-Aralık
- ☐ …
- ☐ 2017-Ocak
- ☐ 2016-Aralık
- ☐ …
- ☐ 2016-Ocak
- ☐ 2015-Aralık
- ☐ …
- ☐ 2015-Ocak
- ☐ 2015 öncesi

Bu bölümdeki son sorunun ardından, 43. soruya geçin

20. Aldığınız fiyat (TL): Hatırlamıyorsanız boş bırakınız

21. Aylık ortalama yakıt harcamanız kaç TL' dir?

- ☐ 200-300 TL
- ☐ 300-400 TL
- ☐ 400-500 TL
- ☐ 500-600 TL

- ☐ 600-700 TL
- ☐ 700-800 TL
- ☐ 800-900 TL
- ☐ 900-1000 TL
- ☐ 1000-1100 TL
- ☐ 1100-1200 TL
- ☐ 1200-1300 TL
- ☐ 1300-1400 TL
- ☐ 1400-1500 TL

22. Şehiriçi 100 km'de yakıt tüketiminiz:

- ☐ 3.0-3.5 litre
- ☐ 3.5-4.0 litre
- ☐ 4.0-4.5 litre
- ☐ 4.5-5.0 litre
- ☐ 5.0-5.5 litre
- ☐ 5.5-6.0 litre
- ☐ 6.0-6.5 litre
- ☐ 6.5-7.0 litre
- ☐ 7.0-7.5 litre
- ☐ 7.5-8.0 litre
- ☐ 8.0-8.5 litre
- ☐ 8.5-9.0 litre
- ☐ 9.0-9.5 litre
- ☐ 9.5-10.0 litre
- ☐ 10.0-10.5 litre
- ☐ 10.5-11.0 litre
- ☐ 11.0-11.5 litre
- ☐ 11.5-12.0 litre
- ☐ 12.0-12.5 litre
- ☐ 12.5-13.0 litre
- ☐ 13.0-13.5 litre

23. Otomobilinizle şehir içinde aylık ortalama kaç km yol yapıyorsunuz?

Şehirlerarası veriler

24. Şehirlerarası - 100 km'de yakıt tüketiminiz:

- ☐ 3.0-3.5 litre
- ☐ 3.5-4.0 litre
- ☐ 4.0-4.5 litre
- ☐ 4.5-5.0 litre

- ☐ 5.0-5.5 litre
- ☐ 5.5-6.0 litre
- ☐ 6.0-6.5 litre
- ☐ 6.5-7.0 litre
- ☐ 7.0-7.5 litre
- ☐ 7.5-8.0 litre
- ☐ 8.0-8.5 litre
- ☐ 8.5-9.0 litre
- ☐ 9.0-9.5 litre
- ☐ 9.5-10.0 litre
- ☐ 10.0-10.5 litre
- ☐ 10.5-11.0 litre
- ☐ 11.0-11.5 litre
- ☐ 11.5-12.0 litre
- ☐ 12.0-12.5 litre
- ☐ 12.5-13.0 litre
- ☐ 13.0-13.5 litre

25. Otomobilinizle YILDA ortalama şehirlerarası kaç km yapıyorsunuz?

Önceki Otomobil Sahipliği

26. Bu otomobilinizden önce otomobiliniz var mıydı?

- ☐ Evet
- ☐ Hayır

43. soruya geçin

Eski otomobile ilişkin sorular

Bu bölümdeki sorular bir önceki otomobilinizle ilgilidir!

27. Eski aracınızı değiştirme sebebiniz:

Birden fazla seçenek işaretleyebilirsiniz. Uygun olanların tümünü işaretleyin

- ☐ Yeterince komforlu olmaması
- ☐ Arac yakıt tüketiminin fazla olması
- ☐ Çevreye fazla zarar vermesi (Karbondioksit salınımının ve enerji tüketiminin fazla olması) Uygun fiyatlı başka bir araç alma imkanının doğması

- ☐ Daha zorunlu sebeplerle değiştirme (Hasar görmesi, daha büyük bir araba ihtiyacı gibi)
- ☐ Diğer:

28. Mevcut otomobilinizi kullanımınızla eski aracınızı kullandığınız son yıl arasında kullanım miktarınızı etkileyen yakıt fiyatları dışında önemli bir değişiklik oldu mu? [İş değişikliği/Ev değişikliği/Çocukların okul,kurs vb. değişiklikleri /Diğer]

- ☐ Evet
- ☐ Hayır

29. Bir önceki otomobilinizin markası

- ☐ Alfa Romeo
- ☐ Audi
- ☐ BMW
- ☐ Chery
- ☐ Chevrolet
- ☐ Citroen
- ☐ Dacia
- ☐ Fiat
- ☐ Ford
- ☐ Honda
- ☐ Hyundai
- ☐ Kia
- ☐ Lancia
- ☐ Mercedes
- ☐ Nissan
- ☐ Opel
- ☐ Peugeot
- ☐ Renault
- ☐ SAAB
- ☐ Seat
- ☐ Skoda
- ☐ Suzuki
- ☐ Toyota
- ☐ Volkswagen
- ☐ Volvo
- ☐ Diğer

30. Modeli (örneğin Polo, Astra Sedan, A180 vb.) *

31. Model Yılı

- ☐ 2018
- ☐ …

- ☐ 2000
- ☐ 2000 öncesi

32. Motor hacmi (cc):

- ☐ 0-1300
- ☐ 1301-1600
- ☐ 1601-1800
- ☐ 1801-2000
- ☐ 2001-2500
- ☐ 2501-3000
- ☐ 3001-3500
- ☐ 3501-4000
- ☐ 4001 ve üzeri

33. Vites (Şanzıman) tipi

- ☐ Düz Vites (Manuel)
- ☐ Otomatik Vites

34. Yakıt türü:

- ☐ Benzin
- ☐ Dizel
- ☐ LPG
- ☐ Hibrid
- ☐ Elektrikli
- ☐ Diğer

35. Satın aldığınız tarih:

Hatırlamıyorsanız aracınızı sattığınız tarihe göre bir önceki yılın tarihini işaretleyebilirsiniz.

