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Reducing Air Pollution in Cairo: Raise User Costs and Invest In Public Transit

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In a nutshell

- *Vehicle exhaust fumes are a major cause of air pollution in developing world megacities, such as Cairo.*
- *Egyptian authorities have taken measures to reduce emission rates for existing vehicles and change relative user costs using policies that are consistent with research findings on the appropriate economic instruments for controlling air pollution.*
- *Research into the impact of the measures shows that the period after they were implemented was associated with a reduction of about 3% in the concentration of suspended particulate matter.*
- *Other instruments can be considered, such as congestion charges; economic instruments, such as taxes or subsidies; and regulatory instruments such as emission standards.*
- • *The development of a mass transit system as a viable transport mode is essential to providing individuals with an alternative to motor vehicles when policies increase the user cost of the latter.*

About the author

Alban Thomas is a senior researcher in agricultural and environmental economics with the French Institute for Agricultural Research (INRA) and Toulouse School of Economics. He has coordinated scientific projects for public and international institutions, and he is the coordinator of the interdisciplinary Inra-Cirad 10-year programme GloFoodS on transitions towards global food security.

The international conference on climate change in Paris in December 2015 was a reminder of the need for coordination in cases where individual contributions to a global environmental issue are too small for anyone to feel personally responsible. A similar problem arises with air pollution from vehicle emissions — a major concern in most fast-expanding cities in developing as well as developed countries. Road traffic and associated emissions depend on factors such as population size, fuel consumption and emission rate per vehicle, annual average distance traveled, and the age distribution of motor vehicles. With the population expected to reach 24 million by 2027, Greater Cairo is one of the largest megacities in the world and is Egypt's largest agglomeration (22% of Egypt's population). The number of motor vehicles in Greater Cairo was about 2.9 million in 2010, of which about 115,000 were registered taxis (58% aged 22 years or more), and about two-thirds of all motorized trips were made by public transport (mostly taxicabs and minibuses). The Egyptian Ministry of State for Environmental Affairs has recently estimated that vehicle emissions represent about 26% of the total pollution load for suspended particulate matter (PM10) in Greater Cairo.

Vehicle exhaust fumes are a major source of local air pollution. These are known as a nonpoint source by environmental economists, as the number of polluters is typically very large and individual contributions to ambient pollution are too costly to monitor. This means that standard 'command and control' direct policies may not always be feasible, and that dedicated policy instruments for the control of nonpoint source pollution need to be implemented instead.

Rank policy options according to their marginal cost

Various policies can be implemented to regulate air pollution due to road traffic in cities: vehicle replacement; inspection and maintenance; use of cleaner fuels; control and traffic management; and improvement of urban transportation infrastructure. In order to design the optimal policy agenda for air pollution control, economists argue that the first step is to rank the policy instruments according to their marginal cost, increasing as a function of cumulative emission abatement efforts (as some policies cost a lot and have high impact, while others are costly with low impact). Policy instruments can then be implemented starting with the least costly option until the target of emission reduction is reached.

This approach would suggest that retrofitting motor vehicle fleets (replacing motor vehicles with less polluting ones), and inspection and maintenance measures should be implemented first, as they are very effective. Indeed, a large share of overall pollution is due to a smaller percentage of vehicle distribution. Per this analysis, fuel improvement policies should be adopted last. Environmental economists sometimes suggest the joint use of two second-best instruments to produce the best feasible policy mix: a policy instrument to reduce road traffic, and a policy to limit the emission rate of motor vehicles.

Cairo authorities have focused on cutting emission rates and changing relative user costs

It is useful to look at the way the Egyptian government has addressed the problem of air pollution from motor vehicles in light of the available economic theory. In the past decades, the Egyptian Environmental Affairs Agency (EEAA) has adopted a number of measures to deal with atmospheric pollution from motor vehicles in Greater Cairo. These projects can be classified into four categories: reduction of emission rates for existing vehicles; retrofitting; development of alternative transport modes; and modification of relative user costs.

