

Using Transportation Control Measures and Economic Instruments to Reduce Air Pollution Due to Automobile Emissions

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INTRODUCTION

Although the use of the air as a medium of waste disposal remains largely unconstrained for economic agents, the social costs associated with declining air quality as a result of pollution are quite substantial, and can be assessed in terms of danger to human health, safety and amenity effects, as well as other long-term welfare damage impacts. It turns out that increased air pollution in today's modern society is a direct consequence of industrialisation and associated economic growth, with the latter generating greater output levels, demand for power, as well as higher levels of consumption and living standards. And yet there is no easy market for trading in environmental quality, thus justifying the need for policy intervention to reduce the negative pollutive activities of economic agents.

The major sources of air pollution are from industrial and transportation activities. On the empirical balance, transportation is identified as a highly significant culprit, accounting for well over 50% of total air pollutants (see Seneca and Tausig, 1984; Jack Faucet Associates, 1992; USDT/USEPA, 1993; Sevigny, 1998). However, only a few of the existing studies deal with the specific experiences of developing countries, and even at that, mobile transportation as a source of air pollution has not been given the attention it deserves.

In specific studies relating to the Nigerian experience, attention has focused more on general industrial pollution or pollution in the oil industry (see for example, Faboya, 1997; Iyoha, 2000; Magbagbeola, 2001, and Orubu et al., 2002), while in other studies, only casual references are made to the gravity of the problem of pollution from mobile transportation sources (see for examples, World Bank, 1995; Garba and Garba, 2001). There are, however indications that the

potential for increased pollution from mobile transportation sources particularly in Nigerian cities has increased in the most recent years. For example, the "black smoke" phenomenon has become one visible feature of the typical Nigerian city, particularly since the 1990s, which period has been marked by substantial increase in per capita vehicle ownership. Over the period 1990 – 1997, the total number of vehicles registered annually increased substantially (FOS, 1995, 1999), implying that per capita ownership of vehicles has been on the upward trajectory, leading to greater traffic congestion of the typical Nigerian city road. This has generally increased the concentration of pollutants in the air in the city, with potential adverse health effects on the human population resulting from inhaling suspended particulates and carbon monoxide. At present the authorities do not seem to be doing anything significant towards the reduction of pollution from this source.

This paper therefore focuses on transportation as a source of air pollution in the typical Nigerian city, the main objective being to provide a conceptual framework for the design of an environmental policy mix of transportation control measures (TCMs) and economic instruments (EIs) to reduce air pollution from automobile transportation sources. Following this introductory section, the remaining part of the paper is organised into four sections. The next section (2) presents the framework of analysis. This is followed by section 3, which discusses the specific problem of pollution from mobile transportation sources, and the potential for increased air pollution from these sources in Nigeria. In section 4, we examine the different instruments available for pollution control, on the basis of which a mix of TCMs and EIs is suggested for the reduction of automobile pollution. Finally, section 5 concludes the paper.

FRAMEWORK OF ANALYSIS

An alteration of the natural environment constitutes pollution if it produces harmful or undesirable consequences on the human population, which can be approximately measured by the willingness of economic agents to pay some value in order to prevent the undesirable state from occurring. Alternatively, we can view pollution as an extractive use of the environment, to the extent that each unit of pollution caused by production or consumption activity reduces environmental quality (Smulders, 2000). Historically, it has been a controversial issue whether economic growth, which generally increases the demand for products of convenience and the use of the environment as a waste sink, can go on without decreasing the quality of the environment significantly. This observation had provided the theoretical basis for the materials balance approach (which carries the implications of the physical *law of mass conservation*) to the economic analysis of environmental problems in the industrial countries during the 1970s (Kneese and Bower, 1976). Essentially, the materials balance approach stresses the ubiquity of the pollutive effects of economic activity, thus underscoring the imperative for policy intervention to reduce environmental diseconomies, in a world where no explicit markets exist for trading in environmental quality. The interaction between the economy's production/ consumption activities and environmental quality can be examined by means of a simple aggregate model that integrates production, consumption and ecological processes¹. Consider a simple aggregate production function,

$$Y = F(Q, S, K, T), \quad (1)$$

Where,

- Y = total volume of output
- Q = index of environmental quality
- S = use of services from the environment in production
- K = stock of man-made capital
- T = state of technology