- ☐ 2018-Nisan
- ☐ 2018-Mart
- ☐ 2018-Şubat
- ☐ 2018-Ocak
- ☐ 2017-Aralık
- ☐ …
- ☐ 2017-Ocak
- ☐ 2016-Aralık
- ☐ …
- ☐ 2016-Ocak
- ☐ 2015-Aralık
- ☐ …
- ☐ 2015-Ocak
- ☐ 2014
- ☐ 2013

- ☐ 2012
- ☐ 2011
- ☐ 2010
- ☐ 2010 öncesi

36. Sattığınız tarih:

Hatırlamıyorsanız mevcut aracınızı satın almadan önceki en yakın zamanı işaretleyebilirsiniz. Yalnızca bir şıkkı işaretleyin

- ☐ 2018-Mayıs veya sonrası
- ☐ 2018-Nisan
- ☐ 2018-Mart
- ☐ 2018-Şubat
- ☐ 2018-Ocak
- ☐ 2017-Aralık
- ☐ …
- ☐ 2017-Ocak
- ☐ 2016-Aralık
- ☐ …
- ☐ 2016-Ocak
- ☐ 2015-Aralık
- ☐ …
- ☐ 2015-Ocak
- ☐ 2014
- ☐ 2013
- ☐ 2012
- ☐ 2011
- ☐ 2010
- ☐ 2010 öncesi

37. Sattığınız fiyat (TL):

Hatırlamıyorsanız boş bırakınız

38. Bir önceki otomobilinizle aylık ortalama yakıt harcamanız: (Satmadan önceki son yılı dikkate alınız)

- ☐ 200-300 TL
- ☐ 300-400 TL
- ☐ 400-500 TL
- ☐ 500-600 TL
- ☐ 600-700 TL
- ☐ 700-800 TL
- ☐ 800-900 TL
- ☐ 900-1000 TL
- ☐ 1000-1100 TL

- ☐ 1100-1200 TL
- ☐ 1200-1300 TL
- ☐ 1300-1400 TL
- ☐ 1400-1500 TL

Şehiriçi veriler

39. Şehiriçi 100 km'de yakıt tüketiminiz

- ☐ 3.0-3.5 litre
- ☐ 3.5-4.0 litre
- ☐ 4.0-4.5 litre
- ☐ 4.5-5.0 litre
- ☐ 5.0-5.5 litre
- ☐ 5.5-6.0 litre
- ☐ 6.0-6.5 litre
- ☐ 6.5-7.0 litre
- ☐ 7.0-7.5 litre
- ☐ 7.5-8.0 litre
- ☐ 8.0-8.5 litre
- ☐ 8.5-9.0 litre
- ☐ 9.0-9.5 litre
- ☐ 9.5-10.0 litre
- ☐ 10.0-10.5 litre
- ☐ 10.5-11.0 litre
- ☐ 11.0-11.5 litre
- ☐ 11.5-12.0 litre
- ☐ 12.0-12.5 litre
- ☐ 12.5-13.0 litre
- ☐ 13.0-13.5 litre

40. Bir önceki otomobilinizle şehir içinde aylık ortalama kaç km yol yapıyordunuz?

Şehirlerarası veriler

41. Şehirlerarası - 100 km'de yakıt tüketiminiz:

- ☐ 3.0-3.5 litre
- ☐ 3.5-4.0 litre
- ☐ 4.0-4.5 litre
- ☐ 4.5-5.0 litre
- ☐ 5.0-5.5 litre

- ☐ 5.5-6.0 litre
- ☐ 6.0-6.5 litre
- ☐ 6.5-7.0 litre
- ☐ 7.0-7.5 litre
- ☐ 7.5-8.0 litre
- ☐ 8.0-8.5 litre
- ☐ 8.5-9.0 litre
- ☐ 9.0-9.5 litre
- ☐ 9.5-10.0 litre
- ☐ 10.0-10.5 litre
- ☐ 10.5-11.0 litre
- ☐ 11.0-11.5 litre
- ☐ 11.5-12.0 litre
- ☐ 12.0-12.5 litre
- ☐ 12.5-13.0 litre
- ☐ 13.0-13.5 litre

42. Bir önceki otomobilinizle YILDA ortalama şehirlerarası kaç km yapıyordunuz?

Ekonomi, çevre ve tasarruf

43. Yeni araç alırken yakıt tüketimi açısından ekonomik olması benim için önemlidir. *

Hiç önemli değil Çok önemli

44. Yeni araç alırken çevreye daha az zarar vermesi benim için önemlidir.
Hiç önemli değil Çok önemli

45. Daha enerji verimli bir araca sahip olduğunuzu varsayalım. Bu sebeple daha çok tasarruf etmiş olacaksınız. Bu tasarrufu hangi şekilde değerlendirirsiniz? (Örneğin; 100 km'de ortalama 6 litre benzin tüketen ve yılda ortalama 10 bin km yol giden bir otomobilin %50 daha verimli bir araçla değiştirilmesi durumunda yılda yaklaşık 1.500 TL civarında yakıt tasarrufu yapma imkanı bulunmaktadır.) Uygun olanların tümünü işaretleyin.

