THE MOTOR VEHICLE AIR POLLUTION AND THE TAX RESPONSE IN BIG CITIES: THE CASE OF LIMA

By

Enrique Pintado Espinoza

THESIS

Submitted to
KDI School of Public Policy and Management
in partial fulfillment of the requirements
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ABSTRACT

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Enrique Pintado Espinoza

Air pollution is one of the main environmental concerns in urban areas for the adverse health effects on the population. Generally, it increases the risk of respiratory and heart disease in the population, and some pollutants in the air are carcinomas. In 2008 in the Balcksmith Institute World's Worst Polluted Places report, the urban air quality was listed as one of the world's worst pollution problems.

Lima, the capital of Peru, is a city which air pollution is very high, and motor vehicles are the major source of pollutants. The problem is very complex: the average age of motor vehicles in Lima is 14 years, and in the case of those used for public transportation 56% are older than 20 years, and 91.6% are older than 10 years; there is an excess of 22,000 of motor vehicles for public transportation; and congestion in Lima produce that an average journey from the north and south of Lima be two hours. Regarding the fuel quality it has been improved few years ago, but there is not incentive to use motor vehicles that consume less fuel.

The Peruvian government has acted contradictory: on the one hand, it promoted air pollution by making cheaper dirty fuels through taxes, and by allowing the import of old motor vehicles with tax benefits; on the other hand it took some delayed measures to reduce the air

pollution problem. The first measure it took was in 1998 banning the content of lead in gasoline (several years after European countries did it). The second measure was taken after 10 years limiting the sulphur content in diesel (the content of sulphur in diesel was 4,000 to 6,000 ppm, while in other Latin American countries it was 350 ppm, and in European countries it was below 100 ppm).

The effect of such command-and-control policies had a positive effect, because the content of Sulfur Dioxide and Nitrogen Dioxide in the air of Lima is below the Air Quality Guidelines established by the World Health Organization. However, the content of particulate matter (2.5 and 10 μm) are still above those guidelines. An important notation is that the Peruvian government is not monitoring the content of other pollutants in the air of Lima, and since 2010 it has not monitored the air pollution in one of the most polluted areas: Lima downtown.

Therefore, more public policies are necessary to reduce air pollution. Unfortunately, the Peruvian government (the same as most of other governments in the world) uses only regulation to deal with this environmental problem. Nonetheless, taxes have proved in some cities to get excellent results in reducing air pollution.

Singapore has an extraordinary experience in the use of taxes and other economic instruments to reduce air pollution: import duties, registration fees, and road charges. London, after a very long political process, applies since 2003 a congestion charge which result has been extraordinary. Many countries in Europe (England, France, and others) apply the excise taxes on motor vehicles based on their emissions.

Learning from those experiences, it is proposed to apply environmental taxes for reducing air pollution in Lima. The use of excise taxes on fuel based on their environmental impact, and of excise taxes on motor vehicles based on different factors (type of fuel they use, engine size, technology, age, etc) can be an incentive for people to purchase environmental friendly motor vehicles. The use of motor vehicle property tax in order to make more expensive to keep old motor vehicles, may be useful to reduce the average age of vehicles in Lima, which would reduce the air pollution. Finally, a road charge for the most congested and polluted area in Lima would be an efficient measure to reduce congestion and pollution in such area.

Dedicated to my Father,

to my parents, Miguel and Janet,

and to my siblings, Miguel, Luis and Joyce

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INTRODUCTION

Air pollution is one of the main environmental concerns in urban areas for the adverse health effects on the population. Pollutants in the air have different health effects on people. Generally, they increase the risk of respiratory and heart disease in the population, and some of them are carcinomas. In 2008 in the Balcksmith Institute World's Worst Polluted Places report, the urban air quality was listed as one of the world's worst pollution problems.

Lima, the capital of Peru, is a city that has suffered the problem of air pollution, and motor vehicles are the major source of pollutants. The aim of this thesis is the study of air pollution and the use of taxes as a policy instrument to abate pollutants in the air, and to evaluate the possibility to apply such environmental taxes for reducing air pollution in Lima. This involves a qualitative analysis.

This thesis is divided into three chapters. The first chapter is about the theory of environmental taxes. It starts with the description of public policy and the environment, explaining what environmental public policy is, what external environmental costs are, and which policy instruments there are (regulation and economic instruments) for dealing with such costs. The second section defines environmental taxes, classifies them, describes their importance and their economic issues, and states what shall be considered when designing them.

The second chapter exposes all the related issues about the air pollution. Its first section defines air pollution, describes the air pollutants and how they affect people's health, and states the World Health Organization's Air Quality Guidelines, which are recommended

maximum content of certain pollutants in the air. The following section describes the problem of the air in Lima: the Peruvian Air Quality Standards, and how polluted has been the air in Lima since 2007. The last section is focused on the motor vehicles air pollution describing the problem with respect to motor vehicles as well as to fuel used by such vehicles.

The last chapter analyses the environmental taxes as a response to the air pollution. Its first section remarks how taxes on motor vehicles and on fuel in Peru have been either neutral or negative to the air in Lima. The second section describes the experience of applying environmental taxes to reduce air pollution in Singapore, London, and France. The third section is the proposal for using environmental taxes to abate air pollution in Lima, by creating a new tax and using existing taxes on vehicles and fuel for environmental purposes.

Finally, it is important to mention that this thesis is focused on the external environmental costs produced by motor vehicles when polluting the air in Lima. Other externalities derived from the use of motor vehicles are out of the scope of this thesis.

I. THE THEORY OF ENVIRONMENTAL TAXES

1. Public Policy and the Environment

1.1 Environmental Public Policy

According to Clarke E. Cochran the term public policy always refers to the actions of government and the intentions that determine those actions.[1] Policy is a statement by government of what it intends to do or not to do, such as a law, regulation, ruling, decision, or order, or a combination of these.[2] There are different types of policies such as health policy, transportation policy, environmental policy and so forth. Regarding environmental policy McCormick defines it as any action deliberately taken to manage human activities with a view to prevent, reduce, or mitigate harmful effects on nature and natural resources, and ensuring that man-made changes to the environment do not have harmful effects on humans.[3]

It is also possible to state that environmental public policy is all the government's actions regarding the external conditions that affect life of people, animals and any other organism. Those external conditions (environmental issues) generally addressed by public policy are protection of natural resources, global warming, air pollution, water pollution, land pollution, renewable energy, waste management, among others.

When an environmental issue shall be addressed by a public policy? In other words, when

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1 Clarke E. Cochran, *American Public Policy: An Introduction*. 6th ed. (New York: St. Martin's Press, 1999).

2 Birkland, Thomas. *An Introduction to the Policy Process*. 2nd ed. (New York: M.E. Sharpe, Inc., 2005), p.139.

3 McCormick, John, *Environmental Policy in the European Union* (The European Series: Palgrave, 2001), p. 21.

must (or can) the government intervene? This is a question which answer is controversial. For welfare economics one reason for government intervention is market failure, which involves market power or non-existence of market. The latter occurs for asymmetric information, public good, and externality.

1.2 External Environmental Costs

An externality is a situation in which one person's behavior affects the welfare of another in a way that is outside existing markets. Thus, the fact that the behavior of some people affects the welfare of others does not necessarily cause market failure, because if the effects are transmitted via prices, markets are efficient.[4] An externality may be either negative or positive, depending on whether it produces a cost or a benefit.

A negative externality or external cost implies that an economic agent is not bearing all the costs of producing a good or providing a service because it does not take into account the cost it imposes to others. Therefore, the price of such good or service does not reflect its total cost, and consequently, the economic agent's production and provision of services are more than economically desirable.

There are different types of external costs, and one of them is the environmental costs, which are called environmental externalities or external environmental costs, and defined as "uncompensated environmental effects of production and consumption that affect consumer utility and enterprise cost outside the market mechanism.[5] Some examples are the air

[4] Harvey S. Rosen, *Public Finance*, 7th ed. (International Edition: McGraw-Hill, 2005), pp. 81-82.

[5] *United Nations, Glossary of Environmental Statistics, Studies in Methods*, Series F, No. 67, (New York: UN, 1997. July 21st, 2011: http://stats.oecd.org/glossary/detail.asp?ID=824

pollution, and solid waste that firms may generate through their production process.

1.3 Policy Instruments for dealing with External Environmental Costs

Policy instruments or policy tools are elements in policy design that cause agents or targets to do something they would not do otherwise or with the intention of modifying behavior to solve public problems or attain policy goals.[6]

What to do when an economic agent produces external environmental costs? As Harvey S. Rosen explains,[7] the presence of external costs may produce private and public response. When private individuals cannot avoid externality problems, the government can intervene through taxes, subsidies, creating a market (such as permits to pollute), or regulations. Those public responses are policy instruments.

Environmental policy, however, can be divided into two types:[8] regulatory instruments and economic instruments. Regulation -also called command-and-control instruments- is legal prohibitions of undesirable practices accompanied by the policing power of the state to control violations of law.[9] Examples of regulation are standards imposed by governments for

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6 Anne Larason Schneider and Helen Ingram, *Policy Design for Democracy* (Lawrence: University Press of Kansas, 1997), p. 93.

7 See Harvey S. Rosen, *supra* note 4, p. 92-99.

8 Some scholars include as a third category "persuasive" policy instruments, which are those used to persuade the behavior of economic agents. J.D. Bernstein states: "Another means of influencing polluter behaviour is through persuasion. In the case of polluting industries, this approach may involve voluntary agreements to undertake pollution control measures. In the case of consumers, it may involve public education and information campaigns to influence patterns of consumption and waste disposal. This approach is applied in countries such as The Netherlands, Japan and Indonesia." The United Nations Environment Programme, Water Supply & Sanitation Collaborative Council, and the World Health Organization, *Water Pollution Control – A Guide to the Use of Water Quality Management Principles*, 2nd ed. (London: 1997). July 21st, 2011: http://www.who.int/water_sanitation_health/resources/watpolcontrol/en/index.html

9 United Nations Environment Programme, *The Use of Economic Instruments for Environmental*

polluting and technology.

Economic instruments -also called market-based instruments or economic-incentive instruments- are measures that provide economic incentives for sustainable economic development and disincentives for practices that degrade the environment or deplete natural resources. Economic instruments include charges, pollution taxes, tradable pollution permits, transferable development rights and payments for environmental services, among others.[10]

Some definitions of economic instruments are "A means by which decisions or actions of governments affect the behavior of producers and consumers by causing changes in the prices to be paid for these activities",[11] or "Fiscal and other economic incentives and disincentives to incorporate environmental costs and benefits into the budgets of households and enterprises."[12]

According to the Organization for Economic Co-operation and Development (OECD) the economic instruments for environmental protection can be distinguished into five categories:[13]

a) Taxes and charges.[14]

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and Natural Resource Management, 1st ed. (2009), p. 3. July 21st, 2011: http://www.unep.ch/etb/publications/EI%20manual%202009/Training%20Resource%20Manual.pdf

[10] See United Nations Environment Programme, *supra* note 9.

[11] Organization for Economic Co-operation and Development, *Glossary of statistical Terms*. July 21st, 2011: http://stats.oecd.org/glossary/detail.asp? ID=6408

[12] Organization for Economic Co-operation and Development, *Glossary of Statistical Terms*, July 21st, 2011: http://stats.oecd.org/glossary/detail.asp?ID=723. It adds that the objective is to encourage environmentally sound and efficient production and consumption through full-cost pricing.

[13] *OECD (1989), Economic Instruments for Environmental Protection,* Paris.

[14] Every reference made in this thesis to taxes includes charges.

b) Subsidies, which include tax incentives such as differentiated tax rates, accelerated depreciation, investment tax credits, tax exemptions or deferrals.

c) Deposit-refund systems, under which consumers pay a charge for purchasing a potentially polluting product, and get a refund when they return such product.

d) Market-creation or redefining property rights. The government creates a market: it sets the maximum limits on pollution emissions, and allocates this total limit among polluters by issuing permits that authorize them to emit stipulated amount of pollutant over a period of time (tradable permits).

e) Financial enforcement incentives, which are penalties imposed to induce polluters to comply with environmental standards.

2. Environmental Taxes

2.1 What are Environmental Taxes?

The Purpose of Taxes

Taxes are fees levied by governments on property, income, or activity. The main purpose of taxes has been to raise revenue for governments, or in other words, to finance governments' expenditure.[15] However, over the years the reason for imposing taxes has evolved, and taxes have been used as policy instrument for different reasons such as to reflect external costs,[16]

[15] For public goods, impure public goods (which consumption is either nonrival or nonexcludable), or even private goods.

[16] In such case, taxes are economically justified by market failure and by allocation of resources that

to correct for information failure, to enhance progressivity in taxation, among others.

Pigouvian Taxes and the Polluter Pays Principle

A Pigouvian tax[17] is a tax levied to producers in order to make them to internalize the external cost that they generate through their economic activity. In other words, it is a tax levied on each unit of a polluter's output in an amount just equal to the marginal damage it inflicts at the efficient level of output.[18]

The goal of Pigouvian taxes is to reduce the economic inefficiency produced by a negative externality; is to increase the price of the goods produced or services provided in order to reduce the consumption and consequently the production of such goods and provision of such services until reach the socially efficient production level. Moreover, the purpose of Pigouvian taxes is that prices reflect external costs generated by the economic activity.

Years after the concept of Pigouvian taxes was borne, the OECD, in the 1970s, elaborated the idea of the Polluter Pays Principle under which the polluter should bear the costs generated by the environmental damage produced by him. This principle does not address the question of what the polluters should pay; it is a non-subsidy principle, according to which the costs of pollution control -not necessarily the costs of pollution- should be paid by the polluter.[19]

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maximizes social welfare.

