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Environmentally related energy taxes in Argentina, Bolivia and Uruguay[#]

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Abstract

We start addressing the performance of environmentally related taxes in Argentina, Bolivia and Uruguay and find differences in level and structure with OECD countries but with the common feature that energy taxes are prime contributors. We then model an energy tax reform process out a status quo and towards environmentally related excises, distinguishing between uniform and non-uniform tax components, positive and normative tax structures, and between non-Ramsey and Ramsey specifications. We implement the model after some effort to estimate local and global environmental costs related to energy consumption. We find a rebalancing of fuel taxes (where gasoline and diesel are main drivers) that is robust to the range of price-demand elasticity and environmental cost parameters. Environmental (almost local) gains of the reform are significant, while fiscal impacts are positive and large but do not allow to claim double dividend effects because of price increases of widespread energy inputs triggered by the reform exercise. In the case of Argentina and Bolivia pre-existing distortions in energy prices imply large increases in end-user prices to accommodate not only tax increases but also corrections of producer prices. The assessment of the distributional impact of tax reforms depends on its type (Non Ramsey vs. Ramsey) and on considering environmental benefits to compensate for negative price effects. A Non-Ramsey tax reform has a positive distributive impact in Uruguay, while large pre-existing price distortions tend to produce negative impacts in Argentina and Bolivia. Overall we recommend non-Ramsey taxes as they are more transparent and easy to implement, avoid inverse-elasticity effects on tax wedges that have nothing to do with environmental costs and have better distributional properties. Moving to multiple instruments is also recommended to integrate other externalities, deal with informality and cope with distributive impacts.

Keywords: environmental taxes, energy, tax models

JEL H23, Q40, Q51

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1. Introduction

Environmental taxation is a sub-area of environmental policy that despite having been established a long time ago in the field of public economics and policy, it has been given increasing international attention in recent years, as the focus shifted towards global environmental problems and the introduction of carbon taxes. Recent comprehensive surveys of environmental taxes (see Fullerton et al., 2010) stress several important dimensions in the assessment of the scope and potential of this type of taxation.[1] First, their choice and design, against other instruments for environmental policy, depend primarily on cost-efficiency. Second, they are most useful when wide-ranging changes in behavior are needed and the cost of regulation and alternative economic instruments are large. Third, the case for environmental tax reform should appeal first and foremost to the potential environmental gains. Rather, their case as revenue raising instruments is not obvious, as existing large-scale taxes such as fuel excises are well on or above the limit of what can be justified by environmental costs. Finally, the empirical evidence on the magnitude of the environmental costs involved is crucial for the correct design of policymaking and of environmental taxes in particular.

This paper contributes to a broader project on the future of taxation in Latin America and the Caribbean. As such, it is a paper about taxes and more precisely about the scope for reform of energy taxes towards environmental objectives. Energy taxes are a distinguished group among so-called environmentally related taxes (ERT). This is so both in OECD countries (as the survey by Barde and Barthen (2005) shows), in Latin America, and in the three countries of this study (Argentina, Bolivia and Uruguay). The fact that energy (mainly fuel) taxes are already distinguished non-uniform excises supplementing a uniform (VAT or equivalent) commodity taxation shows at least two important ingredients of the observed status quo. First, they have an important revenue raising role simply because they are already collecting non-negligible public funds; a fact that does not mean that they necessarily have a potential for further increases. Second, they were voted and implemented in these countries a long time ago for reasons different from environmental concerns such as local (not to even mention, global) externalities.

These two stylized facts give a good starting point for the object and scope of our enquiry. It sets our task as mainly considering the prospects of a reform of a well defined group of pre existing taxes that seeks to redirect them towards environmental objectives. As such, we recognize that we are dealing with a potential reformulation of

[1] See also Ian Parry's (2011) comments made at the Seminar at the IDB, which contain a useful briefing on environmental taxes and policy.

a pre-existing set of fiscal instruments in search of a new rationale.[2] Three main aspects of this search that we should bear in mind at the outset are the role of environmental costs or gains, the fiscal impact or revenue raising concerns and the interplay of political economy constraints that are already embedded in the observed status quo.

We start this paper in **section 2** by addressing the importance of existing energy taxes in relation to a broadly defined set of environmentally related taxes in the three countries. To perform this, we follow a format similar to the one used by the OECD methodology and data base. We briefly review national tax rules and regulations in order to identify ERT, classify them according to OECD methodology and obtain tax revenues collected for each country. Our main task is to review ERT revenues and structure, and to document the importance of energy taxes and other contributors. We also provide some comparison against the values reported in Barde and Barten (2005) for a sample of OECD countries.

The central part of the paper is developed in **section 3**, where we use a simple model of environmental indirect taxation (as developed in Sandmo, 2000) for the purpose of reform analysis. In the setting of our analytical framework, we consider two main reference cases that both start form the observed status quo of uniform indirect taxes and non uniform energy taxes. The first assumes that existing energy excises are "non-Ramsey" (i.e. do not introduce demand price elasticities into explaining the current structure). The second is a "Ramsey-type" framework (where demand price elasticities do play a role in explaining the current structure of energy taxes).

For each case, we distinguish a positive formulation (related to the observed status quo) from a normative formulation (related to the reform or reformulation of taxes towards environmental objectives). The positive formulation explains the observed non-uniformity by adding factors that we term "Becker´s numbers" (after Becker, 1983) representing the influence of pressure groups or political preferences on the final structure of energy taxes. From this observed tax wedges, we are able to "recover" a set of implicit parameters (called observed characteristics of energy goods) that give rise to the Becker's numbers. We further compare these "observed" characteristics with so-called "distributional" characteristics of energy goods (which

[2] As mentioned by Jack Mintz, one of our discussants at a previous seminar on this project, the genealogy of fuel taxes makes clear that they were not intended for correcting externalities but rather as serving revenue collection purposes, earmarked in part to finance roads, etc. Thus the introduction of environmental taxes amounts to asking how to reconfigure energy taxes for environmental purposes. He also mentioned attempts in the Canadian experience in this respect.

are parameters associated with normative indirect tax theory)[3] in order to check for their potential correspondence with distributional objectives.

On the other hand, the normative formulation rationalizes the non-uniformity of energy excise with what we term "Sandmo's numbers" (after Sandmo, 1975; 2000), representing additive terms to the tax wedge introducing environmental objectives. These parameters come from the environmental (local and global) costs of energy, which is one of the central empirical endeavours of this paper.

We will take these two reference model-cases (Non-Ramsey and Ramsey) as the tools to implement and estimate the reform or reformulation of existing energy taxes. The formal development of that analytics behind our tax formulas is provided in Annex A. As the reform lines considered will depend on crucial parameters such as price-elasticities or environmental costs (local-global) that may have errors in measurement, we further adapt a marginal-tax-reform analysis (after Guesnerie (1977), Ahmad and Stern (1984) and others) to check for the robustness of the resulting direction of changes to parameter sensitivity. We also check for the fiscal impact (i.e., changes in fiscal revenues) of the reformulation of energy taxes as environmentally related taxes and discuss the evidence on potential gains and distortionary effects involved. The assessment of the distributional impact of tax reforms is also considered.

After setting the analytical framework, we move on to implement it for the cases of Uruguay, Argentina and Bolivia. We do so in a sequence of steps that proceeds from evaluating the basis data set, estimating Ramsey and Non-Ramsey tax structures, assess the sensitivity of the suggested direction of tax reform to different parameter values, and compute the fiscal revenue, environmental and distributive impacts. In all cases we provide a detailed description (in Annex B) of data sources and methods or assumptions. We use data on market quantities, consumer and producer prices, assumed values of demand (direct and cross) price-elasticities, and own estimates of (local and global) environmental costs associated with each product.

As stated above, environmental costs are critical parameters in an empirical assessment of a reform towards environmental taxes. Energy goods are responsible for the direct emission and secondary formation of several pollutant, local air pollution and global climate change are among the main negative externalities associated to their use. To estimate the social costs of these externalities, the methodology proposed in this study follows what is known by policy analysts as "integrated assessment", using a "damage function" approach. In Annex C, we describe

[3] See Sandmo (2003, pp.103-104). See also Navajas and Porto (1994) for a discussion with the first empirical application to Argentina.

and implement a multi-step estimation procedure, involving injury determination, quantification of effects, and damage determination, using data and models drawn from government institutions and the academic literature. Injury determination links the injury to the release of pollutants; quantification of effects determines in physical terms the reduction in natural resources services; and damage determination involves valuing the injury in monetary terms.

Finally **section 4** draws our main conclusions and policy implications of the paper as well as the suggested extensions in other dimensions that deserve further study.

2. Performance of ERT in Argentina, Bolivia and Uruguay

Introduction

Economic instruments for pollution control have been of considerable interest in academic discussions much earlier than they became an important issue in environmental policy arena. Even though most regulations are not yet based on market incentives, many OECD countries have been increasingly using economic instruments to protect the environment since early 1990s, with an emphasis on tax instruments in the context of the so called "green tax reforms" (Barde and Braathen, 2005). An even greater interest on economic instruments has aroused as a consequence of the international agreement adopted through the Kyoto Protocol, under which a number of industrial countries committed to curb domestic emissions of the main greenhouse gases. The Protocol has not taken into account costs and benefits in order to set goals, but it has applied a cost-effective policy by creating flexible mechanisms by which industrialized countries can transfer emission allowances among themselves and earn emission credits from emissions reductions of developing countries and countries with economies in transition.

As a result of these trends, there has been a remarkable interest in information about the empirical relevance of these instruments, particularly among the OECD countries. The economic instruments include taxes, fees, tradable emissions allowances, pollution charges, deposit-refund systems, etc, but the Statistical Office of the European Communities (Eurostat) and the OECD have focused on developing statistics on taxes, since this is an area where basic data is generally readily available and comparable between countries[4].

[4] The scope of the database has been broadened to also include other economic instruments different from taxes, but their coverage is not yet complete (Personal communication with Nils Braathen, OECD).

Based on the guidelines set by Eurostat (2001), we assess the use of environmentally related taxes are assessed for Argentina, Bolivia and Uruguay, in terms of level and composition, and in comparison with OECD countries[5]

What is an environmental related tax?

An environmental tax is defined as 'a tax whose base is a physical unit such as a liter of petrol, or a proxy for it, for instance a passenger flight, that has a proven specific negative impact on the environment' (Eurostat, 2001). This definition has been agreed by international experts and adopted by Eurostat, the OECD and the International Energy Agency (IEA). It does not take into account the motivation behind their introduction, that is, the aim of reducing income taxes and/or raising government revenue rather than controlling pollution does not preclude it from being classified as an environmental tax. What is decisive for defining a tax as environmental one isits potential impact on economic behavior (through price signals).

In addition to pollution and resources related taxes, all energy and transport taxes are classified as environmental ones, but value added type taxes are excluded because they are levied on all products. Mostly, environmental taxes represent a sub-category of indirect taxes, but may sometimes also represent taxes on the capital stock, such as recurrent taxes for vehicle registration or ownership.

The interpretation and use of measures of environmental taxes is not so straight forward or, for some critical commentators, even useful. First, the revenues obtained from environmental taxes do not necessarily indicate the relative importance or success of environmental policy. The use of non-tax instruments -such as emissions trading allowances or even direct regulation- may explain differences in environmental tax revenues across countries and across the time, without any particular meaning in terms of environmental control efforts. Second, revenues also fails to capture the effects (as externality correcting devices) of environmental taxes that poorly target emissions (Fullerton et al, 1999). Third, environmental tax databases such as the OECD one don't reflect other eventual design bias in relative (and absolute) environmental taxes, in terms of their relationship with the magnitude of the true environmental costs involved: taxes can be set aimed at correcting externalities, but can also be set in a way divorced from the true environmental damage. Finally, environmental taxes revenues could be partially or completely offset by special treatments on generalized taxes (levied on all products[6]); this compensatory policy is not captured by environmental taxes database. The same occurs if the price of the environmental related physical unit is distorted for any

[5] We uses the OECD database available at www.oecd.org/env/policies/database.

[6] Fullerton et.al (2010) show how taxes on fuels in the UK are compensated by a VAT tax that is less than the half paid by other goods.

reason different from externalities, such as subsidies or price controls in any point of the value chain.

In spite of these cautious concepts, statistics on environmental taxes do represent interesting information from both, a fiscal and environmental perspective.

Use of environmental taxes in Argentina, Bolivia and Uruguay[7]

In line with the definition of the Eurostat statistical guideline (Eurostat, 2001), environmental taxes computed for Argentina, Bolivia and Uruguay are classified in three groups:

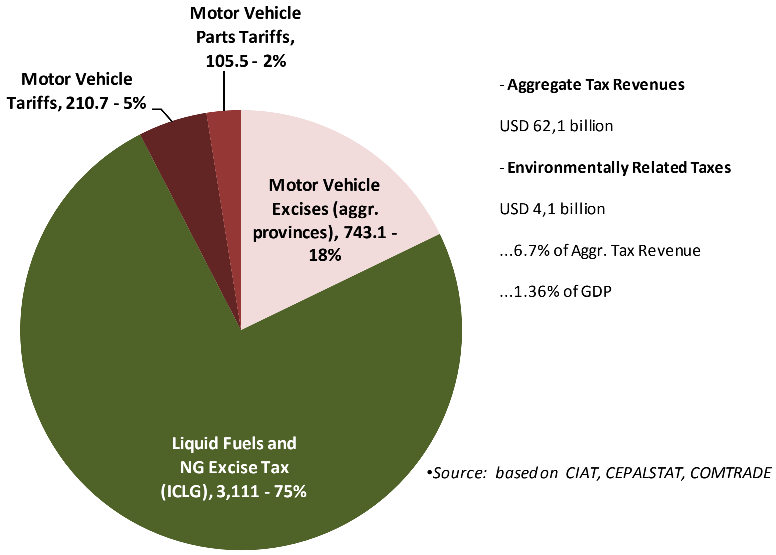
- Energy taxes: include taxes on energy products used for both transport and stationary purposes.
- Transport taxes: exclude taxes on fuels, and mainly include one-off taxes on motor vehicles, such as import or sales taxes, and recurrent taxes on registration or use of motor vehicles. Taxes on other transport equipment, and related transport services are also included.
- Pollution/ resources taxes: include taxes on measured or estimated emissions to air and water, management of solid waste and noise[8]. Resource taxes are taxes levied on the commercial exploitation of natural resources such as water, minerals (excluding oil and gas) and forestry.

Estimates for Argentina show that government revenue from environmental taxes in 2009 was USD 4.1 billion, an amount that represents 1,36% of GDP and 6,7 % of total fiscal revenues (from taxes and social contributions). Excise taxes on energy products, such as petrol, diesel and natural gas, accounted for 75% of total environmental taxation, while transport taxes –mainly motor vehicle excises- explained the remaining 25%, as there are no direct taxes on pollution (Figure 2.1).

[7] Descriptive information about name of the taxes, legal references, responsible collector authorities, definition of tax bases and average (or ranges of) tax rates, for each of the three countries studied are provided in Annex 1 to this section.

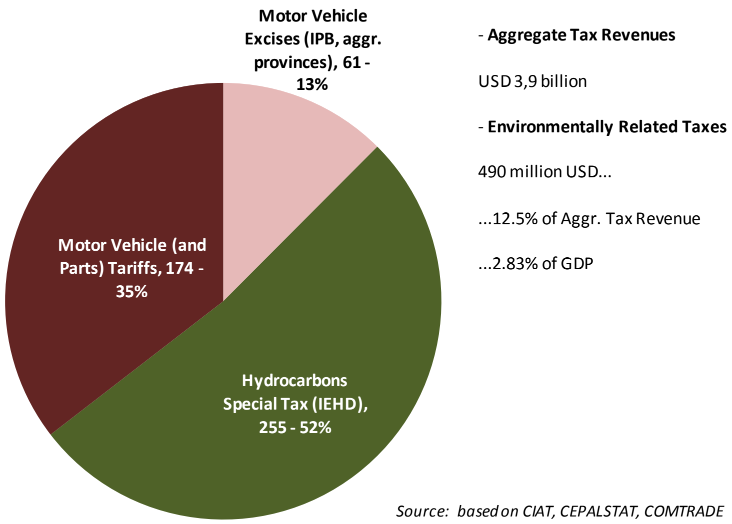
[8] Except for CO_2 taxes, which are included under energy taxes category.

Figure 2.1 Environmentally Related Taxes in Argentina, year 2009 (in million dollars)



At USD 490 million collected from environmental taxes in Bolivia in 2009, they accounted for 2,83% of GDP and 12,5% of total tax revenues. The composition is more balanced than in the Argentine case, with 52% of ERT coming from energy taxes and 48% from transport sector, without direct taxes on pollution (Figure 2.2).

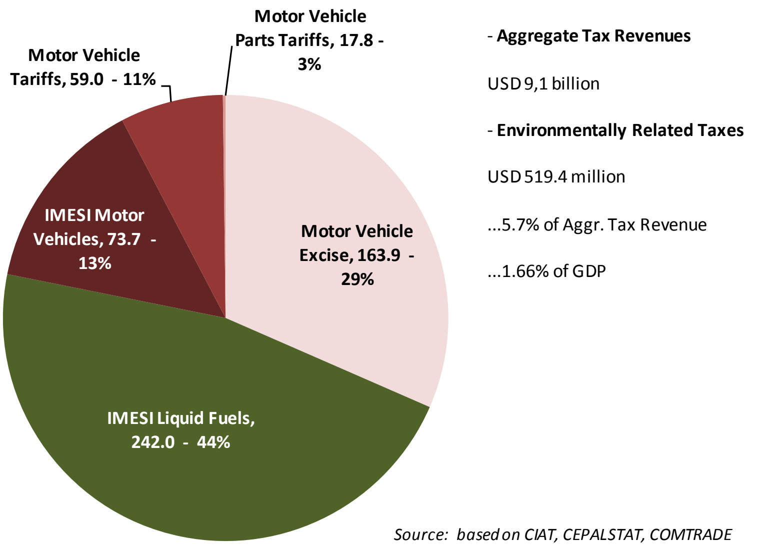
Figure 2.2 Environmentally Related Taxes in Bolivia, year 2009 (in million dollars)



The revenues from ERT in Uruguay in 2009, totalizing USD 519 million, represent a share of 5,7% of total taxes and social contributions and 1,66% as a proportion of

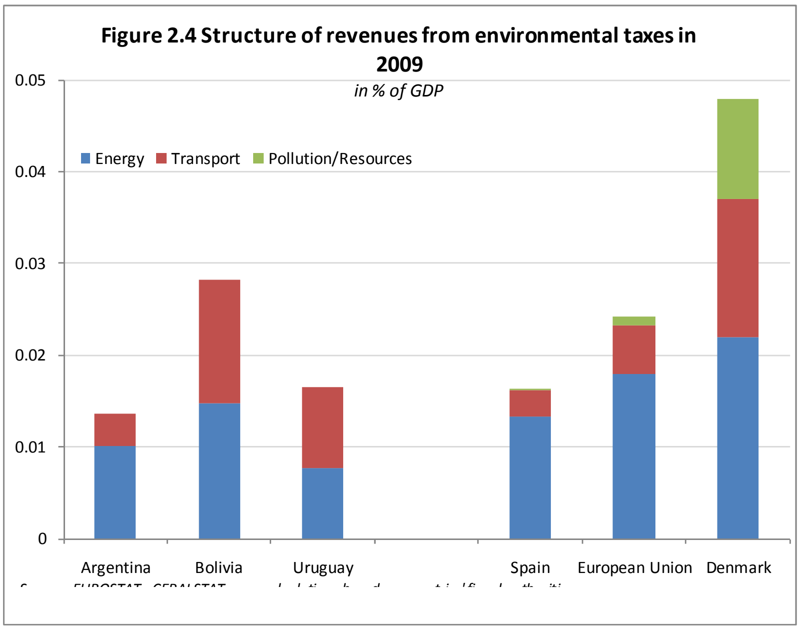
GDP. Transport taxes account for 56%, energy taxes for 44%, and as in Argentine and Bolivia no pollution taxes are levied (Figure 2.3).

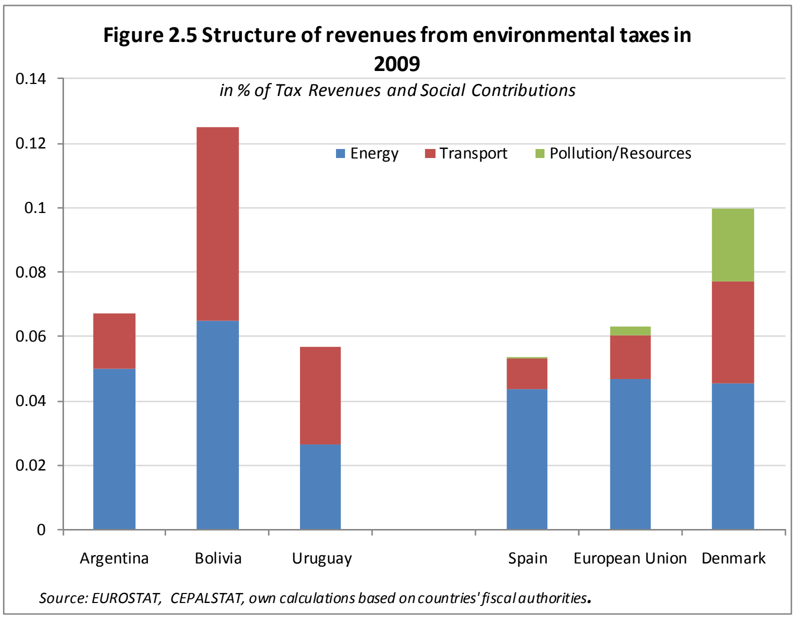
Figure 2.3 Environmentally Related Taxes in Uruguay, year 2009 (in million dollars)



Source: based on CIAT, CEPALSTAT, COMTRADE

In 2009, environmental taxes in the EU-27 (GDP-weighted average) accounted for 2.4 % of GDP and for 6.3 % of total revenues (Figures 2.4 and 2.5). Energy taxes are by far the most significant, representing around 75% of environmental tax revenues and close to 5% of total taxes and social contributions. In the EU-27, transport taxes correspond to, on average, around 20% of total environmental tax revenues and 1.4 % of total taxes and social contributions (in the weighted average). Pollution taxes contribute only a marginal amount of revenue, with less than 5 % of total environmental taxes.