- ☐ Aracımı daha sık kullanırım.
- ☐ Ulaşım dışında başka ihtiyaçlarım için harcarım.
- ☐ Kısa vadede bu tasarrufu harcamam, biriktiririm

46. Yakıt türü

Benzin 47. soruya geçin.

Dizel 77. soruya geçin.

LPG 107. soruya geçin.

Hibrid 47. soruya geçin.

Elektrikli Bu formu doldurmayı bırakın.

Diğer Bu formu doldurmayı bırakın.

Benzin fiyatlarındaki artış

Benzin fiyatlarındaki artış otomobil kullanımınız nasıl etkiler? (Şu anda benzin yaklaşık olarak ortalama 7,15 TL/lt'dir. Diğer değişkenlerin sabit kaldığı varsayılacaktır.)

Şehiriçi Kullanım

47. Benzin fiyatı 8 TL/lt olursa

- ☐ Aylık şehiriçi kullanım miktarım değişmez
- ☐ Aylık şehiriçi kullanım miktarım 0-50 km azalır.
- ☐ Aylık şehiriçi kullanım miktarım 50-100 km azalır.
- ☐ Aylık şehiriçi kullanım miktarım 100-200 km azalır.
- ☐ Aylık şehiriçi kullanım miktarım 200-500 km azalır.
- ☐ Aylık şehiriçi kullanım miktarım en az 500 km azalır.

48. Benzin fiyatı 9 TL/lt olursa

- ☐ Aylık şehiriçi kullanım miktarım değişmez
- ☐ Aylık şehiriçi kullanım miktarım 0-50 km azalır.
- ☐ Aylık şehiriçi kullanım miktarım 50-100 km azalır.
- ☐ Aylık şehiriçi kullanım miktarım 100-200 km azalır.
- ☐ Aylık şehiriçi kullanım miktarım 200-500 km azalır.
- ☐ Aylık şehiriçi kullanım miktarım en az 500 km azalır.

49. Benzin fiyatı 10 TL/lt olursa

- ☐ Aylık şehiriçi kullanım miktarım değişmez
- ☐ Aylık şehiriçi kullanım miktarım 0-50 km azalır.
- ☐ Aylık şehiriçi kullanım miktarım 50-100 km azalır.
- ☐ Aylık şehiriçi kullanım miktarım 100-200 km azalır.

☐ Aylık şehiriçi kullanım miktarım 200-500 km azalır.
☐ Aylık şehiriçi kullanım miktarım en az 500 km azalır.

Şehirlerarası Kullanım

50. Benzin fiyatı 8 TL/lt olursa

☐ Yıllık şehirlerarası kullanım miktarım değişmez
☐ Yıllık şehirlerarası kullanım miktarım 0-250 km azalır.
☐ Yıllık şehirlerarası kullanım miktarım 250-500 km azalır.
☐ Yıllık şehirlerarası kullanım miktarım 500-1000 km azalır.
☐ Yıllık şehirlerarası kullanım miktarım 1000-2500 km azalır.
☐ Yıllık şehirlerarası kullanım miktarım en az 2500 km azalır.

51. Benzin fiyatı 9 TL/lt olursa

☐ Yıllık şehirlerarası kullanım miktarım değişmez
☐ Yıllık şehirlerarası kullanım miktarım 0-250 km azalır.
☐ Yıllık şehirlerarası kullanım miktarım 250-500 km azalır.
☐ Yıllık şehirlerarası kullanım miktarım 500-1000 km azalır.
☐ Yıllık şehirlerarası kullanım miktarım 1000-2500 km azalır.
☐ Yıllık şehirlerarası kullanım miktarım en az 2500 km azalır.

52. Benzin fiyatı 10 TL/lt olursa

☐ Yıllık şehirlerarası kullanım miktarım değişmez
☐ Yıllık şehirlerarası kullanım miktarım 0-250 km azalır.
☐ Yıllık şehirlerarası kullanım miktarım 250-500 km azalır.
☐ Yıllık şehirlerarası kullanım miktarım 500-1000 km azalır.
☐ Yıllık şehirlerarası kullanım miktarım 1000-2500 km azalır.
☐ Yıllık şehirlerarası kullanım miktarım en az 2500 km azalır.

Orta ve Uzun Vadeye Yönelik Görüşler

53. Benzin fiyatı 8 TL/lt olursa, uzun vadede daha az yakıt tüketen bir otomobil almayı düşünebilirim.

Kesinlikle düşünmem Kesinlikle düşünürüm

54. Benzin fiyatı 9 TL/lt olursa, uzun vadede daha az yakıt tüketen bir otomobil almayı düşünebilirim

Kesinlikle düşünmem Kesinlikle düşünürüm

55. Benzin fiyatı 10 TL/lt olursa, uzun vadede daha az yakıt tüketen bir otomobil almayı düşünebilirim.
Kesinlikle düşünmem Kesinlikle düşünürüm

56. Benzin fiyatı 8 TL/lt olursa, uzun vadede işime daha yakın bir eve taşınmayı düşünebilirim.
Kesinlikle düşünmem Kesinlikle düşünürüm

57. Benzin fiyatı 9 TL/lt olursa, uzun vadede işime daha yakın bir eve taşınmayı düşünebilirim
Kesinlikle düşünmem Kesinlikle düşünürüm

58. Benzin fiyatı 10 TL/lt olursa, uzun vadede işime daha yakın bir eve taşınmayı düşünebilirim.
Kesinlikle düşünmem Kesinlikle düşünürüm

Benzin fiyatlarındaki düşüş

Benzin fiyatlarındaki düşüş otomobil kullanımınız nasıl etkiler? (Şu anda benzin yaklaşık 7,15 TL/lt'dir. Diğer değişkenlerin sabit kaldığı varsayılacaktır.)

