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GREEN TAXATION: THE INFLUENCE AND DESIRABILITY OF THE FEEBATE SCHEME IN THE ISRAELI NEW CAR MARKET[1]

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Abstract

In August 2009, a "green taxation" reform was introduced in Israel. The reform included raising the purchase tax on new cars and giving rebates to consumers based on the emissions level of the vehicle. This scheme is similar to other "Feebate" systems around the world. In this study, I estimate the demand equation for a new car, subject to various segments and cross elasticities, using a nested logit model. I find that price and emissions level have a negative influence on a car's market share, while "efficiency" and "safety" have a positive influence. Moreover, the cross-elasticity of "car model" is higher between cars from the same segment.

Using the coefficients of these regressions, I then simulate the effect of removing the green rebate. Excluding the green rebate increases both public revenues from taxation and the emissions from new cars, while also reducing new car purchases. When keeping the number of new car purchases constant by simultaneously reducing the purchase tax on new cars, I find that public taxation revenues and emission levels rise. However, the cost estimation of the additional externalities from emissions is significantly lower than the revenue lost when keeping the green taxation rebate constant, which puts the desirability of the program in question from a government perspective.

I also find that the green score update, which reduced rebates beginning in January 2015, could not be replaced by a reduction in the purchase tax, and that maximum revenues from taxation (Laffer Curve's peak) are obtained when the purchase tax is 99 percent (before the green rebate), making total tax payment (including VAT) 44.98 percent of the final average new car price.

Keywords: Feebate, cars market, green taxation, green reform, purchase tax, tax revenues.

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1. INTRODUCTION

The transportation sector is the largest final energy consumer around the world, accounting for 27 percent of worldwide energy consumption and 22 percent of carbon dioxide (CO_2) emissions (IEA, 2013). Current projections point to a doubling of transportation emissions by 2050 (OECD, 2012). Such figures have encouraged policymakers to find new solutions for reducing emissions in the overall sector, and specifically in the private car market.

Until recently, the main policy tools used to reduce emissions were fuel taxes meant to decrease automobile use, fuel economy standards designed to motivate manufacturers to make fuel-efficient vehicles, and registration fees that increase with engine capacity, horsepower, and weight base (all of which correlate with emission levels). Recently, policymakers have been examining and implementing tools designed to reduce emissions directly. One of these new tools is the Feebate system, which motivates consumers to buy vehicles with low CO_2 emissions by providing rebates for such vehicles, and discourages them from buying vehicles with high CO_2 emissions by implementing fees. In other words, this system changes relative car prices by subsidizing ‘greener’ cars with revenues from fees on high-emission cars.

The Feebate system has been introduced in some European countries, including France (2008), Germany (2009), Ireland (2008), and Sweden (April 2007–June 2009), and other countries like Canada (2007). The ‘Clean Car Discount’ program, which attempted to introduce the system into California in 2008, failed to pass. In Israel, the system was first introduced in August 2009. The method in Israel was to raise the purchase tax on private and commercial vehicles and to give rebates to consumers based on the level of car emissions.

The Feebate system has some advantages. It encourages the purchase of low-emission vehicles and can complement fuel taxes, which are not popular and are already quite high in many countries. It can be planned as revenue neutral, meaning that the fees cover the rebates. Consumers often fail to calculate the full fuel price when choosing a vehicle (e.g., Allcott and Wozny, 2014), so the system can fix some of their underestimation. It also provides a continuing incentive to improve fuel economy as new technologies are developed (Gordon and Levenson, 1989). However, the Feebate system also has some disadvantages, including that it is suited only to new vehicle purchases, and it focuses solely on vehicle purchase and not on usage. Moreover, fuel-efficient cars may encourage greater usage, which can lead to an increase in total emissions (rebound effect). Lastly, it can promote the purchase of more vehicles, thus increasing total emissions, especially if the system is not planned properly (D’Haultfoeuille, Givord, and Boutin, 2014).

The implementation of the Feebate system in Israel makes it possible to present some questions that might help in understanding the influence of the Feebate system on the car market. This article will try to answer: 1) What are the factors that influence the choice of car? 2) How does the level of purchase tax influence the car market, and at what point does an increase in purchase tax result in a decline in tax revenues (the peak of the Laffer

Curve)? 3) Does the Feebate system result in lower emissions, and at what cost? 4) What is the effect of higher penalties for cars with high emission levels, and can it be replaced by an increased purchase tax?

To answer these questions, I estimate the demand for new cars using a nested logit model. Using the coefficients of the estimation, I simulate the market structure under different tax levels and different Feebate fees and rebates.

This paper can be of use to decision makers and contribute to the current literature. The questions asked in this paper are relevant to decision makers who impose taxes on the automotive market and who like to promote green taxation. The contribution to the current literature is due to the special characteristics of the Israeli market. The Israeli market is small and based solely on imports, as opposed to other countries with a Feebate system. Moreover, the Israeli Feebate system includes fees and rebates on different pollutants, while in other countries the system targets only CO_2 emissions.

The paper proceeds as follows: Section 2 provides the background, including a review of the literature and background on Israel's green taxation scheme for new cars. Section 3 outlines the empirical framework, including the econometric model, the database and the estimation of the demand equation for new cars. Section 4 includes simulations of the effect of the green taxation scheme on new car demand based on the results of Section 3, and offers a broad discussion of the meaning of the simulation results. Section 5 concludes.

2. BACKGROUND

a. Literature Review

The Feebate system is relatively new, so the literature on the subject is limited. The existing literature can be divided into two areas of focus: how the system may affect the market (ex-ante) and how the system has already affected the market (ex-post).

In the ex-ante literature on the Feebate system Gordon and Levenson (1989) and McManus (2007) found that the scheme might benefit consumers and manufacturers, and reduce total emissions in California. Others compared the Feebate scheme with other tools in the United States and found advantages and disadvantages (Greene et al., 2005; Fischer, 2008). In Cyprus, Christodoulou and Clerides (2012) investigated a policy that added the Feebate scheme to other tools, and a policy in which the Feebate scheme replaced all other tools, and described the trade-offs between the different tools.

The ex-post literature includes the work of D'Haultfoeuille, Givord and Boutin (2014), who examined the effects of the Feebate system in France. Their main finding was that in the short term the system led to an increase in total emissions. This disappointing outcome was explained as being largely the result of overly generous rebates. Huse and Lucinda (2014) examined the effect of Sweden's Green Car Rebate program. They conducted a conservative estimation, finding that the Feebate system increased the market share of green cars by 5.5 percent, with a cost of US$109 per ton of CO_2 saved. This was five times the price of permitted emissions, meaning that the system was not cost-effective. Sallee and Joel (2012) examined the response of automakers to the brackets in the Feebate system in Canada and found some shifting in the automakers' decisions around the brackets. Rogan et al. (2011) looked at the influence of changing the vehicle registration tax from engine-based to emissions-based (CO_2). They found that new car emissions fell, and shifted from gasoline to diesel cars, and that revenue from tax decreased. Klier and Linn (2015) investigated the effect of emissions-based reform on total emissions and car manufacturing in France, Germany and Sweden and found stronger influence in France than in the other countries.

This paper examines the Israeli automobile market, and was preceded by Fershtman & Gandal (1998), who focused on the Arab boycott's influence on the Israeli car market, and Fershtman, Gandal and Markovich (1999), who focused on the differentiated product oligopoly and the effect of different taxation systems on the consumer.

b. Overview of the "Green Taxation" policy

In Israel the "green taxation" reform was introduced in August 2009, and included a tax on all vehicles weighing up to 3.5 tons. The objective of the reform was to raise the purchase tax on commercial vehicles from 75 to 90 percent, and on private vehicles from 72 to 90 percent, while at the same time giving rebates to consumers based on the emission rating of the vehicle. On November 25, 2010, the purchase tax was reduced to 83 percent due to the cancellation of the benefit for having an ABS system (which became a mandatory requirement). Currently, the final effective purchase tax for regular cars ranges between 30 percent for cars with low emissions and 83 percent for cars with a substantial amount of emissions. The purchase tax for cars without any emissions (mainly electric cars) is 8 percent. The rebates were given based on the "emission level" derived from the vehicle's "green score". The green score is calculated according to the following formula:

$$GreenScore = \frac{30*CO2+10{,}000*NOx+900*HC+500*CO+20{,}000*PM}{30}$$

where CO_2 is carbon dioxide, NO_x is nitrogen oxide, HC is hydrocarbon, CO is carbon monoxide, and PM is particulate matter up to 2.5 microns. All emissions are in g/km units. Finally, the green score is divided into 15 emission levels, which determine the rebate. Table 1 describes the 15 emission levels and the corresponding rebate amount.

Table 1
Emission level and green score rebates, 2009-2014

Emissions level	Green Score	Rebate (NIS)			
		September 2009-2011	2012	2013	2014
1	0-50	10% purchase tax	8% purchase tax	8% purchase tax	8% purchase tax
2 (hybrid)	51-130	30% purchase tax	30% purchase tax	30% purchase tax	30% purchase tax
2	51-130	15,000	16,007	16,238	16,548
3	131-150	13,750	14,673	14,885	15,169
4	151-170	12,000	12,806	12,991	13,239
5	171-175	10,500	11,206	11,368	11,585
6	176-180	9,250	9,871	10,013	10,204
7	181-185	8,250	8,804	8,931	9,102
8	186-190	7,250	7,736	7,848	7,998
9	191-195	6,500	6,935	7,036	7,170
10	196-200	5,500	5,870	5,955	6,069
11	201-205	5,000	5,336	5,413	5,516
12	206-210	4,000	4,269	4,331	4,414
13	211-220	3,250	3,468	3,518	3,585
14	221-250	2,000	2,134	2,165	2,206
15	251+	0	0	0	0

Israel's Feebate scheme differs in a number of interesting ways from schemes in other countries. First, the green score is calculated based on five types of emissions, while in most countries it is calculated solely based on CO_2. While this type of calculation might reduce various emissions, it is more complex to adjust and monitor. Second, Israel's scheme is not linear. Cars with relatively low and high emission levels have a larger range of rebates than cars with medium emission levels. For example, while emission level 3 has a range of 20 green score point (131–150), emission level 6 has a range of only five green score points (176–180).

According to the Israel Tax Authority (2013), the "green taxation" reform has had a significant effect on the automobile market in Israel. Its analysis found that in 2010, a short time after the reform was introduced (August 2009), there were already signals of a trend toward smaller, more efficient, and "greener" vehicles. While in 2008, only a third of vehicles in the local market had emission levels of 2 to 6, in 2011 their share climbed to 65 percent, and in 2012 it was 82 percent. However, it should be mentioned that in those years there were technological advancements leading to more efficient cars.