In the first category, conversion of public sector vehicles to natural gas started in 2004 with a survey by the EEAA of all public sector vehicles, which resulted in about half of the targeted gasoline vehicles converting to natural gas by 2012. Moreover, since 2008, personal motor vehicles can be inspected on the road, and owners of vehicles not complying with emission standards have to follow a procedure of mandatory repair, technical inspection and re-test.

In the second category, a scheme was launched in 2007 to replace private taxicabs older than 35 years in Greater Cairo with natural gas taxicabs. This was extended in 2008 to cover taxicabs aged between 29 and 48 years together with a subsidy of EGP10,000 per vehicle. By August 2009, almost a fifth (18%) of old taxicabs in Greater Cairo had been replaced, and an additional phase targeted all taxicabs aged 20 years or more. In the same category, an inspection program of vehicle emissions was initiated as part of vehicle licensing in 2008 (Egyptian Law 2008/121) for mass transport vehicles (taxicabs, microbuses, trailer trucks and buses) more than 20 years old. Starting in 2008, Cairo Transport Authority buses were tested for compliance with emission standards, resulting in about 20% of buses being taken out of service every year. Finally, a program to reduce motorcycle emissions was launched in December 2007: two-stroke engine motorcycle production in Egypt was banned from December 31, 2007, and their imports were banned from January 11, 2008.

In the third category dealing with the development of alternative transportation modes, the Greater Cairo Urban Transport Master Plan has planned investments reaching USD17 billion for an integrated urban transport system, including mass rapid transit (metro), a suburban railway and expressways. Lines 1, 2 and 3 of the underground metro are already completed, with a commitment to complete line 4 by 2017, totaling 70 km.

Finally, in order to modify relative user costs, the licensing tariff scheme was revised in May 2008, with increases in tariffs of between two to 10 times the previous levels, depending on the power of the vehicle in terms of CC (cubic centimeters of the engine). This was coupled with an increase in fuel prices of about 35% to 57%, depending on octane level. Although those increases were implemented in order to raise government revenues, they had a strong impact on the car market with a 35% decrease in car sales, according to the Cairo Chamber of Commerce.

Non-car owners are more sensitive to costs

The policies described above mostly target emission rates from motor vehicles and congestion rates in Greater Cairo. In order to evaluate the expected impact on air pollution of an environmental policy aimed at modifying individual behavior of vehicle drivers or owners, two ingredients are necessary. First, it is necessary to understand the relationship between air pollution on the one hand, and the number and distribution of vehicles and climate factors on the other. Second, individual behavior regarding the choice of transportation mode has to be analyzed in light of possible alternatives and the cost of each, to determine the degree to which users will switch between different transport modes.

Abou Ali and Thomas (2012) constructed a model for transportation modes at the household level to estimate measures of diversion across transportation modes, and to provide more precise information on the components of demand for transportation in Greater Cairo. They collected data on air quality from monitoring stations in Greater Cairo between 2001 and 2008, and used a household survey on transportation habits and unit costs for the year 2007. The authors adopted a demand-side approach to transportation modes and estimated the demand for each mode as a function of their unit costs. This enabled them to estimate substitutability between different transportation modes, and to predict shifts between different modes following a change in transportation costs, such as an increase in fuel costs or taxicab rates. Because individual behavior is likely to differ regarding public transportation modes depending on whether households own a car or not, two samples were considered: car owners and non-car owners.

Results show that households that do not own a car are more sensitive to transportation unit costs. While most public transportation modes are substitutes for each other, taxicabs are seen as a complementary mode — probably because many households use several transportation means. The network of public transportation is not developed enough to reach all households at walking distance, creating the need to combine public transportation and taxicab modes. The difference in price elasticities (the change in demand for a transportation mode following an increase in user cost) according to whether a household owns a car or not provides indications of the modal shifts if car use is discouraged. If driving a car becomes more costly, car owners will tend to act as non-car owners for their trips within Greater Cairo and switch to other modes. However, because households without a car are more reactive to changes in the cost of taxicabs, one can expect that a policy of reducing the use of private cars will encourage greater use of public transportation (especially public buses) but less for taxicabs.