[17] The name comes from the economist Arthur C. Pigou who proposed the use of the tax in order to correct the externality problem.

[18] See Harvey S. Rosen, *supra* note 4, p.92

[19] Joa Nicolaisen, Andrew Dean and Peter Hoeller, "Economics and the Environment: A survey of Issues and Policy Options", *OECD Economic Studies* No. 16 (Spring 1991), p. 16. July 21st, 2011: http://www.oecd.org/dataoecd/48/11/34281824.pdf

Definition of Environmental Taxes

Environmental taxes are Pigouvian taxes levied to make polluters to internalize the external environmental costs. They deal, for example, with air pollution, soil pollution, and water pollution.

Furthermore, Katri Kosonen and Gaetan Nicodeme define what they call Pigouvian environmental tax as the tax paid by the producer of certain goods or services equal to the social (environmental) costs associated to the production of those goods or services.[20]

Therefore, what makes a tax to be categorized as environmental is the use of such tax as an economic instrument for environmental purposes. The use of certain raising-revenue taxes to reach some environmental goals does not convert them into environmental taxes. In that regard, corporate tax benefits (i.e., depreciation) and low value added tax-VAT rates applicable in order to reduce pollution do not make to consider the corporate tax and VAT as environmental taxes, even though such revenue-raising taxes are partially used with some specific environmental targets.

For that reason, the use of the term 'environmental taxes' in this thesis excludes the tax benefits given for environmental purposes. Those tax benefits are another economic instruments used for environmental purposes, substantially similar to subsidies because they work as if the government collected the tax revenue and later gives part of what it collected back to the taxpayer.

Katri Kosonen and Gaetan Nicodeme also make a distinction among those economic

[20] Claudia Dias Soares et al., *Critical Issues in Environmental Taxation* (United States: Oxford University Press, 2010), p.25.

instruments when they mention a pigouvian approach that may include, on the one hand, the incentive environmental taxes and subsidies, and on the other hand the revenue-oriented environmental taxes. They call it a pigouvian approach since those three alternative policies intend to bring the prices in the markets closer to the full cost of production, including the social costs.[21]

In addition, the use of the collected tax is not important to define an environmental tax. Indeed, an environmental tax may not be an earmarked tax, and its revenue may be used for any purpose other than protect the environment. The OECD, the International Energy Agency (IEA), and the European Commission establish that the definition of environmentally related taxes does not focus on how the revenues raised by the tax are used.[22]

Actually, the OECD, the IEA, and the European Commission provide another definition of environmental taxes. They define environmentally related taxes as "any compulsory, unrequited payment to general government levied on tax-bases deemed to be of particular environmental relevance. The relevant tax-bases include energy products, motor vehicles, waste, measured or estimated emissions, natural resources, etc. Taxes are unrequited in the sense that benefits provided by government to taxpayers are not normally in proportion to their payments."[23]

They add that the definition of environmentally related taxes does not focus on the (alleged)

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[21] See Claudia Dias Soares, *supra* note 20.

[22] OECD, *The Political Economy of Environmentally Related Taxes* (OECD Publishing, 2006), p.26. July 21st, 2011: http://www.oecd-ilibrary.org/environment/the-political-economy-of-environmentally-related-taxes/current-use-of-environmentally-related-taxes_9789264025530-4-en

[23] See OECD, *supra* note 22, p.26. Such document also states that "Requited compulsory payments to the government that are levied more or less in proportion to services provided (e.g. the amount of wastes collected and treated) can be labeled as fees and charges. The term levy covers both taxes and fees/charges."

purpose of a tax either. This opinion, however, seems not to contradict what has been established above, but to complement it: An environmental tax is objectively defined, and its environmental purpose (meaning to internalize the external environmental cost) is not reflected by what the legislator intents to achieve levying the tax, but by what the tax-base is.

Types of Environmental Taxes

The European Environment Agency (EEA) classifies environmental taxes considering different categories. Thus, environmental taxes are distinguished according to their:[24]

a) Main objective:

- Cost-covering charges, which are those levied in order to make the polluter to assume the government's cost of regulating and treating pollution. They can be:
  - User charges, imposed to make the taxpayer to pay for a specific environmental service provided to him.
  - Earmarked charges, which revenue is spent on environmental services that are not individualized to the taxpayer.
- Incentive charges, levied in order to change the behaviour that produce the external environmental cost.
- Fiscal environmental taxes, which are levied to raise revenue for government, and at the same time (even without express purpose) makes polluters to internalize external environmental costs.

These types of environmental taxes are not mutually exclusive.

[24] European Environment Agency, *Environmental Taxes: Recent Developments in Tools for Integration*, Environmental Issues Series No. 18 (Copenhagen: 2000), p.19. July 21st, 2011: http://www.eea.europa.eu/publications/Environmental_Issues_No_18

b) Main field of operation:

- Energy taxes,
- Transport taxes,
- Pollution taxes, and
- Taxes on natural resources (other than energy).

This classification is clearer than that described above, since it is more objectively determined, not depending on the purpose of the tax.

c) Point of application:

- Pollution taxes, which are based on the quantity or quality of discharged pollutants;
- Product taxes, which are imposed on products which consumption is harmful to the environment;
- Taxes on capital goods, which are levied on inputs to production process that are harmful to the environment; and
- Taxes on activities that are harmful to the environment.

d) Tax base: This is an extension of the classification by fields of application, and can be fuel taxes, wastewater taxes, emissions taxes, taxes on packaging, etc.

The importance of each classification described above depends on their use. For example, as the EEA states, Eurostat, OECD and IEA use the classification according to the main field of operation for statistical purposes.[25]

[25] The EEA, *supra* note 24, p.20. The EEA also notes that this classification excludes charges because of poor data availability.

Don Fullerton, Andrew Leicester, and Stephen Smith distinguish different types of environmental taxes to effective targeting the environmental problems the government seeks to influence. They distinguish among:[26]

(i) Taxes on measured emissions. These are direct taxes of polluting emissions; taxes based on polluting emissions in a way that when polluting emission rises, the tax base rises and so do the tax liability. This type of taxes depends on the technology that is available in order to measure polluting emissions and the administrative costs they involve.

(ii) Taxes on market goods that are related to emissions. This is an environmental tax based on the sale or exchange of polluting goods or production inputs. The idea is to tax more those goods that produce environmental damage in production or consumption than those that do not. These taxes require less technology and administrative costs, but they are not as precise as the taxes on measured emissions in targeting the polluting emissions.

Multi-part instruments. This is not a type of environmental tax but combination of economic instruments in order to reduce pollution. The authors remark "In some cases, a more efficiently targeted environmental incentive can be created through artful combination of indirect taxes (…) to approximate more closely the effects of a tax on measured emissions." They provide an example of an excise tax on goods combined with a subsidy for clean technology.

[26] Don Fullerton, Andrew Leicester, and Stephen Smith, *Environmental Taxes* (Oxford: Oxford University Press, 2010), p. 440. July 21st, 2011: http://works.bepress.com/don_fullerton/37

2.2 Why Environmental Taxes?

In order to determine why environmental taxes should be used, it is important to describe their advantages as well as their disadvantages.

Advantages of Environmental Taxes

a) The pollution abatement is generally less costly with environmental taxes than with regulatory instruments where the pollution abatement costs vary across polluters.

   The reason is that through regulatory instruments it is expected that all polluters reduce their polluting emissions to the same extent, disregarding that the cost of doing so varies across each polluter. The alternative would be to apply regulatory instruments in a differentiated way according to the cost it involves to each polluter, but it is very difficult for the public administration to obtain detailed information about the abatement costs of each polluter. Hence -as stated before- regulatory instruments are applicable to every polluter without distinguishing their pollution abatement costs, and for some (or many) polluters applying the regulatory measure may result at a high cost.

   To the contrary, the application of environmental taxes does not require knowing the pollution abatement costs of each polluter. They work providing an incentive to polluters to reduce pollution, and each of them will do it depending on their abatement costs. In other words, through environmental taxes each polluter will make a decision of paying more taxes or reducing pollution, which depends on their marginal cost of pollution abatement versus their marginal tax savings: where the costs of reducing pollution is

higher than the tax, the taxpayer will prefer to pay the tax, and where the costs of reducing pollution is less than the tax, the taxpayer will elect to reduce pollution.

b) Environmental taxes raise revenue, while regulatory instruments do not.

c) Environmental taxes incentive taxpayers to reduce pollution, because the less polluting emissions the less tax liability. Regulatory instruments do not provide such incentive. The incentive effect of environmental taxes exists to the extent the marginal costs of abatement are below the tax rate.

However, the success of an environmental tax in achieving behaviour change depends on the market for the substance being taxed. In the case of inelastic demand of goods either the tax rate has to be higher in order to have an incentive effect with all the negative consequences it can produce, or other instruments have to be used.[27]

d) Environmental taxes promote products, process, and technology innovation. The EEA exemplifies this advantage with the Swedish tax on sulphurous diesel that helped to encourage the development of new, less polluting fuels. It also makes at this point a very important assessment: "Such large scale structural changes in production and consumption can be encouraged by environmental taxes, especially if their price signals are gradual and predictable over the long planning periods required by industry" and "Any innovations that are encouraged by taxes can also help improve competitiveness."[28]

Furthermore, the OECD states that these dynamic efficiency gains are one of the main

[27] The EEA, *supra* note 24, p.17.
[28] The EEA, *supra* note 24, p.18.

advantages of environmental taxes.[29]

e) Environmental taxes involve less compliance and administrative costs than regulatory instruments. If, for example, a regulation requires firms a standard of pollution emission, the larger the number of firms involved the more cost to the authority to control them, but in the case of taxes imposed on transactions (sales of polluting goods), the invoice plays an important role in controlling the tax.

Disadvantages of Environmental Taxes and other economic instruments

a) An environmental tax has an uncertain environmental impact because it depends on the response of polluters. Regulations and tradable permits are more efficient instruments than taxes to achieve a given quantity of pollution reduction required.

Thus, where the priority is to reduce pollution until certain level, regulations or tradable permits may be a better option, but where that is not the priority, environmental taxes may be preferred.

b) An environmental tax may not be efficient where the polluting damage varies in different locations. Regulations that may make such distinction may be more efficient.

c) A low or high environmental tax rate may affect the effectiveness of the tax. On the one hand, a low tax rate may not produce any change in the polluting activity of the taxpayer where their marginal tax saving are lower than their marginal costs of abatement, and it may be even worse because taxpayers may think that paying the tax legitimizes their

[29] The OECD, *Implementation Strategies for Environmental Taxes* (Paris: 1996), p. 12.

polluting activity. On the other hand, a high tax rate may produce adverse effects due to taxpayers may respond through illegal activities that damage the environment even more than the taxed emissions.[30]

d) Environmental taxes may be regressive. These taxes are born more heavily on the poor than on the rich as a proportion of consumption over income.

e) Environmental taxes may affect international competitiveness. For instance, if a good produced in a country is exported, and an environmental tax is levied on inputs used to produce it, the price of such good will be increased affecting its competitiveness.

f) Politically speaking taxes may be less popular since it affects explicitly the prices consumers have to pay, while other instruments may also affect the prices (since the pollution abatement may create a cost in the producer) but they are not explicit.

A general idea of the use of Environmental Taxes

The effectiveness of an environmental tax depends on many different factors. In some cases it can be more effective than other economic or regulatory instruments, in other cases it can be less effective, and in other situations it can get better results by been complemented with such other instruments.

The use of environmental taxes must be defined depending on the type of environmental problem that should be controlled, the necessity or not of a specified pollution reduction, the pollution abatement cost of polluters, the elasticity demand of goods that directly or

[30] Don Fullerton, Andrew Leicester, and Stephen Smith explain this issue with an example where a tax on toxic waste may induce illegal dumping or burning, *supra* note 26, p. 434.

indirectly produce the pollution emissions, among others.

2.3 Economics of Environmental Taxes

Tax Burden

An important concept regarding the tax burden is the tax incidence, and it is important to make a distinction between statutory incidence and economic incidence. The former refers to the person that has the legal obligation to remit the tax to the government (legal payer of the tax), and the latter refers to the person who bears the burden of the tax (real payer of the tax, whose income is reduced by the tax). Economic incidence is the effect of a tax on the distribution of economic welfare.

In the case of commodity taxes economists state that if the tax increases prices, consumers bear the burden of the tax, and if the tax does not affect prices, producers bear the burden of the tax.

Another important issue related to the tax burden and the income of who bears the burden of the tax is to find out whether a tax is progressive, proportional, or regressive. If the ratio of the tax burden to income increases as income rises, the tax will be progressive; if the ratio is the same, the tax will be proportional; and if the ratio decreases, the tax will be regressive. Regarding environmental taxes their incidence and definition as regressive will depend on the type of tax. However, as Don Fullerton, Andrew Leicester, and Stephen Smith state,[31] since environmental taxes may apply to transport, fuels, and energy, a high fraction of low-income consumers and households are potentially vulnerable to environmental taxes, because the

[31] Don Fullerton, Andrew Leicester, and Stephen Smith, *supra* note 26, p. 434.

proportion of the taxed goods they consume with respect to their income is higher than that of the richer people. Therefore, environmental taxes are often regressive.
In addition, for poor people the environmental improvement may not be an important issue, but for richer people it may be.

For those reasons, in applying an environmental tax it is important to consider its distributional effects and the government should include policy measures to offset such effects.