This movement to greener cars had a substantially negative effect on the revenues derived from the purchase tax. Although the scheme was not expected to be budget-neutral, the magnitude of the revenue decline was unexpected. Due to the shortage in tax revenues, it was decided to update the formula every two years. The first update was made on August

1, 2013, four years after the reform was introduced. The formula for calculating the green score was updated to the following:

$$GreenScore = \frac{103 * CO2 + 75{,}461 * NOx + 21{,}454 * HC + 1{,}042 * CO + 145{,}772 * PM}{100}$$

The green score's sensitivity to CO was reduced, it remained nearly the same for CO_2, and it increased for NO_x, HC and PM. The new formula shifted previously low-scoring vehicles into higher scores, which reduced the rebates. According to the Israel Tax Authority (2013), the median emissions level following the change shifted from level 4 to level 6. Further updates were made in January 2015 and in January 2017. These will be discussed in Section 4.4.

It should be mentioned that the weights used for the green score are based on the relative cost of the additional externalities of air pollutants and greenhouse gases, as published by the Ministry of Environmental Protection from time to time. The green score is equal to the emission cost of 10,000 km of driving. For example, a car model with a green score of 150 will have emission externalities of NIS 150 per 10,000 km of driving.

3. THE EMPIRICAL FRAMEWORK

a. The Econometric Model

The econometric model employed in this paper is the *one-level nested logit* model. This model has been used in many articles dealing with the automobile market (e.g., Adamou, Clerides and Zachariadis, 2014; Vance and Mehlin, 2009; Greene et al., 2005; and Fershtman, Gandal and Markovich, 1999).

The method derives an expression of market share from a random utility model of discrete choice at the individual consumer level (Berry, 1994). The utility that consumer *i* receives from brand *j* is given by the mean quality of brand *j* plus idiosyncratic taste for the product:

$$(1) \quad U_{ij} = x'_j\beta - \omega p_j + \gamma e_j + \xi_j + \varepsilon_{ij}$$

where x_j' is a vector of observed product characteristics (such as engine size, general weight, fuel type, etc.), β is a vector of the coefficient of the car parameters to be estimated, p is the price of the observed product, ω and γ are coefficients, e is the emissions level rebate, ξ_j is the average value of product *j*'s unobserved characteristics, and ε_{ij} is the distribution of consumer preference around the mean. Consumer *i* will choose product *j* only if $U_{ij} \geq U_{il} \ \forall \ l \neq j$. Depending on the assumed distribution of the error term, a different model could emerge from (1), the most popular of which is the conditional logit model, which assumes an identical and independently distributed (IID) Type I extreme value error.

One drawback of the logit model is its imposition of the ‘independent of irrelevant alternatives (IIA) assumption, which stipulates that when an alternative is removed from the choice set, the probabilities of the remaining alternatives being chosen must rise by the same proportion. This assumption is violated when the error terms are not independent, as in the case of subsets of alternatives for which unobserved shocks produce concomitant effects. The meaning of this assumption in analyzing the car market is that when we remove one type of car, customers would buy other cars in the same proportion. So, dropping a luxury car type from the sample will have the same proportional and unrelated effect on other luxury cars as it does on cars from the mini segment. (We would expect that dropping a luxury car would increase demand for other luxury cars more than the demand for mini cars.)

Following McFadden (1978), the IIA assumption can be relaxed, and groupings of similar sets of alternatives (e.g. cars belonging to the same market segment) can be accounted for via the nested logit model, which allows for correlations in the error terms for products within G+1, g=0, 1,2…, G, exogenously specified nests. An additional nest is reserved for an outside good, nest 0, thus accounting for the possibility that consumers may decide not to purchase any of the brands. The utility of product j for consumer i in the nested logit model is therefore given by the following:

(2) $$U_{ij} = x'_j\beta - \omega p_j + \gamma e_j + \xi_j + \zeta_{ig} + (1-\sigma)\varepsilon_{ij}$$

where individual heterogeneity enters the model through the random disturbance $\zeta_{ig} + (1-\sigma)\varepsilon_{ij}$, which is assumed to have an extreme-value Weibull distribution. For consumer i, ζ_{ig} is the utility common to all products within nest g and which has a distribution that depends on σ, which measures the degree of substitution within the segments or nests.

The corresponding market share equation is:

(3) $$S_j = \frac{e^{(\frac{\delta_j}{1-\sigma})}}{(D_g^{\sigma}\sum_g D_g^{(1-\sigma)})}$$

where $D_g = \sum_{j\in G_g} e^{(\frac{\delta_j}{1-\sigma})}$, G_g denotes the set of automobiles of type g, and $\delta_j = x'_j\beta - \omega p_j + \gamma e_j + \xi_j$ is the mean utility for product j.

If the mean utility from the outside good is equal to zero, Berry (1994) shows that Equation (3) can be inverted to yield the following demand of 0:

(4) $$Ln(S_{jt}) - Ln(S_{0t}) = x'_j\beta - \omega p_j + \gamma e_j + \sigma Ln(S_{jgt}) + \xi_{jt}$$

where S_{jt} is the market share for car j in period t, S_{0t} is the market share of the outside good (if consumers choose not to buy a new car), S_{jgt} is the market share of car j in nest g, and σ is the corresponding coefficient. The nested logit model is consistent with utility maximization if $0 \le \sigma \le 1$ for any set of values in the data (McFadden, 1978). When $\sigma =$

0, the model collapses to the standard logit model. When σ increases, there is more substitution among cars belonging to the same segment than among cars from different segments.

Because the share S_{jgt} is, by construction, endogenous, it must be estimated using instruments. The analysis consequently follows Berry, Levinsohn, and Pakes (1995), who exploit competition within the market by using the sums of characteristics of other car models as instruments. I used the following instruments: the sum of characteristics for other cars belonging to the same market segment; the sum of characteristics for other cars produced by the same manufacturer; the number of car models produced within the market segment; and the number of car models produced by a given manufacturer. Due the fact that all private cars in Israel are imported, I also add the sum of characteristics for other cars imported by the same importer and the number of car models imported by a given importer.

Another problem can arise from the link between supply and demand for a model. More precisely, the price may be correlated with the supply. To solve this problem, I use instruments to estimate the effect of price on demand. Those instruments include the exchange rate of the US dollar and the exchange rate of the currency of car j's country of origin (the manufacturing country, not the country that the brand is associated with). This method has also been used by Fershtman, Gandal and Markovich (1999), and others. I also followed Berry, Levinsohn and Pakes (1995) and added the natural logarithm of the main car characteristics (such as engine size and weight of the car).

b. Data

The data include car models newly purchased from January 2008 through August 2014, on monthly basis. In this paper a registered car is a proxy for the purchased car models, although they are not the same. The monthly data were obtained from the Israel Vehicle Importers Association and do not include taxis. Private vehicles are not manufactured in Israel, so the data from the Israel Vehicle Importers Association are suitable. The data do not include cars that were imported by small agencies or private individuals (a small fraction of the total cars purchased).

Literature on discrete choice modelling of new car demand has treated the choice set as being the set of car models ("nameplates"). In the data set, most cars are offered in several variants, differing in such aspects as body style, engine size, fuel type, number of doors, weight and model year. Therefore, the number of models is extremely high. For example, there are 2,129 models in the data and there are 4,312 observations for the 2011–2013 period, with some models corresponding to a very small number of units sold.

Estimation using the model with this level of disaggregation is not advisable, as observations with very few corresponding sales are susceptible to measurement or recording error. However, aggregating them by the same nameplates, as many researchers do, could cause errors since two cars with different emission levels might have the same nameplate. Therefore, in the set, each model has a different model nameplate and/or a different trim level (e.g. comfort, executive, sport, inspire, in style, etc.), different engine size, different fuel type, different number of doors, and/or different weight (GVW). After this aggregate, there were still too many models. Therefore, the paper focused on models that had significant market share. We chose models with more than 200 registrations in a given year or 100 registrations in any trimester of a given year. Some models still had very little share in some months, so a threshold of 10 model registrations within a month was chosen, meaning that the model was considered part of the market in a given month only if it had 10 or more registrations in that month.

We split the car models into 7 segments as determined by the importers: mini, small, compact, medium, large, luxury and SUV. These segments served as the nests in the estimation. Cars that belong mostly to the commercial market (van, small van and pick-up) were excluded. I also excluded the Renault Fluence ZE electric car, which had very little market share.

Eventually the dataset included 796 models for the years 2008 to August 2014. The final number of registrations (1,113,971) was approximately 93% of all private cars registered between January 2008 and August 2014. To these, I added data from the Ministry of Transportation and Road Safety private and commercial registered models database (for vehicles weighing up to 3.5 tons). This database includes all the models of cars between the years 2000 and 2014. The database also includes many of the cars' characteristics, such as green score and emission level, horsepower, ABS system and country of manufacture.

The car prices used in this paper are the prices for each model at the beginning of each period (January, May, and September for 2009–2012; January, May, August, and September for 2008 and 2013; January and May for 2014). The prices were taken from two sources: the Israel Tax Authority, which publishes new model prices at the start of every year or when a model is first introduced, and the Levi Yitzhak price list. Levi Yitzhak is a private company that collects data and calculates the prices of new and second-hand cars. Their data were used for prices at the beginning of May, August and September. The Levi Yitzhak price list was also the source of the fuel efficiency data due to the lack of that information in the Ministry of Transportation and Road Safety database.

Another parameter that influences the consumer is the price of fuel. Higher fuel prices may reduce demand for cars. I assume that the consumer is using the fuel price on the day of purchase as the best estimation of future expense. This assumption is common in the literature (e.g., Berry, Levinsohn and Pakes, 1995; Rogan et al., 2011; Anderson, Kellogg and Salle, 2013).

Fuel prices were taken from the Israeli Ministry of National Infrastructures, Energy and Water Resources. In the analysis, I used the average price of gasoline (95 octane rating) for each period. For simplicity, I did not use other fuel prices (such as diesel). This choice is appropriate because more than 90 percent of the cars in the dataset use gasoline, while only 9 percent use diesel (the rest are electric cars and LPG cars). In addition, while the retail price of gasoline is price-controlled, the price of diesel is not, so there are no official data on it. However, there are official data on the wholesale price of diesel (the refinery price) and this price is strongly correlated with gasoline.

The following variables were chosen as the vectors of observed product characteristics: the price of the model (NIS thousand), fuel price, engine size (thousands of cubic centimetres), horsepower, and gross vehicle weight (tons). I added dummies for gasoline-powered cars, four-wheel drive (4x4), and automatic transmission. I used also the number of airbags as a proxy for the model's safety level.

