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The usefulness of pollution examinations of on-road vehicles—The case of Jerusalem

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ABSTRACT

This paper focuses on the usefulness of pollution examinations of on-road vehicles as a tool for vehicle emission control. The case described was carried out in Jerusalem, the capital of Israel, between the years 2005 and 2010. A total of 43,293 on-road vehicles, which represented approximately 5% of the vehicle fleet at that time, were tested: diesel engine vehicles (21,861) were checked for their PM emission levels and petrol engine vehicles (21,432) were checked for their CO emission levels. The results show that these examinations can indicate special problems and, based on re-sampled vehicles' data, lead to benefits such as a reduction in motor emissions over time. More specifically, the share of high-emitting vehicles (i.e. vehicles that do not meet specific emission standards), especially petrol engine vehicles, is declining over the years. However, we observe a worrisome trend for high-emitting vehicles, as the average value of PM emission from diesel engine vehicles, and particularly the average value of CO emission from petrol engine vehicles, has increased over the years. In addition, a significant gap was found in the level of pollution between high-emitting vehicles and appropriate vehicles, especially for petrol engine vehicles. Monetary evaluation of externalities indicates that annually the excessive cost of PM and CO resulting from high-emitting vehicles is 9 million NIS ($1=NIS 3.846). The pollution examinations were found to be economically justified; therefore, they should serve as an efficient means of vehicle emission control.

1. Introduction

Motor vehicles are the major source of urban air pollution. In Israel, according to updated data for 2006, vehicles pollution externalities represent 1.2% of the national GDP (National Director of Revenues, 2009). Similar to the upper range of such figures in other countries, these pollution estimates indicate that as regards fuel type, petrol engine vehicles are the main cause (94%) of carbon monoxide (CO) emission (87% in the US [US Environmental Protection Agency]), whereas diesel engine vehicles are the major cause (75%) of particulate matter (PM) emission, regardless of its concentration levels (Israel Central Bureau of Statistics, 2009).

CO is a toxic gas that can cause harmful health effects by reducing oxygen delivery to body's organs. PM negatively affects more people than any other pollutant. The major components of PM are sulfate, nitrates, ammonia, sodium chloride, carbon, mineral dust and water. It consists of a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air. The effects of PM on health occur at levels of exposure currently being experienced by most urban and rural populations. Chronic exposure to PM contributes to the risk of developing cardiovascular and respiratory diseases, as well as lung cancer (WHO World Health Organization, 2013).

Fig. 1 shows the improvement in pollutant emission in a number of pollution sources and gases emitted from them over the past 18 years. As can be seen, there is also a significant improvement in vehicles' emission, despite the fact that there has been a moderate increase in the annual mileage driven over the years. However, if the emission per mile does not improve, then urban growth may sharply degrade local air quality (Kahn and Schwartz, 2008).

In Israel, during the years 2000–2008 there was a reduction of 40–45% of all kind of pollutants, including CO and PM (Israel Ministry of Environmental Protection, 2013). This reduction is due the "rejuvenating" of Israel's fleet of vehicles, while introducing measures encouraging the scrapping of old cars, stricter emission requirements for diesel vehicles, and the most significant source of change—the installation of the catalytic converter in gasoline vehicles is mandatory in every new car since

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Source Category	$PM_{2.5}$	PM_{10}	NH_3	SO_2	NO_x	VOC	CO	Lead
Stationary Fuel Combustion	-773	-813	+43	-10,490	-5,323	+445	-228	-0.42
Industrial and Other Processes	-343	-217	-446	-731	-144	-3,150	-442	-2.80
Highway Vehicles	-213	-216	+153	-439	-4,386	-5,970	-71,389	-0.42
Non-Road Mobile	-17	-24	-28	+85	+474	-76	-3,411	-0.27
Total Change	-1,346	-1,270	-278	-11,575	-9,379	-8,751	-75,470	-3.91
Percent Change (1990 vs. 2008)	**-58%**	**-39%**	**-6%**	**-50%**	**-36%**	**-35%**	**-53%**	**-79%**

Fig. 1. Change in emission levels of six different types of contaminants and pollution sources Source: US EPA—The U.S. Environmental Protection Agency (2012).

1995. The average age of a passenger car in Israel over the last decade has been quite constant and, in 2008, stood at 7.1 years (Israel Central Bureau of Statistics, 2009). Clean air regulation from 2008 states that renewing vehicle license is subject to air pollution emission examination which is performed as part of the annual license inspection. Principles for the examination, including threshold values for various types of vehicles and model years, were set by the Environmental Protection Regulations (Israel Ministry of Environmental Protection, 2008).