Double Dividend

Some scholars support the existence of a "double dividend" from environmental taxes because such taxes improve the environment and provide revenue that can be used to reduce other distorting taxes on labour supply, investment, or consumption. Therefore, the first dividend comes from reducing pollution, and the second dividend comes only if the environmental taxes' revenue is used to reduce other taxes, replacing taxes that create distortions with taxes that correct distortions.

Furthermore, some scholars mention the existence of "double dividends" for environmental and non-environmental benefits, with different definitions of dividends. The EEA states that environmental taxes have the advantage that, if well designed and implemented, they could deliver a "Double, Double Dividend" by achieving improvements in the environment, innovation and competitiveness, employment, and the tax system. However, it also recognizes that achieving these gains in practice is often difficult.[32] Notwithstanding, in this thesis the second dividend is considered as defined in the first paragraph.

[32] The EEA, *supra* note 24, p.19.

Bovenberg and de Mooij have analyzed the existence of the second dividend, and they state that the environmental tax has its own distorting effects on labour supply and therefore can have more or less excess burden than the labour tax itself.[33]

Don Fullerton, Andrew Leicester, and Stephen Smith establish that the possibility of a double dividend cannot be ruled in or out, because it depends on the circumstances: if the tax system has been designed minimizing excess burden but without taking into account environmental issues, the tax system would be more efficient if environmental taxes are used than if they are not, but this improvement could only hold up to certain point, because as the environmental tax rate increases, the excess burden costs of behavioural changes rise more than proportionately, and such costs can overtake the additional environmental benefits.[34] They conclude that the number of dividends is not important, but the consideration of tax and environmental policy simultaneously, since what matters is whether the net effect is positive or negative on overall welfare.

A decision to rely more on environmental taxes rather than on labour taxes shall take into account also other considerations such as distributional effects. As stated before, environmental taxes are generally regressive taxes, but labour taxes are proportional or even progressive.

[33] Lans Bovenberg and Ruud A. de Mooij, *The American Economic Review*, Vol. 84, No. 4 (1994). July 21st, 2011: http://users.domaindlx.com/cihanyuksel/Environmental%20Levies%20and%20Distortionary%20Taxation.pdf

[34] Don Fullerton, Andrew Leicester, and Stephen Smith, *supra* note 26, p. 450.

2.4 Designing Environmental Taxes

The first issue when creating an environmental tax is to define clearly why an environmental tax is to be imposed, what the purpose of the tax is. As explained at sub section 2.1, taxes can have different purposes, and even though the goal of raising revenue is not mutually excludable with the goal of internalizing external costs, it is not appropriate to have both goals together as the main purpose of a tax as explained in the next paragraphs.

If a government needs to increase its revenue through taxes, it can create new taxes or increase the tax rate of existing taxes. The decision will depend on the amount of revenue required by the government, political acceptance, administrative feasibility, and so forth. Hence, any tax measure has to be set in a way that it will cover the government's expected revenue.

To the contrary, in the case environmental taxes, they are not levied in order to raise revenue. The tax rate, the tax base, and all the elements of the tax are established in order to make producers and consumers to internalize external costs. The revenue is a natural consequence of the levied tax, but it is not the purpose of it.

More over, the effectiveness of raising revenue taxes and environmental taxes are measured in a different way. Whilst in the case of the former the more revenue they produce the more effective they are, in the case of environmental taxes under certain circumstances the more revenue they produce the less effective they are. The reason is very simple: the environmental policy (including environmental taxes) will be effective if pollution is reduced. Thus, if the revenue collected through an environmental tax is increasing because, for example, there are

more sales of ‘dirty’ goods or there are more emissions, that means that pollution is not being reduced, but increased even though the existence of the tax.

Therefore, an environmental tax that does not respond to government’s revenue requirements has to be very specifically targeted: the environmental problem the government wants to influence must be identified.

This first step when creating taxes has a very important legal issue: Does the legislator have Constitutional power to levy environmental taxes? The experience of Mexico is interesting, because under its Political Constitution there cannot be a tax without raising revenue purposes. After that, the issue is what type of environmental tax is the best option, meaning what to tax. Taxing the polluting emission would be the best option since the tax would be directly determined by the amount of pollution; hence, the environmental policy can be better targeted. However, there are constraints that may prevent the application of this tax: the availability of technology in order to measure emissions, or the cost of measuring emissions of all polluters.

An alternative would be to tax goods that are related to emissions. It can be a tax on the sale of polluting goods, provision of polluting services, or production inputs. Generally, this tax does not require special technology and is less costly than tax on emissions. Notwithstanding, the former is less specifically targeted to pollution than the latter is.

Defining the type of environmental tax comes together with the definition of who the taxpayer will be. This is the statutory incidence, the definition of the person that will be the legal payer of the tax.

Once the type of environmental tax is defined, the next issue is what the tax base and the tax rate will be. This is a very important issue since it shall be establish in a way that prices will reflect the external cost caused by economic agents.

II. THE AIR POLLUTION

1. Health Effects of Air Pollution

Air pollution is a significant threat to health worldwide, becoming a major environmental health problem that affects people: it increases the risk of respiratory and heart disease in the population, and it affects more severely people who are already ill, children, the elderly and poor people.[35]

According to a World Health Organization (WHO) assessment worldwide it is estimated that more than 2 million premature deaths each year can be attributed to the effects of air pollution, and more than half of this disease burden is borne by the populations of developing countries.[36]

1.1 What is Air Pollution?

The WHO defines air pollution as contamination of the environment by any chemical, physical, or biological agent that modifies the natural characteristics of the atmosphere.[37] Air pollution is also defined as the release of chemical, physical, or biological materials into the atmosphere that harm humans and other living organisms, or damage the natural environment or built environment.

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[35] World Health Organization, *Air Quality & Health: Questions and Answer*. July 21st, 2011: http://www.who.int/phe/air_quality_q&a.pdf

[36] World Health Organization, *Reducing risks, promoting healthy life*, World Health Report (Geneva: 2002).

[37] July 21st, 2011: http://www.who.int/topics/air_pollution/en/

Those chemical, physical, or biological agents are known as air pollutants, and they are emitted into the air from natural or man-made (anthropogenic) sources in the form of solid particles, liquid droplets, or gases. Air pollutants can be classified as primary pollutants, when they are directly emitted from a process such as carbon monoxide gas from motor vehicle emissions, or secondary pollutants, when they are formed in the air when primary pollutants react or interact such as ozone.

Motor vehicles are the main source of those pollutants that affect people's health, in particular, carbon monoxide (CO), nitrogen oxides (NO_X), unburnt hydrocarbons and lead, suspended particulate matter (PM), sulphur dioxide (SO_2) and volatile organic compounds (VOC), and via atmospheric transformation of ozone and other photochemical oxidants.[38]

The WHO remarks that among the substances in the exhaust of motor vehicles, health effects are caused by:[39]

- Substances mainly affecting the airways: NO_2, ozone (O_3), photochemical oxidants, SO_2 and PM.
- Substances producing toxic systemic effects: CO and lead.
- Substances with potential carcinogenic effects: benzene, polcyclic aromatic hydrocarbons, and aldehydes.

[38] WHO and the Service of Ecotoxicology of the Department of Public Health Geneva, *Motor Vehicle Air Pollution: Public Health Impact and Control Measures* (Geneva: 1997), p. 27. July 21st, 2011: http://www.bvsde.paho.org/comun/airefile/mvr.pdf

[39] WHO and the Service of Ecotoxicology of the Department of Public Health Geneva, *supra* note 38, p. 30.

1.2 The Air Quality Guidelines

The WHO Regional Office for Europe published Air Quality Guidelines for Europe, containing health risk assessments of 28 chemical air contaminants.[40] In the second edition of the guidelines the WHO identified 35 pollutants.[41] The WHO also describes the health effects of the air pollutants, and provides air quality guidelines (hereinafter AQG).[42-43]

a) Particulate matter (PM).

It is produced by the combustion of fuels, and it is mainly divided into two groups: coarse particles (larger than 2.5 μm) and fine particles (smaller than 2.5 μm). The health effects to people exposed to PM are predominantly to the respiratory and cardiovascular systems.

A very important notation made by the WHO is that it has not been identified a threshold below which no adverse health effects would be anticipated, and it is unlikely that any standard or guideline value will lead to complete protection for every individual against all possible adverse health effects of PM.[44] For that reason, it is recommended to aim the lowest concentrations of PM in the air.

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[40] WHO Regional Office for Europe, *Air Quality Guidelines for Europe*, WHO Regional Publications, European Series, No. 23 (Copenhagen: 1987).

[41] WHO Regional Office for Europe, *Air Quality Guidelines for Europe*, 2nd ed., WHO Regional Publications, European series, No. 91 (Copenhagen: 2000). July 21st, 2011: http://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf

[42] The information regarding the health effects and the air quality guideline is extracted from: WHO, *Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide*, Global update 2005. Summary of risk assessment. July 21st, 2011: http://whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf
The information about the health effect is also extracted from WHO and the Service of Ecotoxicology of the Department of Public Health Geneva, *supra* note 38.

[43] The WHO establishes the air quality guidelines for worldwide use in order to support actions to achieve air quality that protects public health in different contexts.

[44] Who, *supra* note 42, p.9.

Notwithstanding, the WHO provides a numeral guideline to reflect the concentrations at which increased mortality responses due to PM air pollution, specifically the lowest levels at which total cardiopulmonary and lung cancer mortality have been shown to increase with more than 95% confidence in response to long-term exposure to $PM_{2.5}$.

For the health effects are produced by both long-term and short-term exposures to PM, the guidelines use two indicators of PM pollution: annual mean and 24-hour mean. The AQG regarding the PM is as follows:[45]

- Long-term indicators.
  - For $PM_{2.5}$ an annual average concentration of 10 $\mu g/m^3$.
  - For PM_{10} an annual average concentration of 20 $\mu g/m^3$.

- Short-term indicators:
  - For $PM_{2.5}$ a 24-hour average concentration of 25 $\mu g/m^3$.
  - For PM_{10} a 24-hour average concentration of 50 $\mu g/m^3$.

b) Ozone (O_3).

It is formed in the atmosphere by photochemical reactions of hydrocarbons and NO_x, which in urban areas are primarily produced by motor vehicles. It affects primarily the lung, producing cellular and structural changes, decreasing its ability to perform normal functions. Although those health effects cannot be attributed only to the ozone, it appears to be the most biologically active.

[45] The WHO states that the use of $PM_{2.5}$ guideline value is preferred.

There are small associations between daily mortality and ozone levels independent of the effects of particulate matter. Exposure to ozone is associated with physiological and inflammatory lung effects in healthy exercising young adults. There is statistically evidence of decrements in lung function, airway inflammatory changed, and exacerbations of respiratory symptoms in healthy children and adults, and symptomatics and functional exacerbations of asthma.

The AQG for O_3 is an 8-hour daily average concentration of 100 $\mu g/m^3$.

c) Nitrogen dioxide (NO_2).

Most atmospheric NO_2 is emitted as NO, which is oxidized by ozone to NO_2. In the presence of hydrocarbons and ultraviolet light, it is the main source of tropospheric ozone and of nitrate aerosols. It is an irritating gas that penetrates the lung periphery with the centriacinar region as its primary deposition site, and is absorbed into the mucosa of the respiratory tract. After a person is exposed to NO_2 it is observed in her blood and urine, nitric and nitrous acids or their salts. The potential human health effects of NO_2 described by the WHO are: increased intensity and severity of respiratory infections; respiratory symptoms; reduced lung function; and worsening of the clinical status of people with asthma, chronic obstructive pulmonary disease or other chronic respiratory conditions.

In addition to its health effects, NO_2 absorbs visible solar radiation, has a potential role in global climate change, regulates the oxidizing capacity of the atmosphere and controls the build-up and fate of radical species and of ozone.[46]

[46] WHO and the Service of Ecotoxicology of the Department of Public Health Geneva, *note 33*, p.11.

The AQG for NO_2 are:

- An annual average concentration of 40 μg/m^3.
- 1-hour average concentration of 200 μg/m^3.

d) Sulfur dioxide (SO_2).

This is a primary combustion product. SO_2 is absorbed in the nose and it irritates the upper airways. High concentrations can cause laryngotracheal and pulmonary oedeme. From the respiratory tract, SO_2 enters the blood, and is eliminated mostly by the urinary route.

Studies have showed that asthmatics experience changes in pulmonary function and respiratory symptoms after a short-term exposure to SO_2. Long-term exposure to SO_2 has been linked to adverse health effects such as childhood respiratory disease and all-age mortality. Notwithstanding, it is still uncertain that the SO_2 is the only cause of such health effects.

The AQG for SO_2 are:

- A 24-hour average concentration of 20 μg/m^3.
- A 10-minute average concentration of 500 μg/m^3.

e) Carbon monoxide (CO).

It is mostly emitted from vehicular exhaust. The CO decreases the oxygen transport to the tissues. Thus, it affects above all the organs largely dependent on oxygen supply, which are the heart and the central nervous system, and also the foetus. It is reported four types of health effects associated with exposure to CO, which are neurobehavioural, cardiovascular, fibrinolysis, and perinatal effects.

The AQG for CO are:

- 15 minutes average concentration of 100 μg/m^3.
- 30 minutes average concentration of 60 μg/m^3.
- 1 hour average concentration of 30 μg/m^3.
- 8 hours average concentration of 10 μg/m^3.

f) Lead.