Table 2 contains a description of the statistics of the key variables. Each observation is a model from a given month in a given year. The least expensive car in the dataset cost NIS 49,990, and the most expensive cost NIS 495,000. Most of the cars use gasoline and have an automatic transmission. The emission types are those that were used for the green score calculation, and the amounts are in grams per kilometer of driving.

For the data analysis, the market share of each model was added. For each model, I calculated the potential market share, the market share as the share of purchased cars, and the market share in the segment.

Table 2
Descriptive statistics of key variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
Price (thousand)	9,761	137.0	47.0	50.0	495.0
Registrations	9,802	115.4	176.2	10.0	3176.0
Car's Features					
km per liter	9,278	13.5	3.4	1.3	27.0
Engine size (thousand cc)	9,802	1.7	0.4	0.9	3.9
Horsepower (thousand)	9,802	0.1	0.0	0.1	0.3
GVW (Ton)	9,802	1.8	0.3	1.0	3.0
Gasoline	9,802	1.0	0.2	0.0	1.0
4x4	9,802	0.1	0.3	0.0	1.0
Automatic gear	9,802	0.9	0.3	0.0	1.0
Airbags	9,802	5.8	1.2	0.0	9.0
Doors	9,802	4.7	0.5	3.0	5.0
Seats	9,802	5.1	0.6	4.0	8.0
Emissions Type					
Basic emissions level	8,981	6.3	3.8	1.0	15.0
CO	9,041	0.34	0.16	0.02	0.89
CO_2	9,041	157.4	31.9	85.0	287.0
HC	9,041	0.04	0.02	0.00	0.25
NO_x	9,041	0.02	0.03	0.00	0.32
PM	9,041	0.00	0.00	0.00	0.05

Table 3
Sample Models (January 2014)

Company	Model	Trim level	Engine	Doors	GVW	Segment	Price	Emissions level	Cars purchased	Market share (Sjt)	Share of total purchased	Model's share of segment (Sjgt)
Toyota	Corolla	GLI	1.6	4	1.77	compact	130.0	3	1629	0.8%	7.8%	12.3%
Kia	Picanto	EX	1.2	5	1.37	mini	78.9	4	871	0.4%	4.2%	33.2%
Mazda	3	Comfort	1.5	4	1.84	compact	132.0	3	716	0.4%	3.4%	5.4%
Mitsubishi	Space Star	Instyle	1.2	5	1.37	compact	79.9	2	707	0.4%	3.4%	5.3%
Suzuki	SX4	GLX	1.6	5	1.73	compact	120.0	3	595	0.3%	2.8%	4.5%
Hyundai	I20	Insight	1.4	5	1.57	compact	97.8	4	547	0.3%	2.6%	4.1%
Hyundai	I35	Inspire	1.6	4	1.8	compact	128.0	5	522	0.3%	2.5%	3.9%
Mazda	2	Dynamic	1.5	5	0.98	small	110.5	6	505	0.3%	2.4%	16.9%
Nissan	Micra	Visia	1.2	5	1.43	small	99.9	3	472	0.2%	2.3%	15.8%
Hyundai	I30	Inspire	1.6	5	1.85	compact	127.0	6	447	0.2%	2.1%	3.4%
Mazda	CX5	Executive	2.0	5	1.97	suv	166.0	4	446	0.2%	2.1%	16.4%
Subaru	Impreza	1.6 I	1.6	4	1.8	compact	126.9	4	429	0.2%	2.0%	3.2%
Suzuki	SX4	GLX	1.6	4	1.65	compact	119.0	4	388	0.2%	1.8%	2.9%
Kia	Forte	EX	1.6	4	1.74	compact	129.9	7	336	0.2%	1.6%	2.5%
Kia	Rio	LX	1.4	4	1.62	compact	110.9	6	335	0.2%	1.6%	2.5%
Ford	Focus	Sport	1.6	5	1.31	compact	132.0	8	327	0.2%	1.6%	2.5%
Kia	Sportage	LX	2.0	5	1.98	suv	166.3	14	310	0.2%	1.5%	11.4%
Honda	Civic	Sport	1.8	5	1.75	compact	144.9	5	302	0.2%	1.4%	2.3%
Nissan	Juke	Tekna	1.6	5	1.68	compact	147.5	6	300	0.2%	1.4%	2.3%
Chevrolet	Cruze	LT	1.6	4	1.86	compact	124.9	9	290	0.1%	1.4%	2.2%
Suzuki	Alto	GLX	1.0	5	1.25	mini	65.0	3	288	0.1%	1.4%	11.0%
Hyundai	I25	Inspire	1.4	4	1.56	compact	109.5	5	286	0.1%	1.4%	2.2%
Skoda	Octavia	Ambition	1.2	5	1.81	medium	132.0	4	283	0.1%	1.3%	16.7%
Opel	Astra ST	Enjoy	1.4	5	2.05	compact	130.0	8	270	0.1%	1.3%	2.0%
Hyundai	I30	Premium	1.6	5	1.85	compact	129.5	6	264	0.1%	1.3%	2.0%
Toyota	Yaris	Style	1.3	5	1.48	mini	104.7	3	264	0.1%	1.3%	10.1%
Hyundai	I25	Inspire	1.6	4	1.56	compact	111.5	4	261	0.1%	1.2%	2.0%
Hyundai	IX35	Open Sky	2.0	5	1.98	suv	166.0	14	245	0.1%	1.2%	9.0%
Chevrolet	Trax	LT	1.8	5	1.82	compact	135.9	11	231	0.1%	1.1%	1.7%
Mazda	6	Luxury	2.0	4	1.47	medium	167.5	4	220	0.1%	1.0%	13.0%
Chevrolet	Spark	LS	1.0	5	1.37	mini	54.9	3	208	0.1%	1.0%	7.9%
Mitsubishi	Outlander	Instyle SR	2.0	5	2.17	suv	179.9	5	202	0.1%	1.0%	7.4%
Kia	Ceed	LX	1.6	5	1.85	compact	128.9	4	198	0.1%	0.9%	1.5%
Honda	Jazz Hybrid	0	1.3	5	1.6	small	117.9	2	194	0.1%	0.9%	6.5%
Renault	Fluence	Privilege	1.6	4	1.77	compact	132.9	8	183	0.1%	0.9%	1.4%
Seat	Ibiza	Reference	1.4	5	1.53	small	77.9	5	180	0.1%	0.9%	6.0%
Mitsubishi	Outlander	Instyle	2.0	5	2.17	suv	169.9	7	179	0.1%	0.9%	6.6%
Suzuki	Alto	GLX	1.0	5	1.25	mini	54.0	3	175	0.1%	0.8%	6.7%
Skoda	Rapid	Ambition	1.4	5	1.39	medium	118.0	13	173	0.1%	0.8%	10.2%
Skoda	Octavia	Elegance	1.4	5	1.82	medium	145.5	4	170	0.1%	0.8%	10.0%
Kia	Rio	LX	1.4	5	1.62	compact	104.9	6	166	0.1%	0.8%	1.3%
Mitsubishi	Attrage	Invite	1.2	4	1.36	compact	93.9	4	162	0.1%	0.8%	1.2%
Ford	Fiesta	Trend	1.6	5	1.57	small	100.0	4	157	0.1%	0.7%	5.3%
Nissan	Qashqai	Visia	2.0	5	1.96	suv	163.0	10	153	0.1%	0.7%	5.6%
Renault	Clio	Expression	1.2	5	1.66	small	105.9	4	151	0.1%	0.7%	5.1%
Chevrolet	Trax	LT	1.4	5	1.83	compact	142.9	9	147	0.1%	0.7%	1.1%
Peugeot	107	Active	1.0	5	1.19	mini	73.5	2	145	0.1%	0.7%	5.5%
Mazda	3	Apirit	2.0	4	1.86	compact	142.0	4	141	0.1%	0.7%	1.1%
Suzuki	Splash	GLS	1.2	5	1.49	mini	95.0	4	137	0.1%	0.7%	5.2%
Chevrolet	Spark	LT	1.2	5	1.37	mini	63.5	3	136	0.1%	0.6%	5.2%
Honda	Civic	Comfort	1.8	4	1.7	compact	141.5	6	135	0.1%	0.6%	1.0%
Peugeot	301	Active	1.6	4	1.56	compact	101.0	13	133	0.1%	0.6%	1.0%
Renault	Fluence	Privilege	1.5	4	1.83	compact	135.9	14	128	0.1%	0.6%	1.0%
Mitsubishi	Attrage	Instyle	1.2	4	1.36	compact	94.9	4	125	0.1%	0.6%	0.9%

Table 3 presents a sample of the dataset. The sample includes the main models that were purchased in January 2014 and their characteristics. The calculation of market share required an assumption of potential market share. As is common in the literature (e.g. Adamou, Clerides and Zachariadis, 2014; Berry, Levinsohn and Pakes, 1995), I used the total number of private households in each year, obtained from the Israeli Central Bureau of Statistics.

c. Estimation

For the estimation of Equation (4), I used three kinds of specification, the results of which are shown in Table 4. The first specification (Column 1) is a simple OLS regression of Equation effect (4), where the first explanatory variable is the price and the second is the market share in the segment. Both are estimated directly from the data. Other explanatory variables include car efficiency (kilometers per liter), gasoline price, horsepower, safety level, engine size, weight, and number of seats. I also added the emissions level base, which is the emissions level in September 2009, or the emissions level as it would have been in September 2009 (for cars that were introduced later). I also added dummies for 3 or 5 doors, gasoline engine, automatic gearbox, 4X4 differential, and years.

The second and third regressions (Column 2 and Column 3) are 2SLS regressions. As mentioned above, because the share S_{jgt} is, by construction, endogenous, it must be estimated using instruments. Those instruments (IVs) include the number of other car models produced within the market segment, the number of other car models produced by the same manufacturer, and their sum of characteristics (such as the size of engine, the total weight, number of doors, number of seats, etc.). In column 3, I added the number of other car models imported by the same importer and their sum of characteristics to the right side of the regression.

The fourth and fifth regressions (Column 4 and Column 5) are both 3SLS regressions using a three-equation system. I used this method due to concern that the price might be correlated with market share. The first equation is the basic model presented in the OLS regression, and the second is the first stage of the 2SLS regression (the market share in the segment).

The third equation is an instrumental estimation of the price effect using the following to estimate the price: the exchange rate of the US dollar, the exchange rate of the currency of car j's country of origin (the producing country, not the country with which the brand is associated), the natural logarithm of horsepower, the natural logarithm of the number of airbags, the natural logarithm of GVW, and the natural logarithm of the number of seats. The difference between these two specifications is that in the first specification (Column 4) I did not use the importer variables (like the regression in Column 2), while in the second (Column 5) I added them (like the regression in Column 3).