Şehiriçi Kullanım

59. Benzin fiyatı 6 TL/lt olursa

- ☐ Aylık şehiriçi kullanım miktarım değişmez
- ☐ Aylık şehiriçi kullanım miktarım 0-50 km artar.
- ☐ Aylık şehiriçi kullanım miktarım 50-100 km artar.
- ☐ Aylık şehiriçi kullanım miktarım 100-200 km artar.
- ☐ Aylık şehiriçi kullanım miktarım 200-500 km artar.
- ☐ Aylık şehiriçi kullanım miktarım en az 500 km artar.

60. Benzin fiyatı 5 TL/lt olursa

- ☐ Aylık şehiriçi kullanım miktarım değişmez
- ☐ Aylık şehiriçi kullanım miktarım 0-50 km artar.
- ☐ Aylık şehiriçi kullanım miktarım 50-100 km artar.
- ☐ Aylık şehiriçi kullanım miktarım 100-200 km artar.
- ☐ Aylık şehiriçi kullanım miktarım 200-500 km artar.
- ☐ Aylık şehiriçi kullanım miktarım en az 500 km artar.

61. Benzin fiyatı 4 TL/lt olursa

- ☐ Aylık şehiriçi kullanım miktarım değişmez
- ☐ Aylık şehiriçi kullanım miktarım 0-50 km artar.
- ☐ Aylık şehiriçi kullanım miktarım 50-100 km artar.
- ☐ Aylık şehiriçi kullanım miktarım 100-200 km artar.
- ☐ Aylık şehiriçi kullanım miktarım 200-500 km artar.
- ☐ Aylık şehiriçi kullanım miktarım en az 500 km artar.

Şehirlerarası Kullanım

62. Benzin fiyatı 6 TL/lt olursa

Yıllık şehirlerarası kullanım miktarım değişmez

Yıllık şehirlerarası kullanım miktarım 0-250 km artar.

Yıllık şehirlerarası kullanım miktarım 250-500 km artar.

Yıllık şehirlerarası kullanım miktarım 500-1000 km artar.

Yıllık şehirlerarası kullanım miktarım 1000-2500 km artar.

Yıllık şehirlerarası kullanım miktarım en az 2500 km artar.

63. Benzin fiyatı 5 TL/lt olursa

Yıllık şehirlerarası kullanım miktarım değişmez

Yıllık şehirlerarası kullanım miktarım 0-250 km artar.

Yıllık şehirlerarası kullanım miktarım 250-500 km artar.

Yıllık şehirlerarası kullanım miktarım 500-1000 km artar.

Yıllık şehirlerarası kullanım miktarım 1000-2500 km artar.

Yıllık şehirlerarası kullanım miktarım en az 2500 km artar.

64. Benzin fiyatı 4 TL/lt olursa

Yıllık şehirlerarası kullanım miktarım değişmez

Yıllık şehirlerarası kullanım miktarım 0-250 km artar.

Yıllık şehirlerarası kullanım miktarım 250-500 km artar.

Yıllık şehirlerarası kullanım miktarım 500-1000 km artar.

Yıllık şehirlerarası kullanım miktarım 1000-2500 km artar.

Yıllık şehirlerarası kullanım miktarım en az 2500 km artar.

Orta ve Uzun Vadeye Yönelik Görüşler

65. **Benzin fiyatı 6 TL/lt olursa, uzun vadede daha konforlu ancak fazla yakıt tüketen bir otomobil almayı düşünebilirim**
    Kesinlikle düşünmem Kesinlikle düşünürüm
66. **Benzin fiyatı 5 TL/lt olursa, uzun vadede daha konforlu ancak fazla yakıt tüketen bir otomobil almayı düşünebilirim**
    Kesinlikle düşünmem Kesinlikle düşünürüm
67. **Benzin fiyatı 4 TL/lt olursa, uzun vadede daha konforlu ancak fazla yakıt tüketen bir otomobil almayı düşünebilirim**
    Kesinlikle düşünmem Kesinlikle düşünürüm
68. **Benzin fiyatı 6 TL/lt olursa, uzun vadede ikinci bir otomobil almayı düşünebilirim**
    Kesinlikle düşünmem Kesinlikle düşünürüm
69. **Benzin fiyatı 5 TL/lt olursa, uzun vadede ikinci bir otomobil almayı düşünebilirim**
    Kesinlikle düşünmem Kesinlikle düşünürüm
70. **Benzin fiyatı 4 TL/lt olursa, uzun vadede ikinci bir otomobil almayı düşünebilirim**
    Kesinlikle düşünmem Kesinlikle düşünürüm
71. **Benzin fiyatı 6 TL/lt olursa, kısa/orta vadede diğer ihtiyaçlarım için harcama yaparım.**
    Kesinlikle düşünmem Kesinlikle düşünürüm
72. **Benzin fiyatı 5 TL/lt olursa, kısa/orta vadede diğer ihtiyaçlarım için harcama yaparım**
    Kesinlikle düşünmem Kesinlikle düşünürüm
73. **Benzin fiyatı 4 TL/lt olursa, kısa/orta vadede diğer ihtiyaçlarım için harcama yaparım**
    Kesinlikle düşünmem Kesinlikle düşünürüm
74. **Benzin fiyatı 6 TL/lt olursa, kısa/orta vadede harcama yapmam biriktiririm.**
    Kesinlikle düşünmem Kesinlikle düşünürüm
75. **Benzin fiyatı 5 TL/lt olursa, kısa/orta vadede harcama yapmam biriktiririm.**
    Kesinlikle düşünmem Kesinlikle düşünürüm

76. Benzin fiyatı 4 TL/lt olursa, kısa/orta vadede harcama yapmam biriktiririm.
Kesinlikle düşünmem Kesinlikle düşünürüm

Dizel fiyatlarındaki artış

Dizel fiyatlarındaki artış otomobil kullanımınız nasıl etkiler? (Şu anda dizel yaklaşık 6,5 TL/lt'dir. Diğer değişkenlerin sabit kaldığı varsayılacaktır.)