The heath effects for exposure to lead are in early neurobehavioural development. Indeed, it is associated to undesirable development outcomes in human fetuses and children, such as lower scores on the mental development index, poor school attainment and lower intellectual coefficients, reduced gestational age, and lower birthweight.

The AQG for lead is an annual average concentration of 0.5 μg/m^3.

g) Benzene.

It is a constituent of crude oil. The major source of benzene is emissions from motor vehicles. Once inhaled, benzene is distributed to the fat rich tissues such as adipose tissue and bone marrow. Exposures to benzene produce toxic effects in humans: haematotoxicity, immunotoxicity, neurotoxicity, and carcinogenicity. It is a human carcinogen classified by the International Agency on Research of Cancer. There is no safe level for airborne benzene as it is carcinogenic for humans.

h) Polycyclic aromatic hydrocarbons (PAH).

This is a group of chemicals formed during the incomplete combustion of fuel. There are hundred types of PAH, and the best known is benzo(a)pyrene (BaP). PAH are absorbed in

the lung and gut, and metabolized via the mixed-function oxidase system. The metabolites are thought to be carcinogens. Many of PAH are mutagenic and carcinogenic. There is no safe level of PAH due to its carcinogenicity, and no known cancer threshold for BaP.

i) Aldehydes.

It is absorbed in the respiratory and gastrointestinal tracts and metabolized, and has irritant effects. Formaldehyde's effects include ocular and olfactory irritation, irritation of mucous membranes and alteration in respiration, coughing, nausea and dyspnea, and it has a probable carcinogenic effect and potential tissue damage.

To avoid irritation, the AQG for formaldehyde is a 30-minute average concentration of $0.1mg/m^3$.

2. The Air in Lima

2.1 The Peruvian Air Quality Standards

In 2001 the executive branch of Peru published the Regulations of the Peruvian Air Quality Standards (hereinafter AQS), [47] which establishes that the General Management of Environmental Health, a public office that is part of the Secretary of Health, is responsible for monitoring and assessing the quality of the air in Peru. Such regulations were modified in 2003[48] and 2008[49].

[47] Free translation of "Reglamento de Estándares Nacionales de Calidad Ambiental del Aire", approved through Decreto Supremo N° 074-2001-PCM, officially published on June 22nd, 2001.
[48] Modified by Decreto Supremo N° 069-2003-PCM, published on July 15th, 2003.
[49] Modified by Decreto Supremo N° 003-2008-MINAM, published on August 22nd, 2008.

It is noteworthy that the article 33 of the Peruvian General Statute of the Environment[50] states that the elaboration of the AQS shall take into account the standards established by the WHO (AQG) or by other international organizations. Thus, in the Table 1 it will be showed the AQS, including those that are expected to be applicable in the future, and the AQG.

Table 1
Air Quality Standards and Air Quality Guidelines

Pollutant		Period	AQS[(a)]	AQG[(a)]
1.	PM_{10}	Annual	50	20
		24-hour	150	50
2.	$PM_{2.5}$	Annual	15	10
		24-hour	65 (2001 to 2009) 50 (2010 to 2013) 25 (since 2014)	25
3.	O_3	8-hour	120	100
4.	NO_2	Annual	100	40
		1-hour	200	200
5.	SO_2	Annual	80	50
		24-hour	365 (2001 to 2008) 80 (2009 to 2013) 20 (since 2014)	20
		10 minutes	--	500
6.	CO	8-hour	10000	10000[(b)]
		1-hour	30000	30000[(b)]
		30 minutes	--	60000[(b)]
		15 minutes	--	100000[(b)]
7.	Lead	Annual	0.5[(c)]	0.5
		Monthly	1.5	--
8.	Hydrogen Sulfide (H_2S)	24-hour	150[(d)]	--
9.	Benzene	24-hour	4 (2010 to 2013) 2 (since 2014)	--
10.	Total Hydrocarbons (THC)	24-hour	100 mg/m^3[(e)]	--

(a) The values are average concentration of $\mu g/m^3$.
(b) The air quality guidelines establish values in mg/m^3, but for purposes of compare with the Peruvian standards such values are converted to $\mu g/m^3$.
(c) The annual value was established in 2003.
(d) This value is applicable since 2009.
(e) It is applicable since 2010.

[50] Ley N° 28611, passed on 2005.

From the comparison between the AQS and the AQG it is possible to assert that for many pollutants the AQS have adopted different values to those of the AQG: PM_{10}, O_3, and benzene, as well as the values for annual assessment of $PM_{2.5}$, NO_2, and SO_2. In all those cases the AQS are higher than the AQG.

In addition, the Peruvian government has established neither AQS of 10 minutes for SO_2, nor the AQS of 15 and 30 minutes for CO, even though the AQG include such assessments.

Finally, there are AQG for other pollutants that have not been considered by the Peruvian government, such as formaldehyde, and polycyclic aromatic hydrocarbons, including benzo(a)pyrene (BaP).

2.2 The air quality in Lima: from 2007 to 2010

According to the WHO the available data indicates that the air pollution is very high in Lima.[51] Then, how polluted is the air in Lima? In order to find out the answer it is necessary to review the reports published by the public office responsible for monitoring the air quality in Lima, which –as stated before- under the Peruvian General Statute of the Environment is the General Management of Environmental Health (hereinafter DIGESA).[52]

Currently, such public institution assesses the air quality in Lima in three air-controlling stations: north of Lima, at C.S. Santa Luzmila; south of Lima, at Maria Auxiliadora hospital; and east of Lima, at Hipolito Unanue hospital.[53] Each station reports the content of only SO_2,

[51] July 21st, 2011: http://www.who.int/phe/air_quality_q&a.pdf
[52] DIGESA is the abbreviation of its Spanish denomination: Dirección General de Salud Ambiental.
[53] The program to assess the air quality in Lima started on 1986, with only one air-controlling station

NO_2, $PM_{2.5}$, and PM_{10} in the air of Lima. Notwithstanding, DIGESA shall monitor other pollutants for which the Peruvian regulations have established AQS. The results since 2007 are detailed in the tables below.[54-55]

Table 2
Air Pollution in Lima – East Station

	2007	**2008**	**2009**	**2010**
SO_2	16.91	15.21	9.87	11.1
NO_2	20.57	31.01	36.97	30.27
$PM_{2.5}$	59.72(*)	55.52	59.54	35.18
PM_{10}	90.98(**)	108.2	78.41	73.82

(*) The mean of 10 months.
(**) The mean of 5 months.

Table 3
Air Pollution in Lima – South Station

	2007(*)	**2008**	**2009**	**2010**
SO_2	26.17	59	34.01	12.4
NO_2	20.26	17	24.75	19.67
$PM_{2.5}$	62.54	59	39.3	32.91
PM_{10}	s.m	105	78.5	78.73

(*) For SO_2 and $PM_{2.5}$ it includes 9 months, and for NO_2, 7 months.

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in downtown Lima, and since 1999 it has been established three more air-controlling stations in Lima (those described above) plus one in Callao. However, there are not reports of the air quality in downtown Lima since 2010, and Callao is not included in this thesis, since it is not part of the city of Lima.

54 Unless something different is indicated at the end of the tables, the results of years 2007, 2009 and 2010, are the mean of the assessments made from February to December of each year.

55 The values are considered to be the annual average concentration of $\mu g/m^3$.

Table 4
Air Pollution in Lima – North Station

	2007	2008	2009	2010
SO_2	31.92	14.72	21.68	11.55
NO_2	25.86	35.74	25.74	24.73
$PM_{2.5}$	54.72	50.97	45.5	34.55
PM_{10}	94.28	103.49	121.1	82.64

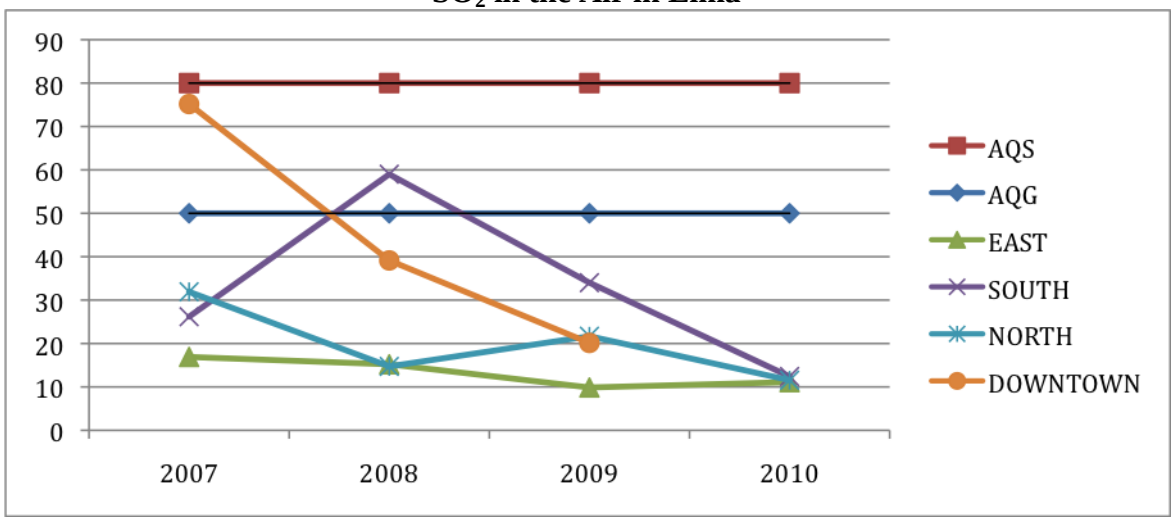
Table 5
Air Pollution in Lima – Downtown Station

	2007(*)	2008	2009(**)	2010
SO_2	75.18	39.14	20.14	-
NO_2	72.7	73.01	37.38	-
$PM_{2.5}$	95.71	76.35	69.88	-
PM_{10}	127.69	125.62	113.75	-

(*) For $PM_{2.5}$ and PM_{10} it includes 10 and 5 months, respectively.
(**) For SO_2 it includes 7 months, and for the other elements it includes 8 months.

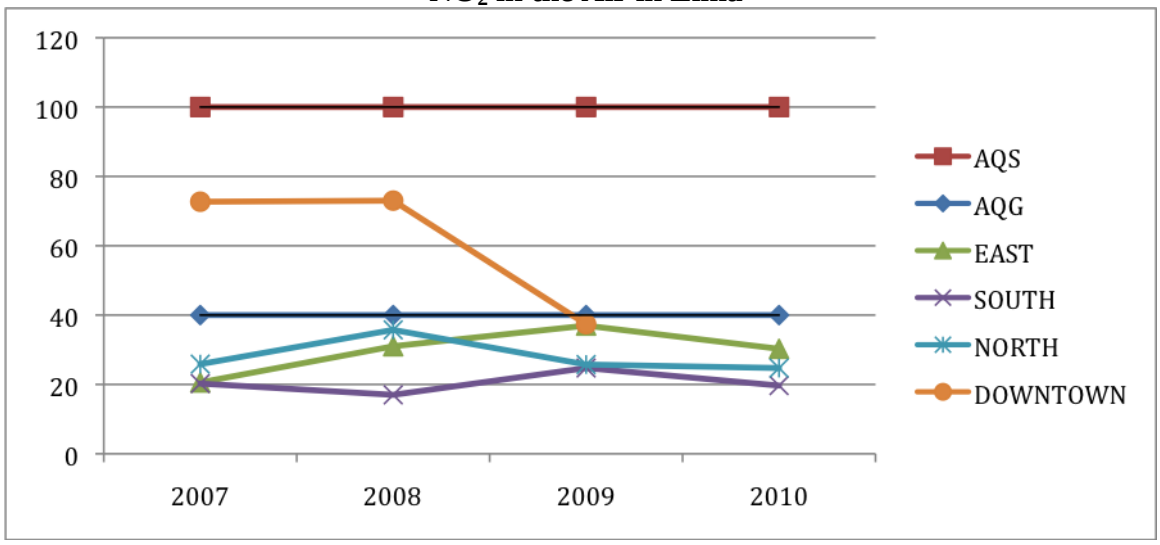
Have these results accomplished the AQS? How far or close are these results from the AQG? The charts below will show such results of each pollutant monitored by DIGESA in each station, and will allow to compare with the AQS and the AQG.

Chart 1
SO_2 in the Air in Lima



Regarding the content of SO_2 in the air in Lima the results have been below the AQS and, with some exceptions, the AQG. Indeed, such results have been over the AQG only in the south of Lima in 2008, and in downtown Lima in 2007. Other important issue is that the DIGESA either does not monitor or does not publish the 24 hours average concentration of SO_2 in the air in 24 hours, as the AQS have established.

Chart 2
NO_2 in the Air in Lima



With respect to the content of NO_2 in the air in Lima it has been below the AQS as well as

the AQG, with some exceptions, specifically the results in downtown Lima in 2007 and 2008 have been over the AQG, being important to stress that there have not been assessments in such area since 2010. In addition, the same as the case of SO_2, the DIGESA does not monitor the one-hour average concentration of such pollutant or, if it does, it has not published the results. In both situations it has not been accomplishing what the Regulations have stated.