The production (technology) block of the simple model can be expanded to include two other equations, one representing the observation that the stock of man-made capital results from accumulated investment, while the other

defines equilibrium in the product market, whereby the supply of goods consists of the demand for produced consumption (C) and investment goods (I) such that,

$$\dot{K} = I + \delta K \text{ ----- (2)}$$

$$Y = C + I \text{ ----- (3)}$$

On the other hand, society's preferences (W) can be modelled within a framework whereby consumption demand, and environmental amenities (S) play a critical role in determining utility (U), such that,

$$W = \int_0^{\infty} U(C, S) \exp(-\theta t) dt \text{ ----- (4)}$$

Where, U(.) = instantaneous utility, θ , utility discount rate - with all variables are dependent upon time (t). On the manifold assumption that all inputs contribute non-negatively to production, from equation (1),

$$F_Q > 0; F_S > 0; F_K > 0; F_T > 0$$

And, from equation (4),

$$U_C > 0; U_S > 0$$

Finally, changes in environmental quality can be modelled by the equation;

$$\dot{Q} = E(Q) - S \text{ ----- (5)}$$

In this simple aggregate model, the index of environmental quality enters into the technology relationship (production function) through its effects on productivity. For example, the wear and tear of buildings, machinery and other productive infrastructure as well as the quality of human health, may worsen with diminished environmental quality brought about by significant pollution. On the other hand, improved air quality may result from better technologies in machinery and combustion systems – which arise implicitly from increasing the investment component of equations (2) and (3), and ultimately increase the volume of output through the familiar multiplier process. Other than representing services from the environment, the variable S appears in equation (4), to take into account the existence value of environmental resources (see Johansson, 2000). Since in principle, pollution constitutes extractive resource use, deterioration of environmental quality can only be counterbalanced by ecological processes E(Q), that improve the quality of the environment, as shown in equation (5). In effect therefore,

the function $E(Q)$ can be equated to the environment's natural capacity to renew itself, and assimilate pollution. Supposing the economy uses less environmental services than are provided by ecological processes such that $S < E(Q)$, then environmental quality should improve over time. On the other hand, if the economy uses more environmental services such that $S > E(Q)$, then environmental quality should deteriorate over time. Within this framework, environmental equilibrium is only guaranteed when $\dot{Q} = 0$, which condition subsists only when pollution does not exceed the environment's maximum assimilative capacity.

There is indeed evidence to suggest that economic growth at the initial stage does increase pollution, and hence deterioration of environmental quality. On the other hand, the capacity to offset this relationship increases at later stages in the growth process. Grossman and Krueger (1991) expressed this observation in the form of an *environmental Kuznets curve* because of the historical U-shape relationship between the intensity of pollution and economic growth as measured by increases in per capita income².

A number of studies provide empirical evidence in support of the environmental Kuznets curve for a variety of pollutants (see for examples, Shafik and Bandyopadhyay, 1992; Selden and Song, 1994, and Panayotou, 1995). A relatively more recent study by Vincent et al. (1997) also found a strong link to exist between pollution and increases in per capita GDP in Malaysia. Economic growth, usually associated with substantial technological progress makes it possible to develop pollution-reducing devices. Rising per capita incomes associated with growth also increase the demand for improved environmental quality. However, as shown by Vincent et al. (1997), sustained economic growth alone may not necessarily provide the sufficient condition for improvement of environmental quality. Indeed, it is possible for a country experiencing economic growth to suffer substantial welfare losses if it does not take proactive and aggressive steps to reduce pollution, or if it fails to enforce existing environmental policies, ignores public demand for a better quality environment, or if it continues to subsidise the use of polluting inputs. The imperative for proactive environ-

mental action should therefore be stronger for the typical developing country if pollution of the environment from industrial and transportation activities is to be significantly reduced.