Şehiriçi Kullanım

77. Dizel fiyatı 7,5 TL/lt olursa
Aylık şehiriçi kullanım miktarım değişmez

Aylık şehiriçi kullanım miktarım 0-50 km azalır.

Aylık şehiriçi kullanım miktarım 50-100 km azalır.

Aylık şehiriçi kullanım miktarım 100-200 km azalır.

Aylık şehiriçi kullanım miktarım 200-500 km azalır.

Aylık şehiriçi kullanım miktarım en az 500 km azalır.

78. Dizel fiyatı 8,5 TL/lt olursa
Aylık şehiriçi kullanım miktarım değişmez

Aylık şehiriçi kullanım miktarım 0-50 km azalır.

Aylık şehiriçi kullanım miktarım 50-100 km azalır.

Aylık şehiriçi kullanım miktarım 100-200 km azalır.

Aylık şehiriçi kullanım miktarım 200-500 km azalır.

Aylık şehiriçi kullanım miktarım en az 500 km azalır.

79. Dizel fiyatı 9,5 TL/lt olursa
Aylık şehiriçi kullanım miktarım değişmez

Aylık şehiriçi kullanım miktarım 0-50 km azalır.

Aylık şehiriçi kullanım miktarım 50-100 km azalır.

Aylık şehiriçi kullanım miktarım 100-200 km azalır.

Aylık şehiriçi kullanım miktarım 200-500 km azalır.

Aylık şehiriçi kullanım miktarım en az 500 km azalır.

Şehirlerarası Kullanım

80. Dizel fiyatı 7,5 TL/lt olursa:

Yıllık şehirlerarası kullanım miktarım değişmez

Yıllık şehirlerarası kullanım miktarım 0-250 km azalır.

Yıllık şehirlerarası kullanım miktarım 250-500 km azalır.

Yıllık şehirlerarası kullanım miktarım 500-1000 km azalır.

Yıllık şehirlerarası kullanım miktarım 1000-2500 km azalır.

Yıllık şehirlerarası kullanım miktarım en az 2500 km azalır.

81. Dizel fiyatı 8,5 TL/lt olursa

Yıllık şehirlerarası kullanım miktarım değişmez

Yıllık şehirlerarası kullanım miktarım 0-250 km azalır.

Yıllık şehirlerarası kullanım miktarım 250-500 km azalır.

Yıllık şehirlerarası kullanım miktarım 500-1000 km azalır.

Yıllık şehirlerarası kullanım miktarım 1000-2500 km azalır.

Yıllık şehirlerarası kullanım miktarım en az 2500 km azalır.

82. Dizel fiyatı 9,5 TL/lt olursa:

Yıllık şehirlerarası kullanım miktarım değişmez

Yıllık şehirlerarası kullanım miktarım 0-250 km azalır.

Yıllık şehirlerarası kullanım miktarım 250-500 km azalır.

Yıllık şehirlerarası kullanım miktarım 500-1000 km azalır.

Yıllık şehirlerarası kullanım miktarım 1000-2500 km azalır.

Yıllık şehirlerarası kullanım miktarım en az 2500 km azalır.

Orta ve Uzun Vadeye Yönelik Görüşler

83. Dizel fiyatı 7,5 TL/lt olursa, uzun vadede daha az yakıt tüketen bir otomobil almayı düşünebilirim

Kesinlikle düşünmem Kesinlikle düşünürüm

84. Dizel fiyatı 8,5 TL/lt olursa, uzun vadede daha az yakıt tüketen bir otomobil almayı düşünebilirim

Kesinlikle düşünmem Kesinlikle düşünürüm

85. Dizel fiyatı 9,5 TL/lt olursa, uzun vadede daha az yakıt tüketen bir otomobil almayı düşünebilirim
Kesinlikle düşünmem Kesinlikle düşünürüm

86. Dizel fiyatı 7,5 TL/lt olursa, uzun vadede işime daha yakın bir eve taşınmayı düşünebilirim.
Kesinlikle düşünmem Kesinlikle düşünürüm

87. Dizel fiyatı 8,5 TL/lt olursa, uzun vadede işime daha yakın bir eve taşınmayı düşünebilirim
Kesinlikle düşünmem Kesinlikle düşünürüm

88. Dizel fiyatı 9,5 TL/lt olursa, uzun vadede işime daha yakın bir eve taşınmayı düşünebilirim.
Kesinlikle düşünmem Kesinlikle düşünürüm

Dizel fiyatlarındaki düşüş

Dizel fiyatlarındaki düşüş otomobil kullanımınız nasıl etkiler? (Şu anda dizel yaklaşık 6,5 TL/lt'dir.Diğer değişkenlerin sabit kaldığı varsayılacaktır.)

Şehiriçi Kullanım

89. Dizel fiyatı 5,5 TL/lt olursa

Aylık şehiriçi kullanım miktarım değişmez

Aylık şehiriçi kullanım miktarım 0-50 km artar.

Aylık şehiriçi kullanım miktarım 50-100 km artar.

Aylık şehiriçi kullanım miktarım 100-200 km artar.

Aylık şehiriçi kullanım miktarım 200-500 km artar.