Regulatory measures can be linked to a 3% cut in pollution

Most regulatory policies were initiated in 2008 — a year when there was a reduction in the concentration level of PM10. The objective of Abou Ali and Thomas (2012) is to test whether the post-implementation period is truly associated with a reduction in PM10 concentration when controlling for changes in road traffic as the major source of pollution and other seasonal effects. Changes in traffic density are approximated by the number of registered motor vehicles over the 2002-2008 period (public and private buses, private cars and trucks), and the influence of peak hours on the PM10 concentration is also accounted for. The PM10 emission model is based on the sample of quality-monitoring stations. Policy, the number of registered motor vehicles, and peak-hour are taken as the determinant factors, and the results are controlled for (monthly) seasonal effects. Results show that the implementation period (2007 onwards) is associated with a reduction of about 3% in PM10 concentration when controlling for the change in the number of motor vehicles per year. A 10% increase in the number of motor vehicles would lead to an increase in PM10 concentration of around 4%, while PM10 emissions are about 8% higher during peak hours compared with lower congestion periods.

What would then be the impact of a change in the unit cost of public transportation on PM10 emissions? Consider a policy that aims at diverting households from taxicabs to tube and public bus, by raising the cost of taxicab fares by 10%. The results of the study on transportation modes reveal that a 10% increase would lead to a decrease of 6% in the use of taxicabs, and a 0.8% increase in bus demand. Since the proportion of taxicabs in the total stock of motor vehicles is about 5%, and assuming households do not divert to private cars or other motor vehicles, we should expect a reduction in emissions of about 0.12%.

Development of a mass transit system as a viable transport mode is essential

Since the results confirm that policy measures consistent with economic theory succeeded in controlling air pollution, the authorities should also consider alternative regulatory measures. First, schemes based on a congestion charge or a fuel tax have proved successful in cities such as London and Singapore, and generated revenues that can be devoted to subsidies for cleaner car vehicles and the development of public transportation networks. Congestion charges generate a significant amount of revenue with moderate management cost, while the policy can target specific areas where congestion (and the resultant pollution) is more severe. This requires public transportation systems to be expanded to cope with the shift away from private vehicle use. By contrast, a fuel tax would not target specific areas of Greater Cairo in terms of traffic congestion, but would provide revenue for public transportation plans and urban planning projects.
Subsidies for replacing motor vehicles with cleaner models can also be considered, but participation in a vehicle-exchange program assumes that the replacement cost is affordable for the majority of households and taxicab drivers in Egypt. Cheaper alternatives include engine modifications to switch to lead-free fuel, Compressed Natural Gas or LPG. Finally policies based on economic instruments, such as taxes or subsidies, and regulatory instruments, such as emission standards, aim to modify relative costs between transport modes. They must therefore be implemented only when alternatives for transportation exist, to avoid negative policy impacts on household welfare. This points to the need for investment in public mass transit systems and associated urban infrastructure policies.

An important issue is how private motor vehicles or taxis compete with public mass transportation (metro), as the latter is associated with much less impact on ambient pollution. In the short run, when the number of car trips and the mass transit infrastructure are constant, the reduction in emissions from a retrofitting policy will be immediate. In the longer run, however, with an expected increase in population as well as in the number of car trips, emissions due to congestion will increase (because of idling time in traffic jams for motor vehicles). This implies that extensions of the existing mass public transit infrastructures must be planned well in advance and need to match the expected increase in road traffic, otherwise the reduction in emissions allowed by vehicle retrofitting programs is likely to be offset by the increase in traffic congestion.

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