Chart 3
$PM_{2.5}$ in the Air in

Lima

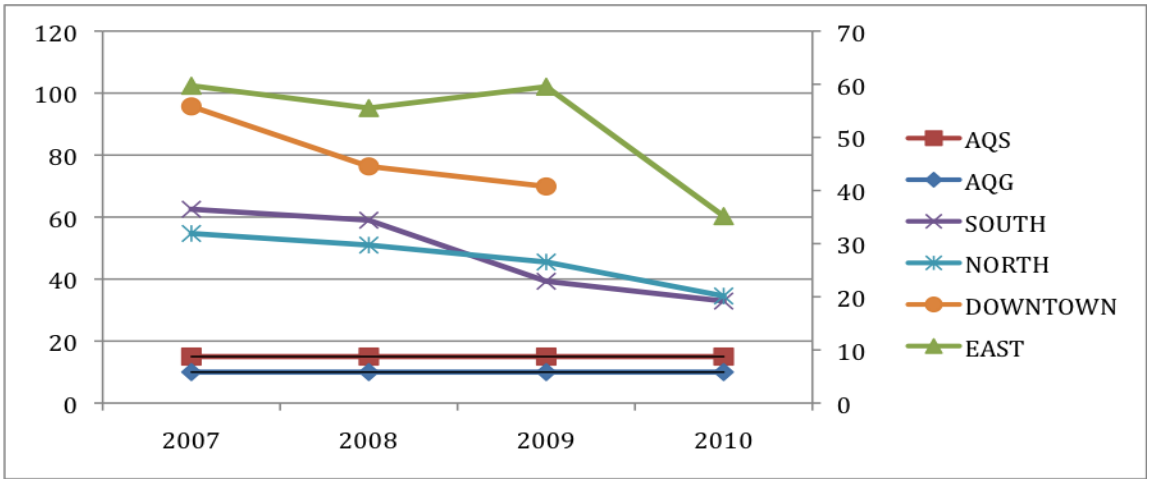
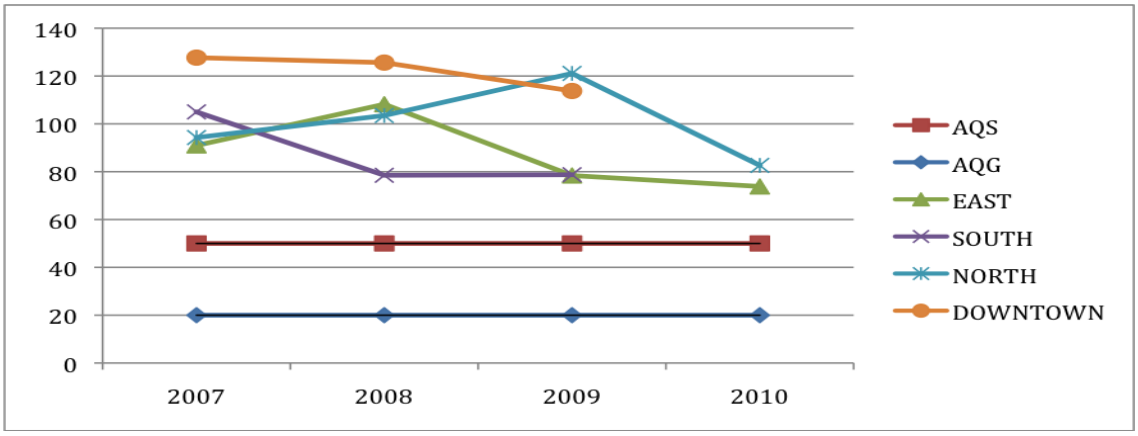


Chart 4
PM_{10} in the Air in

Lima



The $PM_{2.5}$ and the PM_{10} in the air in Lima has always been over the AQS as well as the AQG. Similar to SO_2 and NO_2, the DIGESA has not measured or published the 24-hour concentration of $PM_{2.5}$ and PM_{10} in the air as the Regulations mandate.

Another important issue is that among the four areas of Lima where the air quality is assessed, downtown Lima has been the most polluted area in 2007 and 2008, and during 2009 it has had the highest concentration of NO_2 and $PM_{2.5}$. However, paradoxically, it has not been monitored since 2010.

Finally, from the Charts 1 through 4 it is also possible to assert that:

a) There has been a clear reduction of SO_2 if a comparison is made between the years 2007 and in 2010. However, such reduction has not been constant from 2007 through 2010:

- In the east, the content of SO_2 in 2010 increased compared to that in 2009.
- In the north the content of SO_2 in 2009 increased compared to that in 2008.
- In the south, the content of SO_2 in 2008 and 2009 was higher than that in 2007.[56]

b) Comparing the content of NO_2 in 2007 and 2010, it had increased in the east, but decreased in the other three areas. However, in the north and in the south the decrease had been minimum. In all the four areas there is not a clear trend of reducing NO_2 content in the air:

- In downtown Lima it had increased in 2008 with respect to 2007. It is not possible to

[56] It should be emphasized that in 2007 the content of SO_2 in the south was measured only during nine months.

conclude that the reduction in 2009 has been sustainable due to there be not data of the air quality in 2010 and 2011.

- In the east it had increased from 2007 through 2009, and although in 2010 the NO_2 content was lower than in 2009, it was still higher than in 2007.
- In the north it increased in 2008 compared with that in 2007, and even though in 2009 and 2010 it had decreased with respect to 2008, in both years the NO_2 content was very close to that in 2007.
- In the south it is higher in 2009 and 2010 compared to that in 2008.

c) The content of $PM_{2.5}$ in the air had decreased in 2010 compared with that in 2007, and there is a trend of reducing such pollutant in the air since the reduction had been sustainable from 2007 through 2010, except in the east where there was an increase in 2009 with respect to that in 2008.

d) There has been a reduction of PM_{10} content in the air from 2007 to 2010, and in the case of the south from 2008 through 2010.[57] Except the case of downtown Lima, there is not a clear trend in reducing such pollutant in the air:

- In the east it increased in 2008 compared to that in 2007.
- In the north it increased from 2007 through 2009.
- In the south it increased in 2010 compared to that in 2009.

2.3 Sources of Pollution in Lima

The anthropogenic sources of pollutants can be non-moving (stationary) sources such as

[57] There is not data regarding the PM_{10} content in the air in the south in 2007.

power plants or manufacturing facilities, or moving sources such as automobiles and ships. The air pollution in Lima estimated by source in 2002 was:[58]

Source	CO	HC	NO_x	PM_{10}
Moving Sources	99.6%	98.57%	88.52%	68.55%
Non-moving Sources	0.4%	1.33%	11.47%	31.24%
Total Emissions	**100%**	**100%**	**100%**	**100%**

For purposes of such estimation, moving sources are: motorbikes, passenger cars, light-duty vans, busses, and heavy-duty vehicles. Stationary sources were divided into domestic, commercial and industrial sectors.

Furthermore, CO emissions from moving sources are mainly derived from passenger cars (83.79%), and 48.94% of passenger car's emissions come from taxis. Similarly, HC are also mainly emitted by passenger cars (72.97%), from which 40.71% come from taxis. For NO_2 and PM_{10}, the highest source is busses and light duty vans both used for public transportation.

Therefore, moving sources are the main air polluters in Lima, from which motor vehicles for public transportation have great responsibility.

3. Motor Vehicle Air Pollution

The pollution by vehicles depend on different factors, such as type and quality of fuel that

[58] Comité de Gestión de la Iniciativa de Aire Limpio para Lima - Callao (CGIALLC), *Primer Plan Integral de Saneamiento Atmosférico para Lima – Callao PISA* (Lima: 2004), p. 37. July 22nd, 2011: http://www.comitelc.airelimpio.org.pe/pdf/Primer%20PISA%202005-2010.pdf

they use, the maintenance of the engine, its age and technology, the congestion, etc. All those factors are related to either the motor vehicle or the fuel. Hence, an approach to the problem of the air pollution in Lima will be made analyzing separately both elements that together are the main source of air pollution in Lima.

3.1 Motor Vehicles in Lima

These are the main factors regarding the motor vehicles that explain the problem of the air pollution in Lima: the number of motor vehicles, congestion, the age and maintenance of motor vehicles.

According to the Urban Transportation Management of the Metropolitan Municipality of Lima (MML)[59] in this capital city there are 7.6 million people approximately, and 6.8 million use public transportation to move within the city of Lima. There are 100,381 motor vehicles, which are conformed in this way: station wagon 42.6%, cars 31.6%; vans 11.2%; microbuses 10.9%; buses 3.6%; others 0.2%.

The MML has authorized 29,700 motor vehicles for public transportation, and the Municipality of Callao has authorized 7,300 motor vehicles for public transportation from which 5,200 pass by the city of Lima. In addition, there are around 3,500 vehicles that provide informal public transportation. However, it is estimated that only 22,000 motor vehicles would be enough to provide public transportation in the city of Lima. Consequently,

[59] Public information available in the web page of the Metropolitan Municipality of Lima. July 22nd, 2011: http://www.gtu.munlima.gob.pe/transporte/estadistica.htm

there is an excess of approximately 20,000 vehicles for public transportation. The excessive offer of public transportation produces congestion[60] and, with congestion, more pollution.

More over, the traffic in the main tracks is explained: 30% by private cars, 30% by busses, 30% by taxis, and 10% by other motor vehicles. The highest levels of congestion are where there are bus stops.[61] A study shows that out of the total daily trips 22% are private cars, and 78% public transportation vehicles.[62]

The average age of the motor vehicles in Lima is 14 years. In the specific case of public transportation 56% of motor vehicles are older than 20 years, and 91.6% are older than 10 years. The age of the vehicles is partially explained by a tax incentive that has existed since several years ago that allow importation of used vehicles exempted of excise taxes through specific areas called CETICOS. Old motor vehicles cause more pollution than new ones.

In addition most of those motor vehicles does not receive preventive maintenance, which also makes them to produce more pollution. This is true above all in the case of motor vehicles for public transportation, due to the excess supply of such service makes the economic agents to reduce costs affecting the maintenance of the vehicles.[63] For that reason, few years ago the MML established the obligation of an annual technical review of vehicles in Lima.

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[60] According to the MML there are other additional causes of congestion such as the lack of integration of some streets to the road network, the lack of traffic signs as well as lanes to turn left, the lack of an integrated public transportation system, and so forth. July 22nd, 2011, p. 9-1: http://www.gtu.munlima.gob.pe/ documentos/Lima-Callao/capitulo09.pdf

[61] MML, *supra* note 60, p. 9-2

[62] PROTRANSPORTE et al., *Study for an Integrated Public Transportation System in Lima*, Vol. II, Component II, Part I (July 2010). Table 3.3, p. 3.14. July 22nd, 2011: http://www.protransporte.gob.pe/COSAC_II/Memoria/VolumenII.pdf

[63] PROTRANSPORTE, *supra* note 62, p.3.111.

3.2 Fuel used by Motor Vehicles in Lima

The bad quality of fuel used by motor vehicles in Lima had been one of the main reasons of the air pollution in Lima. It was for the lack of an environmental policy in that regard by the government of Peru as well as the lack of environmental responsibility by the private sector.

The first problem was the contain of lead in the gasoline, but in the year 1998 the government[64] banned the content of lead in gasoline 95 RON, and established the gradual reduction of lead in gasoline 84 RON until its elimination. It seemed that for the government the only problem with fuel oils was the lead content in gasoline, but the quality of the diesel also needed government's intervention since such fuel had been one of the worst in the world with a sulfur content of 4,000 to 6,000 ppm while in Latin America countries as Chile and Mexico had levels of less than 350 ppm, which still was considered of bad quality in Europe.

It is important to mention that sulfur is a natural element in the crude oil with effects associated to emissions of particulate matter and SO_2, which -as stated before- affect the health of people.

Many years later the Congress of Peru enacted the Statute that rules the sulfur content in diesel fuel, Ley N° 28694, and based on such Statute the government passed two regulations:

[64] Through Decreto Supremo N° 019-98-MTC, modified by Decreto Supremo N° 034-2003-MTC.

- Regulation for the trade of biofuels,[65] which mandated the substitution of Diesel B2[66] for Diesel 2 since 2009, and the substitution of Diesel B5[67] for Diesel B2 since 2011.
- Regulation that prohibited the trade in Lima and Callao of Diesel B2 with sulfur content higher than 50 ppm.[68]

After the government ruled the sulfur content on diesel, that element was dramatically reduced. Indeed, on March 2011, the MML contracted two specialized institutions to analyze the quality of diesel that gas stations sell for motor vehicles, and the result of the diesel samples was that they had a sulfur contain of 16 ppm and 24 ppm.

[65] Approved by Decreto Supremo Nº 021-2007-EM, published on April 20th, 2007.
[66] Defined as the mixture of 98% of Diesel 2 and 2% of Biodiesel B100.
[67] Defined as the mixture of 95% of Diesel 2 and 5% of Biodiesel B100.
[68] Decreto Supremo Nº 061-2009-EM, published on September 5th, 2009.

III. ENVIRONMENTAL TAXES AS A RESPONSE TO THE AIR POLLUTION IN LIMA

1. Tax on Vehicles and Fuel in Lima: Current Situation

As stated in Section 3 of Chapter II of this thesis, the air pollution by motor vehicles is produced by the combination of two goods: motor vehicles and fuel. In this section there will be a description of taxes imposed to both goods in Lima, Peru, that influence or can influence consumers' decision. For that reason, even though the Value Added Tax is applicable to both motor vehicles and fuel, it is not mentioned below since it is neutral as long as there is only one tax rate and there is not tax incentive that affects the consumption of such goods.

1.1 Motor Vehicles: The Way they are taxed in Peru

There are two ways Peru taxes motor vehicles: the property and the sale of the vehicle. In the following paragraphs there will be a description of such taxes in order to find out whether they are environmental taxes or not.