Aylık şehiriçi kullanım miktarım en az 500 km artar

90. Dizel fiyatı 4,5 TL/lt olursa

Aylık şehiriçi kullanım miktarım değişmez

Aylık şehiriçi kullanım miktarım 0-50 km artar.

Aylık şehiriçi kullanım miktarım 50-100 km artar.

Aylık şehiriçi kullanım miktarım 100-200 km artar.

Aylık şehiriçi kullanım miktarım 200-500 km artar.

Aylık şehiriçi kullanım miktarım en az 500 km artar

91. Dizel fiyatı 3,5 TL/lt olursa

Aylık şehiriçi kullanım miktarım değişmez

Aylık şehiriçi kullanım miktarım 0-50 km artar.

Aylık şehiriçi kullanım miktarım 50-100 km artar.

Aylık şehiriçi kullanım miktarım 100-200 km artar.

Aylık şehiriçi kullanım miktarım 200-500 km artar.

Aylık şehiriçi kullanım miktarım en az 500 km artar

Şehirlerarası Kullanım

92. Dizel fiyatı 5,5 TL/lt olursa

Yıllık şehirlerarası kullanım miktarım değişmez

Yıllık şehirlerarası kullanım miktarım 0-250 km artar.

Yıllık şehirlerarası kullanım miktarım 250-500 km artar.

Yıllık şehirlerarası kullanım miktarım 500-1000 km artar.

Yıllık şehirlerarası kullanım miktarım 1000-2500 km artar.

Yıllık şehirlerarası kullanım miktarım en az 2500 km arta

93. Dizel fiyatı 4,5 TL/lt olursa

Yıllık şehirlerarası kullanım miktarım değişmez

Yıllık şehirlerarası kullanım miktarım 0-250 km artar.

Yıllık şehirlerarası kullanım miktarım 250-500 km artar.

Yıllık şehirlerarası kullanım miktarım 500-1000 km artar.

Yıllık şehirlerarası kullanım miktarım 1000-2500 km artar.

Yıllık şehirlerarası kullanım miktarım en az 2500 km arta

94. Dizel fiyatı 3,5 TL/lt olursa

Yıllık şehirlerarası kullanım miktarım değişmez

Yıllık şehirlerarası kullanım miktarım 0-250 km artar.

Yıllık şehirlerarası kullanım miktarım 250-500 km artar.

Yıllık şehirlerarası kullanım miktarım 500-1000 km artar.

Yıllık şehirlerarası kullanım miktarım 1000-2500 km artar.

Yıllık şehirlerarası kullanım miktarım en az 2500 km arta

Orta ve Uzun Vadeye Yönelik Görüşler

95. **Dizel fiyatı 5,5 TL/lt olursa, uzun vadede daha konforlu ancak fazla yakıt tüketen bir otomobil almayı düşünebilirim**
    Kesinlikle düşünmem Kesinlikle düşünürüm
96. **Dizel fiyatı 4,5 TL/lt olursa, uzun vadede daha konforlu ancak fazla yakıt tüketen bir otomobil almayı düşünebilirim**
    Kesinlikle düşünmem Kesinlikle düşünürüm
97. **Dizel fiyatı 3,5 TL/lt olursa, uzun vadede daha konforlu ancak fazla yakıt tüketen bir otomobil almayı düşünebilirim**
    Kesinlikle düşünmem Kesinlikle düşünürüm
98. **Dizel fiyatı 5,5 TL/lt olursa, uzun vadede ikinci bir otomobil almayı düşünebilirim**
    Kesinlikle düşünmem Kesinlikle düşünürüm
99. **Dizel fiyatı 4,5 TL/lt olursa, uzun vadede ikinci bir otomobil almayı düşünebilirim**
    Kesinlikle düşünmem Kesinlikle düşünürüm
100. **Dizel fiyatı 3,5 TL/lt olursa, uzun vadede ikinci bir otomobil almayı düşünebilirim.**
    Kesinlikle düşünmem Kesinlikle düşünürüm
101. **Dizel fiyatı 5,5 TL/lt olursa, ulaşım dışında diğer ihtiyaçlarım için harcama yaparım.**
    Kesinlikle düşünmem Kesinlikle düşünürüm
102. **Dizel fiyatı 4,5 TL/lt olursa, kısa/orta vadede ulaşım dışında diğer ihtiyaçlarım için harcama yaparım**
    Kesinlikle düşünmem Kesinlikle düşünürüm
103. **Dizel fiyatı 3,5 TL/lt olursa, kısa/orta vadede ulaşım dışında diğer ihtiyaçlarım için harcama yaparım.**
    Kesinlikle düşünmem Kesinlikle düşünürüm
104. **Dizel fiyatı 5,5 TL/lt olursa, kısa/orta vadede harcama yapmam biriktiririm**
    Kesinlikle düşünmem Kesinlikle düşünürüm
105. **Dizel fiyatı 4,5 TL/lt olursa, kısa/orta vadede harcama yapmam biriktiririm.**
    Kesinlikle düşünmem Kesinlikle düşünürüm

106. Dizel fiyatı 3,5 TL/lt olursa, kısa/orta vadede harcama yapmam biriktiririm

Kesinlikle düşünmem Kesinlikle düşünürüm

LPG fiyatlarındaki artış

LPG fiyatlarındaki artış otomobil kullanımınız nasıl etkiler? (Şu anda LPG yaklaşık 3,90 TL/lt'dir.Diğer değişkenlerin sabit kaldığı varsayılacaktır.)

Şehiriçi Kullanım

107. LPG fiyatı 4,5 TL/lt olursa

Aylık şehiriçi kullanım miktarım değişmez

Aylık şehiriçi kullanım miktarım 0-50 km azalır.

Aylık şehiriçi kullanım miktarım 50-100 km azalır.