This study focuses on Jerusalem, the capital of Israel, located in the Judean Mountains in the central-eastern area of Israel. The city is part of the country's second largest metropolitan area. Data from 2007 shows (Jerusalem Municipality, Air Quality Division, 2007) that transport contributes about 3639 t of CO annually—approximately 99% of the CO emitted in Jerusalem. Estimated external cost per ton of CO emission is NIS 3168 and; consequently, external financial cost resulting from CO emission in Jerusalem in 2007 was estimated at about NIS 11.5 million ($1 = NIS 3.846, as of December 31, 2007). These data also show that transport contributes about 82 t of PM annually—approximately 73% of the PM emitted in Jerusalem. Estimated external cost per ton of PM emission is NIS 126,719 and consequently external financial cost resulting from PM emission in Jerusalem in 2007 was estimated at NIS 10.5 million.

Vehicle emission control is recognized as one of the effective means for reducing motor vehicles emission. This measure mainly covers technology, which applies to engine and vehicle advances, e.g., catalytic converter, air injection, and electrified vehicle concepts and to policy, e.g., emission standards and tax (Thiel et al., 2010; Noland and Quddus, 2006; Zhou et al., 2010; Harrington, 1997; Bertelsen, 2001; Heck et al., 2009; Shindell et al., 2011). In some places, roadside pollution examinations are performed as part of a mobile inspection program, e.g., the Air-Care ON-ROAD Program (ACOR) in British Columbia which runs roadside tests of heavy-duty diesel trucks and buses (Taylor et al., 2002; BC Ministry of Transport and Infrastructure, 2014) and was found to be cost-effective in reducing PM emissions from heavy-duty diesel vehicles (Taylor et al., 2002). In this regard, the impact of new approach, investigating specific pollution examinations of on-road vehicles, should be explored.

This paper focuses on the usefulness of pollution examinations as a tool for vehicle emission control, based on the case study carried out in Jerusalem. More specifically, we probe if and how these examinations contribute to a reduction in the level of CO emission from petrol-fuelled vehicles, and the level of PM emission from diesel-fuelled vehicles. Accordingly, monetary evaluation has been carried out and the usefulness of this tool and procedures for vehicle emission control can be assessed.

The paper is organized as follows: the next section describes the methodology. Following that, we present the results. The paper ends with a Section 5 and Section 6.

2. Methodology

A total of 43,293 on-road vehicles were tested by a special taskforce operated by the Jerusalem Municipality and the Environmental Protection Ministry in 13 locations within the Jerusalem area during the years 2005–2010. The taskforce operated three days a week, eight hours a day. The taskforce checked diesel engine vehicles' (21,861) PM emission levels and petrol engine vehicles' (21,432) CO emission levels. It should be noted that these cars were frequently chosen selectively, rather than randomly. In other words, priority was given to vehicles with greater polluting potential, e.g., old vehicles and vehicles with visible smoke emitted from the exhaust pipe. The driver of the vehicle was stopped and asked to perform the roadside examination. Since every vehicle within Jerusalem jurisdiction needs to meet the city rules, part of the sample may include vehicles which were not registered in Jerusalem.

Vehicles were assessed according to their emission levels, while also taking into consideration model year, engine capacity, vehicle model, and fuel type. Test equipment complies with the Ministry of Transport and Ministry of Environmental Protection according to specifications gauge gases emitted from the contents of soft-powered gasoline engines and diesel engines, according to European Union EC96/96. Measuring instruments were calibrated once a year by the Israel Standards Institute and matched according to international standards so that the measurement results were reliable.

Based on the Israeli pollution prevention regulations from on-road vehicles at the time of this study (Israel Ministry of Environmental Protection), there are few indicators for detecting a pollutant vehicle. One of the most important indicators for petrol engine vehicles is the level of CO (in percentages) emitted from the vehicle's exhaust gases. As regards diesel engine vehicles, one main indicator is the absorption value of PM emitted from the vehicle's exhaust pipe, measured in units per meter (m^{-1}).

The taskforce adopted these two indicators: the level of CO emission for petrol engine vehicles and the level of PM emission for diesel engine vehicles; thus, we use them in the current study. The term *high-emitting vehicle* is used for a vehicle that does not meet its emission standards (i.e. the value of the indicator tested was above the permitted levels for the specific vehicle). High-emitting petrol engine vehicles were required to return for a follow-up test in a test center; otherwise, vehicle owners had to pay a fine. High-emitting diesel engine vehicle owners were obliged to pay a fine. The amount of the fine varies according to several variables (e.g., model year, level of pollution, and vehicle type). All compiled data (e.g., vehicle type, documentation of previous random examinations, levels of emission in various engine conditions, date, location, road grade, season, etc.) were recorded and used for further analysis.

3. Results

3.1. General statistics

Table 1 presents the number of tested vehicles and the number of appropriate and high-emitting vehicles in Jerusalem during the years 2005–2010.