Several studies have identified the negative consequences arising from air pollution due to transportation and industrial activities (see for example, Stedman, 1989; Anderson, 1990; Kinney and Ozkaynak, 1991; Schwartz and Dockery, 1992; Hettige et al., 1992; Cadle et al., 1993; Cameron, 1993). There are therefore several bene-fits for different sectors of the economy by reducing air pollution through appropriate environmental policy. The most important benefit is the resultant healthier and more productive workforce for the economy. This is particularly true in cases where pollutants (such as carbon monoxide and suspended particulates) increase the incidence of respiratory and cardiovascular diseases among the vulnerable segment of the population. At the empirical level, health-related benefits of air pollution abatement programmes have been found to be particularly large (see for example, WRI, 1992; Hall et al., 1992; Krupnick and Portney, 1991, and Kinney and Ozkaynak, 1991). In the next section, we discuss briefly the role of transportation as a source of air pollution, paying particular attention to the Nigerian experience.

TRANSPORTATION AND POLLUTION

First, we examine the specific case of vehicular air pollution, and then the potential for increased air pollution from this source, with specific reference to Nigeria.

Motor Vehicles and Air Pollution

Vehicular pollution arises mainly from inefficient combustion of hydrocarbon fuels. Hydrocarbon gases easily unite with oxides of nitrogen (NO_x) through photochemical reactions in sunlight to produce smog. NO_x can combine with other organic substances in the atmosphere to create ozone, with devastating effects on vegetation and climatic stability. Hydrocarbon fuels also contain varying amounts of sulphur. The combustion of hydrocarbon (HC) fuels therefore has the potential of producing oxides of sulphur, which can combine with water in the atmosphere to form acids of sulphur. Carbon

monoxide (CO), produced as a result of inefficient combustion of hydrocarbon fuels and is highly toxic even at small levels of concentration, and has been known to decrease human efficiency. In effect, cities, which rely on a large number of vehicles for the bulk of daily commuting transportation, and offering few efficient public mass transportation modes, may suffer from extreme CO and other transportation-related emissions³.

It should be noted that perfectly operating motor engines would produce only water and carbon dioxide in the process of fuel combustion. However, in the real world of imperfect engines, improper fuel grades, lack of regular maintenance, physical ageing of engines, intensive use of vehicles, all these factors combine to produce a constraint on perfect fuel combustion. The ultimate effect is the emission of CO, HCs and NO_x from the exhaust system and engine parts of motor vehicles, particularly those using diesel as fuel. The danger posed by air pollution due to mobile transportation should therefore influence environmental policy directed at improving air quality.

Potential for Increased Air Pollution from Motor Vehicles in Nigeria

An assessment of the potential for increased vehicular pollution requires some basic information relating to traffic volume and the intensity of pollutant emissions on road corridors. With respect to traffic volume, the critical factors will include population size, fuel consumption per capita and the proportion of the population that owns motor vehicles as well as annual average distances covered.

Under a *ceteris paribus* assumption, countries with larger populations will exhibit higher traffic pollution potentials due to larger absolute ownership of vehicles and tonnage of fuel consumption. With a population estimated at 108.2 million in 1998 (CBN, 2000), Nigeria stands as the most populous country in Africa. The prices paid for petroleum products, particularly premium motor spirit (petrol) and automotive gas oil (diesel) are generally low in Nigeria (lower than what obtains in other OPEC countries - FGN, 2000). This has in a way encouraged single

occupier vehicle (SOV) ownership. In 1990, the total number of newly registered saloons and station wagons in Nigeria stood at 5,985. This rose to 27,308 in 1991. By 1997, the annual figure had gone up to 574,971! Indeed the total number of all categories of annually newly registered vehicles went up from 9,303 in 1990 to 1,081,938 in 1997 (FOS, 1995, 1999; see Table 1), with the cumulative figure for the period 1990–97 standing at 1,468,483 vehicles.