Compared to the EU countries, environmental taxes in Argentina are low, measured as percentage of GDP, but its composition results similar to the European average[9]. Uruguay, instead, differs in the relative importance of different taxes –more biased to transport taxes- but their share of GDP is close to Spain, the EU country showing the lowest ratio. Bolivia displays a percentage to GDP that more than double the one of

[9] The predominance of energy taxes is common to most Member States.

Argentina and exceeds the European average, with a noticeable high incidence of transport taxes.

The comparison of contribution of revenues from environmental taxes to total fiscal revenues reflects huge differences in general tax bases among countries in different development stages: Bolivia, in particular, with a narrower tax base than other countries, shows a considerable high share of environmental taxes on fiscal revenues; more than 2 points higher than Japan, the OECD country with the largest share.

The evidence of a high ratio of environmental tax revenue to total taxation does not necessarily represent an indication of a high priority being attributed to environmental protection[10]. But this information, as well as the share on GDP, is important to assess the potential use of these instruments, in terms of introducing tax greening reforms in Latin-American countries.

Finally, and concerning to this, it is important to remark that environmental taxes figures –as Eurostat defines them- in Argentina and Uruguay are to some extent not showing the correct taxation of energy products. In Argentina, the reason is that pre-tax prices of a group of energy products are artificially set well below their economic costs; in Uruguay, the explanation is that current tax treatment of energetic products comprises excise taxes –which are considered environmental taxes- but are zero-rated (i.e. untaxed) in the VAT system, and this exception is not taken into account in the environmental taxes estimates.

3. The structure of energy ERT in Argentina, Bolivia and Uruguay

3.1. Modelling strategy for reform analysis

The modelling strategy is a straight adaptation of an optimal environmental tax model to cope with data limitations that we usually face in our countries. There are several works useful for modelling energy ERT that we can adapt to our setting (e.g. Sandmo, 2000; Cremer et.al. 2003; Newbery 2005). In this presentation we keep a simple format that we believe has a minimal structure from which we can progress into estimation. Additional developments steaming from relaxing assumptions or introducing new topics are referred to below.

Rather than formulating and implementing or calibrating a given normative model, we prefer to start with an explicit reference to the observed status-quo of energy taxes. We assume that taxes in reality will define a wedge between (i=0,1,...n-1) producer or pre-tax prices (p_i) and consumer or end-user prices (q_i). General commodity taxes (t)

[10] In fact, energy taxes were originally used purely as revenue raising instruments, without environmental purposes.

will be ad-valorem and uniform (same for all i) across all goods in the economy. Excises applied to energy products will be non-uniform (i.e. they will define non-uniformity) and will be either ad-valorem (τ_i) or specific (T_i). Thus final consumers prices are assumed, without loss of generality, to proceed from $q_i=p_i.(1+t+\tau_i)+T_i$.

The relevant variables to measure in practice, and to derive from any model of indirect taxation with environmental objectives, are the percentage tax wedges $m_i=(q_i-p_i)/q_i$. We take the general reference form for m_i:

$$m_i = \frac{q_i - p_i}{q_i} = \frac{t}{1+t} + Z_i(\tau_i, T_i) \qquad \text{for all i} = 1,\ldots,\text{n - 1} \qquad (1)$$

The observed margins m_i will be the sum of a uniform component for all n commodities in the economy[11] and a non-uniform component for energy goods. This last term, Z_i will depend upon ad-valorem or specific components (t_i,T_i). Working algebraically on the definition of prices, $q_i=p_i.(1+t+\tau_i)+T_i$, we obtain the most general expression for Z and the special cases of only specific or only ad-valorem formats, this is,.

$$Z_i(\tau_i, T_i) = \frac{T_i}{q_i} + \frac{(1 - T_i/q_i).\tau_i}{(1+t+\tau_i)} - \frac{t.(\tau_i + (1+t).T_i/q_i}{(1+t+\tau_i).(1+t)} \qquad \text{For all i} = 1,\ldots\text{n - 1} \qquad (2)$$

$$Z_i(0, T_i) = \frac{T_i}{q_i.(1+t)} \qquad \text{(only specific)} \qquad (2')$$

$$Z_i(\tau_i, 0) = \frac{\tau_i}{(1+t+\tau_i).(1+t)} \qquad \text{(only ad - valorem)} \qquad (2")$$

We take (1) as a reference expression, that along with a benchmark model of indirect taxation under consumption externalities (that is written in Annex A), will have below a "positive" and a "normative" interpretation. Both will lead in turn to different values of the term Z_i. The "positive" Z_i's (Z_i^P) will be the ones that matches the observed status quo of taxes and will be related to a positive model of taxes; while the "normative" Z_i's (Z_i^N) will be obtained from a normative or optimal indirect tax framework.

Non energy goods (the aggregate good "0" in our case) will face uniform taxes, while energy ones will have (in fact they have in the status quo) a non uniform structure. We will treat this structure as either positive -related to the observed status quo- or normative- related to a reform or reformulation that introduces environmental costs-.

[11] We calibrate from our simple formulation that the economy-wide uniform component of the tax wedge m_i, ,i.e. (t/(1+t)) will be determine by a simple term given by $(\lambda-1)/\lambda\eta_0$, where λ is the economy-wide marginal cost of public funds from general uniform indirect taxation and η_0 is the demand price elasticity associated with the aggregate (i.e. consumption) good (i=0)of our model.

However, as the non-uniformity of energy excises may also depend on the interplay of demand price-elasticities for each good, -which introduction is in itself a quasi normative ingredient, representing basic Ramsey taxation (i.e. efficiency)-, we also distinguish between a “Non-Ramsey” and a Ramsey formulation of the Z_i, depending whether demand-price elasticities are considered in the tax formulas. We proceed separating between these cases that are all useful for later measurement. The technical details behind the derivation of tax formulas can be found in Annex A.

3.1.1. Status quo and environmentally related excises reform

Non-Ramsey excises

Assume that the Z_i are determined by factors different from efficiency reasons and that elasticities have not been considered in the observed status quo. In this case (termed case I) the Z_i in expression (1) will be assumed to come from either “political” reasons or will represent the influence of pressure groups. In this case we define Z_i^{IP} (where supra indices IP stands for case I-positive)

$$m_i^{IP} = \frac{t}{1+t} + Z_i^{IP} \qquad \text{where } Z_i^{IP} = \frac{\lambda - \theta_i^I}{\lambda.\eta_0} \qquad (3)$$

We posit that tax wedges in the status quo come from a positive model where demand price elasticities are not considered and the non-uniformity of energy excises depend on parameters θ_i (called implicit characteristics of energy goods) that reflect either lobbying, pressure or influence activities (as in Becker, 1983) or the “preferences” of a political elite (as in Kanbur and Myles, 1992 and Myles 1995). Empirically, we are able to “recover” or estimate the θ_i’s as the parameters that (for the values of λ and η_0) make the tax wedges in (3) to coincide with observed wedges. We call the Z_i^{IP} parameters in expression (3) Becker’s numbers (following Becker, 1983).

We further compare the implicit characteristics θ_i with the so-called distributional characteristics of energy goods (d_i) that are defend and derived in Annex A (see also expression (4’’’) below).[12] The distributional characteristics represent parameters that adapt tax structures to distributive objectives (they are larger as the goods are mostly consumed by low income agents and/or the welfare metrics is more averse to inequality). This simple checking of the θ_i’s against the d_i’s allows us to see if the status quo structure of energy excises reflects distributional concerns.

The normative representation allows for a straightforward interpretation of tax reform or reformulation considering environmental objectives, which is to move from

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[12] This is a natural comparison to make, as Becker (1983) submitted that the θ_i’s in his model were equivalent to the d_i’s in Ramsey type (e.g. Feldstein, 1972) models with distributional objectives. See also Hettich and Winner (1984) and Porto (1996) for modelling positive tax structures.

the above Z_i^{IP} to the ones that come from introducing environmental costs associated to energy products. That is, we define Z_i^{IN} (where IN stands for case I-normative):

$$m_i^{IN} = \frac{t}{(1+t)} + Z_i^{IN} \quad \text{where } Z_i^{IN} = \frac{K_i / q_i^{IN}}{\lambda} \qquad (4)$$

Again, the Z_i enter as additional terms inflating the uniform margins (associated with uniform taxation of commodities) to account for the environmental costs per unit of output (K_i) as a percentage of the consumer price (q_i) and deflated by the marginal cost of public fund from indirect taxation (λ). We term these parameters Sandmo's numbers (following, Sandmo, 2000).

Notice that optimal tax wedge formulas like (4) are not closed-form ones, meaning that the term K/q is endogenous to the optimal tax (even if K is taken as a constant parameter) due to the endogeneity of final prices q to taxes. This is not a problem for computing purposes below as we solve for prices or taxes. In fact, working with (2) and (4) we can obtain the corresponding taxes for the specific-only or ad-valorem-only representations, i.e. $T_i^{IN} = K_i(1+t)/\lambda$ (specific only) and $\tau_i^{IN} = K_i.(1+t)/\lambda.p$ (ad-valorem-only). In both cases, it can be seen that computing tax rates is straightforward as they depend on parametric (exogenous) values of the environmental costs (K_i), the commodity-wide tax rate (t), the marginal cost of public funds (λ) and producer prices (p).

Ramsey excises

The case (named case II) where non-uniformity of energy excises is also due to efficiency or (quasi) inverse-elasticity rule implies some changes to the previous setting. By assuming that optimal (Ramsey like) tax margins are applicable to the whole margin m_i we introduce the interaction with price-elasticities and in this way we break (in the case of the normative analysis) the condition of uniformity of taxes when Z_i's are zero.[13]

Tax wedge formulas for the positive model are now represented by the following expression (where the supra index IIP means case II-positive) (see Annex A for details):

[13] An unavoidable consequence of introducing Ramsey (i.e. inverse elasticity rule) taxes is that we cannot longer get the result that tax wedges will collapse to uniform (t/(1+t)) when K_i=0, i.e. when (normative)environmental motives for differentiation disappear and energy commodities (for example electricity) are essentially similar to the aggregate good. The reason is that introducing efficiency and Ramsey taxes introduces another reason for differentiation, given by the first term of the RHS of (4').

$$m_i^{IIP} = \frac{t}{(1+t)} + Z_i^{IIP} \qquad \text{where } Z_i^{IIP} = [\frac{\lambda - 1}{\lambda.\eta_i} - \frac{t}{(1+t)}] + \frac{1-\theta_i^{II}}{\lambda.\eta_i} \qquad (3')$$

This case model is closer to the Becker (1983) formulation as margins or tax wedges are also determined by efficiency. These Z_i's are Ramsey-Becker tax wedges, and is the sum of a term (within brackets) showing the departure of taxes from uniformity due to efficiency reasons and a term due to political decisions or pressure groups (that we have termed Becker's numbers). Notice also that the implicit parameters θ_i^{II} will be different from parameters θ_i^{I} obtained previously, as they interact with the previous fact and with demand price-elasticities.

The normative representation for this Ramsey case follows the usual simple form of these margins (Sandmo, 2000, ch. 5).They will have two separable terms, one being the inverse elasticity formula (λ-1/$\lambda.\eta_i$) (that we call the "efficiency" component) and the other the additive component (that we term Sandmo´s numbers) incorporating the environmental costs. We can rewrite these margins as (where the supra index IIN means case II-normative, see Annex A)

$$m_i^{IIN} = \frac{t}{(1+t)} + Z_i^{IIN} \qquad \text{where } Z_i^{IIN} = [\frac{\lambda - 1}{\lambda.\eta_i} - \frac{t}{(1+t)}] + \frac{\mathrm{K_i}/q_i^{IIN}}{\lambda} \qquad (4')$$

These Z_i's are Ramsey-Sandmo tax wedges, and is the sum of a term (within brackets) showing the departure of taxes from uniformity due to efficiency reasons and a term due to environmental costs (that we have termed Sandmo's numbers).

A variety of Ramsey taxes that we also compute is a modified version of (4') where we introduce the implicit characteristics of goods that are computed from (3'). This parameters capture the particular configuration of the tax structure associated with the status-quo and are, in a way, instrumental variables were we can approximate distributional (or political) objectives so as to soften some tax increases. We call this case Ramsey taxes with political constraints. The corresponding formulas for this version are (where the supra index IIIN means case III-normative, see Annex A):

$$m_i^{IIIN} = \frac{t}{(1+t)} + Z_i^{IIIN} \qquad \text{where } Z_i^{IIIN} = [\frac{\lambda - \theta^{II}}{\lambda.\eta_i} - \frac{t}{(1+t)}] + \frac{\mathrm{K_i}/q_i^{IIIN}}{\lambda} \qquad (4'')$$

3.1.2. Robustness of environmentally related excise reform

Previous tax wedge formulas will lead to different results depending of on the values assumed for critical parameters. While these values can be subject to sensitivity analysis, we reframe the evaluation in the terms of the marginal-tax-reform literature.

We develop the analytics of this approach for the present case in Annex A. Direction of tax reforms analysis[14] may allow us to detect that certain directions of realignment or rebalancing of taxes are robust enough to parameter sensitivity.[15] The structure of taxes is evaluated at the current status-quo position and, as they do not correspond to optimal taxes, we obtain a set of marginal cost of raising public funds (MCPF) with each tax (λ_i are different i=1,…,n-1) which will produce different numbers suggesting a needed rebalancing of taxes. Those taxes with higher (lower) relative to others (or to λ_0 representing the aggregate good) will have to fall (rise).

Expressions for the MCPF numbers for each good in the two cases (I and II) considered in the previous section are (where supra indices "0" means observed or status-quo prices and tax wedge margins):

$$\lambda_i^{IN} = \frac{1}{1 - m_i^0 .\eta} - \frac{(K_i / q_i^0).\eta}{1 - m_i^0 .\eta} \qquad (5)$$

$$\lambda_i^{IIN} = \frac{1}{1 - m_i^0 .\eta_i} - \frac{(K_i / q_i^0).\eta_i}{1 - m_i^0 .\eta_i} \qquad (6)$$

We test the sensitivity of the robustness of the suggested direction of tax reform (e.g. whether for example a suggested rebalancing reducing the tax wedge of gasoline and increasing that of diesel survives different parameter configurations) for the modelling-cases I and II. Sensitivity is considered for a range of price elasticity values, i.e. $[\underline{\eta}_i, \overline{\eta}_i]$ and a range (e.g. only local and both local and global) of environmental costs, i.e. $[\underline{K}_i, \overline{K}_i]$.

3.1.3. Tax revenue impact

Tax reform exercises are very helpful at hinting directions of change and suggesting a rebalancing of taxes. This rebalancing condition, if it is observed, is an important empirical fact, because it tells that at the current position taxes on some goods may be above optimal levels and hence will have to go down. If these over-taxed goods are important in revenue terms, compared with under-taxed goods it is not clear that an energy ERT reform will imply extra or additional revenue.[16] A related but different

[14] See Guesnerie (1977), Ahmad and Stern (1984), Navajas and Porto (1994), Myles (1995; ch.6).

[15] In an exercise performed for Uruguay in 2004, reported in Navajas (2008) we found that gasolines were overtaxed, while diesel, fuel oil and notably biomass were undertaxed and this was robust enough to a wide range of price elasticities.

[16] The fact that some goods are under-taxed because they are traded in informal markets is an additional constraint that involves an adjustment of taxes on other substitute goods and impairing revenue collection. Taxes on LPG and electricity, if they substitute biomass, should be lowered. Segmentation of urban and rural households (more likely in electricity, less likely in LPG) would help at doing this at a lower cost.

issue (which we avoid confounding with revenue collection of energy taxes impact) is the so-called double-dividend of environmental taxes (i.e. correcting externalities and allowing extra revenues or lower taxes/distortions on other goods in the economy), which in the literature appears as an empirically determined result that depends on the initial conditions of the economy, may not necessarily be a result in the countries studied.[17] Nevertheless, this comparison can only be assessed turning into end-point or final reference values of the reform process, i.e., optimal or normative taxes.

Unlike tax reform analysis, optimal taxes allow for a more precise evaluation of the potential or extra revenue involved in an energy ERT reforms. Simulations of revenue impacts are performed below with this benchmark reference. Observed prices, taxes and quantities, allow us to compute revenues for the status quo (0), while the theoretical revenue collected after the reforms or reformulation in the modelling-cases I and II will depend upon prices and quantities at the end-point (j= IN; IIN; IIIN) that in turn will depend on demand price-elasticities.

We define tax revenue impacts as changes that come from computing margins and prices in expressions (4) and (4´). The existence of an increase in revenues does not constitute a test of the existence of a double dividend if the rebalancing of energy taxes involve an increase of widespread energy inputs that in turn will impact on the prices of non-energy goods.[18] In other words, the given marginal cost of public funds for the economy (λ) may rise under some conditions or increases in some energy taxes.[19]

For computing purposes we define

[17] See Sandmo (2000) and Fullerton et.al (2010) for a discussion of the conditions for the double dividend to emerge. In particular, these latter authors stress the importance of the changes in energy taxes on the non-energy prices, a fact that carries on additional distortions.

[18] See Fullerton et.al. (2010).They use an illustrative example where the higher prices are equivalent to a tax on labour, adding distortions per se. In our case a tax on labour is equivalent to an increase in the general uniform ad-valorem component (t).

[19] In some cases some bounds effects on the required changes in λ to undo potential double-dividend gains may be simulated.

$$\frac{\Delta R^j}{R^0} = \frac{R^j}{R^0} - 1 \qquad (7)$$

where

$$R^j = \sum_{i=1}^{n-1} m_i^j . q_i^j . X_i^j \qquad \text{j = IN; IIN1; IIIN}$$

$$R^0 = \sum_{i=1}^{n-1} m_i^0 . q_i^0 . X_i^0$$

Quantities after reform are computed according the constant elasticity assumption as

$$X_i^j = \exp\{\log X_i^0 - \eta_i .[\log q_i^j - \log q_i^0]\}$$

We also consider the sensitivity of results to interval estimates of demand price-elasticities $[\underline{\eta}_i, \overline{\eta}_i]$.

3.1.4. Distributional impact

Tax reforms induced by the Non-Ramsey or Ramsey normative cases presented above will lead to price changes that will have impacts upon households' income and welfare as well as on the competitiveness of firms exposed to foreign competition. We can measure the impact on households by using household expenditure surveys data and approximate the effect of energy price increases on different income deciles.

These effects will be of two kinds. The first will be the negative direct impact upon income and welfare after a price increase. The second will be the positive effect due to a reduction of environmental costs borne by each household. The former can be differentiated due to simple incidence measures that involve the quantities consumed by households or the share of the energy good in household income or expenditure. The latter is not differentiated in our model of Annex A (or Annex C on environmental costs) as we estimate total environmental costs borne by society and we assume a pro-rata of these effects across households on a uniform basis. This latter assumption will probably bias the distributional impact of benefits of the tax reform, as low income households may borne a larger share of environmental costs due to living location, exposure or absence of avoidance.

We define the impact-price-effect (IP) on households of a tax reform as the sum across households and products of a weighted change in prices (from the status-quo)

$$IP^j = \sum_{h=1}^{H} \sum_{i=1}^{n} \alpha_i^h . \frac{q_i^j - q_i^0}{q_i^0} \qquad \text{where } \alpha_i^h = \frac{x_i^h . q_i^0}{Y^h} \text{ and } j = \text{IN, IIN, IIIN} \qquad (8)$$

Where x_i^h is the consumption of good i by household h, Y^h is the income of h q_i^0 are initial or status quo prices and q_i^j (for j=IN, IIN, IIIN) are final prices after reform in the Non-Ramsey, Ramsey and Ramsey with political constraint cases. We expect that, as most prices will increase after reform, and the share of good i in household h income (α_i^h) is a decreasing function of income, a uniform (across households) price increase (as the ones obtained after tax reform) will be regressive.

We also define the environmental benefit-effect (EB) on households of a tax reform as the sum across households and products of the environmental gains due to lower environmental costs. These come from the sum of the reductions in energy consumption multiplied by the environmental costs per unit, that is, $\sum K_i.(X_i^0 - X_i^j)$. Dividing these costs by the number of households and expressing the gain as a percentage of income we can approximate the gains for households as:

$$EB^j = \sum_{h=1}^{H}\sum_{i=1}^{n}\frac{K_i.\bar{x}_i}{Y^h}\frac{(X_i^0 - X_i^j)}{X_i^0} \quad \text{where } \bar{x}_i = \frac{X_i^0}{H} \text{ and j = IN, IIN, IIIN} \qquad (9)$$

As the environmental gains are a fixed value per households, they represent a progressive transfer as they decrease as a percentage of income.

The difference between (8) and (9) can be expressed as the net impact of a tax reform (NIT), using the definition of elasticity as $\eta_i=-(\Delta X_i/X_i).(\Delta q_i/q_i)$:

$$NIT^j = EB^j - IP^j = \sum_{h=1}^{H}\sum_{i=1}^{n}[\frac{K_i.\bar{x}_i.\eta_i}{Y^h} - \alpha_i^h].\frac{(q_i^j - q_i^0)}{q_i^0} \quad \text{for j = IN, IIN, IIIN} \qquad (10)$$

The estimated value of (10) is not enough to qualify the reform if this reform involves extra fiscal revenues that can be "returned" to consumers. This can be considered from the estimate of extra revenues shown above in expression (7) ΔR^j, which if expressed on a per household basis and as a percentage of household income gives a measure of the "potential" extra fiscal benefits of reform. We can estimate (10) from household expenditure surveys data after some adjustments and decompose it in the net gains for different deciles of household income distribution to have an approximation of gains and losses due to the tax reforms due to Non-Ramsey, Ramsey and Ramsey with political constraint cases. We also include an expected increase in the price of public transport (due to a change in the price of gas oil) to widen our assessment of likely price impacts on households.