Aylık şehiriçi kullanım miktarım 100-200 km azalır.

Aylık şehiriçi kullanım miktarım 200-500 km azalır.

Aylık şehiriçi kullanım miktarım en az 500 km azalır.

108. LPG fiyatı 5 TL/lt olursa

Aylık şehiriçi kullanım miktarım değişmez

Aylık şehiriçi kullanım miktarım 0-50 km azalır.

Aylık şehiriçi kullanım miktarım 50-100 km azalır.

Aylık şehiriçi kullanım miktarım 100-200 km azalır.

Aylık şehiriçi kullanım miktarım 200-500 km azalır.

Aylık şehiriçi kullanım miktarım en az 500 km azalır.

109. LPG fiyatı 6 TL/lt olursa:

Aylık şehiriçi kullanım miktarım değişmez

Aylık şehiriçi kullanım miktarım 0-50 km azalır.

Aylık şehiriçi kullanım miktarım 50-100 km azalır.

Aylık şehiriçi kullanım miktarım 100-200 km azalır.

Aylık şehiriçi kullanım miktarım 200-500 km azalır.

Aylık şehiriçi kullanım miktarım en az 500 km azalır.

110. LPG fiyatı 4,5 TL/lt olursa

Yıllık şehirlerarası kullanım miktarım değişmez

Yıllık şehirlerarası kullanım miktarım 0-250 km azalır.

Yıllık şehirlerarası kullanım miktarım 250-500 km azalır.

Yıllık şehirlerarası kullanım miktarım 500-1000 km azalır.

Yıllık şehirlerarası kullanım miktarım 1000-2500 km azalır.

Yıllık şehirlerarası kullanım miktarım en az 2500 km azalır.

111. LPG fiyatı 5 TL/lt olursa

Yıllık şehirlerarası kullanım miktarım değişmez

Yıllık şehirlerarası kullanım miktarım 0-250 km azalır.

Yıllık şehirlerarası kullanım miktarım 250-500 km azalır.

Yıllık şehirlerarası kullanım miktarım 500-1000 km azalır.

Yıllık şehirlerarası kullanım miktarım 1000-2500 km azalır.

Yıllık şehirlerarası kullanım miktarım en az 2500 km azalır.

112. LPG fiyatı 6 TL/lt olursa

Yıllık şehirlerarası kullanım miktarım değişmez

Yıllık şehirlerarası kullanım miktarım 0-250 km azalır.

Yıllık şehirlerarası kullanım miktarım 250-500 km azalır.

Yıllık şehirlerarası kullanım miktarım 500-1000 km azalır.

Yıllık şehirlerarası kullanım miktarım 1000-2500 km azalır.

Yıllık şehirlerarası kullanım miktarım en az 2500 km azalır.

Orta ve Uzun Vadeye Yönelik Görüşler

113. LPG fiyatı 4,5 TL/lt olursa, uzun vadede daha az yakıt tüketen bir otomobil almayı düşünebilirim

Kesinlikle düşünmem Kesinlikle düşünürüm

114. LPG fiyatı 5 TL/lt olursa, uzun vadede daha az yakıt tüketen bir otomobil almayı düşünebilirim.

Kesinlikle düşünmem Kesinlikle düşünürüm

115. LPG fiyatı 6 TL/lt olursa, uzun vadede daha az yakıt tüketen bir otomobil almayı düşünebilirim

Kesinlikle düşünmem Kesinlikle düşünürüm

116. LPG fiyatı 4,5 TL/lt olursa, uzun vadede işime daha yakın bir eve taşınmayı düşünebilirim.
Kesinlikle düşünmem Kesinlikle düşünürüm

117. LPG fiyatı 5 TL/lt olursa, uzun vadede işime daha yakın bir eve taşınmayı düşünebilirim.
Kesinlikle düşünmem Kesinlikle düşünürüm

118. LPG fiyatı 6 TL/lt olursa, uzun vadede işime daha yakın bir eve taşınmayı düşünebilirim
Kesinlikle düşünmem Kesinlikle düşünürüm

LPG fiyatlarındaki düşüş

LPG fiyatlarındaki düşüş otomobil kullanımınız nasıl etkiler? (Şu anda LPG yaklaşık 3,90 TL/lt'dir.Diğer değişkenlerin sabit kaldığı varsayılacaktır.)

Şehiriçi Kullanım

119. LPG fiyatı 3,5 TL/lt olursa
Aylık şehiriçi kullanım miktarım değişmez

Aylık şehiriçi kullanım miktarım 0-50 km artar.

Aylık şehiriçi kullanım miktarım 50-100 km artar.

Aylık şehiriçi kullanım miktarım 100-200 km artar.

Aylık şehiriçi kullanım miktarım 200-500 km artar.

Aylık şehiriçi kullanım miktarım en az 500 km artar

120. LPG fiyatı 3 TL/lt olursa:
Aylık şehiriçi kullanım miktarım değişmez

Aylık şehiriçi kullanım miktarım 0-50 km artar.

Aylık şehiriçi kullanım miktarım 50-100 km artar.

Aylık şehiriçi kullanım miktarım 100-200 km artar.

Aylık şehiriçi kullanım miktarım 200-500 km artar.

Aylık şehiriçi kullanım miktarım en az 500 km artar

121. LPG fiyatı 2 TL/lt olursa:
Aylık şehiriçi kullanım miktarım değişmez

Aylık şehiriçi kullanım miktarım 0-50 km artar.

Aylık şehiriçi kullanım miktarım 50-100 km artar.

Aylık şehiriçi kullanım miktarım 100-200 km artar.

Aylık şehiriçi kullanım miktarım 200-500 km artar.