The World Bank (1995) had estimated that the number of vehicles per 1000 inhabitants in Nigeria is above the average for other African countries, assuming the ownership ratio to be in the neighbourhood of 30 vehicles per 1000 inhabitants during the first quinquennium of the 1990s. Similarly, fuel consumption in both absolute and per capita terms were also found to be higher for Nigeria in a sample including some other African countries over the period 1989–1992 (see Table 2), for both gasoline (petrol) and diesel. For example, in 1992, total gasoline (premium motor spirit) consumed in Nigeria was estimated at 3,969 thousand tons, with a per capita equivalent of 0.043 thousand tons. For diesel, this was 2,280 tons, with a per capita equivalent of 0.024 thousand tons. For the same year, the total consumption of gasoline in Kenya stood at 376.7 thousand tons, with per capita equivalent of 0.013 thousand tons. For diesel, the total was 537.3 thousand tons, with per capita equivalent of 0.019. As also shown in Table 2, traffic volume is relatively high in Nigeria among other African countries. The World Bank (1995) study also reported that an average Nigerian vehicle runs considerably more distance than an average European car per year – with the former covering as much distance as 30,000 km/year.

Thus the combination of the large number of motor vehicles in Nigeria, higher ratio of vehicle ownership and fuel consumption, traffic work in terms of distance covered per vehicle per year, all contribute to increasing the pollutive potential of automobiles. It should also be noted that the average age of motor vehicles in Nigeria is generally high. Since the adoption of the Structural Adjustment Programme in 1986, new vehicles have been generally out of reach of private individuals due to falling real incomes. Whereas a new 504 brand of Peugeot (saloon)

Table 1: Number of newly registered vehicles in Nigeria (1990 – 1997)

Year	Saloons & Wagons	Lorries, Trucks & Buses	Tippers	Tractors	Others	Total	Cumulative
1990	5,985	832	536	81	1,869	9,303	
1991	27,308	1,100	830	159	7,737	37,134	46,437
1992	37,442	4,558	766	350	5,551	48,667	95,104
1993	63,586	1,407	698	242	12,783	78,716	173,820
1994	45,401	6,804	593	468	4,617	57,883	231,703
1995	46,097	8,558	616	498	1,702	57,471	289,174
1996	62,504	16,094	5,733	976	12,014	97,371	386,545
1997	574,971	333,454	51,003	56,246	66,264	1,081,938	1,468,483

Source: Federal Office of Statistics, *Annual Abstract of Statistics* (1995 and 1999)

Table 2: Traffic volume and fuel consumption in selected African countries

Country	Population (million)	Traffic Work (million vehicles.km)	Gasoline Consumed (thousand tons)		Diesel Consumed (thousand tons)	
			Total	Per Capita	Total	Per Capita
Nigeria (1992)	91.3	8,220*	3,969**	0.043	2,280*	0.024
Kenya (1987)	27.3	4,865	376.7	0.013	537.3	0.019
Madagascar (1989)	13.0	-	75.3	0.005	181.3	0.013
Togo (1991)	4.1	-	20.2	0.003	70.7	0.017
Zimbabwe (1992)	10.8	7,820	1.1	0.0001	2.9	0.0002
Ghana (1989)	16.7	5,160	92.2	0.005	61.0	0.003

Source: Adapted from World Bank (1995).

*Estimate by World Bank (1995)

**Obtained from Central Bank of Nigeria, *Annual Report and Statement of Accounts* (1996).

car sold for less than N7000 in 1985, its average price has been as high as N1800000, since the 1990s. Consequently, only companies and government departments are generally able to buy a few new vehicles. Some of them even now buy second-hand varieties as official vehicles. The number of newly registered vehicles recorded is therefore mainly of the second-hand variety imported from Europe. These vehicles come in different types ranging from trailers, trucks, tippers, buses, to saloons, station wagons, and special vehicles (such as tractors and motorcycles). Some of these are already as old as fifteen years before they are imported into the country, and (some) will continue to be in use for the next twenty years or more! Thus vehicles in Nigeria are characterised by old age, with extensive and intensive usage. Furthermore, the general lack of maintenance culture and poor grade fuels (which were a common feature of the 1990s) combine with all the factors above to increase the pollutive propensity of motor automobiles in

Nigeria.

Statistical information about pollution intensity in different cities and zones in Nigeria is generally not available. However, existing figures for Lagos and the Niger Delta region characterised by high oil industry concentration (Orubu, 2001) provide some useful clues. Lagos, Nigeria's former capital city has a population of about 7 million people, and remains the largest urban commercial and industrial centre in the country. On the other hand, Port-Harcourt and Warri are two major cities in the Niger Delta area with fairly large populations and industrial establishments. Comparative figures from Lagos and the Niger Delta area can therefore be used to make some deductions on the intensity of pollution from automobile sources. Table 3 summarises ambient air pollutants in these two areas respectively.