3.1.5. Selected issues and the reference model

The reference model used in the previous section is a simplified setting that can be exposed to several observations which make it incomplete or require adjustments or extensions. We briefly discuss some of them and indicate what can be done or adjust for the empirical purposes of this paper.

Environmental costs vs. other externalities

The list of externalities that may be related to energy taxes is long as it potentially includes different dimensions. Recent applied papers in the subject (see Parry and Strand, 2010 for Chile) include environmental (local and global impacts) and non-environmental (e.g. transport congestion) issues. They compute other externalities associated to the use of car fuels, mainly accidents and congestion, which account for more than 75% of total externalities for each fuel. They include these external costs for calculating the corrective taxes, even though they recognize (see Parry, 2011) that multiple externalities require multiple instruments rather than relying on fuel taxes alone. They suggest, for example, that peak-period road pricing policy for addressing traffic congestion, and car insurance according to miles driven for accident externalities, would be more efficient instruments than fuel taxes.

Our approach in this paper has been to concentrate on environmental externalities (local health and non health issues and on global costs related to carbon emissions). (See Annex C for our estimation work). Nevertheless, we should call attention that statements about over-taxation of certain energy goods in our results below (for instance gasolines in Uruguay) are relative to the consideration of environmental effects and the use of alternative instruments to deal with transport issues. Given the size of other externalities in total external costs estimated by Parry and Strand (2010) for Chile, it can be seen that the over-taxation result can be easily reverted if only fuel taxes are used to adjust for all external costs.

On another debatable issue, we have decided to include global environmental costs but have made some results sensitive by allowing for an interval of costs $[\underline{K}_i, \overline{K}_i]$ with or without global environmental costs. As we shall see in the applications (see Annex C for background), differences between $\underline{K}_i$ and $\overline{K}_i$ are not large, meaning that for those goods with relatively important local environmental impacts (e.g. Diesel or Gas Oil), global costs are less than 10% of local costs. In other words, local environmental costs are the main determinants of the K_i's parameters.

We agree that the introduction of the global dimension of environmental damage is a debatable decision both in theory and in practice. From an analytical point there exist doubts in the literature on whether global environmental costs (i.e. related to CO_2 emissions) should be dealt with final consumption energy taxes (see Fullerton et.al, 2010) instead of taxes on primary energy (see more on this below). Second, the practical question is whether taxes that incorporate global costs of local emissions will be accepted by politicians or society in developing countries, as they involve an international coordination problem.[20]

Finally, we can make explicit the difference of our estimates and those considered by Parry and Strand (2010) in the part (environmental costs) where the two can be compared.

Parry and Strand (2010) measure the external costs of the use of motor vehicles in Chile through an approach based on combining local data with extrapolations from U.S. literature. The parameters are then applied to formulas for estimating the corrective gasoline and diesel fuel taxes. Their estimates include externalities associated to environmental damage –both, local and global-, congestion, accidents, noise and deterioration of roads. As for local external costs from emissions, the authors assume that two-thirds of local emissions vary with mileage and one-third with fuel combustion, while global environmental damages are fuel-related externalities. They also assume that fuel economy in Chile is 30 miles per gallon of gasoline and 8 miles per gallon of diesel. Thus, those environmental externalities that vary in proportion to vehicle miles driven have to be multiplied by fuel economy in order to convert costs from dollars per mile into dollars per gallon.

The authors calculate national averages of local pollution damages from gasoline and diesel[21], weighting (by fuel consumption) estimated damages for Santiago and for regions outside this city. For Santiago, they compute –based on local calculations- estimates of USD 0.04/mile or USD 0.07/mile of damage provoked by the use of gasoline, under different Value of Statistical Life (VSL) assumptions of USD 1.12 or USD 2.15 million[22]. For regions outside of Santiago, as there are no studies on local pollution damages, the authors extrapolate estimates from the United States, after adjusting for differences in VSL and in vehicle emission rates, which results in damages of USD 0.01/mile and USD 0.02/mile, based on the two different values adopted for the Chilean VSL. They assume pollution damage costs for diesel (trucks), on a per mile basis, are 3.4 times those for gasoline (cars).

Concerning to global environmental damages, as it is usual in the literature, Parry and Strand (2010) consider that combusting a gallon of gasoline and diesel produces 0.009 and 0.010 tons of CO_2 respectively, and they compute in the benchmark case a

[20] Jon Strand commented in the project seminar that the discussion of the Parry and Strand (2010) paper with government authorities in Chile found resistance to incorporate global environmental cost in the efficient tax calculations.

[21] The authors assume that gasoline is consumed by cars and diesel by trucks.

[22] The lower VSL value is the authors' preferred estimate.

value of USD 10/ton of CO2. Therefore, the cost of climate change per gallon of fuel consumed is around USD 0.07 and USD 0.084 for gasoline and diesel, respectively.

Parry and Strand (2010) present the results on pollution damage as a combination of dollars per mile and dollars per gallon (Table 1) or exclusively dollars per mile (Table C1); we have converted these figures into dollars per liter in order to facilitate the comparison with our estimations. Table 1 below shows the environmental externalities from motor fuel consumption estimated by Parry and Strand (2010) for Chile and Santiago, under the authors' preferred VSL, and the ones calculated in this study for Montevideo (Uruguay), Buenos Aires (Argentina) and La Paz (Bolivia).

Table 1

Environmental damages from fuel use in transport sector
US dollars per litre

	Parry and Strand (2010)		**This Paper**		
	CHILE	**SANTIAGO**	**URUGUAY**	**ARGENTINA**	**BOLIVIA**
Gasoline					
local emisions	0.154	0.317	0.099	0.153	0.061
global	0.018	0.018	0.016	0.016	0.016
total	0.173	0.336	0.115	0.169	0.077
Diesel (Gas Oil)					
local emisions	0.135	0.317	0.662	0.927	0.327
global	0.022	0.022	0.016	0.016	0.016
total	0.157	0.339	0.678	0.943	0.343
VSL (000 USD)	1120	1120	892	818	147

One of the results to be highlighted is that even when geographical and meteorological conditions, size of population, quality of fuels, characteristics of the vehicle fleet, income, etc. explain differences in the monetary cost of environmental externalities from fuel use across different locations, the estimates for Uruguay, Argentina and Bolivia have as a common feature a cost per liter much more higher for diesel than for gasoline. Instead, the external costs of these fuels in Parry and Strand (2010), at the nationwide level, show a little difference in favor of diesel. In fact, the authors estimate the same external costs per liter of both fuels for a given location (Santiago or the rest of the country), as the different costs per mile of diesel and gasoline are offset by differences in their fuel economy. The slight difference in favor of (lower costs for) diesel happens because the estimation of a national average proceeds by weighting the cost of damages for Santiago and for the rest of the country, and the external costs in the inner country are much lower than in Santiago are more important for diesel than for gasoline.

Energy supply-side

The reference model deals with a consumption externality arising from energy consumption and as such does not deal with the structure of the energy sector. Instead, in dealing with the energy sector (and energy policy) it can be acknowledge that environmental costs are going to the present in supply side decisions and that the structure of the energy supply matters a lot for the management of environmental impacts. Our modeling strategy does not consider other policy instruments apart from taxes on primary energy sources such as hydrocarbons which because they enter as inputs into the structure of energy supply will have to include associated environmental costs. For example, electricity as a secondary energy source will not be subjected per se to a tax because it carries no (or low) environmental costs. Rather, it is the use of fuels, natural gas or carbon in thermal generation which carries those costs are face taxes, giving a due cost advantage in this respect to renewable.[23] We further do not include environmental costs associated to hydro or nuclear generation. Health costs in urban population (which constitute the brunt of our local costs) are assumed not affected by hydro or nuclear generation (as we neither introduce hazardous substances or catastrophic events). Nor are the global costs associated with carbon taxes.

Inputs vs. final consumption goods

The previous point leads to a more general issue on the treatment of energy goods as inputs rather than final consumption goods (as assumed in the reference model). This will be relevant for the consumption of energy by firms. Following the same treatment of primary energy sources into electricity generation we treat these inputs in a similar fashion as final consumption products, i.e. charging the corresponding environmental costs related to associated emissions. We make an effort to separate whenever possible energy products that go to final (e.g. household) consumption from those that go to firms. As in the case of electricity (which is in fact another industry) we make adjustments into the environmental costs considering differences due to location and altitude of emissions (which are important to local but not global costs).

From an indirect tax perspective as the one adopted in this paper, taxes on inputs are normally not justified except in presence of externalities which is precisely the case.

[23] See Helm (2005) and Fullerton et.al. (2011) for a criticism of taxing electricity in the UK.

Beyond this, other justifications due to distortions different from environmental externalities, that can led to adjustments or different treatment of inputs, are not considered. Another different issue is the impact of environmental taxes on firms or producers in a small open economy, and whether an environmentally related tax on energy inputs requires some adjustment. Uniform indirect taxes (such as VAT like taxation) allow for the deduction of taxes on inputs and corresponding reimbursements of the VAT on inputs do not discriminate against exporters. An environmentally related component without deduction or reimbursement (in the case of exporters) will operate in a different form. The absence of VAT-like deduction as in the case of general inputs (that do not have associated environmental costs) is justified on the basis of the (Pigouvian) Polluter Pays Principle (PPP) that inspires environmental taxation. Producers are, both on static and dynamic efficiency justifications, those who make relevant decisions to tax. To do otherwise would be to shift the burden to final consumers who are not responsible for choices associated with corresponding environmental costs. The export oriented nature of some goods do not change much this argument, as both local and global environmental costs will have to be borne by someone and to waive producers from facing those costs will be inefficient. A different question is whether pressures will accumulate to treat exporters differently on concerns that (for instance the introduction of global environmental costs) will harm competitiveness.[24] This relates to a previous point on the acceptance of environmental costs and to the political economy of taxes in general.

A final point to notice regarding this discussion is that we have adjusted our modeling structure to distinguish between a uniform (VAT like) component of taxes (t/(1+t) in expression (1) above) and a non-uniform component which will be reformulated as an environmentally related excise. Beyond being a due representation of the status quo this separation makes clear that a part of the tax wedge on energy as an input will indeed be deducted from final sales (by all producers) or recovered (by exporters). This is not a minor point as the traditional analysis of indirect environmental taxes focuses on the whole tax-wedge as the relevant variable of the model without paying much attention of what can be deducted or not. The separation will prove useful, as we shall see below, to evaluate whether in the case of Uruguay, where the 2005 reform eliminated the VAT component (t/(1+t)) and reabsorbed it into the excise, this apparent simplification is in fact an inefficient arrangement in relation to distinguishing between different taxes.

Distributional equity issues

[24] Fullerton et.al. (2010) discusses the alternative regime of introducing border carbon tax adjustments on goods, which have both theoretical and practical problems. They conclude that wider international coordination of carbon taxes will be preferable to border tax adjustments.

Distributional issues may enter into the above framework by acknowledging heterogeneous agent and introducing distributional characteristics of goods, with tax wedges now sensitive to those parameters. Annex A shows how this model can be obtained. The extension is one on model-case II and on expression (4'), i.e.

$$m_i^{IIN2} = \frac{\lambda^{IIN2} - d_i}{\lambda^{IIN2}.\eta_i} + Z_i^{IIN2} \quad \text{where } Z_i^{IIN2} = \frac{\mathrm{K_i}/q_i^{IIN2}}{\lambda^{IIN2}} \qquad (4'')$$

$$d_i = \sum_{\mathrm{h}} \beta^h . \frac{x_i^h}{X_i} \qquad \beta^h = \frac{\partial W}{\partial V^h} . \frac{\partial V^h}{\partial Y^h} = \sigma^h . \alpha^h \qquad (4''')$$

Where d_i are so-called distributional characteristics, β^h is the social marginal utility of income of household h which are a product of welfare weights and the private marginal utility of income. In applied studies, estimation of all theses parameters requires further specification of welfare or utility functions (such that β^h can be estimated from household income) and the use of micro-data from Household expenditure surveys.

This extension has several shortcomings as a practical assistance of an analysis of reform. One line of criticism has to do with available instruments to deal with social issues. When other instruments are available they may do better than taxes for dealing with equity issues. On the other hand, this may not be the case for the countries considered. Certainly, from the point of view of the modeller, life is much easier separating away equity issues, as it implies working with an homogenous household world. The problem starts once results for optimal tax structures imply large changes from the observed status quo, that are going to be resisted in real life because of society's aversion to energy price increases in particular sensitive products (e.g. those related to transport for instance). The fact that this resistance does indeed occur and the reference to distributive impacts, puts the equity issues at the centre of the stage. Thus, equity considerations in practical tax design cannot be ignored on the grounds that other instruments could in theory could do better.

The acknowledgement that equity issues are important perhaps does not necessarily imply that third degree price discrimination with distributional characteristics (i.e. tax non uniformity) is the right way to deal with the problem. One serious problem with the "distributional characteristic approach" of model-case IIN2 above is that it will have serious flaws at the implementation stage. One is the low power of focalized transfers trough pricing (except in the case of personalized two part tariffs) as energy consumption is only partially correlated with income, and low-income households consume energy due to other characteristics.[25] For example, Ian Parry (2011)

[25] See Navajas (2009) on this for the case of natural gas in Argentina.

presentation in the project seminar considered equity impacts such issues but instead talked about targeted rebates and feebates to compensate poor families and to avoid price impacts. We, in Argentina, have been working in recent years in mechanisms that look at compensating poor households from the correction or elimination of energy price subsidies. Thus targeted transfers could be introduced into the framework as opposed to the distributional-characteristics approach to taxes.

A second problem with the distributional characteristics approach comes from the above mentioned the fact that energy goods are inputs apart from final consumption goods. This creates another severe difficulty for the empirical implementation of the model, as the distributional characteristic of an input will depend on its destination to final goods. In some cases, such as fuels that hit transport (diesel) this can be solved by considering the distributional characteristic of urban (public) transport. In other cases, estimating the distributional characteristic in these cases as that referred to the consumption good in our model (assuming energy inputs enter into this final good) is a possibility albeit an imperfect one. As the (uniform) tax on the aggregate consumption good in our model assumes that distributional issues are not considered) this is equivalent to assume that distributional impacts of energy taxes matter only when energy is sold to households or enter in goods (such as transport) that have an impact on households.

Distortions in energy pricing

The reference model assumes that producer prices represent opportunity costs of energy because they come from (or are approximations to) a competitive equilibrium. Imperfect competition or public enterprise inefficiencies may lead to higher values and would require adjustments. On the other hand, government price interventions that set producer prices below opportunity costs create the inverse problem. In our sample we have one country (Uruguay) which can be potentially affected by the first case (as most of the energy supply is imported but intermediated by public entities in the value chain) and two countries (Argentina and Bolivia) are heavily affected by the second case (as direct price interventions have separated energy prices from opportunity costs).

Reforming non-uniform energy excises towards environmental objectives can be done under certain assumptions independently of the distortions in producer prices. For example, a specific tax form component that incorporates environmental costs can do this without reference to energy prices, implying that environmental costs will enter into the tax framework adding up to whatever prices government policies allow for. Another possibility is to introduce adjustments in producer prices. Even so, we can by-pass the adjustments for the Uruguayan case (as we consider them to be minor ones) albeit we cannot neglect the cases of Argentina and Bolivia where differences are large. In the latter cases we consider border (i.e. import parity) prices as a substitute for observed producer prices.

Informality and non-taxed goods

Energy tax compliance and control is normally higher (in the world and in Latin American countries) than the average standard of the economy. This means, in terms of our reference model that, for example, the aggregate consumption good X_0 will face more evasion in the uniform VAT tax (t) than energy goods.[26] However, compliance across energy taxes is not uniform. It is relatively high for fuel taxes[27], lower for products such as LPG and very low or nil for biomass. This latter is an important energy products in Latin America and we consider this issue in section 4 for the case of Bolivia. In the general analysis of tax reform towards energy ERT we do not make further adjustments for the effects on tax structures that differential avoidance or evasion could introduce. Further, in the exercises performed for the countries studied –where we consider biomass as an untaxed good- we do not adjust for the introduction of environmental taxes (even when we estimate these) in the revenue impacts calculations. In a similar fashion to what was discussed on equity issues, we believe this sectors or goods need to be approached with different instruments.

3.2. Applications

3.2.1. Data

Our data set for this study is described in Annex B for quantities, prices, taxes and consumer surveys and in Annex C for environmental costs. We construct detailed data sets for observed prices with and without taxes (including some corrections when distortions due to subsidies occur in Argentina and Bolivia)[28] as well as sales of a large list of energy goods. This gives us a precise characterization of the status quo in each country. Environmental costs are estimated separately following the procedure described in Annex C. Estimates of the marginal costs of raising public funds assumed in a simple fashion according the simple grammar of our model. Likely intervals of direct price-elasticities of demand are also assumed as reasonable values to calibrate

[26] Whether this implies an adjustment of optimal taxes of energy and non energy taxes in face of evasion is not considered for the sake of simplicity. Energy taxes face better compliance as they are better controlled an applied on few producers. In some Latin American countries where tax pressure is low (for instance Central America) fuel taxes are a high percentage of total revenues (see Artana et.al. 2007).

[27] Even for fuels there are problems of tax avoidance through several practices. See Ahumada et.al. (2000) for description and estimates for the argentine case.

[28] We make corrections for gas oil, electricity and natural gas for Argentina, and gasolines, gas-oil and LPG for Bolivia.

but are based on previous existing studies (in the case of Argentina) or taken from meta-analysis of world values (see for example, Dahl 2011).

The sequence of summary results presentation is the following. We first introduce in Tables X1 (X=U,A and B standing for Uruguay, Argentina and Bolivia) the basic data of the problem (prices, taxes, quantities, environmental costs, price-elasticity intervals, etc.). Second, we present both non-Ramsey (in Tables X2) and Ramsey (in Tables X3) solutions for energy environmentally related taxes. We also depict (in Figure X1) the "grammar" of tax wedge margins in the status-quo and in the Non-Ramsey case and the corresponding final price chances due to tax reform. Third, we explore (in Tables X4) the robustness of the direction of tax reform for different values of environmental costs and price-elasticities. Fourth, we estimate (in Tables X5) tax revenue impacts. Sixth, we estimate the change on environmental costs after reform (in Table X6). Finally, we present data and results (in Figures X2 to X5 and in Table X7) of our evaluation of the distributional impact of all (Non-Ramsey and Ramsey) tax reforms.

3.2.2. Uruguay

Table U1 below shows the basic data for the case of Uruguay.

Table U1
Uruguay: Basic data and estimates for ERT analysis
Data for June 2011

products	Units	(A) Consumer prices *q*	(B) Consumer Prices without taxes *c*	(C) Observed % Tax Wedge *(q-p)/q*	(D) Observed non uniform component Zi	Environmental Damage K		Price elasticity range (direct)		
						(E.1) Local	(E.2) Local + Global	(F1) Low	(F2) Expected	(F3) High
Transport										
Gasoline special 87	$/l	1.81	1.06	0.41	0.23	0.14	0.16	0.7	0.9	1.1
Gasoline super 95	$/l	1.81	1.04	0.43	0.25	0.13	0.15	0.6	0.8	1
Gasoline premium 97	$/l	1.89	1.07	0.43	0.25	0.13	0.15	0.5	0.7	0.9
Jet Fuel (AV Gas)	$/l	2.29	1.37	0.40	0.22	0.00	0.02	0.5	0.7	0.9
Jet Fuel A1	$/l	1.30	1.26	0.03	-0.15	0.00	0.02	0.5	0.7	0.9
Gas Oil	$/l	1.75	1.44	0.18	0.00	0.53	0.55	0.5	0.7	0.9
Special Gas Oil	$/l	2.20	1.80	0.18	0.00	0.44	0.46	0.5	0.7	0.9
Households										
LPG	$/kg	1.40	1.15	0.18	0.00	0.01	0.02	0.2	0.5	0.7
Kerosene	$/l	1.32	1.11	0.16	-0.02	0.16	0.18	0.2	0.5	0.7
Natural gas residential	$/m3	0.61	0.50	0.18	0.00	0.01	0.03	0.2	0.5	0.7
Electricity residential	$/KWh	0.23	0.18	0.22	0.04	0.00	0.00	0.2	0.5	0.7
Wood residential	$/kg	0.17	0.17	0.00	-0.18	0.32	0.33	0.2	0.5	0.7
Industry										
Diesel	$/l	1.28	1.03	0.19	0.01	0.42	0.44	0.5	0.7	0.9
Fuel Oil heating	$/l	0.89	0.73	0.18	0.00	0.26	0.28	0.5	0.7	0.9
Fuel Oil special	$/l	1.09	0.90	0.18	0.00	0.26	0.28	0.5	0.7	0.9
Fuel Oil heavy	$/l	0.73	0.60	0.18	0.00	0.26	0.28	0.5	0.7	0.9
Propane industry	$/kg	1.57	1.29	0.18	0.00	0.00	0.02	0.5	0.7	0.9
Natural gas industry	$/m3	0.45	0.37	0.18	0.00	0.00	0.02	0.5	0.7	0.9
Electricity industry	$/KWh	0.22	0.17	0.22	0.04	0.00	0.00	0.5	0.7	0.9
Wood industry	$/kg	0.09	0.09	0.00	-0.18	0.05	0.06	0.5	0.7	0.9
"Aggregate Good (Xo) (benchmark)				**0.18**					**0.9**	

We classify for easiness of exposition energy products into those maily related to transport, households and industry, even though there exist overlaps of residential and industrial or commercial customers in the transport block.