Table 4
Specifications of market share*

	Dependent Variable: Market Share (Sjt)				
	OLS (1)	2SLS some IVs (2)	2SLS all IVs (3)	3SLS some IVs (4)	3SLS all IVs (5)
Price	-0.009*** (0.00)	-0.007*** (0.00)	-0.007*** (0.00)	-0.005*** (0.00)	-0.012*** (0.00)
Ln(Sjgt)	0.541*** (0.01)	0.108*** (0.01)	0.176*** (0.01)	0.038*** (0.01)	0.138*** (0.01)
Base emissions level	-0.019*** (0.00)	-0.032*** (0.00)	-0.030*** (0.00)	-0.007** (0.00)	-0.008** (0.00)
km/l	0.012*** (0.00)	0.013*** (0.00)	0.013*** (0.00)	0.012*** (0.00)	0.019*** (0.00)
fuel_price	0.121*** (0.02)	0.066** (0.03)	0.074*** (0.03)	0.101*** (0.02)	0.111*** (0.02)
Horsepower	2.349*** (0.61)	-1.990*** (0.77)	-1.311* (0.73)	0.853 (0.65)	4.569*** (0.63)
Airbags	0.041*** (0.01)	0.038*** (0.01)	0.038*** (0.01)	0.025*** (0.01)	0.049*** (0.01)
Engine	-0.145*** (0.05)	0.266*** (0.06)	0.202*** (0.05)	-0.020 (0.04)	0.083** (0.04)
GVW	0.138*** (0.05)	-0.124** (0.06)	-0.083 (0.06)	-0.129** (0.05)	0.173*** (0.05)
Seats	0.367*** (0.02)	0.242*** (0.02)	0.261*** (0.02)	0.189*** (0.01)	0.263*** (0.02)
Doors3	-0.690*** (0.06)	-0.943*** (0.08)	-0.903*** (0.07)	-0.265*** (0.05)	-0.287*** (0.05)
Doors5	-0.488*** (0.02)	-0.510*** (0.02)	-0.507*** (0.02)	-0.186*** (0.02)	-0.235*** (0.02)
Gasoline	-0.266*** (0.05)	-0.025 (0.06)	-0.063 (0.06)	-0.007 (0.04)	-0.188*** (0.05)
Auto	0.433*** (0.03)	0.352*** (0.04)	0.365*** (0.04)	0.111*** (0.03)	0.234*** (0.03)
4X4	-0.248*** (0.03)	-0.058 (0.04)	-0.088** (0.04)	-0.099*** (0.03)	0.004 (0.04)
Years Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	8,462	8,462	8,462	8,462	8,462
R-squared	0.55	0.30	0.37	0.17	0.30

* The dependent variable is the market share of car *j* in a given month in a given year. Price is the price of car *j* in thousands of shekels (roughly equal to $256). *Lnsgjt* is the market share of car *j* in its segment; Base emissions level is the emissions level as it was in September 2009; km/l is the driving distance on one liter of fuel as reported in the Levi Yitzhak price list; fuel price is the price of gasoline; Doors3 is a dummy for cars with 3 doors and Door5 is a dummy for cars with 5 doors; auto is a dummy for an automatic transmission; and 4x4 is a dummy for car with a 4X4 differential. The dependent variable of the first step in Regression 2 is *Lnsgjt*, and the explanatory variables are the number of registered cars in the segment and the sum of the following characteristics of cars in car *j*'s segment: km/l, horsepower, engine, gasoline, 4x4, GVW, auto, seats and emissions level. It also includes the number of registered cars of the same producer and the sum of the same characteristics by the producer of car *j*. The first step in Regression 3 is based on all the IVs and includes the same variables as Regression 2, the number of registered cars of the same importer as car *j*, and the sum of the same characteristics by the importer of car *j*. Regression 4 uses the first step of Regression 2 as the second regression, and exchange rate, ln(Horsepower), ln(airbags), ln(engine), ln(GVW) and ln(seats) as explanatory variables of price in the third regression. Regression 5 is the same as Regression 4, plus the number of registered cars of the same importer as car *j* and the sum of the same characteristics by the importer of car *j*. Dummies for year include dummies for 2009, 2010, 2011, 2012, and 2013. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The share in the segment (σ) in all specifications is positive and less than 1, which is consistent with theory. The results of the 2SLS regressions and the 3SLS regressions (Columns 2–5) suggest that market share in the segment has less of an effect than the OLS regression results. In other words, in the OLS estimation, the effect of market share in the segment has a positive bias. The specifications that include the number of other car models from the same importer and the sum of their characteristics (Columns 3 and 5) resulted in a higher effect of market share in the segment than specifications that do not include instruments (Columns 2 and 4). The estimated price effect (Columns 1–5) suggests that price has a negative and significant effect on demand. As mentioned previously, there may be a correlation between price and unobserved error. The 3SLS regressions (Columns 4 and 5), which suggest a solution to this problem of price, estimate a higher price effect. The emissions level base has a significant and negative effect on the market share of a model in all specifications. This suggests that, when all other variables are held constant, the consumer will prefer greener cars.

Variables related to the size and power of the car did not give consistent results. The effect of horsepower is positive and significant, as one might expect, in the OLS and second 3SLS specifications (Columns 1 and 5), but negative and significant in the 2SLS regressions (Columns 2 and 3). The effect of engine size is positive and significant in the 2SLS and second 3SLS specifications, but not in the OLS specification. Finally, the effect of gross vehicle weight (GVW) is positive and significant, as one could expect, in the OLS and second 3SLS specifications (Columns 1 and 5), but negative and significant in the 2SLS regressions and the first 3SLS specification (Columns 2 and 4).

In order to examine these inconsistencies, I prepared a *Variance inflation factor* (VIF) test for revealing multicollinearity between these variables. The test did not find a variable with a VIF score higher than 10, a score that indicates suspicion of multicollinearity (the VIF score for horsepower is 6.69, for engine power 5.44, for GVW 3.65, and for car efficiency 1.59), and found that the average VIF score is 2.85 (lower than 6, which is considered a limit for suspicion). Moreover, the tolerance is not unusual, and higher than 0.1 for all variables. I also try different specifications with different combinations (removing one, two or three variables), but those tests did not lead to consistent results. This inconsistency may be explained by the price endogeneity problem that had been solved in the full 3SLS specifications (Column 5).

Another variable that is not consistent with expectations is fuel price. I expect that an increase in fuel price will lower the demand for cars, but the results are opposite and significant. I believe that the reason for that is due to depression expectations, which may be negatively correlated with fuel price. When running the same regressions without observations from 2008, the coefficient of fuel price is positive but not significant, and when running them only between 2011 and 2014, the coefficient is negative and significant, as expected.

Consistent with the expectations for all specifications, the market share of a model is positively correlated with the fuel efficiency of the car, the safety level, the number of seats, and automatic transmission. Consumers also appear to prefer a four-door model to the three- or five-door models.

The ability of the variables to explain the market share of a specific model is limited with respect to the data size. Thus, the R^2 (the basic and the adjusted) of the OLS regression is 0.55. A possible explanation of this limitation is that the choice of a car model depends on many unobserved variables and on personal taste. For example, the choice of a car model depends, among other things, on the model's design and image. It should be noted that the variables are more effective in explaining the model price than in explaining market share. Thus, the R^2 of specification, where the price is on the left side of the equation and the other explanatory variables are on the right side, is 0.84. Other papers that use the nested logit model to estimate the car market can be divided as follows: Some of them did not present the R^2 score (e.g. Adamou, Clerides and Zachariadis, 2014; Christodoulou and Clerides, 2012; Fershtman and Gandal, 1998), and others suggest a similar score to our finding. For example, Berry, Levinsohn and Pakes (1995) suggest an R^2 score of 0.39 in their OLS model result, and a higher level can be found in Mehlin and Vance (2009), who found an R^2 score of 0.65. Nevertheless, I tried some other variables and alternative variables (such as ABS system in the car, sunroof and magnesium wheels) that did not generate a higher R^2 score. It should be noted that I do not present the R^2 score in the 2SLS or 3SLS results, such that the meaning of this indictor is limited and does not vouch for the quality of the explanation.

I believe that the 3SLS all IV regression (Column 5) is best suited for describing the market. First, it includes solutions for the endogeneity problem I presented. Second, it includes the importer effect on market share in the segment. Third, it produces reasonable results for the effect of engine and weight. The following estimations, tables and simulation therefore use this specification.

The results presented in Table 4 can only offer us a sense of the effects of different characteristics of a car model on its market share. More detailed results cannot be easily shown according to the structure of the econometric model. First, the model is not linear, and second, as mentioned in the model description, changing one characteristic of a car model (e.g. reducing price) would lead to a change in all car models relative to their segment and market share. The elasticity of price, for example, is determined by the following rule:

$$\eta_{jk} = \frac{\partial s_j}{\partial p_k}\frac{p_k}{s_j} = \begin{cases} -\alpha p_j[1-\sigma\bar{s}_{j/g}-(1-\sigma)s_j]/(1-\sigma) & if\ \ j=k \\ \alpha p_k[\sigma\bar{s}_{k/g}+(1-\sigma)s_k]/(1-\sigma) & if\ \ j,k\in g \\ \alpha p_k s_k & otherwise \end{cases}$$

where η_{jk} is the price elasticity between model j and model k, s_j is the market share of model j, p_k is the price of model k, α is the price indicator, σ is the model share in the segment indicator, and g is a segment. If $k_1 \& j \in g, k_2 \in g', s_{k_1} = s_{k_2}, p_{k_1} = p_{k_2}$, then $\eta_{jk_1} > \eta_{jk_2}$, meaning that the cross-price elasticity of two products in the same group is higher than the cross-price elasticity of two products in different groups, all else being equal.

Table 5 shows the elasticity of the bestselling model for January 2014 (out of 176 model samples) with regard to price and the results from the last regression presented in Table 3 (3SLS all IV). Similar tables can be built for other months or other explanatory variables. In Column 1, Row 1 (Table 5) of the results, we can observe the elasticity of the Toyota Corolla to its own price. In Column 1, Row 2 of the results, we observe the elasticity of the Toyota Corolla with respect to the price of the Kia Picanto. In Column 2, Row 1 of the results, we observe the elasticity of the Kia Picanto with respect to the price of the Toyota Corolla. For example, an increase of 5% in the price of the Toyota Corolla could reduce its market share by 9.1 percent and increase the market share of the Kia Picanto by 0.07 percent. The full results (which do not appear in this paper) are that a 5 percent increase in the Toyota Corolla price could reduce its registration numbers in January 2014 by 277 (1,629 to 1,352) and increase other models' registrations by 68. This means that 209 consumers would choose the "outside goods" and would not buy a new car. According to the positive estimation of the effect of market share in the segment (σ), we can see that the elasticity of a model to other models' prices is greater when the other model is from the same segment, as theory suggests. For example, the elasticity of the Kia Picanto is smaller than the elasticity of the Mazda 3 regarding the price of the Toyota Corolla.