The pollutants selected are total suspended particulates (TSP), measured in mg/m³, nitrogen oxides (NO_x), measured in parts per billion (ppb),

Table 3: Ambient air pollutants in Lagos and Niger Delta Area

<i>Pollutant</i>	<i>Lagos Area</i>		<i>Niger Delta Area</i>		
	<i>Non-traffic Urban Zone</i>	<i>Traffic Zone</i>	<i>Oil Communities</i>	<i>Cities</i>	<i>FEPA Standards</i>
TSP $\mu\text{g}/\text{m}^3$	31.4 – 746.5	72 – 950	92.2 – 348.5	396.8 – 583.3	250
NO _x (ppb)	81 – 81.5	34 – 131.6	22.0 – 295.0	35 – 370	40 – 60
SO ₂ (ppb)	0.5 – 43	20 – 250	7.0 – 97.0	16 – 300	100
CO (ppm)	0.5 – 3.9	10 – 250	5.0 – 61.0	1.0 – 52	10
CO/NO _x	0.0 – 6.0	50 – 200	20	15 – 130	–

Source: Adapted from Jerome (2000).

sulphur dioxide (SO₂), measured in ppb, and CO, measured in parts per million (ppm). The measured pollution intensities are compared to the standards recommended by the defunct Federal Environmental Protection Agency (FEPA). With respect to the traffic zone of urban Lagos, it is seen that the implied average concentrations recorded for TSP, NO_x, SO₂ and CO are far in excess of the standards recommended by FEPA. This is also generally true for the cities in the Niger Delta oil-producing region. CO emissions constitute the greatest hazard from automobile pollution. Concentration of CO emissions for Lagos road corridors is quite high, being in the range of 10 – 250ppm recorded – higher than the ranges of 5.0 – 61.0ppm and 1.0 – 52ppm recorded for oil communities and cities respectively in the Niger Delta. Lagos being the city with the highest concentration of traffic in Nigeria, it is expected that CO emissions in its road corridors will be higher than what obtains in other parts of the country. The TSP concentrations recorded are also high, when compared to WHO's standard of 75mg/m³.

Generally, the figures recorded above indicate that air pollution due to automobile emissions is real, and poses a potential hazard to the population. It is this which explains the increasing intensity of the "black smoke" phenomenon in the typical Nigerian city, particularly associated with old diesel engines of trailers, lorries, trucks, buses and other categories of vehicles. Old and rickety petrol-driven vehicles are also culprits. Indeed, the potential for increased pollution from this source is very high, given the large number of old and second-hand vehicles being imported into the country annually – a situation that has also led to more congested city roads, thereby

increasing pollutant concentration levels in periods of peak traffic flow in one day. A proactive policy is therefore required to address the problem. Some of the instruments that can be used to reduce automobile pollution in Nigeria are examined in the next section.

TRANSPORTATION CONTROL AND ECONOMIC INSTRUMENTS TO REDUCE AUTOMOBILE AIR POLLUTION

Generally, mobile source abatement can result from successful implementation of transportation control measures (TCMs) aimed at decreasing motor vehicle trips, and vehicle mile travel (VMT), reducing congestion by encouraging off-peak period travels (or driving under more optimal conditions), and by encouraging the use of transportation modes other than single occupant vehicle (SOV) travel. Mobile source abatement can also result from better vehicle maintenance practices, retrofitting older vehicles with newer emissions control technology and replacing existing vehicles with lower-emitting vehicles. A large number of TCMs fall within the "control and command" (CAC) approach to environmental policy⁴. The success of the CAC instruments depends significantly on monitoring of the standards set and ensuring that non-compliance is punished.

On a broad line of classification, we can identify two categories of TCMs. On the one hand, there are those TCMs that focus on the supply of alternatives to SOVs. This category includes regulations that encourage the adoption of public transit transportation modes, traffic flow improvements, high occupancy vehicles, the provision of travel lanes and non-motorised vehicle paths and accommodation. On the other

hand, there are those TCMs, which more specifically place restriction on automobile travel demand. Successful implementation of the supply – and demand – oriented TCMs should reduce per capita pollution from automobile sources.