A simple inspection of data on tax wedges show that non-uniform energy excises (Z_i) in Uruguay are concentrated in a few fuel products. Most of the energy products, including Gas Oil (for urban and freight transport and the agricultural sector) do not face excises at all. Some products, notably biomass and Jet fuel or Kerosene face negative excises, i.e. they do not pay VAT or pay a tax below the uniform one (of 23%).

We complete Table U1 with our estimates of local $(\underline{K}_i)$ and both local and global $(\overline{K}_i)$ environmental costs. Precisely, Gas Oil (which bears no Z_i) is the product with the highest costs, followed by Diesel and by Biomass. Finally, we add price-elasticity intervals for each product. A rapid insight from Table U2 is that gasolines are overtaxed and Gas Oil is undertaxed, considering only environmental costs as main drivers of energy excises.[29] This is a feature shared by many economies in the region. We proceed to evaluate the implications of a reform towards environmental taxes following our previous guidelines.

Table U2 shows the results of following our case-model I, which is the non-Ramsey excise case.

[29] As said before the inclusion of other external costs associated to transport externalities may change the statement that gasoline is overtaxed if fuel taxes are the only instrument to correct for these externalities.

Table U2							
Uruguay: Model-Case I, Non Ramsey Excises							
	Case I: Positive Approach		*Case I: Normative Approach*				
products	(A) Observed % Tax Wedge	(B) Becker's Numbers Zi	(C) Normative % Tax Wedge	(D) Sandmo's Numbers Zi	(E) Consumer prices before reform	(F) Consumer prices after reform	(G) % difference
Transport							
Gasoline special 87	0.41	0.23	0.27	0.09	1.81	1.46	-19.4%
Gasoline super 95	0.43	0.25	0.27	0.09	1.81	1.42	-21.5%
Gasoline premium 97	0.43	0.25	0.27	0.09	1.89	1.46	-22.8%
Jet Fuel (AV Gas)	0.40	0.22	0.19	0.01	2.29	1.69	-26.2%
Jet Fuel A1	0.03	-0.15	0.19	0.01	1.30	1.56	20.4%
Gas Oil	0.18	0.00	0.38	0.20	1.75	2.31	31.8%
Special Gas Oil	0.18	0.00	0.32	0.14	2.20	2.67	21.2%
Households							
LPG	0.18	0.00	0.19	0.01	1.40	1.43	1.8%
Kerosene	0.16	-0.02	0.28	0.10	1.32	1.54	16.8%
Natural gas residential	0.18	0.00	0.21	0.03	0.61	0.64	4.3%
Electricity residential	0.22	0.04	0.18	0.00	0.23	0.22	-4.8%
Wood residential	0.00	-0.18	0.68	0.50	0.17	0.54	215.4%
Industry							
Diesel	0.19	0.01	0.39	0.21	1.28	1.71	33.4%
Fuel Oil heating	0.18	0.00	0.38	0.20	0.89	1.17	31.8%
Fuel Oil special	0.18	0.00	0.35	0.17	1.09	1.38	25.8%
Fuel Oil heavy	0.18	0.00	0.41	0.23	0.73	1.01	38.8%
Propane industry	0.18	0.00	0.19	0.01	1.57	1.59	1.3%
Natural gas industry	0.18	0.00	0.21	0.03	0.45	0.47	4.4%
Electricity industry	0.22	0.04	0.18	0.00	0.22	0.21	-4.8%
Wood industry	0.00	-0.18	0.48	0.30	0.09	0.16	90.8%

The observed tax wedges and consumer prices have implicit Z_i that we term Becker's numbers (see expression (3)). The largest values for these numbers correspond to gasolines and a class of Jet Fuel for domestic small planes (AV Gas) while the lowest are for LPG, Gas oil (transport). Biomass (and Kerosene to a smaller extent) and Jet Fuel have negative Becker's numbers. Overall, the pattern of Becker's numbers is somewhat consistent with distributional impacts (the rich flight personal planes, the poor consume biomass) but also with lower prices to the median voter (LPG, gas oil for public transport) and to pressure groups (transport lobby). Our analysis of the correspondence of the implicit characteristics of goods (θ_i) with distributional characteristics d_i (see (4''')) show some strong (but not perfect) correlation between both parameters, suggesting that distributional concerns are one driver of the Becker's numbers.

On the other hand, we obtain quite different normative Z_i that are base on environmental costs, and we call Sandmo's numbers (expression (4)). The corresponding difference between observed and normative values leads to a rebalancing of final prices shown in the last column of Table U.2. Gasolines and a class of Jet Fuel (for domestic small planes) prices would fall about 20%, while the price of Gas oil should move up by more than 30%. Other heavy fuels for households (heating), industry or electricity generators should also face increases. The largest increases are associated with biomass (which we consider hardly implementable due to informality) while LPG is correctly priced and face a small increase. Figure U1 shows tax wedge margins in the status quo (light bars) and after reform (dark bars) and the corresponding increase in final end-user prices (in dots).

Figure U.1

Uruguay: Tax wedge margins. Non Ramsey Tax Reform vs. Status quo

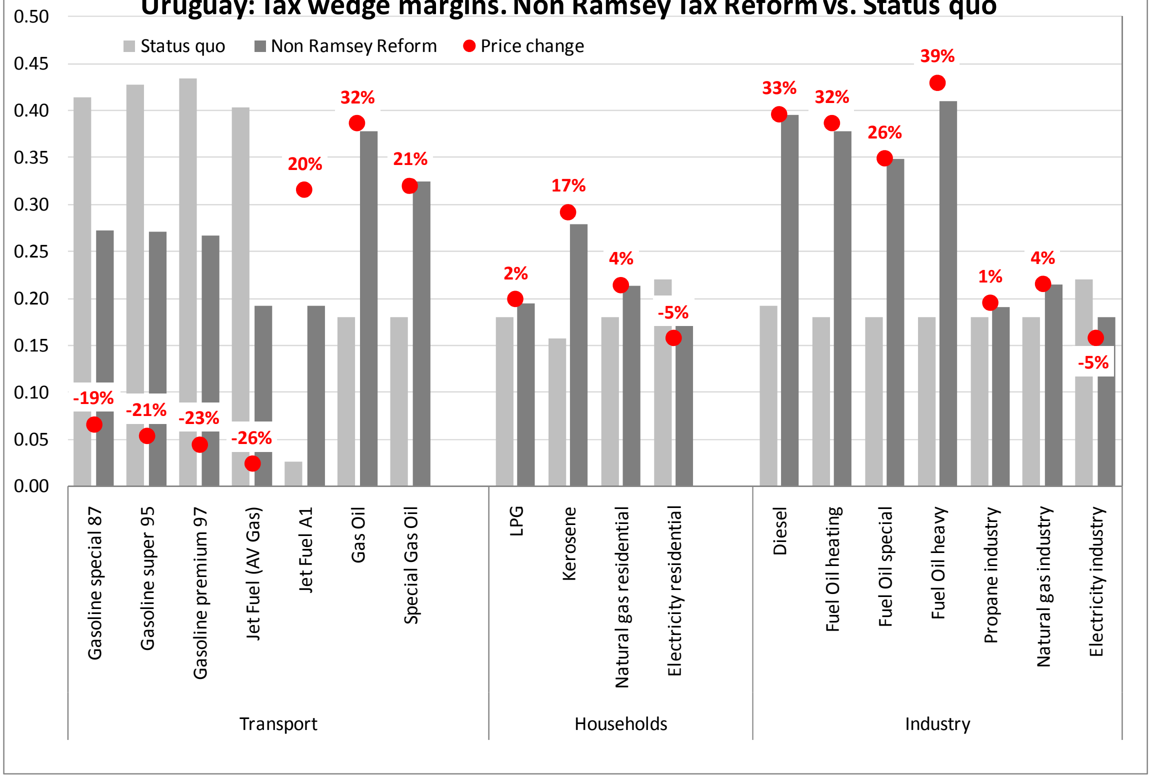


Table U3 shows the results of implementing model-case II based on Ramsey excises.

Table U3 Uruguay: Model-Case II, Ramsey Excises							
		Ramsey Excises			*Ramsey Excises with Political Constraints*		
products	(A) Observed % Tax Wedge	(B) Normative % Tax Wedge	(C) Consumer prices after reform	(D) % Price Change	(E) Normative % Tax Wedge	(F) Consumer prices after reform	(G) % Price Change
Transport							
Gasoline special 87	0.41	0.27	1.46	-19%	0.48	2.04	13%
Gasoline super 95	0.43	0.29	1.46	-19%	0.49	2.04	12%
Gasoline premium 97	0.43	0.31	1.56	-18%	0.49	2.11	12%
Jet Fuel (AV Gas)	0.40	0.24	1.81	-21%	0.41	2.33	1%
Jet Fuel A1	0.03	0.24	1.66	28%	0.04	1.31	1%
Gas Oil	0.18	0.42	2.47	41%	0.38	2.31	32%
Special Gas Oil	0.18	0.37	2.85	29%	0.32	2.67	21%
Households							
LPG	0.18	0.34	1.73	24%	0.19	1.43	2%
Kerosene	0.16	0.41	1.87	42%	0.26	1.50	14%
Natural gas residential	0.18	0.35	0.78	27%	0.21	0.64	4%
Electricity residential	0.22	0.32	0.27	15%	0.22	0.23	0%
Wood residential	0.00	0.74	0.66	283%	0.61	0.45	159%
Industry							
Diesel	0.19	0.43	1.82	42%	0.40	1.73	35%
Fuel Oil heating	0.18	0.42	1.25	41%	0.38	1.17	32%
Fuel Oil special	0.18	0.39	1.47	34%	0.35	1.38	26%
Fuel Oil heavy	0.18	0.45	1.08	48%	0.41	1.01	39%
Propane industry	0.18	0.24	1.70	8%	0.19	1.59	1%
Natural gas industry	0.18	0.26	0.51	11%	0.21	0.47	4%
Electricity industry	0.22	0.23	0.23	2%	0.22	0.22	0%
Wood industry	0.00	0.51	0.18	104%	0.36	0.14	56%

As expected, the introduction of efficiency objectives changes taxes. They occur in a due to price-elasticities which tend to increase (reduce) tax-wedges and final prices for goods with smaller (higher) price-elasticity. Also as expected, Ramsey excises with political constraints (see expression (4'')) show qualitative changes, as the required adjustments to environmental costs are allocated across products in a way that respect implicit characteristics of goods (θ_i). Notably, gasoline will now face an increase rather a decrease in taxes and prices, and the increase in gas-oil shown under Ramsey excises (41%) is soften to 32%.

The preliminary insights from Table U1 already suggested a strong case for a direction of reform that reduces gasoline taxes and increases others, mainly Gas oil. The estimates obtained in Table U2 and U3 simply confirm this and present estimates of the new taxes and prices. A question however is whether this direction of reform is robust enough to critical parameters such as environmental cost estimates in model-case I (non Ramsey excises) and these costs and price-elasticities in model-case II (Ramsey excises). We perform such sensitivity analysis (computing expressions (5) and (6)) in Tables U4 by referring to the estimates of MCPF at the initial (status-quo) situation.

Table B4

Uruguay: ERT Reform, Marginal Cost of Public Funds (MCPF) Indicators for Directions of Reform

products	(C) Observed % Tax Wedge *(q-c)/q*	MCPF, Non Ramsey Case (environmental costs)		MCPF, Ramsey Case (price elasticities)			MCPF, Ramsey Case (environmental costs)	
		Local	Local and Global	Low	Expected	High	Local	Local and Global
Transport								
Gasoline special 87	0.41	1.48	1.47	1.33	1.48	1.68	1.48	1.47
Gasoline super 95	0.43	1.52	1.50	1.29	1.43	1.62	1.43	1.42
Gasoline premium 97	0.43	1.54	1.52	1.23	1.37	1.54	1.37	1.36
Jet Fuel (AV Gas)	0.40	1.57	1.56	1.25	1.39	1.57	1.39	1.38
Jet Fuel A1	0.03	1.02	1.01	1.01	1.02	1.02	1.02	1.01
Gas Oil	0.18	0.87	0.86	0.93	0.90	0.87	0.90	0.90
Special Gas Oil	0.18	0.98	0.97	0.99	0.99	0.98	0.99	0.98
Households								
LPG	0.18	1.19	1.17	1.04	1.10	1.14	1.10	1.09
Kerosene	0.16	1.04	1.02	1.01	1.02	1.03	1.02	1.01
Natural gas residential	0.18	1.18	1.15	1.03	1.09	1.13	1.09	1.08
Electricity residential	0.22	1.25	1.25	1.05	1.12	1.18	1.12	1.12
Wood residential	0.00	-0.67	-0.70	0.63	0.07	-0.30	0.07	0.05
Industry								
Diesel	0.19	0.85	0.84	0.93	0.89	0.85	0.89	0.88
Fuel Oil heating	0.18	0.88	0.86	0.94	0.91	0.88	0.91	0.90
Fuel Oil special	0.18	0.94	0.92	0.97	0.95	0.94	0.95	0.94
Fuel Oil heavy	0.18	0.81	0.79	0.90	0.86	0.81	0.86	0.84
Propane industry	0.18	1.19	1.18	1.10	1.14	1.19	1.14	1.13
Natural gas industry	0.18	1.19	1.15	1.10	1.14	1.19	1.14	1.11
Electricity industry	0.22	1.25	1.25	1.12	1.18	1.25	1.18	1.18
Wood industry	0.00	0.45	0.39	0.70	0.58	0.45	0.58	0.53
Note: Colors indicate taxes should face:	Large reductions		Small reductions		Increases		Large increaes	

The MCPF parameters estimated in Table U.4 represent the welfare costs of an additional dollar raised by tax on good "i" evaluated in the current (satus quo) situation. Estimated parameters are compared among themselves and with reference to the assumed marginal cost of public funds for indirect taxation (on an aggregate good) estimated at 1.19. Values above this figure show that taxes should be reduced to produce a welfare improvement, while the opposite holds for values lower than 1.19. Columns represent the sensitivity of those estimates to environmental costs intervals for the Non-Ramsey model and to price-elasticity and environmental costs intervals for the Ramsey model. For easiness of observation, we have shaded values according to the cases where the marginal tax reform direction suggests a large reduction in taxes (in blue) a moderate reduction (in green) an increase (in yellow) and a large increase (in orange). Gasolines and domestic Jet fuel belong to the first group. Very few cases (electricity for some cases) belong to the second group. All others goods exhibit a room for increases in taxes. They are mild for the case of LPG and natural gas in both households and industry. They are rather large for Gas Oil and Jet Fuel in transport and also for Fuel oil and Diesel Oil in industry. Largest increases should be associated with wood for households and industry. The main result is that directions of tax reform are robust enough to parameter sensitivity.

Table U5 shows an estimation of the revenue impact of the reform of energy taxes towards ERT.

Table U5

Uruguay: Impact of ERT Reform on Tax Revenues

Data for 2010 in millions of US dollars

		Case I	**Case II Ramsey excises**	
products	**Status-quo 2010**	***Non-Ramsey excises***	***Ramsey excises***	***Ramsey with Political Constraints***
Transport	**688**	**921**	**1032**	**1127**
Gasoline special 87	20.1	13.0	13.0	23.6
Gasoline super 95	337.3	203.6	219.9	396.3
Gasoline premium 97	32.3	18.4	22.0	38.1
Jet Fuel (AV Gas)	3.3	1.4	1.9	3.4
Jet Fuel A1	3.2	24.3	31.4	4.7
Gas Oil	281.9	641.8	722.1	641.8
Special Gas Oil	9.9	18.9	21.8	18.9
Households	**189**	**163**	**318**	**193**
LPG	28.4	31.0	59.0	31.0
Kerosene	2.1	3.9	6.3	3.6
Natural gas residential	2.5	3.0	5.5	3.0
Electricity residential	155.8	124.6	247.0	155.8
Wood residential	0.0	228.9	272.7	186.0
Industry	**111**	**124**	**152**	**140**
Diesel	0.3	0.6	0.6	0.6
Fuel Oil heating	6.1	14.0	15.7	14.0
Fuel Oil special	6.9	14.3	16.4	14.3
Fuel Oil heavy	9.1	22.8	25.4	22.8
Propane industry	0.4	0.4	0.5	0.4
Natural gas industry	1.7	2.0	2.5	2.0
Electricity industry	86.1	69.5	91.2	86.1
Wood industry	0.0	28.9	31.6	20.7
TOTAL	**988**	**1208**	**1502**	**1461**

The first column indicates the status quo of tax revenues computed from observed taxes and quantities in 2010. The second column shows the revenue impact of the model case I with non-Ramsey excises. The rebalancing of taxes implied by the reorientation towards environmental objectives has a positive fiscal impact (with a gain 220 million dollars or 23% of revenues). This comes mostly from the fact that the increase in the tax on Gas Oil is larger than reductions in gasolines. We do not consider the theoretical revenue collected on biomass as assume that taxes will not be collected. From Table U3 above we know that the move towards Ramsey excises involves larger changes in taxes and therefore in revenues. Again, we do not consider the theoretical revenue collected on biomass as assume that taxes will not be collected.

In Table U6 we show the level of environmental costs in the status quo and after reform.

Table U6

Uruguay: Estimated Environmental costs before and after Reform

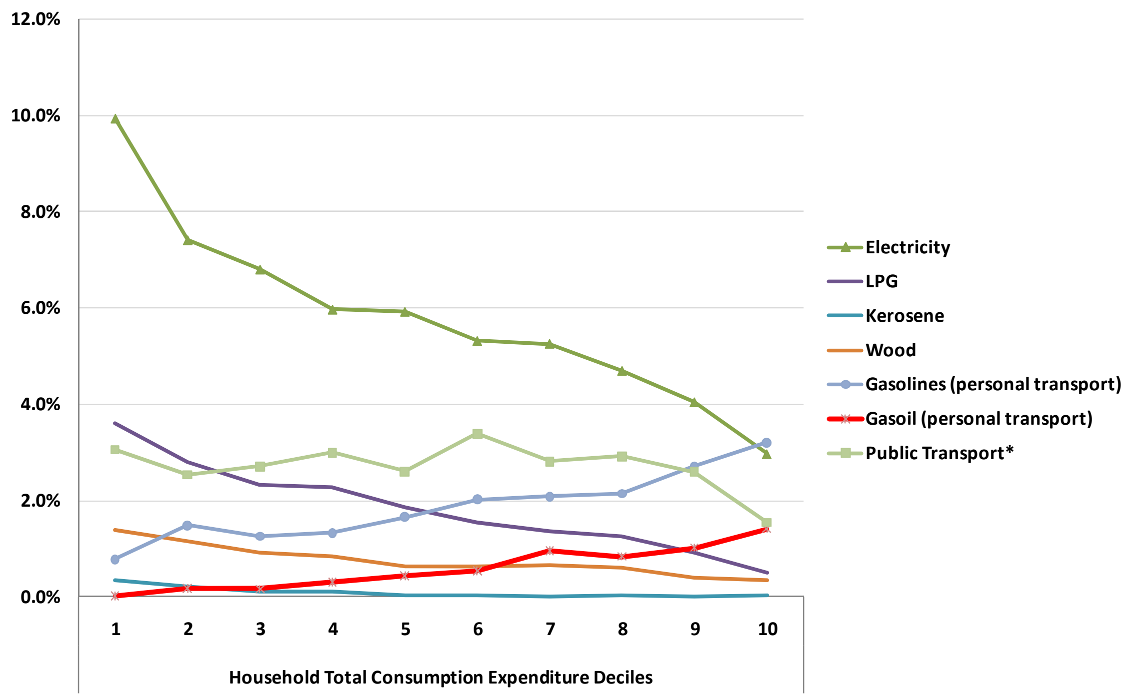
in million dollars

products	*Status Quo*		*Case I* Non-Ramsey Excises		*Case II* Ramsey Excises		Ramsey with Political Constraints	
	Local	*Total*	*Local*	*Total*	*Local*	*Total*	*Local*	*Total*
Transport	**546**	**576**	**476**	**506**	**457**	**485**	**456**	**483**
Gasoline special 87	3.7	4.3	4.5	5.2	4.5	5.2	3.3	3.9
Gasoline super 95	57.3	66.9	69.6	81.1	68.0	79.4	52.2	60.9
Gasoline premium 97	5.1	6.0	6.1	7.1	5.9	6.8	4.7	5.5
Jet Fuel (AV Gas)	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1
Jet Fuel A1	0.0	1.9	0.0	1.7	0.0	1.6	0.0	1.9
Gas Oil	468.5	485.9	386.3	400.6	369.1	382.8	386.3	400.6
Special Gas Oil	11.0	11.4	9.6	10.0	9.1	9.6	9.6	10.0
Households	**353**	**362**	**353**	**362**	**353**	**362**	**353**	**362**
LPG	0.7	2.8	0.7	2.7	0.7	2.5	0.7	2.7
Kerosene	1.6	1.8	1.5	1.7	1.3	1.5	1.5	1.7
Natural gas residential	0.2	0.6	0.2	0.6	0.2	0.5	0.2	0.6
Electricity residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wood residential	350.9	357.1	350.9	357.1	350.9	357.1	350.9	357.1
Industry	**68**	**74**	**61**	**67**	**60**	**65**	**61**	**67**
Diesel	0.4	0.5	0.4	0.4	0.3	0.4	0.4	0.4
Fuel Oil heating	10.0	10.6	8.2	8.7	7.8	8.3	8.2	8.7
Fuel Oil special	9.1	9.7	7.8	8.3	7.4	7.9	7.8	8.3
Fuel Oil heavy	18.0	19.2	14.3	15.2	13.7	14.6	14.3	15.2
Propane industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural gas industry	0.0	0.4	0.0	0.4	0.0	0.4	0.0	0.4
Electricity industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wood industry	30.4	33.7	30.4	33.7	30.4	33.7	30.4	33.7
TOTAL	**967**	**1013**	**890**	**935**	**869**	**912**	**870**	**912**

Again, as in the case of the fiscal impact, we do not consider biomass in the estimates. Both cases I (Non Ramsey) and II (Ramsey) reduce the environmental costs in relation to the status quo in the order of 78 to about 100 million dollars per year. These gains come from a reduction in local environmental costs.

