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Accelerated vehicle retirement program: Estimating the optimal incentive payment in Israel

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ABSTRACT

The paper analyzes two main aspects of the accelerated vehicle retirement program in Israel: the optimal incentive payment of private cars, and the feasibility of expanding the program to include light commercial vehicles. The benefits are the reduction of pollutant emissions and safety benefits, which were compared to the costs of the incentive payment. A differential payment scheme for private vehicles according to the vehicle's age, is shown to have a higher net benefit than a uniform payment scheme. It is also found that the optimal payment is higher than the existing incentive payment. Additionally, it is found economically feasible to include light commercial vehicles in the program.

1. Introduction

Accelerated vehicle retirement programs (AVR), which are normally voluntary, encourage vehicle owners to retire their old, more polluting, less energy efficient, and less safe vehicles, through a payment made by the government, and is seen as an option to further reduce regional vehicle emissions. The challenge is to determine the optimal payment. On the one hand, the amount affects participation rates with higher payments increasing participation (Alberini et al., 1995, 1996). On the other, the amount should allow the program to be economically feasible. This trade-off is generally done using a cost-effectiveness analysis (CEA).[1]

Israel's high population density and vehicle fleet composition, which includes a significant proportion of old and heavily polluting vehicles, contributes significantly to air pollution; the costs have been estimated at about $530 million annually (Lavee and Becker, 2009). In early 2010 the Israeli Ministry of Environmental Protection in cooperation with the Ministry of Finance and the Ministry of Transport, initiated an AVR program, offering a payment of 3000 NIS[2] to owners of vehicles over 20 years of age, aimed at scrapping older private cars. Currently, the program in Israel includes only the scrapping of private vehicles.

Here we conduct a CEA of this program and estimate the optimal incentive payment, examine whether it is possible to maximize the net social benefit of the program, and to consider the feasibility of including light commercial vehicles (LCV) in the program.

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[1] Van Wee et al. (2011) provide a survey of earlier work in this field.
[2] $1 equaled approximately 3.578 NIS in 2011.

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2. The model

Initially, we define vehicle type by manufacturer, the model and the year of manufacture. We assume that there are J vehicle types, and that the policy objective is to maximize the discounted flow of the net benefits that occur from early retirement of vehicles during the current year. Future benefits are included in the objective function because early retirement will have effects over the entire period in which that vehicle was supposed to operate until its natural retirement. The challenge is to:

$$MAX\sum_{j=1}^{j}\left[\sum_{t=0}^{T_j}\frac{TB_j(p_j)}{(1+r)^t}-TC_j(p_j)\right] \tag{1}$$

where $TB_j(p)_j$ is the annual benefit of retiring vehicles of type j and $TC_j(p_j)$ is the costs of scrapping vehicles of type j, which are equal to the amount paid to the corresponding scrapped vehicle owners. The benefits and the costs are functions of the incentive payment p_j (as will be shown p_j determines the amount of the participated vehicles, which affects the benefits and costs). T_j is the years by which the vehicle retirement of type j has been accelerated. The vehicle type is modeled because benefits of the retirement of different vehicle types may differ; e.g., polluting emissions differing among vehicle types.

The annual benefits of scrapping vehicles of type j are:

$$TB_j(p_j) = q_j(p_j)\cdot B_j \tag{2}$$

where $q_j(p_j)$ is vehicles of type j in the AVR program as a function of the incentive payment p_j. and B_j is the annual benefit of scrapping a vehicle of type j.

The costs of scrapping vehicles of the type j are:

$$TC_j(p_j) = q_j(p_j)\cdot p_j \tag{3}$$

We assume that the marginal benefit is a decreasing function of the payment p_j and the marginal cost is an increasing function of the payment. We expect that the maximization problem has a solution (Lavee and Becker, 2009), and hence, the optimal payment level is that which maximizes Eq. (1). Furthermore, the optimal payment should be obtained for a positive value of the objective function so that the AVR program is economically viable. Estimation of the supply function is necessary to estimate the number of vehicles participating in the program as a function of the payment level, and is used to identify the optimal payment.

Many parameters could influence the vehicles owners' decision of participation in the program. The value of the vehicle in the used-car market is a principle determinant of the vehicle's owner's participation in the program, owners comparing the payment paid by the program relative to the market price of their vehicles. It may thus be expected that the higher this ratio, the more vehicles will participate in the scrappage program. The age of the vehicle is also a likely determinant of the vehicles supply for scrapping. Vehicle owners have a tendency to move forward to newer vehicles, thus a higher rate of older vehicles in the program may be anticipated. The operation and maintenance costs of the vehicle may also influence the decision to participate; owners of larger engine-capacity vehicles with greater fuel consumption having a stronger incentive to retire their vehicles.

In general, the participation rate of vehicles is:

$$PR_j = f\left(\frac{p_j}{v_j}, \quad z_j\right) \tag{4}$$

where PR_j is the participation rate of vehicle of type j (the ratio of the amount of participating vehicles to the entire vehicles of the same type). v_j is the market value of a vehicle of type j, while z_j is a vector of other variables that may affect the vehicles' participation rate. We assume that these variables are the vehicle's age, engine-capacity and manufacturer; the last two variables control for operation and maintenance costs.

Eq. (4) can be estimated by utilizing data of scrapped vehicles to find the relationship between the amount of participated vehicles and the payment level offered by the AVR program. Particularly, the amount of the participated vehicles of type j is given by:

$$q_j(p_j) = PR_j\cdot Q_j = f\left(\frac{p_j}{v_j}, \quad z_j\right)\cdot Q_j \tag{5}$$

where Q_j is the amount of vehicles of type j in the vehicle fleet at the beginning of the period, and $q_j(p_j)$ is the amount of the participated vehicles in the AVR program (these are vehicles that are expected to be scrapped during the corresponding period).

The value of the benefit of reducing pollutant emissions from retired vehicles depends firstly on the behavior of the vehicle owner. It was assumed that some of the retired vehicle owners replace their vehicle with another one, while others switch to public transportation.