Economic instruments can also be used to reduce pollution from mobile sources. Although economic-based instruments of environmental policy have a strong theoretical foundation (see for example, Baumol and Oates, 1988; Segviny, 1998; Barde, 2000), they have only a short history of actual application in pollution control. They include general charges and taxes per unit emitted, subsidies for each unit abated, tradable permit systems in which the polluter must acquire a permit for each unit emitted, and deposit refund systems. Other economic incentives include congestion pricing and higher parking fees. The implicit objective of these economic instruments is to increase the cost of SOV travel, which should ultimately reduce pollution per capita, as well as enhance the relative attractiveness of alternative and cleaner modes of transportation⁵.

A combination of TCMs and economic instruments can therefore be profitably used to reduce pollution due to automobile emissions in Nigeria, where pollution from mobile sources is conspicuously visible in urban centres. As already noted, no definite action is currently being taken to reduce emissions from motor vehicles by the authorities beyond the use of slogans of moral suasion. It is instructive for us to compare the Nigerian case with the experience of a country like Malaysia⁶.

In Malaysia, the Motor Vehicles (Control of Smoke and Gas Emissions) Rules were put in place as far back as December 1977 (Vincent et al., 1997). Under these rules, the Department of Environment with the Road Transport Department and the traffic police could randomly stop vehicles and check for violations of the prescribed standards, and fine offenders when necessary.

Table 4 summaries the combination of TCMs and EIs suggested, which can be used to reduce pollution from automobile sources in Nigeria. As already noted, the ultimate objective of TCMs is to reduce the demand for SOVs, VMT, and to encourage the provision of alternative and more

environmentally friendly modes of transportation. It should be noted that President Obasanjo, in his presentation of the Year 2002 Federal Government budget had indicated the intention of Government to place restriction on the importation of pre-1995 second-hand vehicles into the country. Although there is manifest opposition to this policy proposal, if the scheme is well implemented, it will provide one sure way of reducing mobile source emissions in our cities, even though the original objective of the proposal is not necessarily to improve environmental quality. The economic instruments suggested implicitly work through the reduction of demand for vehicle ownership by increasing the cost of ownership and maintenance. In this way, SOVs will be greatly reduced. A judicious combination of some of the TCMs and EIs listed in Table 4 can therefore be used in an environmental policy mix to reduce pollution from automobile.

SUMMARY AND CONCLUSION

This paper identified pollution as one major consequence of man's economic activities – either in production or consumption, and spotted mobile transportation as one major source of pollution. Although statistical information relating to pollution from transportation sources is relatively scanty in Nigeria, evidence based on Lagos and Niger Delta areas point to the possibility of increased pollution from transportation sources. A combination of TCMs and EIs is therefore suggested within a proactive framework in an environmental policy mix to reduce air pollution from that source.

It should however be noted that certain aspects of the market based alternatives would require some institutional changes in the functions of the Revenue Department, as well as technological improvements to make the instruments effective. The reduction of pollution due to automobile sources in Nigeria would also require structural-organisational modifications in the mechanisms of environmental policy and planning in Nigeria. After the establishment of the Federal Environmental Protection Agency (FEPA) in 1988, a number of state governments had set up their own State Environmental Protection Agencies (SEPA's). In some states

Table 4: TCMs and EIs to reduce pollution from automobile transportation sources in Nigeria