Finally, we proceed to evaluate the distributional impact of the Non-Ramsey and Ramsey tax reforms according expression (10) in section 3.14. Figure U.2 show the incidence of the expenditures in energy goods in Uruguay, according to the micro-data of the National Household Expenditure Survey 2005-2006.

Figure U.2
Uruguay: Decile distribution of expenditures of energy as a percentage of Household Consumption Expenditure



The data shows different patterns of expenditure shares across deciles. Electricity and LPG are clearly decreasing; Gasolines and Gas-Oil for personal transport are increasing and public transport (which we include as an additional good to account for the impact of fuel prices) is stable and decreasing at the end of the distribution. Thus, the distributional price impacts of tax reforms estimated above are not necessarily regressive and will depend on empirical estimates.

Further, as shown in section 3.1.4, distributional impacts have to be completed with the environmental benefits brought about by tax reforms, which we assume are a lump sum benefit distributed across households. Figure U3 shows the distribution of environmental costs as a percentage of household expenditures of the decile of income distribution in Uruguay. Costs are large indeed for transport liquid fuels (Gas Oil and Gasolines) due to our unit environmental cost estimates for these products. The same fact that implies large corrections in taxes for these products will also imply large environmental benefits.[30]

Figure U.3
Uruguay: Decile distribution of environmental cains as a percentage of household consumption expenditure

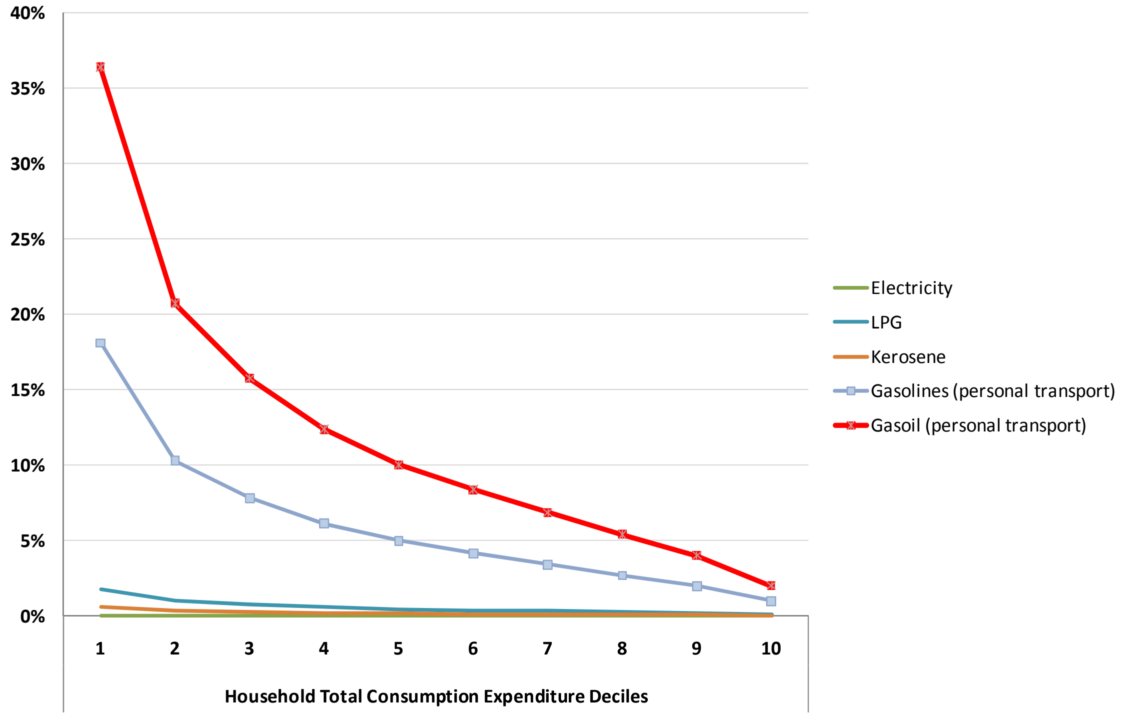


Table U.7 summarizes the estimation of expression (10) of section 3.1.4 to approximate the distributional impact of the tax reforms. It decomposes total net gains in effects due to price impacts and due to environmental gains, across deciles, for all reforms (Non-Ramsey, see Table U2; Ramsey and Ramsey with political constraints, see Table U3).

[30] Price impacts and environmental gains have not the same status as the former are going to be directly perceived by households while the latter are gains to society that will depend on the willingness to pay for environmental gains, despite the fact that society does indeed benefit individually and collectively from the gains.

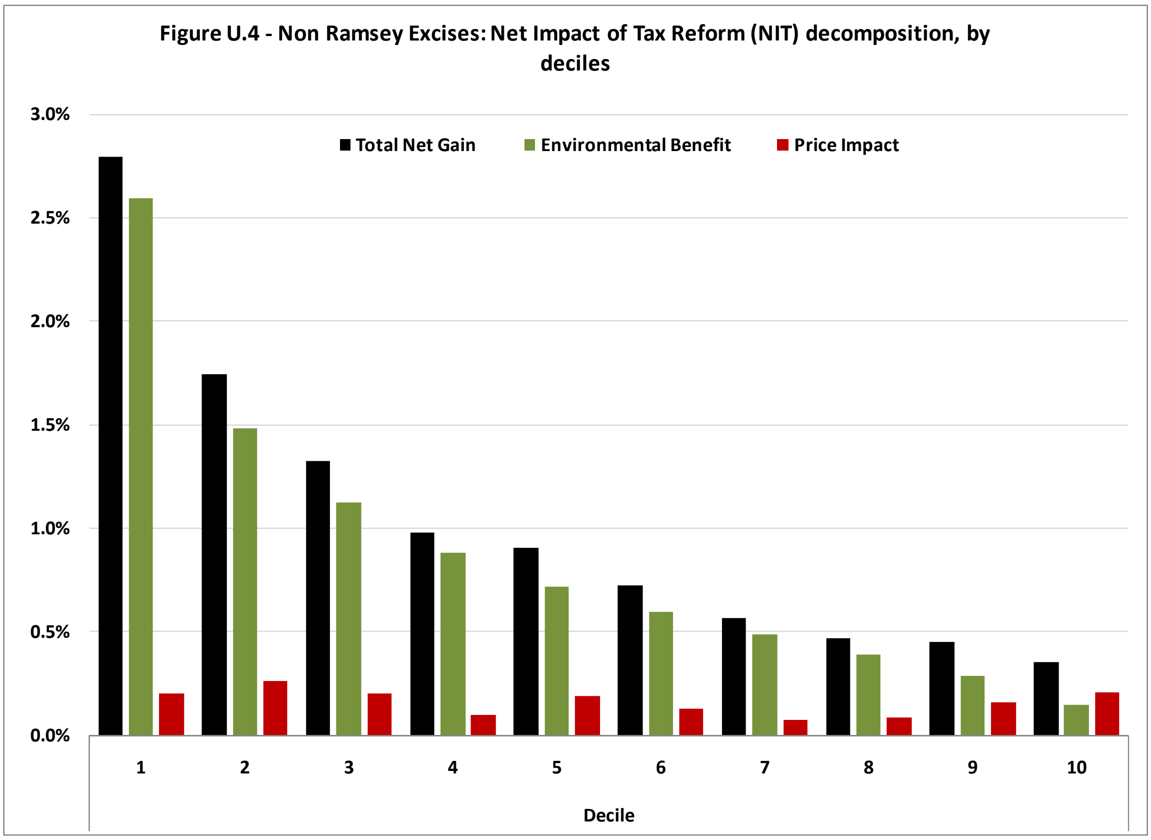
Table U7
Uruguay:Distributional Impact Net Gains of Tax Reforms

	Decile 1	2	3	4	5
Case I: Non Ramsey Excises					
Total Net Gain	**2.85%**	**1.78%**	**1.35%**	**1.00%**	**0.92%**
Environmental Benefit	2.66%	1.51%	1.15%	0.90%	0.73%
Price Impact	0.20%	0.26%	0.20%	0.10%	0.19%
Case II: Ramsey Excises					
Total Net Gain	**2.00%**	**0.70%**	**0.24%**	**-0.16%**	**-0.26%**
Environmental Benefit	4.79%	2.73%	2.08%	1.63%	1.32%
Price Impact	-2.80%	-2.03%	-1.84%	-1.79%	-1.58%
Case II: Ramsey Excises with Political Constraints					
Total Net Gain	**7.58%**	**4.04%**	**2.96%**	**2.12%**	**1.58%**
Environmental Benefit	8.12%	4.63%	3.51%	2.76%	2.24%
Price Impact	-0.54%	-0.59%	-0.55%	-0.64%	-0.66%

	Decile 6	7	8	9	10	**Total**
Case I: Non Ramsey Excises						
Total Net Gain	**0.74%**	**0.57%**	**0.48%**	**0.45%**	**0.35%**	**10.50%**
Environmental Benefit	0.61%	0.50%	0.40%	0.29%	0.15%	8.90%
Price Impact	0.13%	0.07%	0.08%	0.16%	0.21%	1.60%
Case II: Ramsey Excises						
Total Net Gain	**-0.38%**	**-0.61%**	**-0.65%**	**-0.56%**	**-0.49%**	**-0.18%**
Environmental Benefit	1.10%	0.90%	0.71%	0.53%	0.27%	16.07%
Price Impact	-1.49%	-1.51%	-1.36%	-1.09%	-0.75%	-16.25%
Case II: Ramsey Excises with Political Constraints						
Total Net Gain	**1.05%**	**0.64%**	**0.34%**	**-0.06%**	**-0.57%**	**19.68%**
Environmental Benefit	1.87%	1.53%	1.21%	0.90%	0.45%	27.21%
Price Impact	-0.82%	-0.89%	-0.87%	-0.96%	-1.02%	-7.53%

Non Ramsey excises on energy products that turn into environmental objectives give rise to a total net gain equivalent to 10.5% of household expenditure which is due to gains in price changes (1.6%) and in environmental gains (8.9%). The gains are concentrated (57%) in the 30% poorest households, indicating the reform is a progressive one. At the product level (not shown here) Gas Oil is the largest contributor to the gains, even after accounting for the likely increase in public transport costs[31]. On the other hand, Gasolines contribute to net losses as the reduction in prices means higher consumption and higher environmental costs that more than compensate the gains due to price reductions. Figure U3 shows the distribution of price impacts and environmental gains across deciles for this reform.

[31] We assume that the passthrough of Gas Oil prices to public transport prices is 0.33, which means that public transport will increase by about 11% after the increase in 32% in Gas Oil prices.



Ramsey excises, on the other hand, show a balanced or slightly negative total net gain due to almost equal negative price effects (equivalent to 16.2% of household income) and positive environmental gains (16%). The bottom 30% of income distribution faces a net gain equivalent to 3% of household income that is decomposed in environmental gains (9.6% of expenditure) and a negative price impact (-6,6%). Again, a considerable share of gains and losses are concentrated in this group. At the product level (not shown here) Gas Oil is again a big contributor to gains even considering a passtrough to public transport. However, losses in the reform towards Ramsey excises come now from price changes in electricity (almost based on efficiency grounds, given that electricity has zero environmental costs –and therefore do not produce environmental gains-) and LPG, where the poor have large expenditure shares (see again the discussion of Figure U2).

The results for the move to Ramsey excises that incorporate environmental costs but also take account of implicit characteristics of goods are a mixture of the results Non-Ramsey and Ramsey excise reforms. Total net gains are substantially higher than in the former case (19.7% of household expenditure) because of much larger environmental gains (27.2%) that dominate over also larger and negative price effects (-7.5%).

3.2.3 Argentina

Table A.1. shows the basic data for the exercise on Argentina.

Table A1
Argentina: Basic data and estimates for ERT analysis
Data for June 2011

products	Units	(A) Consumer prices *q*	(B) Consumer prices w/o taxes *p*	(C) Producer prices *c*	% Tax Wedge		Non-Uniform Component Zi		Environmental Damage K	
					(D) Observed (q-p)/q	(E) Reference (q-c)/q	(F) Observed	(G) Reference	(H.1) Local	(H.2) Local + Global
Transport										
Standard Gasoline (92 RON)	$/l	1.124	0.723	0.723	0.36	0.36	0.18	0.18	0.21	0.23
Special Gasoline (92-95 RON)	$/l	1.182	0.742	0.742	0.37	0.37	0.20	0.20	0.20	0.22
Premium Gasoline (97 RON)	$/l	1.363	0.836	0.836	0.39	0.39	0.21	0.21	0.20	0.22
Aerokerosene (Jet Fuel)	$/l	1.098	0.907	0.907	0.17	0.17	0.00	0.00	0.00	0.02
Aeronafta (propeller)	$/l	1.799	1.486	1.486	0.17	0.17	0.00	0.00	0.00	0.02
Gas Oil (*)	***$/l***	***1.085***	***0.729***	***0.856***	***0.33***	***0.21***	***0.15***	***0.04***	***0.68***	***0.70***
Vehicle NG (GNC) (*)	***$/m3***	***0.102***	***0.074***	***0.185***	***0.27***	***-0.82***	***0.10***	***-0.99***	***0.03***	***0.04***
Households										
LPG	$/kg	0.483	0.437	0.437	0.10	0.10	-0.08	-0.08	0.01	0.03
Kerosene	$/l	1.122	0.780	0.780	0.30	0.30	0.13	0.13	0.33	0.35
Natural gas (residential and commercial) (*)	***$/m3***	***0.031***	***0.025***	***0.185***	***0.17***	***-4.99***	***0.00***	***-5.16***	***0.01***	***0.03***
Electricity (residential and commercial) (*)	***$/KWh***	***0.011***	***0.008***	***0.059***	***0.26***	***-4.17***	***0.09***	***-4.35***	***0.00***	***0.00***
Wood	$/kg	0.183	0.183	0.183	0.00	0.00	-0.17	-0.17	0.60	0.60
Industry										
Diesel Oil	$/l	0.863	0.616	0.616	0.29	0.29	0.11	0.11	0.65	0.67
Fuel Oil	$/l	0.551	0.455	0.455	0.17	0.17	0.00	0.00	0.11	0.13
Natural gas (*)	***$/m3***	***0.149***	***0.111***	***0.185***	***0.26***	***-0.23***	***0.09***	***-0.41***	***0.00***	***0.02***
Electricity (*)	***$/KWh***	***0.034***	***0.024***	***0.074***	***0.29***	***-1.17***	***0.12***	***-1.35***	***0.00***	***0.00***
Wood	$/kg	0.153	0.153	0.153	0.00	0.00	-0.17	-0.17	0.11	0.12
"Aggregate Good (Xo) (benchmark)						**0.17**				

(*) Goods with fiscal subsidies

As before, we reproduce a Table with observed consumer (q) and producer (p) prices, the observed tax-wedge margin (q-p)/q the observed non-uniform tax-wedge component (Z_i) and the estimated local and global environmental costs per unit $(\underline{K}, \overline{K})$. We do not include the range of assumed price-elasticities as we take the same interval values as in the case of Uruguay. The additional information we include in this case is what we call opportunity costs (c), which are non-distorted producer prices. This introduces a difference between "observed" tax-wedge margins and what we call "reference" tax wedge margins defined in terms of non-distorted producer prices, i.e. (q-c)/q. We perform this correction for the case of those goods (Gas Oil for transport, Vehicular Natural Gas, Natural Gas for residential and non-residential demand and Electricity for residential and non-residential demand) that are heavily subsidized through distorted producer prices and also have a large share in fiscal subsidies related to the energy sector. All relevant data for these goods is shaded in Table A.1 and in the following Tables.

The distinction between prices net of taxes and producer prices is very relevant for the case of Argentina as the price of energy goods has been subject to different constraints and interventions that in general gave rise to producer prices below opportunity costs. This is notably true in the case of natural gas and electricity, where opportunity costs are assumed, respectively, from border (import) values of natural gas, and from an efficient combined cycle electricity generator (with gas priced at opportunity costs). Other energy products such as gasoline and gasoil or fuel oil have important although not very large differences with opportunity costs.[32]

The importance of theses distortions is clear insofar as their effect on consumption and on environmental damage, as they undo the effects of taxes and of course have also fiscal consequences[33]. Distorted end-user prices below import prices (in the case of Natural Gas and Gas Oil) or below production costs (as in the case of electricity) imply a large amount of fiscal subsidies. In our computing example of Argentina (with 2010 quantities; see Table A.5 below) we find that subsidies in the products we have chosen to correct is as much as 72% of the total taxes (uniform and non-uniform) collected on those goods, or 37% higher that the full amount of excises collected on all energy goods.

To ignore these distortions in key energy goods does not only blur the correct grammar about environmentally reoriented taxes but also misses large amounts of fiscal funds that are being used under the current structure of prices and taxes. For this reason, we perform the exercises on tax reform evaluation below using "reference" producer prices, as the use of observed pre-tax prices would distort the picture and lead to misleading conclusions about the right taxes and the fiscal, environmental and welfare impacts that we asses. In so doing, however, we have to distinguish between increases in end-user prices due to re-pricing of goods to reference producer prices and increases due to tax corrections. As the increases due to re-pricing are very large (as are distortions), attributing the welfare effects of price changes only to a environmentally re-oriented tax reform is incorrect. We are thus particularly careful to assess the distributional effects of tax reform only to the change due to tax reform properly.

Data from Table A.1 show that the largest non-uniform tax-wedge margins (Z_i) are concentrated in few gods, mainly gasoline and gas oil (diluted by price distortions in this case). As in the Uruguayan case, the former have associated lower environmental costs than transport fuels such as gas oil, indicating where the major rebalancing of taxes is going to occur. However, pre existing price distortions produce a deformation

[32] Nevertheless in the case of gasoil, there are important down-stream distortions as there are mechanisms –not capture by the data in Table A.1- to subsidize the price faced by the urban transport sector.

[33] See Cont, Hancevic and Navajas. (2011) for an analysis of energy subsidies, which are mainly concentrated in the electricity sector and to a lesser extent in natural gas and in transport fuels. But there is not a one-to-one correspondence between economic subsidies (departure of prices from opportunity costs) and fiscal subsidies (subsidies that involved budget or off budget resources). This is due to the fact that government intervention depressing producer prices have been in some cases at the expense of the private sector given previous sunk investments.

of tax wedge margins in the case of goods related to natural gas and electricity. That is, large subsidies imply large negative tax wedge margins. These do not bear large associated environmental costs, but the corrections in tax wedge margins will proceed by correcting price distortions, with large impacts in end-user prices. Finally, other products with negative Z_i such as LPG, Kerosene and biomass show political cum distributive concerns apart from inability to tax (in the case of biomass) that are similar to what we have found in Uruguay.

Table A.2 shows the results for the model-case I where we assume Non-Ramsey Excises. Columns (A) and (B) reproduce the reference tax wedge margin its non-uniform component Z_i^{IP} that we call Becker's numbers. These are to be compared by the so-called Sandmo's (Z_i^{IN}) numbers in column (D) capturing the additive environmental cost component ($K_i/\lambda.q_i^{IN}$) shown in expression (4). The comparison of the normative Z_i^{IN} with the positive Z_i^{IP} indicates that gasoline taxes will go down, while Gas oil oil will go up, in part due to a re-pricing correction and in part due to a tax reform that reflects environmental costs. All products with large price increases apart from Gas Oil are related to re-pricing of natural gas and electricity. For these there are either important tax increases –as in the case of vehicular NG, and residential NG- or tax reductions –as in the case of electricity-, in all cases reflecting an accommodation to environmental costs. Other important increases only due to taxes are of course biomass, in the same vein as found in Uruguay.

Complementing Table A2, Figure A1 shows initial status-quo reference tax-wedge margins, Non-Ramsey tax wedge margins and the corresponding price increases for all goods.