Table 5: Price elasticities of the best-selling models

Model	Segment	Elasticity of the car model												
		Corolla	Picanto	Mazda 3	Space Star	SX4	I20	I35	Mazda 2	Micra	I30	CX5	Impreza	SX4
Toyota Corolla (GLI, 1598, 4 Doors)	compact	**-1.819**	0.013	0.045	0.045	0.045	0.045	0.045	0.013	0.013	0.045	0.013	0.045	0.045
Kia Picanto (EX, 1248, 5 Doors)	mini	0.004	**-1.075**	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Mazda 3 (Comfort, 1496, 4 Doors)	compact	0.020	0.006	**-1.873**	0.020	0.020	0.020	0.020	0.006	0.006	0.020	0.006	0.020	0.020
Mitzubishi Space Star (Instyle, 1193, 5 Doors)	compact	0.012	0.004	0.012	**-1.134**	0.012	0.012	0.012	0.004	0.004	0.012	0.004	0.012	0.012
Suzuki SX4 (GLX, 1586, 5 Doors)	compact	0.015	0.005	0.015	0.015	**-1.705**	0.015	0.015	0.005	0.005	0.015	0.005	0.015	0.015
Hyundai I20 (Insight, 1396, 5 Doors)	compact	0.011	0.003	0.011	0.011	0.011	**-1.391**	0.011	0.003	0.003	0.011	0.003	0.011	0.011
Hyundai I35 (Inspire, 1591, 4 Doors)	compact	0.014	0.004	0.014	0.014	0.014	0.014	**-1.821**	0.004	0.004	0.014	0.004	0.014	0.014
Mazda 2 (Dynamic, 1498, 5 Doors)	small	0.004	0.004	0.004	0.004	0.004	0.004	0.004	**-1.544**	0.041	0.004	0.004	0.004	0.004
Nissan Micra (Visia, 1198, 5 Doors)	small	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.034	**-1.398**	0.003	0.003	0.003	0.003
Hyundai I30 (Inspire, 1591, 5 Doors)	compact	0.012	0.004	0.012	0.012	0.012	0.012	0.012	0.004	0.004	**-1.809**	0.004	0.012	0.012
Mazda CX5 (Eexcutive, 1998, 5 Doors)	suv	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	**-2.322**	0.005	0.005
Subaru Impreza (1.6I, 1600, 4 Doors)	compact	0.012	0.003	0.012	0.012	0.012	0.012	0.012	0.003	0.003	0.012	0.003	**-1.808**	0.012
Suzuki SX4 (GLX, 1586, 4 Doors)	compact	0.010	0.003	0.010	0.010	0.010	0.010	0.010	0.003	0.003	0.010	0.003	0.010	**-1.696**
Kia Forte (EX, 1591, 4 Doors)	compact	0.009	0.003	0.009	0.009	0.009	0.009	0.009	0.003	0.003	0.009	0.003	0.009	0.009
Kia Rio (LX, 1396, 4 Doors)	compact	0.008	0.002	0.008	0.008	0.008	0.008	0.008	0.002	0.002	0.008	0.002	0.008	0.008
Ford Focus (Sport, 1596, 5 Doors)	compact	0.009	0.003	0.009	0.009	0.009	0.009	0.009	0.003	0.003	0.009	0.003	0.009	0.009
Kia Sportage (LX, 1998, 5 Doors)	suv	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.041	0.003	0.003
Honda Civic (Sport, 1798, 5 Doors)	compact	0.009	0.003	0.009	0.009	0.009	0.009	0.009	0.003	0.003	0.009	0.003	0.009	0.009
Nissan Juke (Tekna, 1598, 5 Doors)	compact	0.009	0.003	0.009	0.009	0.009	0.009	0.009	0.003	0.003	0.009	0.003	0.009	0.009
Chevrolet Cruze (LT, 1598, 4 Doors)	compact	0.008	0.002	0.008	0.008	0.008	0.008	0.008	0.002	0.002	0.008	0.002	0.008	0.008
Suzuki Alto (GLX, 996, 5 Doors)	mini	0.001	0.015	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Hyundai I25 (Inspire, 1368, 4 Doors)	compact	0.007	0.002	0.007	0.007	0.007	0.007	0.007	0.002	0.002	0.007	0.002	0.007	0.007
Skoda Octavia (Ambition, 1197, 5 Doors)	medium	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Opel Astra ST (Enjoy, 1362, 5 Doors)	compact	0.007	0.002	0.007	0.007	0.007	0.007	0.007	0.002	0.002	0.007	0.002	0.007	0.007

Table 6 summarizes the car model price elasticity of demand by segment for January 2014. We do not present the elasticity for the luxury segment due to the low number of models. In the first column we present the average price elasticity of demand by segments. As we see, the highest average price elasticity is in the SUV segment. On average, a price increase of 1 percent would reduce the market of an SUV car by 2.67 percent. The price elasticity in the compact segment ranged between 0.96 percent and 3.14 percent with an average of 1.77 percent. Low average price elasticity can be found in the mini segment (1.05 percent) and the small segment (1.45 percent).

Table 6
Price elasticities by segment

	Average own price elasticity of demand	Minimum own price elasticity of demand (absolute terms)	Maximum own price elasticity of demand (absolute terms)
Segment:			
Mini	-1.05	-0.77	-1.68
Small	-1.45	-1.06	-2.29
Compact	-1.77	-0.96	-3.14
Medium	-2.31	-1.67	-3.74
Large	-2.70	-2.24	-3.38
SUV	-2.67	-1.75	-5.08
Total	-1.81	-0.77	-5.08

Table 7 presents the price elasticity of segments and the price elasticity across segments for January 2014. Column 1, Row 1 (Table 7) of the results shows the elasticity of the mini segment to price change in that segment, and Column 2, Row 1 shows the elasticity of the mini segment to a price change in the small segment. Row 3, Column 1 shows the elasticity of the compact segment to a price change in the mini segment. For example, a possible price increase of 1 percent on all models belonging to the mini segment decreases the market share of those models by 0.92 percent and increases the market share of other segments by 0.01 percent. A price increase of 1 percent on all models belonging to the compact segment increases the market share of cars belonging to the mini segment by 0.1 percent. The compact segment has the biggest influence on other segments. Moreover, in each segment the influence on all other segments is equal. This is as outcome of the nested logit model construction.

Table 7
Cross price elasticities by segment

Segment:	Mini	Small	Compact	Medium	Large	SUV
Mini	-0.92	0.01	0.01	0.01	0.01	0.01
Small	0.02	-1.24	0.02	0.02	0.02	0.02
Compact	0.10	0.10	-1.43	0.10	0.10	0.10
Medium	0.02	0.02	0.02	-1.99	0.02	0.02
Large	0.00	0.00	0.00	0.00	-2.50	0.00
SUV	0.03	0.03	0.03	0.03	0.03	-2.29

4. MODEL SIMULATION

a. General

This section of the paper presents several different simulations based on the results obtained in the analyses presented above. The simulations are based on the results of the 3SLS all IV regression presented in Table 4, Column 5, and which were discussed in detail in the estimation section. In the simulations, I examined the effect of changing the tax regime on the following: the number of cars purchased; the market structure subject to the model's segment; the aggregate and average emissions levels; and the aggregate and average revenues from taxes. The results are from the period between September 1, 2013 and the end of August 2014. In other words, I simulated the new car market between September 2013 and August 2014 under different tax regimes. In the analysis, I used the assumption that the entire tax gap between the two tax regimes is passed on to the consumers.

The choice of this period (September 2013 to August 2014) was not random. I chose this period for the following reasons: a) The updated formula for green taxation became effective in August 2013, and I preferred not to use the first month following the update, as consumers could have preferred to buy a new car earlier to avoid paying more taxes, which I assume would mainly affect the following month; b) This 12-month period could be referred to as a full year; and c) August was the last recorded data available. I believe that results for this period can help us to better understand the influence of different taxation levels and methods on the future Israeli market, and maybe on other markets as well.

To change the tax regime, I first needed to know the purchase tax of each car. Unfortunately, this information is not published, so I had to use the following assumption to calculate it: The importer's share of the price is fixed and equal to 35 percent of the price of the car before the purchase tax (after customs), and includes the green rebate (and the customs levy if needed). I also had to consider the rebate for safety accessories, which is between 0 and NIS 2,250 (like the green rebate), as well as the luxury tax. This luxury tax, first introduced in September 2013, is a tax on new luxury cars. The purchase tax level of a car model with a final consumer price of NIS 300,000 or more (including VAT) is 83 percent, plus 20 percent of the final price above NIS 300,000, divided by the final price.

For example, a car model that costs NIS 1 million is taxed at 83%+0.2*(1,000,000-300,000)/1,000,000 = 97% without the green or safety accessory rebates.

Table 8 shows the number of cars purchased, the total import price, and the tax revenues of cars purchased between September 2013 and August 2014. Column 1 presents the results of the dataset, and Column 2 presents the results of the dataset weighted by the full number of cars purchased in this period according to the Israel Vehicle Importers Association (the data source). As stated above, I needed to assume the importer's share of the price to calculate the real purchase tax. To see whether the assumption was logical, I wanted to compare it to information from the Israel Tax Authority regarding revenues from purchase taxes on cars. However, I was not able to gain access to revenues for the period of investigation. Therefore, as a proxy, I used the tax revenues for 2014 (the full year). Column 3 presents these aggregates and Column 4 shows the difference between the weighted dataset results and the Israel Tax Authority data.

Table 8
Basic data

	Base data September 2013 to August 2014	Extrapolation data September 2013 to August 2014	Tax Authority data January 2013 to December 2013	Difference between (2) & (3)
	(1)	(2)	(3)	(4)
Cars purchased	199,354.0	210,334.0	225,297	7.1%
Total import value (NIS million)			11,812	
Total customs revenues (NIS million			316	
Total import value and customs revenues (NIS million)	10,942.4	11,545.0	12,128	5.0%
Average purchase tax (NIS)	32,182.7	32,182.7	31,271	-2.8%
Total purchase tax revenues (NIS million)	6,415.7	6,769.1	7,045	4.1%

Notes: The results of the simulation based on the car market between September 2013 and August 2014. In our dataset we managed to observe 94.5 percent of the market as defined by the Israel Vehicle Importers Association. The weighted results are the basic results multiplied by 1.055078. The Tax Authority data are based on taxes and data on the car market in the year 2013 as published by the Israel Tax Authority.