A) Motor Vehicle Property Tax[69]

This is an annual tax on the property of motor vehicles: cars, pickup trucks, vans, station wagons, trucks, and busses. This tax shall be paid only for three years after the vehicle is registered in the Registry Office, which means that the property on motor vehicles is taxed after they are registered for the first time in Peru, disregarding whether the vehicles

[69] Tax ruled by the Statute of Taxes for Municipalities, Decreto Legislativo N° 776.

are new or not. The tax rate is 1% applicable on the purchase price or import value of the car, but the tax base can never be lower than the amounts the Ministry of Economy publishes annually.

Therefore, the motor vehicle property tax is a tax based on the value of the taxed good, disregarding the age, engine, or any other factor that could make the vehicle to pollute more.

There is a tax exemption for public transportation vehicles that are authorized to provide transportation service, but only if they are not older than 3 years.

This is a local government tax, collected by each local government. Hence, this is a tax collected by the MML from the owners of motor vehicles registered in the Registry Office of Lima. In the table below there is information of the tax revenue of the MML in 2010 that comes from national taxes collected by it.[70-71]

Table 6
Revenue from National Taxes Collected by the MML – 2010

National Tax	Revenue (Thousands of Nuevos Soles)	Revenue In Percentages
Purchase Immovable Property Tax	303,944	60%
Motor Vehicle Property Tax	127,586	25%
Immovable Property Tax	27,957	5.5%
Other Taxes	46,580	9.5%
Total	**506,067**	**100%**

[70] The budget of the MML is published in its web page: http://www.munlima.gob.pe/transparencia.html

[71] It is important to mention that local governments in Peru -aside from other sources of revenue- have income from two types of national taxes (meaning taxes created by the Congress of Peru in favor of the local governments): taxes that are collected by the national government and later distributed to all local governments of Peru, and taxes that are collected directly by each local government.

The total income of the MML is 1,969 millions of Nuevos Soles; consequently, its revenue from national taxes collected by itself are almost 26% of its total revenue, and the revenue from the Motor Vehicle Property Tax is around 6.5% of its total revenue.

B) Excise Tax on Motor Vehicles[72]

This is a tax on imports of motor vehicles, and on the sales of motor vehicles in Peru by the producer or importer. The tax base for importing motor vehicles is the import value of the vehicle plus the import duties, and for selling the motor vehicles is the sale price. This is an ad valorem tax, which rate varies as follows:[73]

- Zero percent for:
  - Used motor vehicles that are reconditioned or repaired in the CETICOS.[74]
  - New assembled motor vehicles for public passenger transport, with a projected capacity at the factory up to 24 seats including the driver.

- Ten percent for:
  - New assembled motor vehicles principally designed for the transport of people.
  - New pickup trucks assembled in single or double cab.
  - New chassis cab pickups.

- Thirty percent for:

[72] This tax is ruled by the Statute of the General Sales Tax and the Selective Consumption Tax (hereinafter LIGV).
[73] Appendix IV Literal a) of the LIGV.
[74] CETICOS are special geographic areas within Peru where used vehicles can be imported but before coming into the country, those vehicles must be repaired in CETICOS.

- Used motor vehicles assembled for public passenger transport.
- Used motor vehicles for the transport of goods.
- Used chassis of motor vehicles, fitted with engines.
- Used bodywork of motor vehicles, including cabs.

1.2 Taxes on Fuel for Motor Vehicles in Lima

A) Gasoline Tax[75]

This tax was created as a tax over the vehicles that use gasoline. However, it is determined with a tax rate of 8% applicable over the sales price of the gasoline in the refinery, with no inclusion of the excise tax nor the VAT. Therefore, such tax affects the price of the gasoline but not that of the motor vehicles. For that reason, in this thesis this is included as a fuel tax.

Gasoline tax is not applicable to liquefied petroleum gas, diesel, or any other fuel different to gasoline.

This is one of the national taxes created for local governments but collected by the National government and later distributed to local governments.

B) Excise Tax on Fuel

[75] Created by Decreto Legislativo N° 8.

This is a tax on the sale of fuel made by producers and importers, determined as a specific amount by each gallon of fuel that is sold.[76]

Traditionally, the excise tax on fuel in Peru had been a raising-revenue tax and its amount had never considered how dirty or clean each type of fuel was for the environment. For example, in December 2005 when the diesel in Peru had a sulfur content of thousands of ppm, it was taxed at S/. 1.4 per gallon, while cleaner fuel as gasoline 97 RON[77] was taxed at S/. 3.85. Consequently, even though producing diesel was more costly than gasoline, due to taxes the former had become cheaper than the later. It is important to mention that gasoline tax increased such effect because it is applicable only to gasoline but not to diesel.

Table 7
Price Structure of Fuel
Peru - December 2005(*)

Fuel	Price on Oil Refinery before tax	Taxes			Price on Oil Refinery after tax
		Gasoline 8%	Excises S/.	VAT 19%	
Liquefied Petroleum Gas	1.78	--	0.14	0.36	2.28
Gasoline 97 RON	6.80	0.54	3.85	2.13	13.32
Gasoline 95 RON	6.63	0.53	3.62	2.05	12.83
Gasoline 90 RON	6.16	0.49	3.31	1.89	11.86
Gasoline 84 RON	5.73	0.46	2.60	1.67	10.46
Diesel 2	6.95	--	1.40	1.59	9.94

(*) Prices and taxes per gallon of fuel, except LPG that is per kilogram.

Source: Peruvian Ministry of Energy and Mines.

[76] This is the type of excise tax known as specific tax. The tax amount is in Appendix III of the LIGV.
[77] Research Octane Number.

With respect to the law the Congress of Peru enacted to rule the sulfur content in diesel in 2006, it established not only a command-and-control policy[78], but also an economic policy based on taxes, making the traditionally raising-revenue excise taxes on fuels to switch over to environmental taxes: It mandated that, gradually, since January 1st, 2008 the amount of the excise tax on fuel shall be determined applying a harmfulness' index that the Ministry of Economy and the National Agency of the Environment (currently, Ministry of the Environment) will approve annually. Such index shall be constructed by taking into account the environmental health problem each fuel causes, and since January 1st, 2016 the excise tax on fuels shall consider only the environmental health problem the fuel produce.

In compliance with such law, the National Agency of the Environment approved the harmfulness' index for 2005-2006, and after that the Ministry of Economy approved the amount of the excise taxes on fuel that could be applicable since January 1st, 2008 which include the harmfulness' index.[79]

Table 8
Excise Tax on Fuel
Based on the Harmfulness' Index

Fuel	2008	2009	2010	2011	2012	2013	2014	2015	2016
Liquefied Pet. Gas	--	--	--	0.08	0.17	0.25	0.42	0.42	0.50
Gasoline 97 RON	3.15	2.86	2.56	2.27	1.98	1.68	1.39	1.09	0.80

[78] As explained before, the Executive Power passed Regulations establishing limits of the sulfur content in diesel.

[79] Through Decreto Supremo Nº 211-2007-EF, published on December 23rd, 2007.

Fuel	2008	2009	2010	2011	2012	2013	2014	2015	2016
Gasoline 95 RON	2.92	2.66	2.39	2.13	1.86	1.60	1.33	1.07	0.80
Gasoline 90 RON	2.46	2.25	2.05	1.84	1.63	1.42	1.22	1.01	0.80
Gasoline 84 RON	1.85	1.72	1.59	1.46	1.33	1.19	1.06	0.93	0.80
Diesel	1.39	1.47	1.54	1.62	1.70	1.77	1.85	1.92	2.00

Regarding the Table 8, on the one hand, it was published when the sulfur content on diesel was very high, and that is the reason the target was to tax such fuel higher than gasoline. However, currently the sulfur content is much lower, and that table needs to be updated. On the other hand, the amounts described in the table are not mandatory, but a guideline that the same Ministry could take into account when establishing the amount of the tax.[80] Thus, it is necessary to review the amount of the excise tax on fuel approved since December 2007.

Table 9
Excise Tax on Fuels (Dec. 2007 – Jun. 2011)

Fuel	2007	2008				2009		2010			2011
	Dec 23rd	Mar 7th	Jun 1st	Oct 29th	Nov 28th	Mar 4th	Dec 31st	Jan 22nd	Dec 24th	Dec 29th	Jun 8th
Gasoline 97	3.15	2.30	2.30				2.24		2.12		2.00
Gasoline 97 + 7.8% AC											1.87
Gasoline 95	2.92	2.07	2.07				2.03		1.94		1.83
Gasoline 95 + 7.8% AC											1.69
Gasoline 90	2.46	1.86	0.66		1.78		1.76		1.67		1.57
Gasoline 90 + 7.8% AC											1.46

[80] Article 1º of Decreto Supremo Nº 211-2007-EF states that the amounts approved 'could' be established gradually since January 1st of each year.

Fuel	2007	2008				2009		2010			2011
	Dec 23rd	Mar 7th	Jun 1st	Oct 29th	Nov 28th	Mar 4th	Dec 31st	Jan 22nd	Dec 24th	Dec 29th	Jun 8th
Gasoline 84	1.85	1.30	0.40		1.36		1.35		2.12		1.17
Gasoline 84 + 7.8% AC											1.07
Gasoline -84	1.85	1.30	0.40		1.36		2.30		2.27		1.17
Diesel B2 – 50ppm								1.24		1.24	1.04
Other Diesel B2						1.44		1.44		1.44	1.24
Other Diesel B5						1.47				1.40	1.20
Diesel B5 – 50ppm										1.21	1.01
Diesel 2	1.39	0.99	0.39	1.04	1.47	1.47				1.27	
GLP						2.10			0.08	0.00	

A comparison between Tables 8 and 9 shows the difference between the specific taxes on fuel that were programmed by the Ministry of Economy considering the harmfulness' index, and the taxes that have been applied since 2008. From Table 8 it is possible to see that the proposal was a gradual:

- Reduction of the excise tax on gasoline in a way that by 2011 gasoline of 97 RON would be taxed at S/. 2.27; 95 RON, S/. 2.13; 90 RON, S/. 1.84; and 84 RON, S/. 1.4.
- Increase of the specific tax on liquefied petroleum gas and diesel, and by 2011 they would be taxed at S/. 0.08 and S/. 1.62, respectively.

Notwithstanding, as can be seen in Table 9, the excises on gasoline and liquefied petroleum gas by 2011 are below the amounts were proposed by the Ministry of Economy. In the case of gasoline it does not affect the tax reduction proposed because the current taxes are higher than the taxes programmed for 2016, which is S/. 0.80. In the case of liquefied petroleum gas, however, it should have been started to be taxed since 2011 at S/. 0.08 (S/. 0.50 by 2016), but the zero tax rate has been kept during 2011.

The reduction of such taxes has not followed any environmental criteria. Furthermore, all the Regulations passed by the government in order to modify the excises tax rates on fuel have not been justified in the harmfulness' index.[81]-[82]

For diesel there is a different problem. The increase of the excise tax on diesel was planned until 2016, but the diesel considered in 2006 is not traded anymore in Lima, but a better (cleaner) diesel. The current biodiesels traded in Lima have been taxed without any environmental ground. The main problem is that the government has not applied what the law mandated: the Ministry of Economy and the Ministry of the Environment must establish annually the harmfulness' index.

Table 10
Price Structure of Fuel
Peru - April 2011(*)

Fuel	Price on Oil Refinery before tax	Taxes			Price on Oil Refinery after tax
		Gasoline 8%	Excises S/.	VAT 19%	
Liquefied Petroleum Gas	1.78	--	00.0	0.34	2.12
Gasoline 97 RON	7.47	0.60	2.27	1.96	12.30
Gasoline 95 RON	7.35	0.59	2.07	1.90	11.91
Gasoline 90 RON	6.86	0.55	1.78	1.75	10.93
Gasoline 84 RON	6.64	0.53	1.36	1.62	10.15
Diesel B5	7.45	--	1.40	1.68	10.53

(*) Prices and taxes per gallon of fuel, except LPG that is per kilogram.

Source: Peruvian Ministry of Energy and Mining.

81 Decreto Supremo N° 210-2007-EF, published on December 23rd, 2007; Decreto Supremo N° 037-2008-EF, published on March 7th, 2008; Decreto Supremo N° 071-2008-EF, published on June 1st, 2008; Decreto Supremo N° 126-2008-EF, published on October 29th, 2008; Decreto Supremo N° 131-2008-EF, published on November 28th, 2008; Decreto Supremo N° 052-2009-EF, published on March 4th, 2009; Decreto Supremo N° 322-2009-EF, published on December 31st, 2009; Decreto Supremo N° 013-2010-EF, published on January 22nd, 2010; Decreto Supremo N° 265-2010-EF, published on December 24th, 2010; Decreto Supremo N° 270-2010-EF, published on December 29th, 2010; and Decreto Supremo N° 097-2011-EF, published on June 8th, 2011.

82 During 2008 for example the Ministry of Economy justified the reduction of the excises on fuel as means to reduce inflation. July 22nd, 2011: http://mercadoenergia.com/mercado/2008/03/08/rebaja-arancelaria-y-del-isc-a-combustibles-favoreceran-reduccion-de-inflacion-en-04 4-puntos-asegura-mef.html

From Table 10 it can be seen that the taxes on fuel still have a great influence in the price, although such difference is lower than that on 2005 (showed in Table 7). However, there is a need that the Ministries of Economy and the Environment establish which of those fuel are more pollutant (harmfulness' index) in order to determine the specific tax on each fuel.