Aylık şehiriçi kullanım miktarım en az 500 km artar

Şehirlerarası Kullanım

122. LPG fiyatı 3,5 TL/lt olursa

Yıllık şehirlerarası kullanım miktarım değişmez

Yıllık şehirlerarası kullanım miktarım 0-250 km artar.

Yıllık şehirlerarası kullanım miktarım 250-500 km artar.

Yıllık şehirlerarası kullanım miktarım 500-1000 km artar.

Yıllık şehirlerarası kullanım miktarım 1000-2500 km artar.

Yıllık şehirlerarası kullanım miktarım en az 2500 km artar.

123. LPG fiyatı 3 TL/lt olursa:

Yıllık şehirlerarası kullanım miktarım değişmez

Yıllık şehirlerarası kullanım miktarım 0-250 km artar.

Yıllık şehirlerarası kullanım miktarım 250-500 km artar.

Yıllık şehirlerarası kullanım miktarım 500-1000 km artar.

Yıllık şehirlerarası kullanım miktarım 1000-2500 km artar.

Yıllık şehirlerarası kullanım miktarım en az 2500 km artar.

124. LPG fiyatı 2 TL/lt olursa

Yıllık şehirlerarası kullanım miktarım değişmez

Yıllık şehirlerarası kullanım miktarım 0-250 km artar.

Yıllık şehirlerarası kullanım miktarım 250-500 km artar.

Yıllık şehirlerarası kullanım miktarım 500-1000 km artar.

Yıllık şehirlerarası kullanım miktarım 1000-2500 km artar.

Yıllık şehirlerarası kullanım miktarım en az 2500 km artar.

Orta ve Uzun Vadeye Yönelik Görüşler

125. **LPG fiyatı 3,5 TL/lt olursa, uzun vadede daha konforlu ancak fazla yakıt tüketen bir otomobil almayı düşünebilirim**
Kesinlikle düşünmem Kesinlikle düşünürüm

126. **LPG fiyatı 3 TL/lt olursa, uzun vadede daha konforlu ancak fazla yakıt tüketen bir otomobil almayı düşünebilirim**
Kesinlikle düşünmem Kesinlikle düşünürüm

127. **LPG fiyatı 2 TL/lt olursa, uzun vadede daha konforlu ancak fazla yakıt tüketen bir otomobil almayı düşünebilirim**
Kesinlikle düşünmem Kesinlikle düşünürüm

128. **LPG fiyatı 3,5 TL/lt olursa, uzun vadede ikinci bir otomobil almayı düşünebilirim**
Kesinlikle düşünmem Kesinlikle düşünürüm

129. **LPG fiyatı 3 TL/lt olursa, uzun vadede ikinci bir otomobil almayı düşünebilirim.**
Kesinlikle düşünmem Kesinlikle düşünürüm

130. **LPG fiyatı 2 TL/lt olursa, uzun vadede ikinci bir otomobil almayı düşünebilirim.**
Kesinlikle düşünmem Kesinlikle düşünürüm

131. **LPG fiyatı 3,5 TL/lt olursa, kısa/orta vadede ulaşım dışında diğer ihtiyaçlarım için harcama yaparım**
Kesinlikle harcamam Kesinlikle harcarım

132. **LPG fiyatı 3 TL/lt olursa, kısa/orta vadede ulaşım dışında diğer ihtiyaçlarım için harcama yaparım.**
Kesinlikle harcamam Kesinlikle harcarım

133. **LPG fiyatı 2 TL/lt olursa, kısa/orta vadede ulaşım dışında diğer ihtiyaçlarım için harcama yaparım**
Kesinlikle harcamam Kesinlikle harcarım

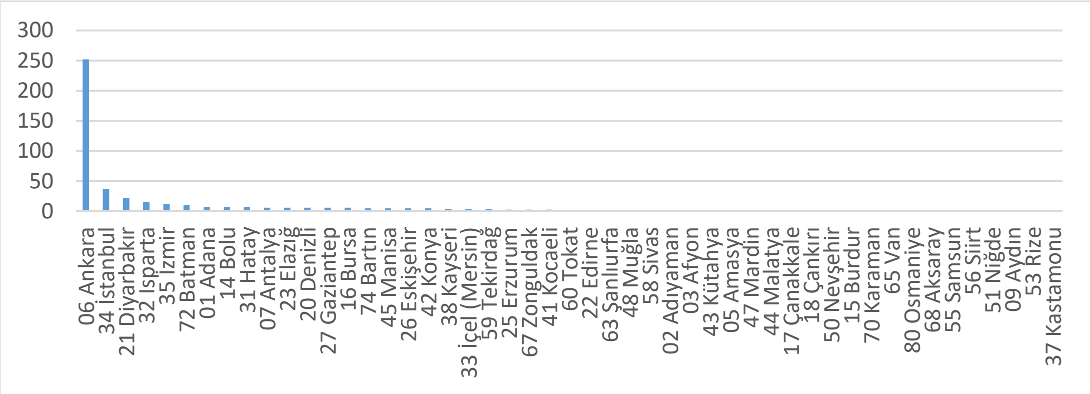
134. **LPG fiyatı 3,5 TL/lt olursa, kısa/orta vadede harcama yapmam biriktiririm.**
Kesinlikle harcamam Kesinlikle harcarım

135. **LPG fiyatı 3 TL/lt olursa, kısa/orta vadede harcama yapmam biriktiririm**
Kesinlikle harcamam Kesinlikle harcarım

136. LPG fiyatı 2 TL/lt olursa, kısa/orta vadede harcama yapmam biriktiririm

Kesinlikle harcamam Kesinlikle harcarım

B. Participants’ Provinces



C. Participants’ Towns