As Table 8 shows, I analyzed data on 199,354 new private cars purchased between September 2013 and August 2014. The original data, prior to aggregation and removing cars with small market shares, included 210,334 new private cars, meaning that I was left with 94.8 percent of the original dataset (not including small vans, vans and pickups). The total import value and customs cost was NIS 10,942 million. The average purchase tax was NIS 32,182.7 and the total purchase tax revenue was NIS 6,415.7 million. Comparing the weighted results with the Tax Authority results shows several differences: a difference of

7.1 percent in the number of cars purchased, a difference of 5.0 percent in total import value and customs, and a difference of 4.1 percent in total purchase tax revenues. These differences may seem high, but it should be noted that the period is different and there may be different car types included in the dataset. The average purchase tax is higher in the dataset, which is logical with the change in the formula for calculating the green rebate and the final purchase tax.

b. Changes in tax level

In the first simulation, I simulated different purchase tax levels. As mentioned in the overview of the policy section (Section 3), the base purchase tax rate is equal to 83 percent without the green car rebate (we kept the tax level constant for hybrid cars). This tax level could raise the question of whether by reducing the tax level the government could raise the base tax, which would eventually lead to an increase in purchase tax revenue. The following analysis attempts to answer this question.

Table 9 presents the results of the first simulation. Every column shows the effect of the introduction of a different purchase tax level on the market. The table shows that increasing the purchase tax by 2 percent (Column 4) reduced the number of cars purchased by 3,063 (1.6 percent). Most of the differences are seen in the compact segment, which was reduced by 1,711 cars (1.6 percent). The average green score declined slightly. The average purchase tax increased from NIS 32,182.7 to NIS 33,142.8, and purchase tax revenues increased by 1.4 percent, meaning that a small increase in the tax rate increases the revenues but reduces the tax base. Total tax revenues (purchase tax and VAT), increased from NIS 10,227.2 million to NIS 10,290.0 million (0.6 percent). The increase in total tax revenues is smaller than the increase in purchase tax revenues. The reason is that VAT revenues decline with the number of cars purchased, which makes total tax revenues more sensitive than purchase tax revenues to the number of cars purchased.

This result raises a question: At what point is the change in purchase tax level great enough to decrease total revenue (the peak of the Laffer Curve)? Figure 1 presents the results for purchase tax revenues, VAT revenues, and total tax revenues. The maximum purchase tax revenues are generated at the 109 percent tax level. At this point (point A in the figure), purchase tax revenues total NIS 7,017.9 million, overall tax revenues total NIS 10,373.9 million, and the number of cars purchased is 159,535. However, this point does not maximize total tax, which includes purchase tax and VAT. VAT revenue decreases with an increase in purchase tax. Therefore, the optimal point is a 99 percent purchase tax level (point B in the graph), which generates revenue of NIS 6,931.5 million from purchase tax and total tax revenue of NIS 10,488.8 million, with 174,849 cars purchased. Figure 2 presents the total tax revenue (the left axis) and the level of tax on the final price (the right axis). The optimal point (B) is equivalent to 44.98 percent of the final price.

Table 9
Simulation 1 - The car market under different tax rates

	Purchase tax level					
	70% (1)	80% (2)	83% (base) (3)	85% (4)	90% (5)	100% (6)
Cars purchased						
Total	**219,265**	**203,949**	**199,354**	**196,291**	**188,634**	**173,318**
By segment:						
Mini	28,282	26,993	26,606	26,348	25,704	24,415
Small	24,722	23,317	22,896	22,615	21,913	20,508
Compact	121,361	112,804	110,237	108,526	104,246	95,687
Medium	17,787	16,432	16,025	15,754	15,076	13,721
Large	1,858	1,673	1,617	1,580	1,487	1,301
SUV	24,935	22,407	21,649	21,144	19,882	17,356
Green indicators						
Average green score	**166.1**	**165.6**	**165.5**	**165.4**	**165.1**	**164.4**
Total green score	**36,420,084**	**33,778,595**	**32,986,318**	**32,458,173**	**31,137,794**	**28,496,892**
Average emissions level	5.5	5.4	5.4	5.4	5.4	5.3
Total emissions level	1,203,371	1,110,394	1,082,506	1,063,921	1,017,454	924,506
Emissions						
Average CO_2	137.5	137.1	137.0	136.9	136.7	136.2
Total CO_2	30,156,913	27,970,169	27,314,219	26,877,014	25,783,865	23,597,337
Average CO	0.3	0.3	0.3	0.3	0.3	0.3
Total CO	74,868	69,640	68,071	67,025	64,411	59,181
Average NO_x	0.0	0.0	0.0	0.0	0.0	0.0
Total NO_x	3,862	3,565	3,476	3,417	3,269	2,973
Average HC	0.04	0.04	0.04	0.04	0.04	0.04
Total HC	8,432	7,837	7,659	7,540	7,242	6,647
Average PM	0.00	0.00	0.00	0.00	0.00	0.00
Total PM	28.9	26.4	25.6	25.1	23.9	21.3
Revenue						
Average purchase tax revenue	25,788.4	30,729.8	32,182.7	33,142.8	35,511.1	40,089.9
Total purchase tax revenue (NIS million)	5,654.5	6,267.3	6,415.7	6,505.6	6,698.6	6,948.3
Total revenue: purchase tax plus VAT (NIS million)	**9,611.0**	**10,117.1**	**10,227.2**	**10,290.0**	**10,409.2**	**10,486.9**

Notes: The results of the simulation based on the 3SLS all IVs regression (Column 5 in Table 3). These results reflect a simulation of the private car market between September 2013 and August 2014, subject to different purchase tax regimes. The luxury segment is not presented due to the small number of registrations.

Figure 1: Revenues from Purchase Tax, VAT and Total Tax

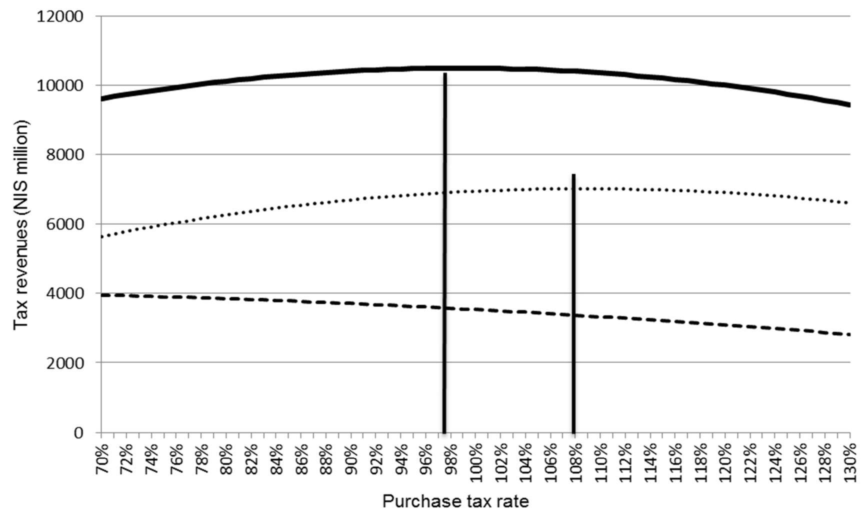
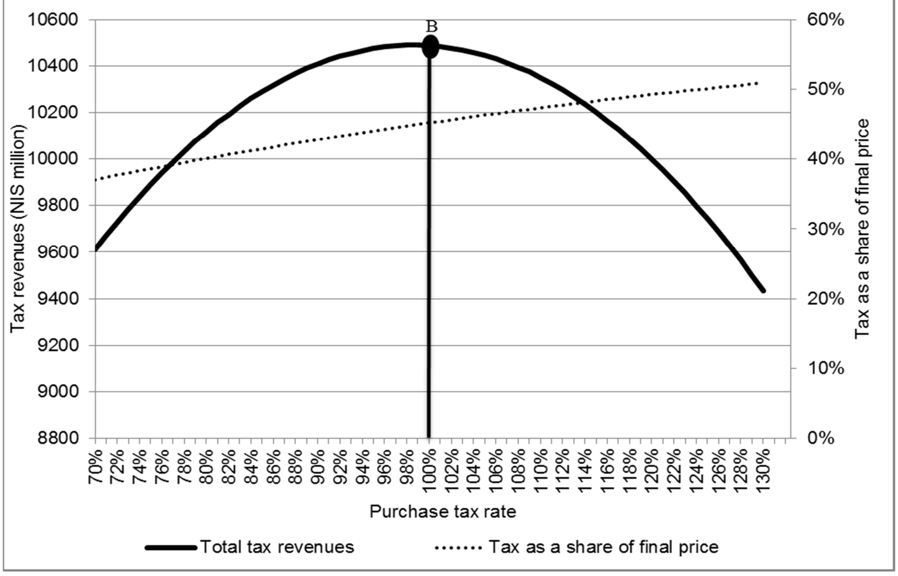


Figure 2: Total Tax Revenues and Tax as a Share of Final Price



c. Green Tax Reform

In this section I simulate the alternative costs of the green rebate scheme and the effect of changing the green score scheme. Each simulation presents the base data between September 2013 and August 2014, the effect of changing the base, and Hicksian compensated price changes. I do the last by preserving the public utility. However, there are three different factors that are connected to the public utility. Therefore, each simulation presents a compensated analysis for each factor. The first factor is the number of new cars purchased, the second is the amount of emissions, and the last is tax revenues. The public utility from new cars can be split into two parts: the number of new cars and their quality. By changing the tax regime, I can change the number of cars as well as the bundle of cars that are chosen by all consumers. While the former is easy to measure, the latter is much more complicated and perhaps even impossible to measure. Thus, I will focus only on the number of new cars. It can be said that more cars are better for the public, when all other factors are held constant. The amount of emissions can be split into five types, which are also used to determine the green score, CO_2, CO, HC, NO_x and particulate matter (PM). While I report each one separately, the aggregate makes up the green score. In the analysis, the lower the total green score, the higher the public utility. The last dimension is revenue from taxes, which can be used for the public good. Thus, higher tax revenues lead to greater public utility.

In the second (overall) simulation, I examined the alternative costs of the green rebate scheme. Column 1 in Table 10 presents the base results (the market between September 2013 and August 2014, as in Table 8), while Column 2 contains the results in a world without a rebate and with an 83 percent purchase tax. The number of cars purchased drops from 199,354 to 166,903 (a decrease of 16.3 percent). The average green score increases, from 165.5 to 166.7, but the total green score decreases due to the reduced number of cars purchased. Total tax revenues increase significantly, from NIS 10,227.2 million to NIS 10,801.8 million. In Column 3, there is no rebate but the number of cars purchased remains the same as in the base results, which was accomplished by lowering the purchase tax to a rate of 61.79 percent. In this scenario, we have a more polluted world than in the base results (total green score of 33.42 million instead of 32.98 million), but with more tax revenues (NIS 10,450.0 million instead of NIS 10,227.2 million). In Column 4, I kept the same green score as the base results, which led to greater revenue but fewer cars, and in Column 5, I maintained the same tax revenues as the base results, which resulted in more cars purchased but a greater amount of pollution.