2. Experiences of Applying Environmental Taxes in Other Countries

2.1 Singapore[83]

Singapore has a great experience with very good results in the use of economic policies in order to regulate the traffic, reducing in this way the motor vehicle pollution. As stated by Lin-Heng Lye[84] the result of this policy is that "roads in Singapore are relatively congestion-free, and most cars in Singapore are relatively new (less than ten years old), well maintained and therefore less likely to pollute. This, in turn, has helped to improve air quality in Singapore."

For purpose of this thesis the taxes imposed in Singapore will be categorized within two: taxes on motor vehicles, and taxes on fuel. After that, a description of a market-based instrument used by Singapore will be made for its interesting results in controlling the number of vehicles within such country.

[83] The case of Singapore is extracted from: Janet Milne, Kurt Deketelaere, Larry Kreiser, Hope Ashiabor, ed., *Critical Issues in Environmental Taxation*, Vol. I (London: Richmond Law & Tax Ltd., 2002), p. 387-405.

[84] Janet Milne et al., *supra* note 83, p. 390.

A) Taxes on the Motor Vehicle

- Import tax, and good and services tax.

- Registration fee. It is a lump sum tax that used to be very high until the Electronic Road Pricing system was introduced.

- Additional registration fee. It is a tax for new cars and taxis of 140% of their open market value of the vehicle, and it is doubled for corporations. The owner of a new car that is registering that owns another car not more than ten years old which is de-registered, will have a preferential additional registration fee.

- Road tax. It is based on the vehicle's engine capacity that allows the use of the vehicle on the roads. This is a specific tax per c.c. that has to be paid annually or twice a year. Cars that are older than ten years pay an annual road tax of 10% above the usual rate, being increased such rate by 10% yearly up to 50%, which is applicable to cars that are 15 years or older.

There are special cases to which vehicle owners get tax savings or are subject to special taxes:

(1) The off-peak cars -that substituted the system of the weekend car receive a tax rebate for their COE and savings in their road tax, since they are cars that can be used during off-peak hours, basically Sundays, holidays, and from Monday to Saturday at certain hours.

(2) Foreign cars pay a fixed amount of tax either per day or per month, but they are subject to the same restrictions as off-peak cars.

(3) Electric and hybrid cars as well as environmentally friendly motor vehicles are subject to rebate on registration fees and additional registration fees, and for the COE.

(4) The Electronic Road Pricing System[85] under which all motor vehicles[86] are required to have an electronic device that reads a smart card and debits charges from the card each time the car passes under a set of gantries in some restricted areas. This system has the benefit that the charge can be adjusted more accurately for congestion (depending on the location, days, and peak-hours) and allows better control.

This economic measure has had effective environmental impacts. In a publication of the United States Department of Transportation[87] it is stated that immediately after the introduction of the road pricing system the CO concentration in the morning peak in the restricted areas was reduced (partially attributable to this system), and the monthly average values of NO_x also was reduced (completely attributable to this system).

[85] This system replaced the Area Licensing Scheme and the Road Pricing Scheme, under which a car could not enter to restricted areas in peak hours or in some expressways, unless it is purchased a license per day or per month.

[86] This charge is not applicable to ambulances, fire engines, police vehicles, and few other special cases.

[87] July 22nd, 2011: http://ops.fhwa.dot.gov/publications/fhwahop08047/02summ.htm

B) Taxes on Fuel

Fuel taxes for diesel are different to those for gasoline, and in the case of gasoline it varies depending on its grades. Due to the tax on fuel is very high, to avoid that cars tanks be filled in Malaysia, it is considered an offense to leave Singapore without at least three-quarter tank of fuel.

C) Market-Based Instrument: Certificates of Entitlement

Singapore not only used taxes as economic policy to reduce congestion (and consequently, air pollution) but also marked-based instruments, through the Certificate of Entitlement to own the car (COE) which works in a way that limits the number of vehicles within Singapore.

Roughly, it works as follows: the government determines annually the number of vehicles that can be registered, taking into account the number of vehicles taken off the roads permanently and the traffic conditions, and authorizes the purchase of only such number of vehicles through issuing COEs monthly. Thus, only the owners of COEs can buy a new vehicle, with some exceptions: public and school buses, diplomatic vehicles, ambulances and emergency vehicles, and vehicles for the disabled.

The purchasers of new vehicles have to bid for a COE. The COE lasts for ten years, after which the owner can either purchase another COE for five or ten years, or de-register the vehicle and export it or sell it for been destroyed. There are economic incentives to opt

for de-registering the vehicle. Other important feature of the COEs is that they are not transferable, with some exceptions.

2.2 London

A) Congestion Charge

Central London Congestion Charging.[88] After a long political process,[89] this charging program started in February 2003 for reducing traffic congestion and raise revenues to fund transport improvements. Different to the case of Singapore, this is a flat fee, and it is charged on weekdays during certain hours to vehicles that cross into, leave, or travel within the restricted area. There are exemptions for buses, licensed taxis, emergency vehicles, hydrid cars, motorcycles, and vehicles for disabled people, and discounts of 90% to residents of such area.

The way it is controlled is with closed-circuit cameras at the cordon, and moving vans police within the zone, that capture live video images of the license plates of all vehicles. The charge is paid at selected retail outlets or payment machines, or by Internet, SMS text message, or phone. It can even be paid the day after with an additional charge, but after such day penalties are applied.

[88] This information is extracted from publications of the United Stated Department of Transportation. July 22nd, 2011: http://ops.fhwa.dot.gov/publications/fhwahop08047/02summ.htm

[89] The first proposal of congestion charging in London was in 1964. In 1973 there was a detailed study that concluded this charge would improve traffic and environment, and additionally increase revenue. However, it was opted to invest in public transportation. In 1999, it was conferred power to levy road charges to the Greater London Authority. There were 18 months of public consultation in 2000-2002.

The impact of this charge on the air quality has been positive: between 2002 and 2003 NO_x fell by 13.4%, CO_2 by 15%, and PM_{10} by 7%; and between 2003 and 2006 NO_x fell by 17%, CO_2 by 24%, and PM_{10} by 3%, but this result was also caused by better technology of vehicles.

B) Vehicle Excise Duty – VED (or annual car tax)

From March 1st, 2001 the VED rates are determined by CO_2 emissions and type of fuel used. Since April 1st, 2011 there are 13 emission bands according to which vehicles that are under Band A (with the lowest CO_2 emissions) pay zero tax, and vehicles under Band M (with the highest CO_2 emissions) pay £1000 which is the highest tax for first year registration of petrol and diesel cars.[90] These emission bands are applicable to vehicles registered on or after March 1st, 2001[91].

After the first year of registration, vehicles are subject to lower VED. Clean-fuel cars as natural gas and LPG pay lower tax rates.

There are some vehicles that are exempted of the VED such as electrically propelled vehicles, police vehicles, fire engines, ambulances, vehicles for disabled people, etc.[92]

[90] July 22nd, 2011: http://www.direct.gov.uk/en/Motoring/OwningAVehicle/HowToTaxYourVehicle/DG_10012524

[91] Vehicles registered before March 1st, 2001 are taxed based only on the engine size, with one rate for engine sizes up to and including 1549cc and one for engines over 1549cc.

[92] Vehicle Excise and Registration Act 1994. July 22nd, 2011: http://www.legislation.gov.uk/ukpga/1994/ 22/schedule/2

2.3 France

A) Motor Vehicle Tax on Company Cars

Tax on motor vehicles is levied on companies' property. For vehicles purchased before January 2006 the tax rate is based on the engine horsepower, and those purchased since January 2006 are taxed based on the CO_2 emission.

B) Feebate

The so-called feebate is an economic instrument under which fees are imposed for less efficient vehicles, and rebates are provided for more efficient vehicles. One of the advantages of this instrument is that incorporates fuel efficiency into consumer decision making and rewards the consumer in a tangible way for the societal benefits of reduced CO_2 emissions and lower oil consumption.[93]

The feebate system was introduced in France in January 2008 with rebates of €5000, 1000, 700, 200 and zero for CO_2 emissions of ≤ 60, 61-100, 101-120, 121-130, and 131-160 g/km, respectively, and fees of €200, 750, 1600 and 2600 for CO_2 emissions of 161-165, 166-200, 201-250, and >250 g/km, respectively. This system had an immediate effect on CO_2 reductions. According to the International Council on Clean Transportation in 2008 the CO_2 emissions dropped by 6% in one year, which is twice the

[93] The International Council on Clean Transportation, *Best Practices for Feebate Program Design and Implementation*, April 2010, p. 3. July 22nd, 2011: http://www.theicct.org/pubs/feebate_may10.pdf

average in the European Union and five times the reduction there was in France from 2000 to 2007.

3. Environmental Taxes: A Proposal for Lima

In order to apply an economic instrument it is necessary to determine what is the problem that has to be addressed, in this case the air pollution in Lima (see section 2 of chapter 2). However, any policy instrument to be designed requires more detail about the problem. From Charts 3 and 4 it is evident that $PM_{2.5}$ and PM_{10} are pollutants that affect the air in Lima, and they have to be reduced. However, it is not clear whether there are other pollutants in the air of Lima that require to be abated, because even though according to the AQG, and even the AQS, such other pollutants shall be measured in the air, the General Management of Environmental Health is not monitoring them.

Regarding what causes the air pollution problem, motor vehicles are the main source of pollution, and that involve two goods: motor vehicles and fuel. Actually, the problem of motor vehicle air pollution is related to:

- The choice of vehicle. Different types of motor vehicles (motorcycles, motor cabs, trucks and so forth) pollute differently. There are environmentally friendly cars. New vehicles pollute less than old ones. The engine size of a car can determine more pollution.

- The use of the vehicle. This is a complex issue that has many different aspects. The quality of the fuel that used by motor vehicles. The more a vehicle is used the more it pollutes. Driving during peak hours pollutes more than driving off-peak hours. There is more

pollution if each individual drives her own car than if many of them use one vehicle. Properly use and maintenance of vehicles reduces pollution.

Therefore, the government needs to update data with respect to the number of motor vehicles, their use (private or public transportation), their age, the fuels they use, and to determine how harmful are such fuels. After that, it has to determine what is the desirable growth rate of the number of motor vehicles; the number of motor vehicles required for public transportation; the expected average age of motor vehicles and until what age those vehicles can be used within the country; the type of vehicles that are considered as environmental friendly and those that are not; the fuels that are the least and the most polluting; the roads or geographical areas where congestion is of main concern.

Once determined the current situation and what is the desirable situation under which the air pollution would be reduced, the government has to define the type of policy instrument (or a mix of them) that is the most effective in reaching the desirable situation.

The Peruvian government, that same as many other governments around the world, has used regulations as the instrument to reduce air pollution, mainly banning or establishing limits to the content of lead in gasoline, and sulphur in diesel. Notwithstanding, as learned from the experiences of other countries, the use of economic instruments, and specifically of environmental taxes, can play an important role in the air pollution abatement.

Although the Congress of Peru has established the gradual use environmental taxes in order to reduce the air pollution (through the excise tax on fuel), the government has not applied such instrument. More over, even if the government had applied the excise tax on fuel as an

environmental tax, as explained above, the air pollution generated by motor vehicles is by far more than the type of fuel used. It does not mean that tax on fuels is not important; actually, it is, but it is not enough.

In the next paragraphs there will be an analysis of how the existing taxes can be turned into environmental taxes or eliminated, and what new environmental taxes can be levied to reduce the air pollution in Lima. The government must define specific tax rates and exemptions taking into account the desirable situation it wants to reach.

3.1 Existing Taxes: Moving towards Environmental Taxes

A) Motor Vehicle Property Tax

This is a raising-revenue tax, ad valorem, imposed the first three years after the vehicle's registration. It has a negative effect on the environment because it makes larger the price difference between new and old cars: purchasing a new car has the burden of three years of vehicle property tax, but buying an old car (registered for more than three years) is free of such tax. As stated before, old cars pollute more than new ones.

This tax, however, can be a useful tool to incentive the purchase of environmental friendly vehicles or fuel-efficient vehicles, and also to increase the revenue for local governments. In that regard, the property vehicle tax can be used in the same way as the road tax in Singapore, the VED in England, or the Motor Vehicle Tax on Company Cars in France.

The proposal is:

- To establish the tax rate based on the type of vehicle (trucks, cars, etc), standard emissions, the fuel economy, and the age of the vehicle. It shall consider a discount for taxpayers who purchase a new car and de-registers an old car (for example, ten years). It shall be a specific tax, not an ad valorem one.

- To establish a tax on motor vehicle's property with no limits, which means to eliminate the three-year limit of the current tax.

The rationale of this proposal is to internalize the external costs of using the motor vehicles.[94] The implementation of this proposal requires the participation of the following official actors:

- The Congress of Peru. Taxes are levied and modified only by the Congress; consequently, the use of vehicle property tax as an environmental economic instrument has to be approved by the Congress.

- The Ministry of Transportation and the Ministry of the Environment. The Congress cannot determine the tax base and tax rate due to technology changes all the time. Hence, it has to delegate in the Executive Branch the power to establish the tax base and tax rate, and both require technical knowledge of vehicle's technology (Ministry of Transportation) and pollutants (Ministry of Environment).

[94] The air pollution is one of the external costs produced by driving motor vehicles. In the design of this tax other external costs shall be taken into account such as noisy pollution, the use of roads, and accidents.

- MML, the Ministry of Health and the above mentioned Ministries. The policy evaluation is as important as the design and implementation of the policy. Therefore, after implementing the vehicle property tax as environmental instrument, those public agencies have to measure permanently the effect of this tax on the air pollution abatement.