Table A2

Argentina: Model-Case I, Non Ramsey Excises

products	*Case I: Positive Approach*		*Case I: Normative Approach*						
							(G) % Price Change		
	(A) Reference % Tax Wedge	(B) Becker's Numbers Zi	(C) Normative % Tax Wedge	(D) Sandmo's Numbers Zi	(E) Consumer prices before reform	(F) Consumer prices after reform	(1) Total	(2) Due to Energy Prices Correction	(3) Due to Tax Reform
Transport									
Standard Gasoline (92 RON)	0.36	0.18	0.35	0.18	1.12	1.11	-0.9%	*0.0%*	*-0.9%*
Special Gasoline (92-95 RON)	0.37	0.20	0.34	0.17	1.18	1.13	-4.7%	*0.0%*	*-4.7%*
Premium Gasoline (97 RON)	0.39	0.21	0.32	0.15	1.36	1.24	-9.2%	*0.0%*	*-9.2%*
Aerokerosene (Jet Fuel)	0.17	0.00	0.19	0.02	1.10	1.12	1.9%	*0.0%*	*1.9%*
Aeronafta (propeller)	0.17	0.00	0.18	0.01	1.80	1.82	1.3%	*0.0%*	*1.3%*
Gas Oil (*)	***0.21***	***0.04***	***0.51***	***0.34***	***1.08***	***1.75***	***61.7%***	***14.2%***	***47.5%***
Vehicle NG (GNC) (*)	***-0.82***	***-0.99***	***0.29***	***0.12***	***0.10***	***0.26***	***156.1%***	***131.5%***	***24.6%***
Households									
LPG	0.10	-0.08	0.22	0.04	0.48	0.56	15.6%	*0.0%*	*15.6%*
Kerosene	0.30	0.13	0.40	0.23	1.12	1.30	15.9%	*0.0%*	*15.9%*
Natural gas (residential and commercial) (*)	***-4.99***	***-5.16***	***0.27***	***0.10***	***0.03***	***0.25***	***724.4%***	***624.8%***	***99.6%***
Electricity (residential and commercial) (*)	***-4.17***	***-4.35***	***0.17***	***0.00***	***0.01***	***0.07***	***525.9%***	***536.3%***	***-10.4%***
Wood	0.00	-0.17	0.78	0.61	0.18	0.84	357.8%	*0.0%*	*357.8%*
Industry									
Diesel Oil	0.29	0.11	0.57	0.40	0.86	1.43	65.9%	*0.0%*	*65.9%*
Fuel Oil	0.17	0.00	0.33	0.16	0.55	0.68	23.6%	*0.0%*	*23.6%*
Natural gas (*)	***-0.23***	***-0.41***	***0.24***	***0.07***	***0.15***	***0.24***	***63.1%***	***59.8%***	***3.4%***
Electricity (*)	***-1.17***	***-1.35***	***0.17***	***0.00***	***0.03***	***0.09***	***162.9%***	***177.1%***	***-14.2%***
Wood	0.00	-0.17	0.50	0.33	0.15	0.31	100.2%	*0.0%*	*100.2%*

(*) Goods with fiscal subsidies

Figure A.1: Tax wedge margins. Non Ramsey Tax Reform vs. Status quo

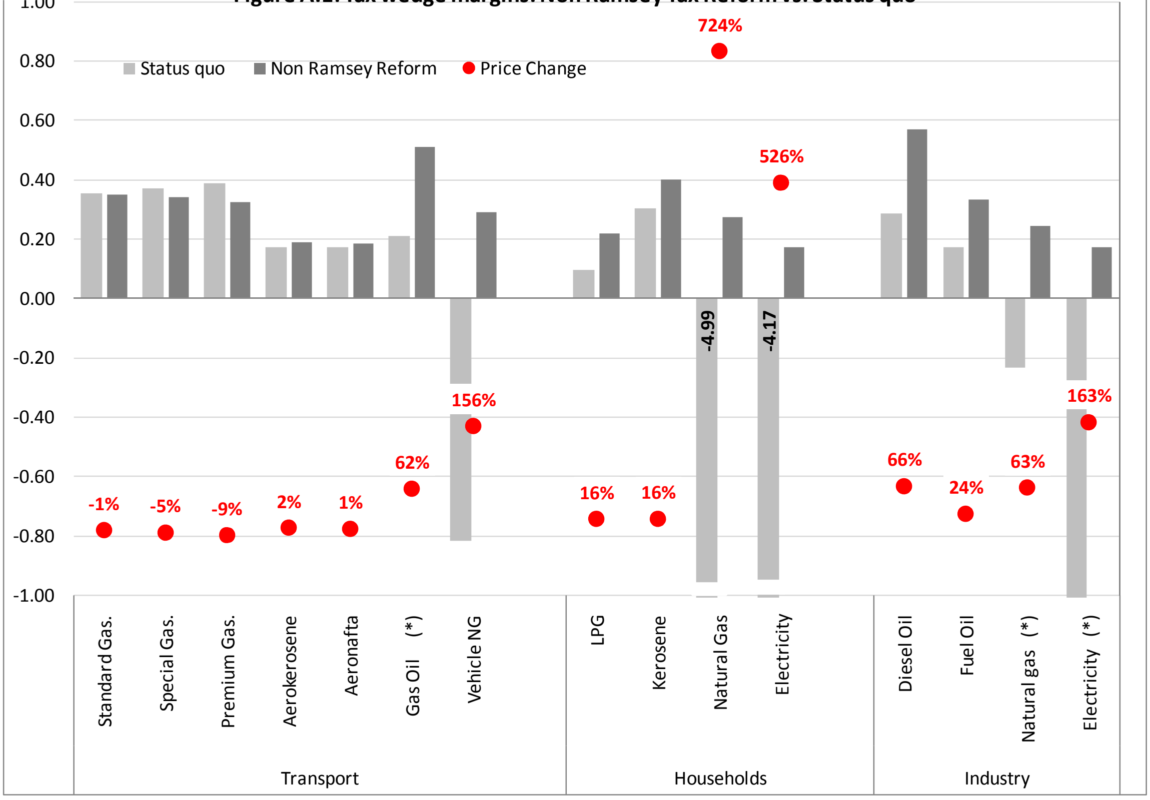


Table A.3 shows the estimate of model case II with Ramsey excises and with Ramsey taxes with political constrains. Two main observations are in order. First, as usual, the interactions of price elasticities imply changes in normative tax-wedge margins and, through the effect in prices. Looking at column D it can be seen that taxes are higher for Gas Oil and Natural Gas related products. They are also higher for LPG, Kerosene and in particular for electricity, despite the fact that electricity does not have direct environmental effects, reflecting the effects of introducing price elasticities associated with Ramsey taxes. The second observation is the interpretation of results in the case of Ramsey taxes with political constraints. As political constraints are equivalent to the acceptance of subsidies and the undoing of the re-pricing towards reference producer prices, we obtain large negative tax changes (from the situation of re-priced products), which are simply a consequence that subsidies are back in some way. Also in correspondence with a reform in a politically constrained scenario, gasoline taxes are higher instead of lower.

Table A3

Argentina: Model-Case II, Ramsey Excises

products	(A) Reference % Tax Wedge	*Ramsey Excises* (B) Normative % Tax Wedge	(C) Consumer prices after reform	(D) % Price Change (1) Total	(2) Due to Energy Prices Correction	(3) Due to Tax Reform	*Ramsey Excises with Political Constraints* (E) Normative % Tax Wedge	(F) Consumer prices after reform	(G) % Price Change (1) Total	(2) Due to Energy Prices Correction	(3) Due to Tax Reform
Transport											
Standard Gasoline (92 RON)	0.36	0.35	1.11	-1%	0%	-1%	0.49	1.43	27%	0%	27%
Special Gasoline (92-95 RON)	0.37	0.36	1.16	-2%	0%	-2%	0.50	1.48	26%	0%	26%
Premium Gasoline (97 RON)	0.39	0.37	1.32	-3%	0%	-3%	0.50	1.67	22%	0%	22%
Aerokerosene (Jet Fuel)	0.17	0.24	1.19	8%	0%	8%	0.19	1.12	2%	0%	2%
Aeronafta (propeller)	0.17	0.23	1.94	8%	0%	8%	0.18	1.82	1%	0%	1%
Gas Oil (*)	0.21	0.54	1.87	72%	14%	58%	0.53	1.84	69%	14%	55%
Vehicle NG (GNC) (*)	-0.82	0.33	0.28	172%	131%	41%	-0.56	0.12	17%	131%	-115%
Households											
LPG	0.10	0.35	0.67	39%	0%	39%	0.14	0.51	6%	0%	6%
Kerosene	0.30	0.50	1.56	39%	0%	39%	0.50	1.55	38%	0%	38%
Natural gas (residential and commercial) (*)	-4.99	0.40	0.31	891%	625%	266%	-4.27	0.04	14%	625%	-611%
Electricity (residential and commercial) (*)	-4.17	0.31	0.09	652%	536%	116%	-4.17	0.01	0%	536%	-536%
Wood	0.00	0.82	1.01	450%	0%	450%	0.74	0.69	278%	0%	278%
Industry											
Diesel Oil	0.29	0.60	1.52	76%	0%	76%	0.63	1.66	92%	0%	92%
Fuel Oil	0.17	0.37	0.72	31%	0%	31%	0.33	0.68	24%	0%	24%
Natural gas (*)	-0.23	0.29	0.26	74%	60%	14%	-0.13	0.16	9%	60%	-51%
Electricity (*)	-1.17	0.22	0.10	180%	177%	3%	-1.17	0.03	0%	177%	-177%
Wood	0.00	0.53	0.32	113%	0%	113%	0.40	0.25	65%	0%	65%

(*) Goods with fiscal subsidies

Table A.4 tests the robustness of the direction of reform under sensitivity changes to environmental costs and price elasticities. Values computed in Table A4 are to be compared with an assumed marginal cost of public funds from indirect taxation estimated at $\lambda=1.185$. To avoid mixing the effects of distorted prices we have performed theses evaluations looking at "observed" (instead of corrected) tax margins.[34] We find that directions of tax reform are robust enough to parameter sensitivity. In particular, introducing global environmental costs does not change the prescribed directions of change. Nor different values of demand-price elasticities seem relevant for changing the directions of reform, except with some minor qualifications.

Table A4

Argentina: ERT Reform, Marginal Cost of Public Funds (MCPF)

products	Observed % Tax Wedge *(q-p)/q*	MCPF, Case I (environmental costs)		MCPF, Case II (price elasticities)			MCPF, Case II (environmental costs)	
		Local	Local and Global	Low	Expected	High	Local	Local and Global
Transport								
Standard Gasoline (92 RON)	0.36	1.22	1.20	1.16	1.22	1.30	1.22	1.20
Special Gasoline (92-95 RON)	0.37	1.27	1.25	1.16	1.23	1.32	1.23	1.21
Premium Gasoline (97 RON)	0.39	1.33	1.31	1.15	1.23	1.33	1.23	1.22
Aerokerosene (Jet Fuel)	0.17	1.19	1.17	1.10	1.14	1.19	1.14	1.12
Aeronafta (propeller)	0.17	1.19	1.17	1.10	1.14	1.19	1.14	1.13
Gas Oil (*)	0.33	0.61	0.59	0.82	0.73	0.61	0.73	0.71
Vehicle NG (GNC) (*)	0.27	0.97	0.90	0.99	0.98	0.97	0.98	0.93
Households								
LPG	0.10	1.07	1.03	1.01	1.04	1.05	1.04	1.02
Kerosene	0.30	1.01	0.99	1.00	1.01	1.01	1.01	1.00
Natural gas (residential and commercial	0.17	0.71	0.15	0.94	0.85	0.78	0.85	0.56
Electricity (residential and commercial)	0.26	1.30	1.30	1.05	1.15	1.22	1.15	1.15
Wood	0.00	-1.94	-1.97	0.35	-0.63	-1.29	-0.63	-0.65
Industry								
Diesel Oil	0.29	0.43	0.40	0.73	0.59	0.43	0.59	0.57
Fuel Oil	0.17	0.97	0.94	0.98	0.98	0.97	0.98	0.95
Natural gas (*)	0.26	1.27	1.15	1.13	1.20	1.27	1.20	1.11
Electricity (*)	0.29	1.35	1.35	1.17	1.26	1.35	1.26	1.26
Wood	0.00	0.34	0.30	0.63	0.48	0.34	0.48	0.46

Note: Colors indicate taxes should face: Large reductions (blue); Small reductions (green); Increases (yellow); Large increaes (orange)

Table A5 complements the measurement with an estimation of the revenue impact of the reform of energy taxes towards ERT. The difference with the Uruguayan case is that we now include an estimate of subsidies in the status-quo. Subsidies are fiscal transfers computed as the gap between corrected producer prices (either imported prices for Gas Oil and Natural Gas or costs of production for electricity) and the prices paid by consumers, multiplied by the corresponding quantities involved (imported amounts in the case of Gas Oil and Natural Gas or total amounts in the case of electricity).

[34] To do otherwise would imply suggesting the need of large tax increases to correct for negative tax wedges, when the reason behind is not low taxes but rather distorted producer prices. For example in the case of electricity it would suggests large tax increases when the direction of tax reform recommends a different change.

Table A5
Argentina: Impact of ERT Reform on Tax Revenues

Data for 2010 in millions of US dollars

products	*Status-quo 2010*				Case I *Non-Ramsey excises*			
	Fiscal Revenues (1)	*of which: Excises*	Subsidy (2)	Net balance (1) - (2)	Fiscal Revenues (1)	*of which: Excises*	Subsidy (2)	Net balance (1) - (2)
Transport	**6881**	*3900*	**1642**	**5238**	**11661**	*8492*	**0**	**11661**
Standard Gasoline (92 RON)	111.6	*69.3*	0.0	111.6	109.8	*67.1*	0.0	109.8
Special Gasoline (92-95 RON)	1985.6	*1254.1*	0.0	1985.6	1794.3	*1034.4*	0.0	1794.3
Premium Gasoline (97 RON)	652.8	*431.4*	0.0	652.8	528.5	*291.6*	0.0	528.5
Aerokerosene (Jet Fuel)	306.7	*0.0*	0.0	306.7	335.9	*33.2*	0.0	335.9
Aeronafta (propeller)	3.3	*0.0*	0.0	3.3	3.5	*0.2*	0.0	3.5
Gas Oil (*)	***3747.5***	***2113.6***	***1598.1***	***2149.5***	***8784.5***	***7014.6***	***0.0***	***8784.5***
Vehicle NG (GNC) (*)	***73.1***	***31.6***	***44.2***	***28.9***	***104.3***	***50.9***	***0.0***	***104.3***
Households	**281**	*24*	**2849**	**-2568**	**663**	*160*	**0**	**663**
LPG	48.9	*-48.9*	0.0	48.9	120.1	*29.3*	0.0	120.1
Kerosene	19.5	*10.1*	0.0	19.5	27.5	*18.9*	0.0	27.5
Natural gas (residential and commercial) (*)	***55.8***	***0.0***	***320.7***	***-264.9***	***252.2***	***111.4***	***0.0***	***252.2***
Electricity (residential and commercial) (*)	***157.1***	***62.8***	***2528.3***	***-2371.2***	***263.1***	***0.0***	***0.0***	***263.1***
Industry	**1010**	*354*	**1433**	**-423**	**1202**	*428*	**0**	**1202**
Diesel Oil	9.9	*4.7*	0.0	9.9	22.9	*19.2*	0.0	22.9
Fuel Oil	199.4	*0.0*	0.0	199.4	405.4	*233.5*	0.0	405.4
Natural gas (*)	***466.5***	***186.6***	***84.4***	***382.1***	***506.7***	***175.5***	***0.0***	***506.7***
Electricity (*)	***334.4***	***163.1***	***1348.8***	***-1014.4***	***266.7***	***0.0***	***0.0***	***266.7***
TOTAL	**8172**	*4279*	**5924**	**2247**	**13525**	*9080*	**0**	**13525**

products	Case II *Ramsey excises*				*Ramsey excises with political constraints*			
	Fiscal Revenues (1)	*of which: Excises*	Subsidy (2)	Net balance (1) - (2)	Fiscal Revenues (1)	*of which: Excises*	Subsidy (2)	Net balance (1) - (2)
Transport	**12643**	*9591*	**0**	**12643**	**13370**	*10422*	**17**	**13353**
Standard Gasoline (92 RON)	109.8	*67.1*	0.0	109.8	158.7	*124.6*	0.0	158.7
Special Gasoline (92-95 RON)	1901.6	*1157.8*	0.0	1901.6	2838.8	*2229.3*	0.0	2838.8
Premium Gasoline (97 RON)	608.2	*381.3*	0.0	608.2	900.8	*708.5*	0.0	900.8
Aerokerosene (Jet Fuel)	430.3	*140.5*	0.0	430.3	335.9	*33.2*	0.0	335.9
Aeronafta (propeller)	4.5	*1.4*	0.0	4.5	3.5	*0.2*	0.0	3.5
Gas Oil (*)	***9467.1***	***7772.3***	***0.0***	***9467.1***	***9290.7***	***7576.8***	***0.0***	***9290.7***
Vehicle NG (GNC) (*)	***121.9***	***70.7***	***0.0***	***121.9***	***-158.3***	***-251.1***	***17.4***	***-175.7***
Households	**1168**	*709*	**0**	**1168**	**-3878**	*-5018*	**2743**	**-6621**
LPG	211.4	*128.5*	0.0	211.4	75.5	*-19.6*	0.0	75.5
Kerosene	37.8	*29.9*	0.0	37.8	37.2	*29.2*	0.0	37.2
Natural gas (residential and commercial) (*)	***399.9***	***271.5***	***0.0***	***399.9***	***-1462.1***	***-1841.1***	***214.7***	***-1676.8***
Electricity (residential and commercial) (*)	***519.2***	***279.2***	***0.0***	***519.2***	***-2528.3***	***-3186.5***	***2528.3***	***-5056.7***
Industry	**1449**	*709*	**0**	**1449**	**-1158**	*-2297*	**1385**	**-2543**
Diesel Oil	24.4	*20.9*	0.0	24.4	26.3	*23.1*	0.0	26.3
Fuel Oil	463.0	*298.4*	0.0	463.0	405.4	*233.5*	0.0	405.4
Natural gas (*)	***612.6***	***295.4***	***0.0***	***612.6***	***-241.2***	***-679.9***	***36.0***	***-277.2***
Electricity (*)	***349.4***	***93.9***	***0.0***	***349.4***	***-1348.8***	***-1873.5***	***1348.8***	***-2697.6***
TOTAL	**15261**	*11009*	**0**	**15261**	**8334**	*3107*	**4145**	**4189**

Table A.5 shows that subsidies in our exercise (which is a mixed exercise of 2011 prices with 2010 quantities, and only for some products or segments among them) was more than 5.9 billion dollars (close to 1% of GDP). This is a very large amount if it is compared either with excises (is 37% larger that the amount collected through excises on all goods) or even with total fiscal revenues (that also include VAT). Argentina has a structure of uniform (VAT) taxes, non uniform excises and implicit (in price distortions) subsidies that collects in our exercise 2.5 billion dollars.[35] Looking at the Non-Ramsey excises case, the combination of re-pricing and tax rebalancing due to the reorientation towards ERT will produce a large increase of fiscal revenues of more than 11 billion dollars, or more than 1.8% of GDP. This is shared in similar parts by the elimination of subsidies and the collection of excises. Total fiscal revenues increase in more than 5 billion dollars, or more than 60%. As expected, Ramsey taxes have an additional impact on revenues, while Ramsey taxes with political constraints will only reduce subsidies partially, but nevertheless have a visible impact on revenues. Again, we do not consider the theoretical revenue collected on biomass as assume that taxes will not be collected.

Moving into environmental cost, Table A6 shows the changes in levels associated with the reforms.

Table A6
Argentina: Estimated Environmental costs before and after Reform
in million dollars

products	*Status Quo*		*Case I*		*Case II*			
			Non-Ramsey Excises		Ramsey Excises		Ramsey with Political Constraints	
	Local	*Total*	*Local*	*Total*	*Local*	*Total*	*Local*	*Total*
Transport	**10759**	**11214**	**8087**	**8463**	**7768**	**8130**	**7646**	**7994**
Standard Gasoline (92 RON)	58.9	65.2	59.4	65.8	59.4	65.8	47.4	52.5
Special Gasoline (92-95 RON)	953.8	1056.6	990.8	1097.7	970.0	1074.5	794.8	880.5
Premium Gasoline (97 RON)	252.2	279.4	269.9	299.1	258.5	286.4	219.0	242.6
Aerokerosene (Jet Fuel)	0.0	33.0	0.0	32.6	0.0	31.2	0.0	32.6
Aeronafta (propeller)	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.2
Gas Oil (*)	*9414.8*	*9683.5*	*6725.8*	*6917.8*	*6440.7*	*6624.5*	*6513.6*	*6699.5*
Vehicle NG (GNC) (*)	*79.6*	*96.3*	*41.2*	*49.8*	*39.5*	*47.7*	*71.5*	*86.5*
Households	**263**	**455**	**168**	**247**	**161**	**233**	**251**	**431**
LPG	11.6	30.8	10.7	28.7	9.8	26.1	11.2	30.0
Kerosene	18.8	19.9	17.4	18.5	15.9	16.9	16.0	17.0
Natural gas (residential and commercial) (*)	*143.4*	*313.3*	*49.9*	*109.1*	*45.6*	*99.5*	*134.5*	*293.8*
Electricity (residential and commercial) (*)	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Wood	89.8	90.6	89.8	90.6	89.8	90.6	89.8	90.6
Industry	**319**	**551**	**266**	**436**	**256**	**418**	**275**	**490**
Diesel Oil	26.1	26.9	18.3	18.8	17.5	18.0	16.5	17.0
Fuel Oil	231.5	265.2	199.6	228.7	191.2	219.0	199.6	228.7
Natural gas (*)	*46.0*	*242.1*	*32.7*	*171.9*	*31.3*	*164.6*	*43.3*	*227.7*
Electricity (*)	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Wood	15.8	16.6	15.8	16.6	15.8	16.6	15.8	16.6
TOTAL	**11342**	**12220**	**8521**	**9146**	**8185**	**8782**	**8173**	**8916**

[35] This is rather impressive for comparative purposes, as it only doubles the status-quo fiscal revenues of Uruguay, while Argentina has a GDP in dollars about 15 times that of Uruguay. The results of the reform exercises we perform are a mirror of this under-performance of energy tax revenues in Argentina.

In the case of Argentina, the reforms have a large environmental gain –of more than 3 billion dollars- that is mainly due to reduced quantities in Gas Oil responding to higher prices. As the changes in final prices in the case of Gas Oil are also mainly due to tax changes (see Tables A.2 and A.3) we can estimate that at least 2 out of the 3 plus billions of dollars of environmental gains are due to tax reform with the remaining due to price reform. The largest effects due to re-pricing are located in Natural Gas and Electricity, that –despite large changes in quantities- have a low (or nil) impact on environmental costs.

Turning into the assessment of the distributional impact of tax reforms, we show in Figure A2 the share of energy goods in total expenditures by decile, so as to give a first impression of their likely impact of price changes due to tax changes. In contrast with the Uruguayan case (see Figure U2) where some goods (gasoloine and Gas Oil) show expenditure share that are increasing across deciles, in the case of Argentina shares are decreasing, implying that price changes are going to be on average more regressive than in the case of Uruguay. In particular, public transport (that we include in our evaluation due to the impact of reform in the price of Gas Oil) not only has a large expenditure share but it is also steeply decreasing across deciles. Gasoline and electricity also show important magnitudes.