Table 10
Simulation 2 - The Impact of Abolishing the Green Rebate

	Base (1)	Without rebate (2)	Without rebate same number of cars purchased (3)	Without rebate same total green score (4)	Without rebate same total revenues (5)
Purchase tax	83%	83%	61.79%	63.46%	56.80%
Rebate	Yes	No	No	No	No
Cars purchased					
Total	**199,354**	**166,903**	199,354	**196,797**	**206,997**
By segment:					
Mini	26,606	21,134	23,868	23,652	24,512
Small	22,896	18,685	21,665	21,430	22,367
Compact	110,237	91,701	109,819	108,390	114,097
Medium	16,025	13,788	16,663	16,436	17,340
Large	1,617	1,543	1,937	1,906	2,030
SUV	21,649	19,721	25,079	24,658	26,329
Green indicators					
Average base green score	**165.5**	**166.7**	**167.7**	**167.6**	**167.8**
Total green score	**32,986,318**	**27,830,601**	**33,427,100**	**32,986,318**	**34,744,255**
Average base emissions level	5.4	5.7	5.7	5.7	5.7
Total emissions level	1,082,506	944,833	1,141,849	1,126,343	1,188,129
Emissions					
Average CO_2	137.0	137.8	138.6	138.6	138.8
Total CO_2	27,314,219	23,007,175	27,640,441	27,275,490	28,731,004
Average CO	0.34	0.34	0.34	0.34	0.34
Total CO	68,071	57,241	68,327	67,453	70,939
Average NO_x	0.017	0.018	0.018	0.018	0.018
Total NO_x	3,476	3,025	3,654	3,604	3,801
Average HC	0.038	0.039	0.039	0.039	0.039
Total HC	7,659	6,432	7,691	7,592	7,988
Average PM	0.000	0.000	0.000	0.000	0.000
Total PM	25.6	21.5	26.9	26.5	28.2
Revenue					
Average purchase tax revenue	32,182.7	43,408.0	32,897.2	33,749.6	30,328.6
Total purchase tax revenue (NIS million)	6,415.7	7,244.9	6,558.2	6,641.8	6,277.9
Total revenue: purchase tax plus VAT (NIS million)	**10,227.2**	**10,801.8**	**10,450.0**	**10,512.5**	**10,227.2**

Notes: The results of the simulation based on the 3SLS all IVs regression (Column 5 in Table 3). These results reflect a simulation of the private car market between September 2013 and August 2014, subject to different purchase tax regimes. The luxury segment is not presented due to the small number of registrations.

This analysis, however, doesn't answer the question of whether the rebate scheme pays off from an economic point of view. As was described in the literature review section, the Feebate scheme was introduced in several countries, and in some of them the cost of the program was higher than expected, so that the program was not profitable when compared to the cost of emissions that were saved. In Israel, as well as in other countries, the government quantifies the pollution cost for decision-making. Others use pollution quotas that can be traded in the markets. To answer this question, I expand the results of a world without a rebate but with a purchase tax of 61.79 percent, which has the same increase in number of cars purchased (Table 10, Column 3).

The gap between the tax revenue is the alternative cost of the program, and the gap between the different emissions is the benefit of the program. To calculate the cost of the additional externalities of emissions, I used the estimated costs from the Israeli Ministry of Environmental Protection regarding the additional externalities of air pollutants and greenhouse gases. This estimation is based on the Impact Pathway Approach (European Commission, 1998), which considers the increase in emission concentrations at different sites, its impact on public health, and the valuation of the health costs. The cost label in Israel for HC, NO_x, CO and PM is the average between the Benefit-Transfer method and Dose-Response method adjusted to Israel's population dispersion and urbanization. The CO_2 cost is calculated on the basis of the average between prevention cost in Europe (Maibach et al., 2008) and the prevention cost in United States (Greenstone et al., 2011). As mentioned, these are also used also to determine the green score.

Table 11 presents the cost estimation per ton of emission. On that basis I compute the cost using the green score, which is equal to the emission externality cost of 10,000 km of driving, and determine the average distance a new car drives during its lifespan. For the latter, I consider two options shown in Table 12. The first follows Adamou, Clerides and Zachariadis (2014), who use an estimation of 200,000 km, and the second is 400,000 km, which can also be used as an upper limit. I also present the average distance driven per year by a private car in Israel (Central Bureau of Statistics, 2014).

Table 11
Emissions cost per ton

Emission	Cost per ton 2013 (NIS)	Cost per ton 2013 ($)
CO_2	103	28.8
CO	1,042	291.2
NO_x	75,461	21,090.9
HC/VOC	21,454	5,996.3
PM2.5	14,577.2	40,742.3

Notes: The costs published by the Israeli Ministry of Environmental Protection. The exchange rate is the average exchange rate in 2014.

Table 12
Emission Savings Externality

Period	Travel distance of new car	Emission gap cost (NIS million)	Emission gap cost ($ million)	Profit (NIS million)	Profit ($ million)
Year	37,787 km	1.67	0.47	-221.05	-61.78
Car Life (low)	200,000 km	8.82	2.46	-213.90	-59.79
Car Life (high)	400,000 km	17.63	4.93	-205.09	-57.32

Notes*:* The gap is the difference between Columns 3 and 1 in Table 7. The exchange rate is the average exchange rate in 2014.

As Table 12 shows, the program is not cost effective from a government budget perspective if the emission externalities are valued by the prices shown in Table 11. The emissions savings externality from the green scheme is between NIS 8.82 million and NIS 17.63 million depending on the lifespan of the new car, and the lost revenues are NIS 222.7 million. In this scheme saving one shekel in emission externalities requires an investment of between NIS 12.63 and NIS 133.39.

As mentioned before, in most countries the Feebate scheme is focused only on lowering CO_2 emissions. In the results, the cost saving of 1 ton of CO_2, when the average car travels 400,000 km is NIS 1,706 or $477. The value for public decision making in Israel is only $28.8.

d. Influence of updating the Green Score

The final simulation examines the effect of the green score update that took place in January 2015. As mentioned, the Israel Tax Authority decided to change the green score due to changes in the estimated emissions cost, as well as other reasons, to make it harder to have a high emissions level. The new formula is as follows:

$$GreenScore = \frac{110 * CO2 + 80{,}978 * NOx + 23{,}023 * HC + 1{,}119 * CO + 156{,}428 * PM}{100}$$

This means that each emission effect is increased by about 7 percent. Raising the green score affects the rebates differently, depending on the old emissions level. Rebates for cars with a relatively low emissions level and those with a relatively high emissions level didn't change much, while rebates for cars with middle emissions levels were reduced. The Tax Authority explained this update as a measure to encourage an increase in the market share of “green” cars, technological changes in the car industry, and a decrease in tax revenues. Due to exogenous changes in market, it was important to check what would happen in the market if the same update had been introduced between September 2013 and August 2014.

Column 1 in Table 13 contains the base results, while Column 2 shows the results if the update had been in effect between September 2013 and August 2014. The number of cars purchased is reduced from 199,354 to 194,225 (2.6 percent) and total revenue is increased from NIS 10,227.2 million to NIS 10,350.1 million (1.2 percent). This result is consistent with the fact that the new green score scheme is less generous with new car buyers (i.e. it is harder to get a "good" green score to benefit the consumers).

I also report the base (before the update) and updated green score results. The average and total green scores are reduced, meaning that the update would encourage consumers to buy a greener car. The total CO_2 level is decreased by 2.8 percent, total CO is decreased by 2.8 percent, total NO_x is decreased by 2.2 percent, total HC is decreased by 2.8 percent, and total PM is decreased by 2.2 percent. In summary, the new scheme reduces both the number of cars and emissions.

In the next three columns in Table 13 (3–5), I examine alternative regimes that can produce the same result as the update by changing the purchase tax and leaving the green score scheme the same. Column 3 shows the results of a simulation that produced the same number of cars purchased as the update. Column 4 shows a simulation that produces the same green score and Column 5 has the same revenues from purchase tax. The results show that increasing the purchase tax by 3.35 percent instead changing the scheme could result in a small decrease in the number of cars, preserve a similar overall green score, and reduce the tax revenue. In other words, similar results can be achieved in terms of emissions and number of cars, but only at the cost of reducing tax revenues. Trying to maintain the tax revenues (Column 5) will decrease the number of new cars in the market. All in all, one cannot produce a similar result by replacing the scheme with an increase in purchase tax.

Table 13
Simulation 3 - Updated green score and alternatives

	Tax Regime				
	Base regime (1)	Updated regime (2)	Base regime with updated number of cars purchased (3)	Base regime with updated green score (4)	Base regime with updated revenues (5)
Purchase tax	**83.00%**	**83.00%**	**86.35%**	**86.33%**	**87.24%**
Cars purchased					
Total	**199,354**	**194,225**	**194,225**	**194,252**	**192,856**
By segment:					
Mini	26,606	26,326	26,174	26,177	26,059
Small	22,896	22,421	22,425	22,428	22,300
Compact	110,237	106,896	107,371	107,386	106,606
Medium	16,025	15,559	15,571	15,573	15,450
Large	1,617	1,597	1,555	1,555	1,538
SUV	21,649	21,100	20,803	20,808	20,578
Luxury	324	325	325	325	325
Green indicators					
Average old green score	165.5	165.3	165.3	165.3	165.2
Total old Green Score	32,986,318	32,099,889	32,101,780	32,106,506	31,865,852
Average new green score	177.7	177.5	177.4	177.4	177.4
Total new Green Score	35,416,627	34,469,199	34,464,109	34,469,199	34,210,050
Average old emission level	5.4	5.4	5.4	5.4	5.4
Total old emission level	1,082,506	1,055,144	1,051,378	1,051,544	1,043,075
Average new emission level	6.8	6.8	6.8	6.8	6.8
Total new emission level	1,352,907	1,313,823	1,314,300	1,314,506	1,304,003
Emissions					
Average CO_2	137.0	136.8	136.9	136.9	136.8
Total CO_2	27,314,219	26,571,358	26,581,957	26,585,870	26,386,632
Average CO	0.3	0.3	0.3	0.3	0.3
Total CO	68,071	66,205	66,319	66,329	65,852
Average NO_x	0.017	0.018	0.017	0.017	0.017
Total NO_x	3,476	3,402	3,377	3,378	3,351
Average HC	0.038	0.038	0.038	0.038	0.038
Total HC	7,659	7,447	7,460	7,461	7,406
Average PM	0.00	0.00	0.00	0.00	0.00
Total PM	25.6	25.1	24.8	24.8	24.6
Revenue					
Average purchase tax revenue	32,182.7	33,865.6	33,786.6	33,778.1	34,211.0
Total purchase tax revenue (NIS million)	6,415.7	6,577.5	6,562.2	6,561.5	6,597.8
Total revenue: purchase tax plus VAT (NIS million)	**10,227.2**	10,350.1	10,327.4	10,327.0	6,597.8

Notes: The results of the simulation based on the 3SLS all IVs regression (Column 5 in Table 3). These results reflect a simulation of the private car market between September 2013 and August 2014, subject to different purchase tax regimes. The luxury segment is not presented due to the small number of registrations.

e. Discussion

The main results from the different simulations are that: a) reducing the tax level would not result in higher revenues; b) reducing the emission level through the green taxation scheme involves significant cost; and c) increasing the purchase tax level instead of updating the Green Score cannot produce a similar market where the emissions level, the number of new cars and tax revenues are the same or better. The following are some points that can be generated from these results.