The advantage of this proposal is that it will reduce the air pollution in Lima as well as in other cities of Peru.[95] The air pollution abatement would be a consequence of the increase in prices of more polluting vehicles, creating an incentive to purchase less polluting vehicles, and also of the renovation of cars for the tax benefit provided to those that de-register an old car and purchase a new one. Another advantage is the additional revenue it will produce for local governments for this tax will be paid not only during three years after the vehicle registration, but even after that. The advantage of applying a specific tax instead of an ad valorem tax is that the former reduces relative price differences between environmental friendly and other type of vehicles.

The efficiency of this measure will depend on the tax rates applicable and the accuracy on the determination of which are more and which are less polluting vehicles.

The disadvantage is that it will make the tax more complicated for taxpayers and for the Tax Administration. Another disadvantage is that this tax can be regressive since the property of cheaper cars could be heavier taxed than some expensive cars.

[95] Of course, this measure as part of other measures the government can apply with that purpose. The effect also would be for other cities of Peru because this is a national tax for local governments.

B) Excise Tax on Motor Vehicles

This is a raising-revenue tax, ad valorem, imposed on the importation of cars, or the sale of cars by importers or producers. Unlike vehicle property tax, the excise tax on motor vehicles explicitly affects the purchase price of the motor vehicles. For that reason, it has had a perverse environmental effect since it has increased the price of new cars by 10% whilst has not affected (tax exemption) the price of used cars that are imported through CETICOS.

The excise tax can become an environmental tax without affecting the government tax revenue. It can work as a complementary tool of the vehicle property tax. The proposal is that the tax rate of the excise tax be determined based on the type of motor vehicles the government wants to decrease in number and those that it wants to increase, which is defined under an environmental standpoint. A tax benefit shall be given to those that de-register a vehicle and buy brand new cars, and in this case coordination with the motor vehicle property tax is necessary, since such tax has to take into account the age of the car. The elimination of any lower tax rate for importing old motor vehicles has to be made.

The official actors to implement this measure are:

- The Ministry of Economy. It is responsible to propose the tax rate of the excises on motor vehicles, which is approved by the Executive Power.

- The Ministry of Transportation and the Ministry of the Environment. They have to determine the bands of the tax rates based on the type of vehicle.

- The MML, and the Ministries of Health, Transportation and Environment. They have to evaluate the effects of the excise tax on air pollution and other external costs.

The advantage of this tax measure is that it would reduce air pollution in Lima because it works as an additional incentive to purchase environmental friendly new cars. The increase or decrease of revenue for the government will depend on what the tax rates will be.

The disadvantage of this tax with different rates is that it makes more complex the determination of the tax by the taxpayer, and the collection and control of the tax by the Tax Administration. It can be a regressive tax.

3.2 Gasoline Tax: Eliminating an Unnecessary Tax

It is an old tax that even though was levied as a tax on cars (that use gasoline) it has been a tax on gasoline. It was the main reason why during several years much more polluting diesel was much cheaper than gasoline (see Tables 7 and 10).

Technically, there is no reason to have a gasoline tax additional to the VAT and excise tax on fuel. In addition, what can justify a tax levied only on gasoline and not other fuel? Although gasoline tax raises revenue for local governments, they also have revenue for the VAT. If to

the lack of technical justification for this tax it is added the perverse effect on the environment, this tax shall be eliminated.

The elimination of this tax will reduce the revenue of local governments and drop the price of gasoline. Thus, this tax can be substituted by an increase on the excise tax on fuels that do not affect final prices on fuels, but later gradually modified until reaching the external cost. If the additional revenue that local governments would receive for the modification of the vehicle property tax does not offset their less revenue for the elimination of the gasoline tax, the national government shall require the Congress to authorize by law that part of the revenue that would come from excises on fuels be transferred to local governments.

In 2010 the tax revenue for gasoline tax was S/. 210.2 million[96], and for excise tax on fuels was S/. 2,831 million (from which the tax on gasoline of 95 RON was S/. 236 million, and the tax on Diesel B2 was around S/. 1,700 million).

The implementation of the proposal to eliminate gasoline tax requires the approval of the Congress of Peru, as well as the transfer of part of the excise tax on fuel to the local governments.

3.3 Levying a New Environmental Tax: Road Charges

So far the proposal for environmental taxes has a national dimension, affecting not only Lima but also other cities in Peru. However, there is a useful and efficient economic instrument

[96] That is 6.4% of the Municipality Compensating Fund in 2010 (S/. 3,284 million).

used in Singapore and London that reduced congestion and consequently air pollution: road charges.

Lima has approximately 34% of the population of Peru, and 68% of Peru's motor vehicles stock. The population of Lima generates 11 million journeys per day, and average journey from the north and south cones is over two hours, causing waste of man-hours and fuel. The traffic is chaotic, with congested roads, and high levels of atmospheric pollution.[97]

As in any other country, there are specific geographic areas that are the most affected by congestion, and that is the case of Lima downtown. From Charts 1 through 4 it is possible to see that Lima downtown has had the highest levels of pollution in the air. Consequently, reduction of congestion in Lima downtown has to be aimed.

In addition to regulation, road taxes have to be used. Lima downtown is the oldest part of the city of Lima and there is no way to expand roads in order to reduce the traffic. Improving public transportation is an important tool that currently the government is using, but it is not enough since the number of motor vehicles in the city is increasing everyday. Therefore, there is a room for using the road taxes.

The proposal is to levy a road tax for motor vehicles driven within Lima downtown. The scheme could be similar to London's. The road tax applied by Singapore seems to be more precisely designed, but it would require higher investments. It would be a flat fee for every motor vehicle that driven within Lima downtown. The payment, however, shall be made

[97] Inter-American Development Bank, *Metropolitan Lima Urban Transportation Program (PTUL) – North-South Subsystem*, p.2. July 23rd, 2011: http://www.protransporte.gob.pe /pdf/info/publi2/PE-0187_e.pdf

before driving within the restricted area. Electronic monitoring would be the best way to control it. Extra charges can be imposed if the payment is made after entering to the restricted area, and high penalties if charges are paid after a reasonable period of time. It is important to consider exceptions for example for ambulances, fire engines, etc.

Another important issue is the use of the revenue that would come from the road charge. For the political difficulties it can face, it is necessary people see clearly the benefits of the road charge, and using the revenues of road charge for improving roads, public transportation, and other issues that have been detected as other causes of congestion.

The rationale of this proposal is to make the users to pay for the external costs they create by driving in a congested area as Lima downtown. The implementation of this proposal requires the participation of:

- The Congress of Peru. It has to approve this charge by law. It is important to mention that the MML has the Constitutional power to levy charges with the limits imposed by law. The law recognizes that local governments can impose charges by an amount that covers the cost of the services the MML provides to the taxpayer. In other words, the taxpayer can be obligated to pay charges to the MML to the extent she receives a direct and individualized service from the MML. Nonetheless, the article 61 of the Municipality Tax Statute has limited such power by banning local governments to levy any charge for the use of infrastructure: "Municipalities may not impose any charge levied on entry, exit or transit of people, goods, merchandise, products and animals in the country or which limit the free market access… It is not allowed user fees for (…) use of roads, bridges, and infrastructure."

- The MML. Although the Congress has to approve the charge, it has to delegate the MML the determination of the amount of the charge because it is necessary to have flexibility in its determination in order to adjust it according the evaluation of its effects.

A road charge for driving in Lima downtown has the advantage that precisely determined, it would reduce the congestion in Lima, reducing air pollution and other externalities that traffic produce. It also produces revenue for the MML that not only can be used for implementing the charge but also to improve public transportation and roads within the restricted area.

The disadvantage of a road charge is that it is politically unattractive. As saw in the experience of London, it took several years of political process before the government allowed the creation of a road charge. Another disadvantage is that being a flat fee it would be a lump sum tax that is regressive.

3.4 Constitutional Contingencies of the Proposal

The article 74 of the Political Constitution of Peru states that the tax power shall be exercised respecting fundamental human rights and the principles of legality and equality. However, it is not clear whether taxes shall be levied only for fiscal (revenue raising) purposes or they can be imposed for other purposes. For that reason any environmental tax can be challenged in the Constitutional Court. Spain[98] and Mexico[99] have experience in that regard.

[98] The case of Spain is extracted from: Janet Milne, Kurt Deketelaere, Larry Kreiser, Hope Ashiabor, ed., *Critical Issues in Environmental Taxation*, Vol. I (London: Richmond Law & Tax Ltd., 2002), p. 111-123.

The Spanish Constitution recognizes the right of everyone to enjoy an environment suitable for the development of the person, and the duty to preserve it, as well as the obligation of the authorities to protect the environment. It also establishes the possibility to impose criminal penalties, fines and compensation for environmental damage, but it does not state expressly any other measure to protect the environment. Notwithstanding, the Constitutional Court in the case 289/2000 has asserted that the legislative power enjoys great freedom when adopting actions to protect the environment and may also implement fiscal measures.

Therefore, environmental taxes can be used as part of the government's obligation to protect the environment. The application of such taxes, however, can conflict with other constitutional principles such as equity, and modernization and development of all economic sectors.

The balance between environmental protection and other constitutional principles is made through the 'proportionally control' approach: the measure must be useful to achieve its goal (suitability test), the measure is allowed even though it restricts other constitutional principles if there are not other means at a similar cost to achieve the same goal (necessity test), and the measure has benefits that are more important than its negative consequences (proportionality in its strictest sense).

In the case of Mexico it is considered that its Political Constitution does not grant specific bases for the development of environmental taxation. The following constitutional principles

[99] Janet Milne, ed., *supra* note 98, p. 137-148.

have important consequences on this matter:

a) The budgetary character of the taxes.

The Mexican Constitution does not expressly authorize taxes for non-fiscal purposes. Taxes are created for the support of government's expenditure, and according to the Constitution all Mexicans have the obligation to contribute to public expenses. In that regard, the National Supreme Court of Justice of Mexico has established jurisprudence that recognizes that taxes have an immediate objective: to cover public expenses, and also those taxes could have other objectives. Specifically, such Court has stated that "for a tax to be constitutionally valid three fundamental requirements need to be satisfied: first, it should be proportional; second, equitable; and third, to be destined for the payment of the public expenses." Therefore, the Mexican Federal Constitution does not authorize environmental taxes that have not as their main purpose to raise revenue.

b) The construction of the fiscal system based on the ability to pay principle.

According to this principle Mexicans have to contribute equally and proportionally to the public expenses. It may create a problem because it could be argued that taxes based on pollution do not reflect the ability to pay of the taxpayer.

Taking into account the cases of Spain and Mexico, the first step for creating environmental taxes and in order to avoid any constitutional contingency, it is necessary to modify the Political Constitution of Peru to authorize the creation of taxes with environmental purposes.

CONCLUSIONS

1. Air pollution is one of the main environmental concerns in Lima. However, the Ministry of Health of Peru evaluates the content of only four pollutants in the air of Lima, and since 2010 it has not monitored the air quality of one of the most polluted areas in Lima: Lima downtown.

2. The Peruvian Air Quality Standards authorizes the content of pollutants in the air in higher levels than those recommended by the World Health Organization through its Air Quality Guidelines. It is mainly because the former were approved before the last edition of the latter.

3. Regulations have been the only policy instrument used to reduce the air pollution in Lima, and they have been focused only on the quality of fuel. Even though under Peruvian law the amount of excise taxes on fuel shall consider harmfulness' index (environmental criteria), the government has not published such index.

4. Taxes, as economic instruments, have many advantages that can complement regulations, and both together can reach better results in the air pollution abatement.

5. Any policy instrument (regulations, taxes and other economic instruments) used to abate air pollution shall be focused not only on fuel but also on motor vehicles (its age, technology, use, among others).

6. Current gasoline tax, and excise taxes on motor vehicles and fuel are used for fiscal purposes, and have had a negative effect on the air. The excise tax on vehicles has not taxed the import of used vehicles through CETICOS, but taxed the import of new ones, being an incentive to purchase used motor vehicles which are more polluting than new ones. The gasoline tax and the excise tax on fuel have caused that dirtier fuel became cheaper than cleaner fuel.

7. Motor vehicle property tax is a raising revenue tax that imposes an economic burden for owning new vehicles, since old vehicles registered in the Registry Office for more than three years are not subject to such tax.

8. Lima has a chaotic traffic, and congestion causes more air pollution. Nonetheless, government has not adopted any specific economic policy to reduce it.

9. The use of taxes for environmental purposes requires the modification of the Peruvian Political Constitution.

RECOMMENDATIONS

1. The Ministry of Health of Peru shall evaluate the content in the air of Lima of all identified pollutants that affect health, and restart to monitor the air quality in Lima downtown.

2. The Peruvian Air Quality Standards shall be updated taking into account the Air Quality Guidelines.

3. The government of Peru shall publish the harmfulness' index in order to consider it when establishing the amount of excise taxes on fuel.

4. The government of Peru and the Metropolitan Municipality of Lima shall use taxes in order to reduce the air pollution in Lima. In order to do that, first the Congress has to modify the Political Constitution of Peru to authorize the use of taxes for environmental purposes.

5. The gasoline tax shall be eliminated, and the amount of the excise tax on fuel shall be increased to avoid the loss of government revenue. The increase on the excises shall affect all fuels used by motor vehicles in proportion to the pollution they produce.

6. Current excise taxes on motor vehicles and fuel as well as motor vehicle property tax can be used for environmental purposes. This measure would have a positive effect not only in Lima but also in other cities of Peru.

7. A road charge can be levied to reduce congestion in the most polluted and congested area in Lima: Lima downtown. It will have an effect reducing the pollution of the air. The experience of London can be useful when designing and implementing such charge.

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