Figure A.2
Argentina: Decile Distribution of Expenditures of Energy as a percentage of Household Consumption Expenditure

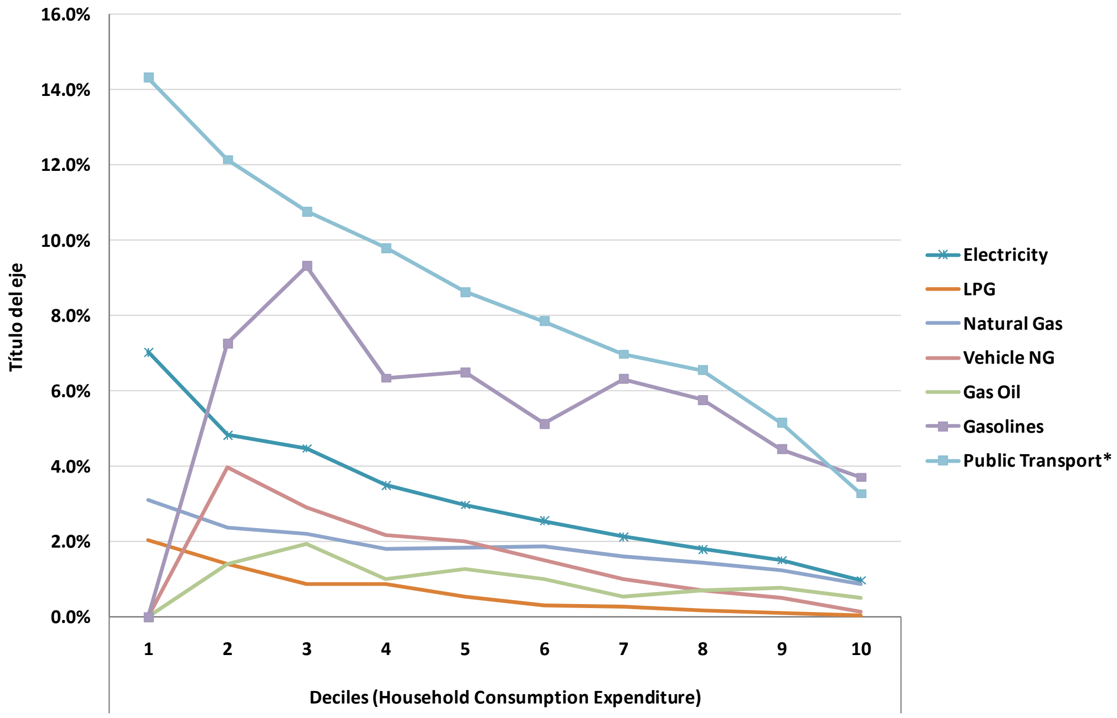


Figure A3 shows the distribution of environmental costs per household as a percentage of household expenditures across deciles, assuming that costs are distributed uniformly across households. Potential benefits of reductions in environmental costs (i.e. potential environmental gains) are particularly large for low income households in the case of gasoline and Gas Oil.

Figure A.3
Argentina: Decile distribution of environmental costs as a percentage of household consumption expenditures

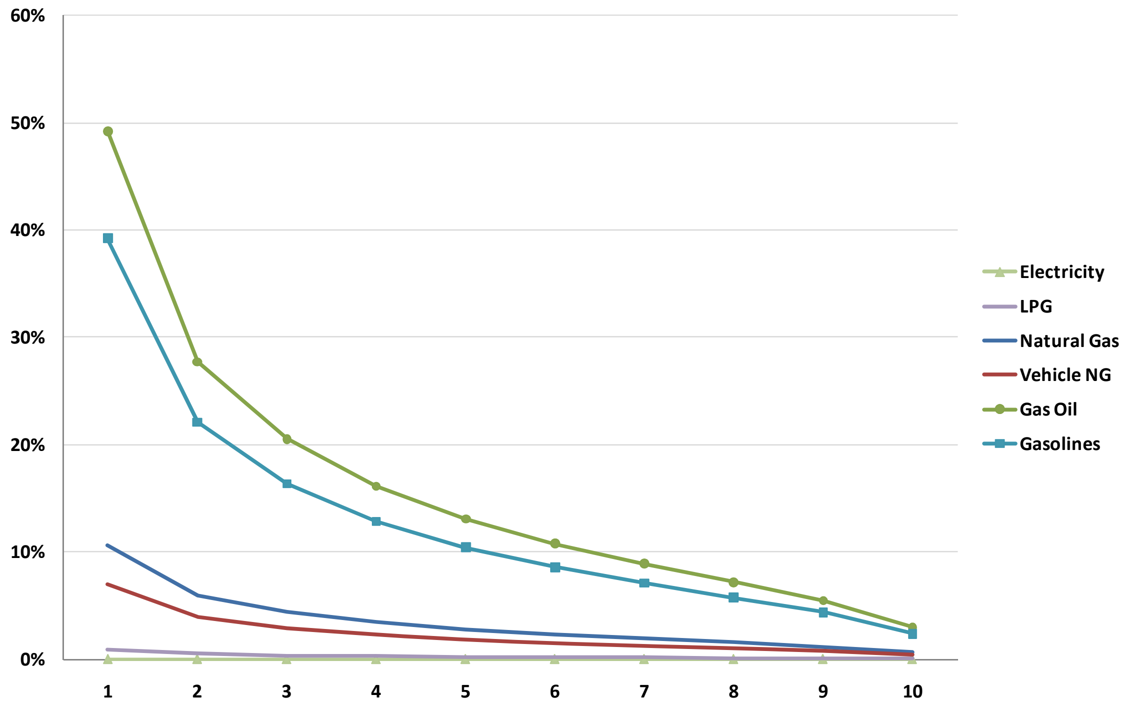


Table A.7 summarizes the estimation of expression (10) of section 3.1.4 to approximate the distributional impact of the tax reforms. It decomposes total net gains in effects of price impacts due to taxes and due to environmental gains (explained by prices changes only due to tax changes), across deciles, for all reforms (Non-Ramsey, see Table A2; Ramsey and Ramsey with political constraints, see Table A3).

Table A.7 shows very large impact effects of tax reform for the Argentine case. Non Ramsey excises on energy products that turn into environmental objectives give rise to a total net gain equivalent to 22% of household expenditure. But this is a product of very large price effects and environmental benefits that work in opposite directions. Price changes due to taxes generate large impact losses as a percentage of household expenditure (-34%). On the other hand, large environmental gains as a percentage of household expenditure (56%) more compensate the previous losses. Losses and Gains are concentrated the poorest households, indicating the reform is a progressive one only if environmental gains are actually perceived by households. Rather, impact effects of price changes due to tax reform show a clear regressive pattern. Figure A2 shows the distribution of price impacts and environmental gains across deciles for this reform.

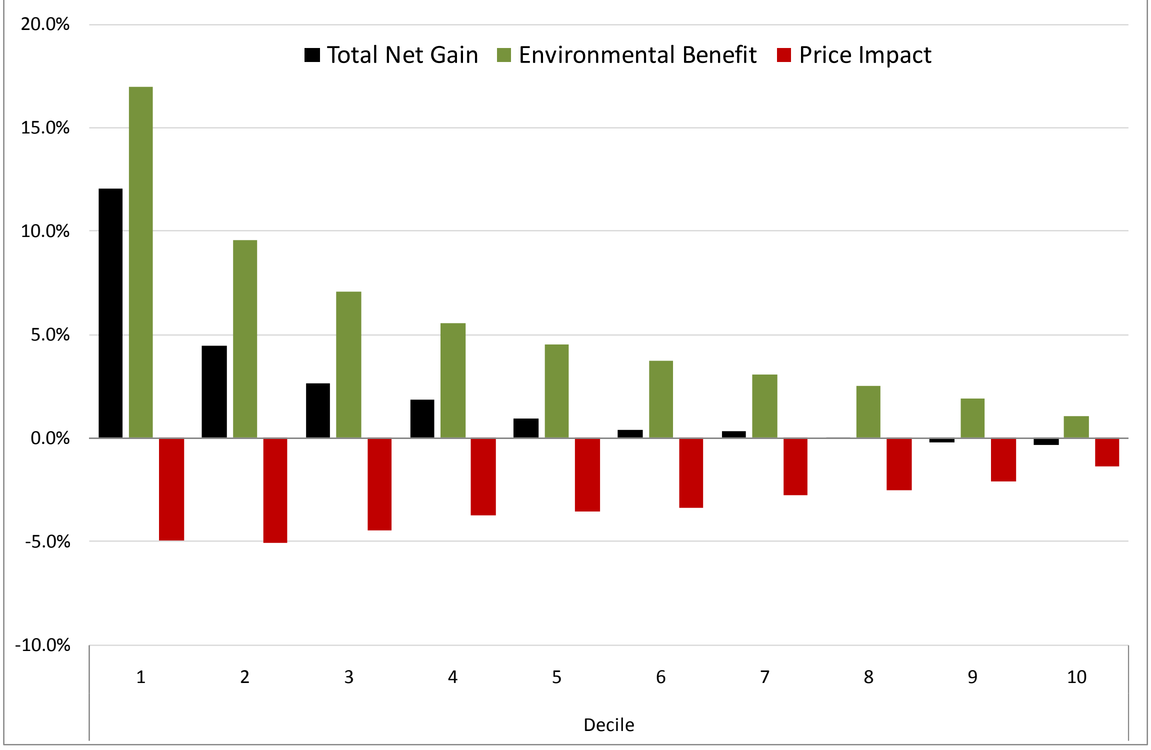
Table A7
Argentina: Distributional impact of tax reforms, by deciles

	Decile 1	2	3	4	5
Case I: Non Ramsey Excises					
Total Net Gain	**12.0%**	**4.5%**	**2.6%**	**1.8%**	**0.9%**
Environmental Benefit	17.0%	9.6%	7.1%	5.6%	4.5%
Price Impact	-4.9%	-5.1%	-4.4%	-3.7%	-3.6%
Case II: Ramsey Excises					
Total Net Gain	**9.5%**	**-0.1%**	**-2.7%**	**-2.5%**	**-3.4%**
Environmental Benefit	29.5%	16.6%	12.3%	9.7%	7.8%
Price Impact	-20.0%	-16.7%	-15.0%	-12.2%	-11.3%
Case II: Ramsey Excises with Political Constraints					
Total Net Gain	**36.1%**	**31.6%**	**30.0%**	**23.9%**	**22.3%**
Environmental Benefit	-17.8%	-10.0%	-7.4%	-5.8%	-4.7%
Price Impact	53.9%	41.6%	37.5%	29.7%	27.0%

	Decile 6	7	8	9	10	Total
Case I: Non Ramsey Excises						
Total Net Gain	**0.4%**	**0.3%**	**0.0%**	**-0.2%**	**-0.3%**	**22.0%**
Environmental Benefit	3.7%	3.1%	2.5%	1.9%	1.0%	55.9%
Price Impact	-3.3%	-2.8%	-2.5%	-2.1%	-1.3%	-33.8%
Case II: Ramsey Excises						
Total Net Gain	**-3.9%**	**-3.4%**	**-3.4%**	**-3.2%**	**-2.4%**	**-15.5%**
Environmental Benefit	6.5%	5.3%	4.3%	3.3%	1.8%	97.1%
Price Impact	-10.4%	-8.7%	-7.7%	-6.5%	-4.2%	-112.6%
Case II: Ramsey Excises with Political Constraints						
Total Net Gain	**20.8%**	**17.2%**	**14.8%**	**12.8%**	**8.6%**	**218.0%**
Environmental Benefit	-3.9%	-3.2%	-2.6%	-2.0%	-1.1%	-58.6%
Price Impact	24.7%	20.4%	17.4%	14.8%	9.6%	276.6%

The large magnitude of the effects computed above is not a generalized phenomenon, but rather the consequence of a few goods that face large tax chances and suggests that additional mechanisms to soften the distributional burden of tax increases (like lump sum rebates to low income families) should be a necessary ingredient of a tax reform towards environmental taxes. However, much of what we see in the Argentine case is due to the fact that under-pricing of critical energy goods implies that (leaving aside re-pricing of producer prices) incorporating environmental costs into tax structures will easily lead to large price increases. For instance, more than 93% of the price impact effect is due to Natural Gas and Public Transport and almost all the environmental gains impact is due to Gas-Oil and Natural gas. In the case of Natural Gas the reason is that the introduction of some environmental costs in very low current prices gives rise to an increase in taxes close to 100%.[36] In the case of Gas-Oil the increase in prices after tax corrections has not so much a direct effect on prices but rather an indirect one through Public Transport. Also, as explained in the discussion of Table A6, Gas-Oil is the main driver behind environmental gains.

Figure A.4 - Non Ramsey Excises: Net Impact of Tax Reform (NIT) decomposition, by deciles



As shown in Table A3, Ramsey taxes exploit efficiency effects and, in addition to environmental costs, accommodate tax wedge margins in an inverse-elasticity fashion, giving rise to larger tax and price changes or new tax and price changes (as in the case of electricity). The results are larger losses due to price changes that cannot be even compensated by environmental gains, leading to aggregate net losses. Results from a Ramsey tax reform with political constrains, as commented before, needs some explanation for the case of Argentina, as it is an exercise where taxes and end-user

[36] Electricity, which starts from also a visible under-pricing, and faces large increases in prices due to re-pricing of producer prices does not share the property of Natural Gas. Rather, electricity faces lower taxes and therefore the tax reform, per se, has a positive and progressive price effect on households. Also, electricity does not participate in environmental gains as it has no environmental costs.

prices "re-adjust" after producer prices have been adjusted upwards. This makes explicit tax reductions or subsidies, as shown in Table A3. In the evaluation of distributive effects of tax reform, since this an isolated change from a new status quo of non-subsidized energy prices, it means that taxes overshoot to give rise to reductions in prices and positive price impacts along with negative environmental effects.

3.2.4. Bolivia

Table B.1 shows the basic modeling data for the case of Bolivia.

Table B1
Bolivia: Basic data and estimates for ERT analysis
Data for June 2011

products	Units	(A) Consumer prices q	(B) Consumer prices w/o taxes p	(C) Producer prices c	% Tax Wedge		Non-Uniform Component Zi		Environmental Damage K	
					(D) Observed (q-p)/q	(E) Reference (q-c)/q	(F) Observed	(G) Reference	(H.1) Local	(H.2) Local + Global
Transport										
Special Gasoline (*)	***USD/l***	***0.54***	***0.31***	***0.64***	***0.42***	***-0.19***	***0.31***	***-0.30***	***0.08***	***0.11***
Premium Gasoline (*)	***USD/l***	***0.69***	***0.32***	***0.73***	***0.53***	***-0.07***	***0.42***	***-0.18***	***0.08***	***0.10***
AV Gas (*)	***USD/l***	***0.66***	***0.34***	***1.17***	***0.49***	***-0.79***	***0.37***	***-0.90***	***0.00***	***0.02***
Jet Fuel (*)	***USD/l***	***0.40***	***0.30***	***0.71***	***0.24***	***-0.79***	***0.12***	***-0.90***	***0.00***	***0.02***
Diesel Oil (*)	***USD/l***	***0.53***	***0.31***	***0.63***	***0.43***	***-0.18***	***0.31***	***-0.30***	***0.34***	***0.36***
Vehicular NG	USD/m3	0.16	0.14	0.14	0.12	0.12	0.00	0.00	0.03	0.05
Households										
LPG (*)	**USD/kg**	**0.32**	**0.28**	**0.72**	**0.14**	**-1.23**	**0.02**	**-1.35**	**0.01**	**0.03**
Kerosene	USD/l	0.39	0.30	0.30	0.23	0.23	0.11	0.11	0.02	0.04
Natural Gas - Households	USD/m3	0.04	0.04	0.04	0.12	0.12	0.00	0.00	0.00	0.02
Electricity - Households	USD/KWh	0.04	0.04	0.04	0.12	0.12	0.00	0.00	0.00	0.00
Wood - Households	USD/kg	0.03	0.03	0.03	0.00	0.00	-0.12	-0.12	0.17	0.17
Industry										
Natural Gas - Industry	USD/m3	0.06	0.05	0.05	0.12	0.12	0.00	0.00	0.00	0.02
Electricity - Industry	USD/KWh	0.06	0.05	0.05	0.12	0.12	0.00	0.00	0.00	0.00
Wood - Industry	USD/kg	0.02	0.02	0.02	0.00	0.00	-0.12	-0.12	0.17	0.17
"Aggregate Good (Xo) (benchmark)					**0.12**					

(*) Goods with fiscal subsidies

Bolivia is another case, like Argentina, where price distortions are associated with very large fiscal subsidies. As they are mainly located in the transport sector, we have proceeded to include producer prices estimated from import parity values and from the share of imports in total consumption.[37] The effect of price distortions on the percentage tax wedge margins is shown in Table B1 above for the shaded rows of goods that have fiscal subsidies. It implies negative tax wedges for all goods in the transport sector (except natural gas, where we have not introduced adjustments) and LPG. Correspondingly, and according our modeling framework of section 3.1.1, there

[37] Producer prices are average prices formed by import parities and domestic prices weighted by the respective shares in total demand. Import parities are consistent with unitary import values estimated from trade statistics. Thus, reference producer prices reflect what the economy is paying for the goods to producer. They are also consistent with unitary fiscal subsidies estimates, as these come from the difference between reference producer prices and what the demand (i.e. consumers) is paying.

are negative non uniform percentage tax wedge components (Z_i) for all these goods which will face a change after reform. Again, a great part of this change will be due to re-pricing energy goods as we shall see below.

Other goods with negative tax wedges are biomass for households and industry, as in the previous cases of Uruguay and Argentina. At the end of this section we will add some insights and data on the problem of controlling environmental damage from biomass use in Bolivia and the implication for taxes when markets are informal. Electricity and natural gas do not face excises and the Z_i component is zero. Finally, environmental damages are transferred from our calculations in Annex C in a similar fashion to the previous cases. Again, the largest costs are associated with Gas-Oil for transport, followed by biomass and gasoline. Global environmental costs estimates complete the costing of the estimated damages.

Table B2 shows the results of the Non-Ramsey tax reform.

Table B2

Bolivia: Model-Case I, Non Ramsey Excises

	Case I: Positive Approach		*Case I: Normative Approach*						
							(G) % Price Change		
products	(A) Reference % Tax Wedge	(B) Becker's Numbers Zi	(C) Normative % Tax Wedge	(D) Sandmo's Numbers Zi	(E) Consumer prices before reform	(F) Consumer prices after reform	(1) Total	(2) Due to Energy Prices Correction	(3) Due to Tax Reform
Transport									
Special Gasoline (*)	***-0.19***	***-0.30***	***0.23***	***0.12***	***0.54***	***0.83***	***54.4%***	***68.9%***	***-14.5%***
Premium Gasoline (*)	***-0.07***	***-0.18***	***0.21***	***0.10***	***0.69***	***0.93***	***35.7%***	***67.6%***	***-31.8%***
AV Gas (*)	***-0.79***	***-0.90***	***0.13***	***0.02***	***0.66***	***1.35***	***105.5%***	***144.0%***	***-38.5%***
Jet Fuel (*)	***-0.79***	***-0.90***	***0.14***	***0.02***	***0.40***	***0.82***	***107.2%***	***115.8%***	***-8.6%***
Diesel Oil (*)	***-0.18***	***-0.30***	***0.42***	***0.30***	***0.53***	***1.08***	***102.1%***	***68.7%***	***33.5%***
Vehicular NG	*0.12*	0.00	0.32	0.21	0.16	0.21	31.0%	*0.0%*	*31.0%*
Households									
LPG (*)	***-1.23***	***-1.35***	***0.14***	***0.03***	***0.32***	***0.84***	***160.2%***	***155.0%***	***5.3%***
Kerosene	*0.23*	0.11	0.21	0.10	0.39	0.38	-2.0%	*0.0%*	*-2.0%*
Natural Gas - Households	*0.12*	0.00	0.35	0.23	0.04	0.06	36.1%	*0.0%*	*36.1%*
Electricity - Households	*0.12*	0.00	0.12	0.00	0.04	0.04	0.0%	*0.0%*	*0.0%*
Wood - Households	*0.00*	-0.12	0.86	0.74	0.03	0.21	601.1%	*0.0%*	*601.1%*
Industry									
Natural Gas - Industry	***0.12***	0.00	0.29	0.18	0.06	0.08	25.5%	*0.0%*	*25.5%*
Electricity - Industry	***0.12***	0.00	0.12	0.00	0.06	0.06	0.0%	*0.0%*	*0.0%*
Wood - Industry	***0.00***	-0.12	0.90	0.78	0.02	0.20	895.1%	*0.0%*	*895.1%*

(*) Goods with fiscal subsidies

The first two columns show the reference tax wedge and the so-called Becker's numbers for Bolivia. This numbers, which are negative for goods receiving subsidies, are replaced in the reform by the so-called Sandmo's numbers (column D) leading to normative tax wedges (column C) that imply a new set of end-user prices (column F) that replace existing ones (column E). The changes in prices can be decomposed in changes due to a re-pricing towards reference producer prices (which will be positive for distorted prices and zero for the rest) and changes due to tax reform. Apart from biomass, which show as before large normative changes due to a non-taxed status quo (that remains so in our computing of effects below) the largest increases in taxes are in Diesel Oil (the same product as Gas-Oil in Uruguay and Argentina) and in products associated with Natural gas (for transport, households and industry). The rest of the energy goods have either small tax increases (LPG) or small to large tax reductions (Kerosene, Jet Fuel and Gasoline) regardless they have or not price increases related to re-pricing of producer prices. Thus the exercise for Bolivia shows once again a rebalancing between gasoline and diesel dictated by their environmental costs per unit and their current observed excise tax burden. Figure B1 shows the grammar of tax wedge margins before and after a Non-Ramsey excise reform and the corresponding changes in end-user prices due to taxes.