The finding that the tax level does not pass the peak of the Laffer Curve shows that reducing the tax level would not increase tax revenues. Nevertheless, according to other results presented, there is a significant cost to the high tax level, which is reflected in its influence on the number of cars and therefore on the utility to consumers.

The relatively high cost of reducing emission levels through the feebate scheme should lead us to question whether this scheme is the best answer to the problem. The State of Israel has other tools that can reduce emission levels, which are not being used due to their budgetary cost. For example, the program offering a financial incentive to scrap old cars that are still functioning, although cost effective (Pareto Group, 2001; Bank of Israel, 2015), was cancelled due to budgetary constraints.

However, the analysis in this paper, which is based on the alternative cost, does not consider the transmission from used cars to new cars or the length of the car’s lifespan. Emissions are generally higher in old cars than in new cars. For example, the green score of a 2008 Mazda 3 is 47 points higher than the 2014 model using the same calculation method. Changing the purchase tax may encourage or discourage the consumer from replacing his car, thereby decreasing or increasing total emissions. The influence of increasing (or decreasing) the tax level on new cars on the total emissions of old cars is unclear. While increasing the tax on new cars makes them less attractive and therefore delays the replacement of old cars with newer cars, the rebate could encourage consumers to replace their larger old cars with smaller and less polluting vehicles. In other words, the scheme influences the lifespan and cumulative distance traveled of the vehicle, depending on the car type (in this paper the cumulative distance is an external variable). Therefore, it may influence the alternative cost.

This paper does not address the question of whether there is a tax model that can reduce total emissions without decreasing the number of cars in the market and without lowering tax revenues. It should be noted that the answer to this question is complex. In Israel there are 15 emission groups, and changing them would require a model with many brackets of different sizes, and with an upper limit to the highest bracket. Simple testing, such as increasing or reducing the rebate or cancelling some of the brackets did not lead to a solution. While it may be done, finding such a model exceeds the scope of this paper.

5. SUMMARY AND CONCLUSIONS

In this paper, I investigated the Israeli private car market and the influence of the green rebate program. First, I estimated the factors influencing the market share of different models, based on monthly data between January 2008 and August 2014. For this purpose, I used the nested logit model and regressed three different specifications that address the endogeneity problem with that model. I found that the price and emissions level of the car have a negative influence on the market share of a car model, while fuel efficiency and safety have a positive influence on market share.

Based on these results, I investigated the influence of different tax regimes on market equilibrium. I chose the period between September 2013 and August 2014 as a benchmark. First, I examined the influence of changing the purchase tax. I found that increasing the purchase tax reduces the number of cars purchased and total emissions, and increases the revenue from the tax. However, this effect was limited, as I found that the maximum revenue from the tax was generated at the 99 percent purchase tax level (before the green rebate), or 44.98 percent of the total average new car price (including VAT).

Second, I examined the effectiveness of the green rebate scheme. I found that the green rebate reduces total emissions but also reduces the number of car registrations, as well as revenues from the tax. When cancelling the green rebate and holding the number of cars purchased fixed (done by reducing the purchase tax), both emissions and revenues increased. I also found that the program is not profitable from a government budget perspective, and the cost is much higher than the benefit gained by reducing emissions. The cost of eliminating one ton of CO_2 is NIS 1,191 or US$ 332.85, for an upper limit of 400,000 km of driving distance. This amount is higher than the cost set by the Israeli Ministry of Environmental Protection as the basis for government decision-making.

Last, I examined the influence of the green rebate scheme update that took effect in January 2015. I found that this update had a similar effect to increasing the purchase tax by 3.35 percent.

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Appendix

This appendix presents the calculation method of the simulation.

Pc_{jt}	Original consumer price of car *j* at time *t*	Pi_{jt}	Importer price of car *j* at time *t*
V_t	Value added tax at time *t*	M	Lower bound for luxury tax. *M*=300,000
GRb_{jt}	Original green rebate on car *j* at time *t*	Tlb_{jt}	Purchase tax on car *j* at time *t* (%)
SR_{jt}	Safety rebate on car *j* at time *t*	$Electric_j$	= 1 if the car is an electric car = 0 otherwise
Is	Importer's share of import price. Assumption: *Is*=0.35	$Hybrid_j$	= 1 if the car is a hybrid car = 0 otherwise
Pn_{jt}	Consumer price of car *j* at time *t* after update of the tax regime	*Emission level j*	Emission level of car *j*
Tb_{jt}	Original purchase tax on car *j* at time *t* (NIS)	σ	Degree of substitution in nests
Tn_{jt}	Purchase tax on car *j* at time *t* following tax regime update (NIS)	g	Nest g
η_{jkt}	Price elasticity between car *j* and car *k* at time *t*	ΔS_{jt}	The difference in model *j*'s market share following the tax regime update.
a	Price coefficient	Nn_{jt}	Total number of cars of model *j* at time *t*, following tax regime update
K	Total number of cars of the model	HH_t	Number of households at time *t*

Import price of car *j* at time *t* equals:

$$Pi_{jt} = \begin{cases} \dfrac{\dfrac{Pc_{jt}}{1+V_t} + GRb_{jt} + SR_{jt}}{1 + Is + Tlb_{jt}}, & Pc_j < M \\[2ex] \dfrac{\dfrac{Pc_{jt}}{1+V_t} + GRb_{jt} + SR_{jt}}{1 + Is + Tlb_{jt} + 0.2 * (Pc_{jt} - M)/Pc_{jt}}, & Pc_j \geq M \end{cases}$$

where the purchase tax Tlb_{jt} is determined by:

$$Tlb_{jt} = \begin{cases} 8\%, & Electric_j = 1 \\ 30\%, & Electric_j = 0 \ and \ Hybrid_j = 1 \ and \ Emission\ Level_j = 2 \\ 83\%, & else \end{cases}$$

and equal to:

$$Tb_{jt} = \begin{cases} Pi_{jt} * Tlb_{jt} & , \quad Pc_{jt} < M \\ Pi_{jt} * \left(Tlb_{jt} + 0.2 * \frac{Pc_{jt} - M}{Pc_j t}\right) & , \quad Pc_{jt} \geq M \end{cases}$$

To estimate the purchase tax of car *j* at time *t* after the update of the tax, I need to split the tax into two options: 1) The car price was reduced and now the price is under the luxury tax ceiling; 2) The new price is higher than the luxury tax ceiling.

$$Tn1_{jt} = Tln_{jt} * Pi_{jt}$$
$$Tn2_{jt} = Tln_{jt} * Pi_{jt} + 0.2 * \frac{Pn2_{jt} - M}{Pn2_{jt}}$$

And the same for the consumer price:

$$Pn1_{jt} = \left(Pi_{jt} + Pi_{jt} * Il + Tn1_{jt} - GRn_{jt} - SR_{jt}\right) * (1 + V_t)$$
$$Pn2_{jt} = \left(Pi_{jt} + Pi_{jt} * Il + Tn2_{jt} - GRn_{jt} - SR_{jt}\right) * (1 + V_t)$$

The second option is equal to:

$$Pn2_{jt} = \frac{1+V}{2} * (Pi_{jt} + \quad Pi_{jt} * Il - GRn_{jt} - SR_{jt} + \sqrt{-0.8 * M(1 + V_t) + \left(\quad Pi_{jt} + \quad Pi_{jt} * Il - GRn_{jt} - SR_{jt} - 0.2\right)^2})$$

The updated purchase tax depends on the final price of the car

$$Tn_{jt} = \begin{cases} Tn1_{jt}, & Pn_{jt} < M \\ Tn2_{jt}, & Pn_{jt} \geq M \end{cases}$$

And the final price depends on the lower ceiling of the luxury tax.

$$Pn_{jt} = \begin{cases} Pn1_{jt}, & Pn1_{jt} < M \\ Pn2_{jt}, & Pn1_{jt} \geq M \end{cases}$$

The original price elasticity between car *j* and car *k* at time *t* is equal to:

$$\eta_{jkt} = \frac{\partial Sb_{jt}}{\partial Pc_{kt}} \frac{Pc_{kt}}{Sb_{jt}} = \begin{cases} -\frac{\alpha Pc_{jt}\left[1 - \sigma \bar{s}_{\frac{jt}{g}} - (1-\sigma) Sb_{jt}\right]}{1-\sigma} & if \;\; j = k \\ \frac{\alpha Pc_k \left[\sigma \bar{s}_{\frac{kt}{g}} + (1-\sigma) Sb_{kt}\right]}{1-\sigma} & if \;\; j,k \in g \\ \alpha Pc_{kt} Sb_{kt} & otherwise \end{cases}$$

On that basis, I calculated the change in the market share of car *j* at time *t*,

$$\Delta S_{jt} = \sum_{k=0}^{K} \eta_{jk} * (Pn_{jt}/Pb_{jt} - 1)$$

then:

$$Sn_{jt} = Sb_{jt} * (1 + \Delta S_{jt})$$

The total number of cars is equal to the shares of all cars multiplied by the entire market (estimate with the number of households):

$$Nn_{jt} = Sn_{jt} * HH_t$$

On the basis of number of cars from each model, the new purchase tax and the new price, I calculate the tax revenue in each month.

$$Total\ Revenue\ From\ Purchase\ Tax\ at\ Time\ t = \sum_{j=1}^{K} Nn_{jt} * Tb_{jt}$$

$$Total\ Revenue\ From\ Tax\ at\ Time\ t = \sum_{j=1}^{K} Nn_{jt} * Tb_{jt} + \sum_{j=1}^{K} Nn_{jt} * Pn_{jt} * (\frac{V_t}{1 + V_t})$$