<i>Category of instruments</i>	<i>Programme</i>	<i>Remarks</i>
A. TCMs	1. Improvement of public transit, provision of high occupancy and shared rides. 2. Programmes to improve traffic flow and restriction of movement of trailers and heavy trucks to off-peak periods in areas of dense traffic. 3. Programmes to reduce idling period for motor vehicles. 4. Programmes to encourage use of non-fuel vehicles for individuals e.g. bicycles. 5. Encouraging voluntary withdrawal of old vehicles from use and the market, and restricting the purchase of older vehicles. 6. Retrofitting old vehicles with emission reduction gadgets. 7. Programmes for construction or tracks solely for the use of pedestrians. 8. Empowering the traffic police and Road Safety Corps to check and sanction motor vehicles emitting "black smoke," and maintenance history of vehicles.	Require good roads in cities to reduce to-work journey time. Could reduce extreme pollutant concentration during peak traffic periods. May require provision of alternative roads for different categories of vehicles. Costly to implement Must take into account safety considerations. Provide bicycle lanes and parking facilities. Likely to face social resistance. May face resistance, on economic grounds, but one sure way of reducing automobile pollution. Must take into account technological and economic feasibility. Will reduce the effect of pollutant doses on individuals. Long overdue. Absence of 'black smoke' should be a key requirement— in issuing certificate of road worthiness.
B. Economic Instruments	1. Introduce emission tax for all categories of vehicles based on: (a) annual distance covered by vehicle; (b) age of vehicle; (c) fuel type used. 2. Programme to reduce or remove subsidy on petroleum products. 3. Increase other vehicle fees and charges (e.g. licence fees and insurance), parking fees, registration fees based on age of vehicles etc. 4. Who to be responsible for economic liability for pollution damage to be unambiguously defined. 5. Impose higher parking fees	Requires establishment of environment unit in the Revenue Department of Government to monitor hartridge smoke units. Implementation requires cooperation of police and other agencies such as Road Safety Corps Effect is to increase cost of maintaining vehicles and may reduce SOV. Increased revenue for government. May reduce demand for SOV, increase revenue, and decrease pollution per capita. Would require legislative framework in line with the polluter pays principle To be implemented by local Authorities
C. Others	1. Programmes of effective town planning. 2. Education and voluntary approaches 3. Better communication facilities (e.g. improved telephone services)	Potential for emissions reduction quite high. Reduction of congestion and VMT

such as Lagos, Rivers, Delta and Edo, the SEPAs were relatively active in the monitoring of environmental conditions at the local level. However, the conditions existing then, carved no explicit role for the SEPAs in monitoring and enforcing regulations on transport-induced emissions. The scrapping of FEPA in 1999 and its merger with the Ministry of Environment has further blurred the role that the individual state governments would play in the process of

environmental policy. To make environmental policy work at the local level therefore, it will be necessary to evoke the *subsidiary* principle, which advocates some degree of decentralisation of environmental policy action to guide the design of policy instruments to reduce pollution from mobile sources of emissions. There is however the strong need to take into account cooperation between the different government Ministries such as Environment, Finance,

Economic Planning, Health, Urban Planning, Transport, the Police and other agencies as the Federal Road Safety Corps, even at the local level.

NOTES

1. The analytical framework adopted here is based mainly on Smulders (2000).
2. This observation is so dubbed as the *environmental Kuznets curve* by Grossman and Krueger because of the analogous similarity of the U-shape relationship between environmental quality and economic growth and the observation made by Kuznets (1955) that income inequality worsens as the economy grows up to a point, then it begins to improve at some turning income point.
3. I am grateful to an anonymous colleague in the Department of Chemistry, Delta State University, for comments on this section of the original draft.
4. For a more comprehensive discussion of the CAC approach to environmental policy, see Barde (2000).
5. Under a market-based approach, each polluter decides whether it is worthwhile to pollute or if abatement is more cost-effective. As Baumol and Oates have shown, a tax per unit of emission is a cost-effective tool for reducing emissions. In principle, such taxes ensure that each source abates up to the point where the unit tax is equal to the marginal abatement cost.
6. During the early 1960s Nigeria and Malaysia were approximately on the same level of development rating. Both countries are also rich in petroleum resources.

KEYWORDS Automobile pollution, control measures.

ABSTRACT Pollution is identified as one inevitable consequence of man's economic activities, and mobile transportation is one of its major sources. The paper examines the problem of pollution due to mobile transportation sources, taking Nigeria as a case. Inferences based on statistics available for Lagos and Niger Delta areas indicate relatively high pollution potentials, with several pollutant concentrations in excess of FEPA standards. The author suggests a proactive policy, using a combination of transportation control measures (TCMs) and economic instruments (EIs) to address the problem.

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