Figure B.1: Tax wedge margins. Non Ramsey Tax Reform vs. Status quo

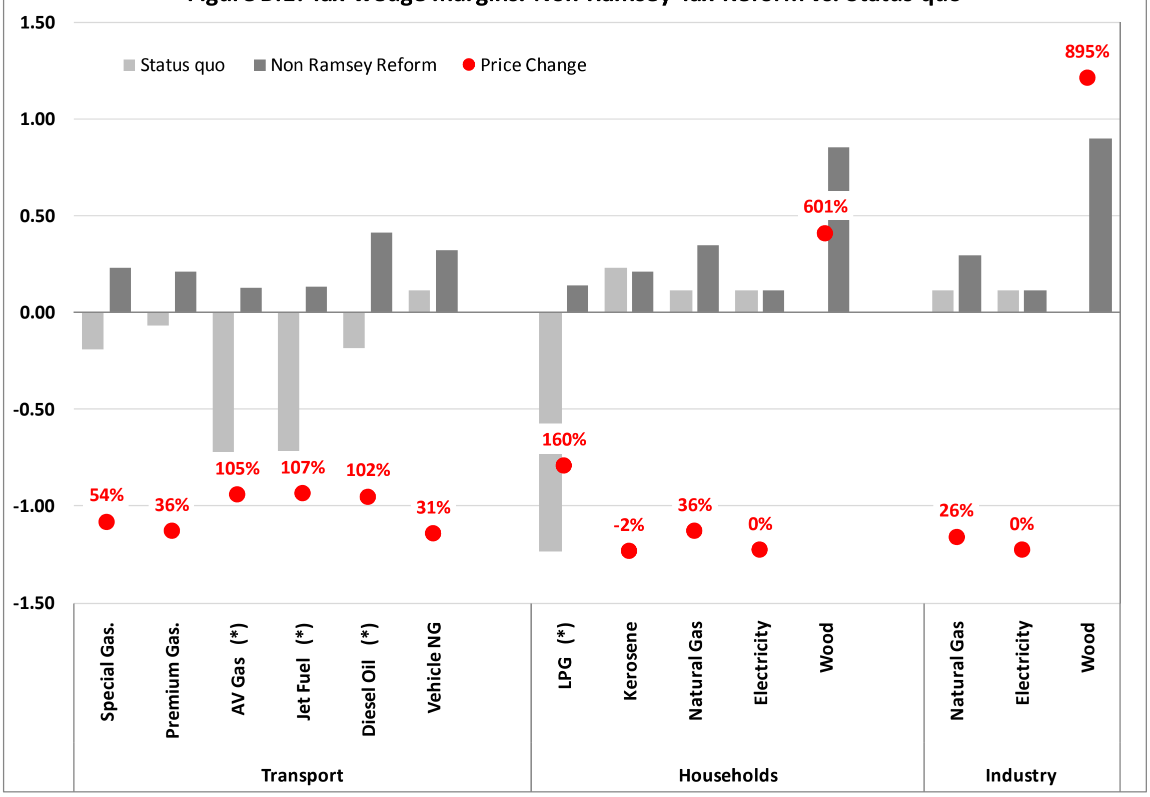


Table B3 refers to the reform towards Ramsey excises. Results are again in the similar fashion as in the previous countries. Including price-elasticity effects change the structure of tax increases and reductions. Tax collection from goods that previously had no excises (electricity) given their zero environmental impact is due to the inverse elasticity rule. Ramsey excises with political constrains also have expected signs and magnitudes.

Table B3

Bolivia: Model-Case II, Ramsey Excises

products	(A) Reference % Tax Wedge	Ramsey Excises					Ramsey Excises with Political Constraints				
		(B) Normative % Tax Wedge	(C) Consumer prices after reform	(D) % Price Change			(E) Normative % Tax Wedge	(F) Consumer prices after reform	(G) % Price Change		
				(1) Total	(2) Due to Energy Prices Correction	(3) Due to Tax Reform			(1) Total	(2) Due to Energy Prices Correction	(3) Due to Tax Reform
Transport											
Special Gasoline (*)	-0.19	0.23	0.83	54%	69%	-15%	0.50	1.27	136%	69%	67%
Premium Gasoline (*)	-0.07	0.23	0.95	38%	68%	-30%	0.58	1.76	156%	68%	88%
AV Gas (*)	-0.79	0.16	1.40	113%	144%	-31%	0.50	2.33	254%	144%	110%
Jet Fuel (*)	-0.79	0.17	0.86	115%	116%	-1%	0.26	0.96	140%	116%	25%
Diesel Oil (*)	-0.18	0.44	1.12	110%	69%	41%	0.62	1.67	213%	69%	144%
Vehicular NG	0.12	0.35	0.22	36%	0%	36%	0.32	0.21	31%	0%	31%
Households											
LPG (*)	-1.23	0.23	0.94	190%	155%	35%	0.16	0.86	167%	155%	12%
Kerosene	0.23	0.30	0.43	9%	0%	9%	0.32	0.44	13%	0%	13%
Natural Gas - Households	0.12	0.42	0.07	52%	0%	52%	0.35	0.06	36%	0%	36%
Electricity - Households	0.12	0.21	0.05	12%	0%	12%	0.12	0.04	0%	0%	0%
Wood - Households	0.00	0.87	0.23	682%	0%	682%	0.84	0.19	520%	0%	520%
Industry											
Natural Gas - Industry	0.12	0.32	0.08	30%	0%	30%	0.29	0.08	26%	0%	26%
Electricity - Industry	0.12	0.15	0.06	4%	0%	4%	0.12	0.06	0%	0%	0%
Wood - Industry	0.00	0.90	0.21	933%	0%	933%	0.89	0.18	781%	0%	781%
(*) Goods with fiscal subsidies											

Table B4 makes the sensitivity analysis of a direction of tax reform exercise under different configurations of parameters. The MCPF parameters estimated in Table B4 represent the welfare costs of an additional dollar raised by tax on good "i" evaluated in the current (satus quo) situation. Estimated parameters are compared among themselves and with reference to the assumed marginal cost of public funds for indirect taxation (on an aggregate good) estimated at 1.115. Values above this figure show that taxes should be reduced to produce a welfare improvement, while the opposite holds for values lower than 1.115. Columns represent the sensitivity of those estimates to environmental costs intervals for the Non-Ramsey model and to price-elasticity and environmental costs intervals for the Ramsey model. For easiness of observation, we have shaded the figures according to the cases where the marginal tax reform direction suggests a large reduction in taxes (in blue) a moderate reduction (in green) an increase (in yellow) and a large increase (in orange). Gasolines and domestic Jet fuel belong to the first group. Very few cases (Kerosene for some cases) belong to the second group. All others goods exhibit a room for increases in taxes. They are mild for the case of LPG, Kerosene and in natural gas and electricity in both households and industry under some parameter configurations. They are rather large for Gas Oil and Vehicular Natural Gas in transport and of course for biomass. The main result is that directions of tax reform are robust enough to parameter sensitivity.

Table B4

Bolivia: ERT Reform, Marginal Cost of Public Funds (MCPF)

products	(C) Observed % Tax Wedge *(q-c)/q*	MCPF, Case I (environmental costs)		MCPF, Case II (price elasticities)			MCPF, Case II (environmental costs)	
		Local	Local and Global	Low	Expected	High	Local	Local and Global
Transport								
Special Gasoline (*)	0.42	1.38	1.32	1.26	1.38	1.54	1.38	1.32
Premium Gasoline (*)	0.53	1.71	1.66	1.36	1.57	1.88	1.57	1.53
AV Gas (*)	0.49	1.78	1.72	1.32	1.52	1.78	1.52	1.48
Jet Fuel (*)	0.24	1.27	1.21	1.13	1.20	1.27	1.20	1.16
Diesel Oil (*)	0.43	0.69	0.63	0.86	0.79	0.69	0.79	0.75
Vehicular NG	0.12	0.91	0.81	0.95	0.93	0.91	0.93	0.85
Households								
LPG (*)	0.14	1.12	1.06	1.02	1.06	1.09	1.06	1.03
Kerosene	0.23	1.20	1.14	1.04	1.10	1.14	1.10	1.07
Natural Gas - Households	0.12	1.11	0.76	1.02	1.06	1.08	1.06	0.87
Electricity - Households	0.12	1.12	1.12	1.02	1.06	1.09	1.06	1.06
Wood - Households	0.00	-4.05	-4.22	-0.12	-1.81	-2.93	-1.81	-1.90
Industry								
Natural Gas - Industry	0.12	1.11	0.86	1.06	1.08	1.11	1.08	0.90
Electricity - Industry	0.12	1.12	1.12	1.06	1.09	1.12	1.09	1.09
Wood - Industry	0.00	-6.58	-6.84	-3.21	-4.90	-6.58	-4.90	-5.10
Note: Colors indicate taxes should face:	**Large reductions**		**Small reductions**		**Increases**		**Large increaes**	

Fiscal revenue impacts of the tax reforms for Bolivia are shown in Table B5. Again we have separated total fiscal revenues, revenues collected through excises, subsidies and the net balance. In the status quo of our modeling exercise (which combines quantities of year 2010 with prices evaluated at June 2011) Bolivia had "theoretical" total revenues (i.e. those computed from our tax wedges) of 445 million dollars, of which excises were about 324 million. These figures match well with the estimates obtained from other sources and used in the international section 2 above. However, Bolivia has subsidies due to distorted producer prices of about 91 million dollars, with a net balance of 354 million dollars. These subsidies are certainly underestimated as other subsidies (for electricity for example) have not been included in the analysis.

A Non-Ramsey excise reform towards environmental related taxes would produce a large increase in revenues from tax increases in Gas Oil and LPG and a reduction of gasoline excises. Total revenues of reform go up by more than 180 million dollars, shared equally by a reduction of subsidies and an increase in taxes. As expected, Ramsey taxes collect more revenues.

Table B5
Bolivia: Impact of ERT Reform on Tax Revenues
Data for 2010 in millions of US dollars

products	*Status-quo 2010*				*Case I – Non-Ramsey excises*			
	Fiscal Revenues (1)	*of which: Excises*	Subsidy (2)	Net balance (1) - (2)	Fiscal Revenues (1)	*of which: Excises*	Subsidy (2)	Net balance (1) - (2)
Transport	**402**	***320***	**83**	**320**	**472**	***343***	**0**	**472**
Special Gasoline (*)	***222.1***	***182.5***	***18.7***	***203.4***	***130.3***	***73.7***	***0.0***	***130.3***
Premium Gasoline (*)	***1.2***	***1.1***	***0.0***	***1.2***	***0.5***	***0.3***	***0.0***	***0.5***
AV Gas (*)	***1.4***	***1.2***	***0.6***	***0.8***	***0.6***	***0.1***	***0.0***	***0.6***
Jet Fuel (*)	***15.3***	***8.9***	***0.0***	***15.3***	***11.0***	***2.0***	***0.0***	***11.0***
Diesel Oil (*)	***153.4***	***126.7***	***63.4***	***90.0***	***301.8***	***246.8***	***0.0***	***301.8***
Vehicular NG	9.0	*0.0*	0.0	9.0	27.4	*20.0*	0.0	27.4
Households	**27**	***3***	**8**	**19**	**39**	***7***	**0**	**39**
LPG (*)	***15.1***	***2.8***	***8.2***	***6.9***	***26.6***	***5.7***	***0.0***	***26.6***
Kerosene	0.7	*0.4*	0.0	0.7	0.6	*0.3*	0.0	0.6
Natural Gas - Households	0.4	*0.0*	0.0	0.4	1.5	*1.2*	0.0	1.5
Electricity - Households	10.8	*0.0*	0.0	10.8	10.8	*0.0*	0.0	10.8
Industry	**16**	***0***	**0**	**16**	**25**	***9***	**0**	**25**
Natural Gas - Industry	4.9	*0.0*	0.0	4.9	13.4	*9.2*	0.0	13.4
Electricity - Industry	11.2	*0.0*	0.0	11.2	11.2	*0.0*	0.0	11.2
TOTAL	**445**	***324***	**91**	**354**	**536**	***359***	**0**	**536**

products	*Case II – Ramsey excises*				*Case II – Ramsey excises with political constraints*			
	Fiscal Revenues (1)	*of which: Excises*	Subsidy (2)	Net balance (1) - (2)	Fiscal Revenues (1)	*of which: Excises*	Subsidy (2)	Net balance (1) - (2)
Transport	**505**	***377***	**0**	**505**	**969**	***865***	**0**	**969**
Special Gasoline (*)	***130.3***	***73.7***	***0.0***	***130.3***	***293.4***	***254.8***	***0.0***	***293.4***
Premium Gasoline (*)	***0.6***	***0.3***	***0.0***	***0.6***	***1.7***	***1.5***	***0.0***	***1.7***
AV Gas (*)	***0.7***	***0.2***	***0.0***	***0.7***	***2.6***	***2.2***	***0.0***	***2.6***
Jet Fuel (+)	***13.7***	***5.0***	***0.0***	***13.7***	***21.4***	***13.4***	***0.0***	***21.4***
Diesel Oil (*)	***329.8***	***274.8***	***0.0***	***329.8***	***622.6***	***573.5***	***0.0***	***622.6***
Vehicular NG	29.9	*22.7*	0.0	29.9	27.4	*20.0*	0.0	27.4
Households	**69**	***38***	**0**	**69**	**44**	***12***	**0**	**44**
LPG (*)	***45.8***	***26.0***	***0.0***	***45.8***	***31.1***	***10.5***	***0.0***	***31.1***
Kerosene	0.9	*0.6*	0.0	0.9	1.0	*0.7*	0.0	1.0
Natural Gas - Households	1.9	*1.6*	0.0	1.9	1.5	*1.2*	0.0	1.5
Electricity - Households	20.5	*10.3*	0.0	20.5	10.8	*0.0*	0.0	10.8
Industry	**29**	***14***	**0**	**29**	**25**	***9***	**0**	**25**
Natural Gas - Industry	14.7	*10.7*	0.0	14.7	13.4	*9.2*	0.0	13.4
Electricity - Industry	14.6	*3.7*	0.0	14.6	11.2	*0.0*	0.0	11.2
TOTAL	**603**	***429***	**0**	**603**	**1038**	***887***	**0**	**1038**

(*) Goods with fiscal subsidies

Table B6 refers to the change in environmental costs associated with the tax reforms.

Table B6

Bolivia: Estimated Environmental costs before and after Reform

in million dollars

products	Status Quo		Case I		Case II			
			Non-Ramsey Excises		Ramsey Excises		Ramsey with Political Constraints	
	Local	*Total*	*Local*	*Total*	*Local*	*Total*	*Local*	*Total*
Transport	**557**	**618**	**350**	**390**	**342**	**381**	**258**	**289**
Special Gasoline (*)	***84.6***	***107.6***	***57.2***	***72.8***	***57.2***	***72.8***	***39.0***	***49.6***
Premium Gasoline (*)	***0.3***	***0.4***	***0.2***	***0.3***	***0.2***	***0.3***	***0.1***	***0.2***
AV Gas (*)	***0.0***	***0.1***	***0.0***	***0.1***	***0.0***	***0.1***	***0.0***	***0.1***
Jet Fuel (*)	***0.0***	***3.3***	***0.0***	***2.0***	***0.0***	***1.9***	***0.0***	***1.8***
Diesel Oil (*)	***456.7***	***482.6***	***279.0***	***294.9***	***271.7***	***287.2***	***205.7***	***217.4***
Vehicular NG	15.9	23.9	13.2	19.8	12.8	19.2	13.2	19.8
Households	**140**	**152**	**139**	**149**	**138**	**148**	**139**	**148**
LPG (*)	***2.5***	***9.0***	***1.6***	***5.6***	***1.5***	***5.3***	***1.5***	***5.5***
Kerosene	0.2	0.3	0.2	0.3	0.2	0.3	0.2	0.3
Natural Gas - Households	0.0	1.3	0.0	1.1	0.0	1.1	0.0	1.1
Electricity - Households	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wood - Households	136.9	141.5	136.9	141.5	136.9	141.5	136.9	141.5
Industry	**254**	**273**	**254**	**272**	**254**	**272**	**254**	**272**
Natural Gas - Industry	0.2	10.7	0.2	9.1	0.2	8.9	0.2	9.1
Electricity - Industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wood - Industry	254.2	262.8	254.2	262.8	254.2	262.8	254.2	262.8
TOTAL	**951**	**1043**	**743**	**810**	**735**	**801**	**651**	**709**

(*) Goods with fiscal subsidies

Turning into the evaluation of the distributional impacts of tax reforms we show in Figure B.2 the expenditure share of energy goods across deciles which in the case of Bolivia is expressed as a percentage of household income (because the survey we use is an income household survey with data on expenditures that allow us to compute shares, see Annex B).

Again as in the case of Argentina, most goods have expenditure shares that are decreasing across households. Most prominent cases are electricity, with very large shares for low income households and public transport and LPG. But like Uruguay (and unlike Argentina) some goods, such as gasoline, have increasing expenditure shares.

Figure B.3 represent the distribution of environmental costs across deciles as a percentage of income. Gasoline, Diesel and LPG are the main contributors, with a decreasing share across deciles, as in the cases of Argentina and Uruguay.

Figure B.2
Bolivia: Decile distribution of expenditures of energy as a percentage of household Total Income

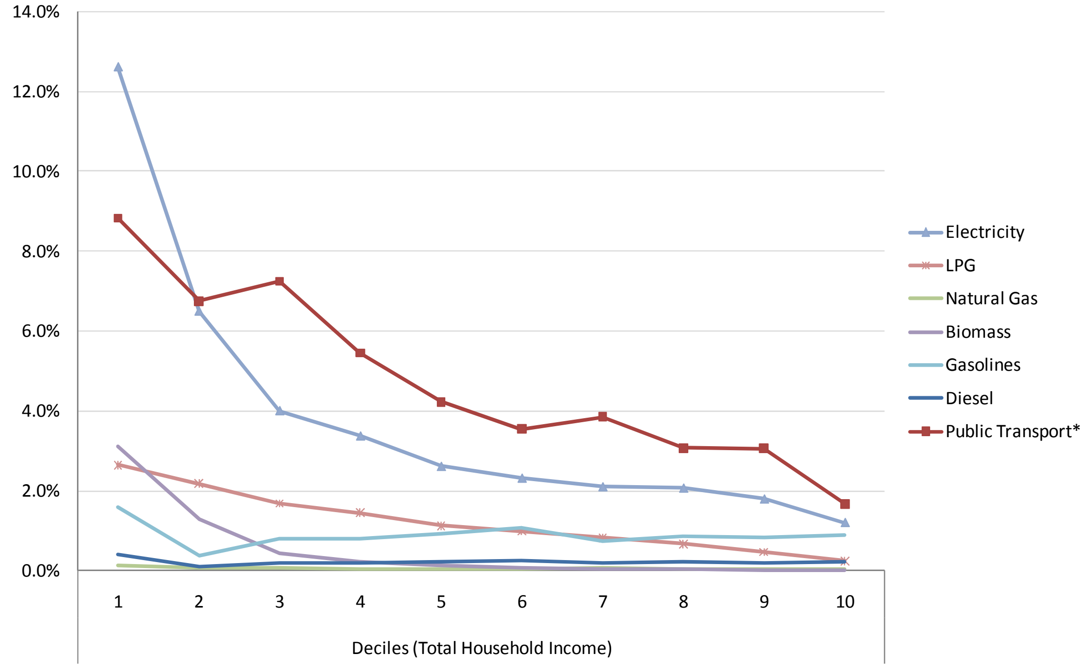


Figure B.3
Bolivia: Decile distribution of environmental costs as a percentage of total household income

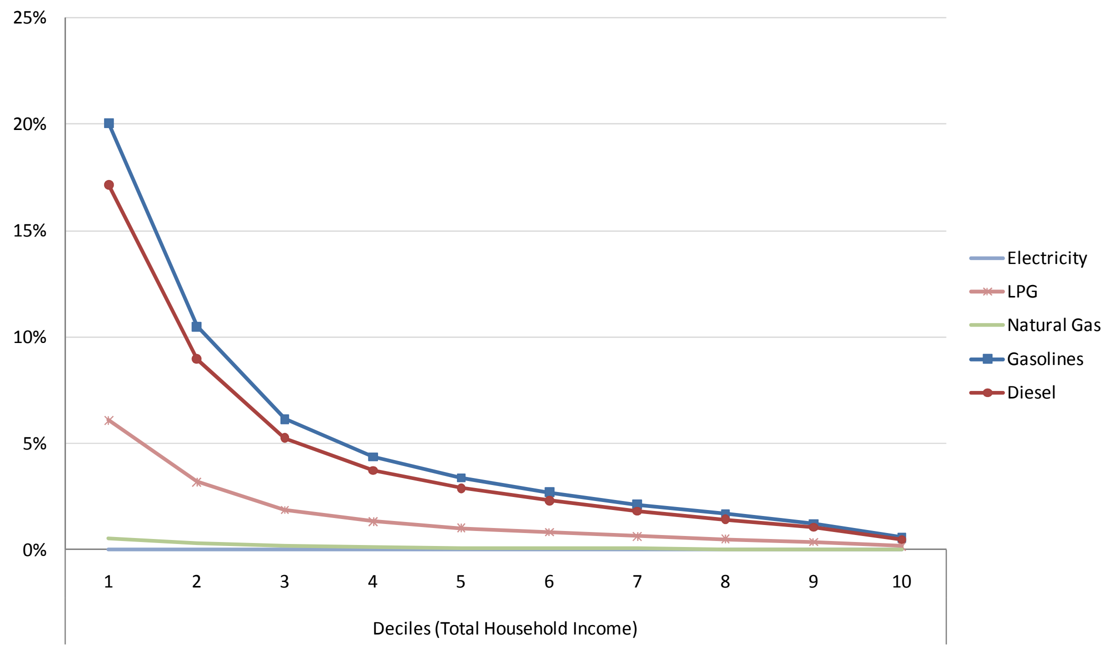
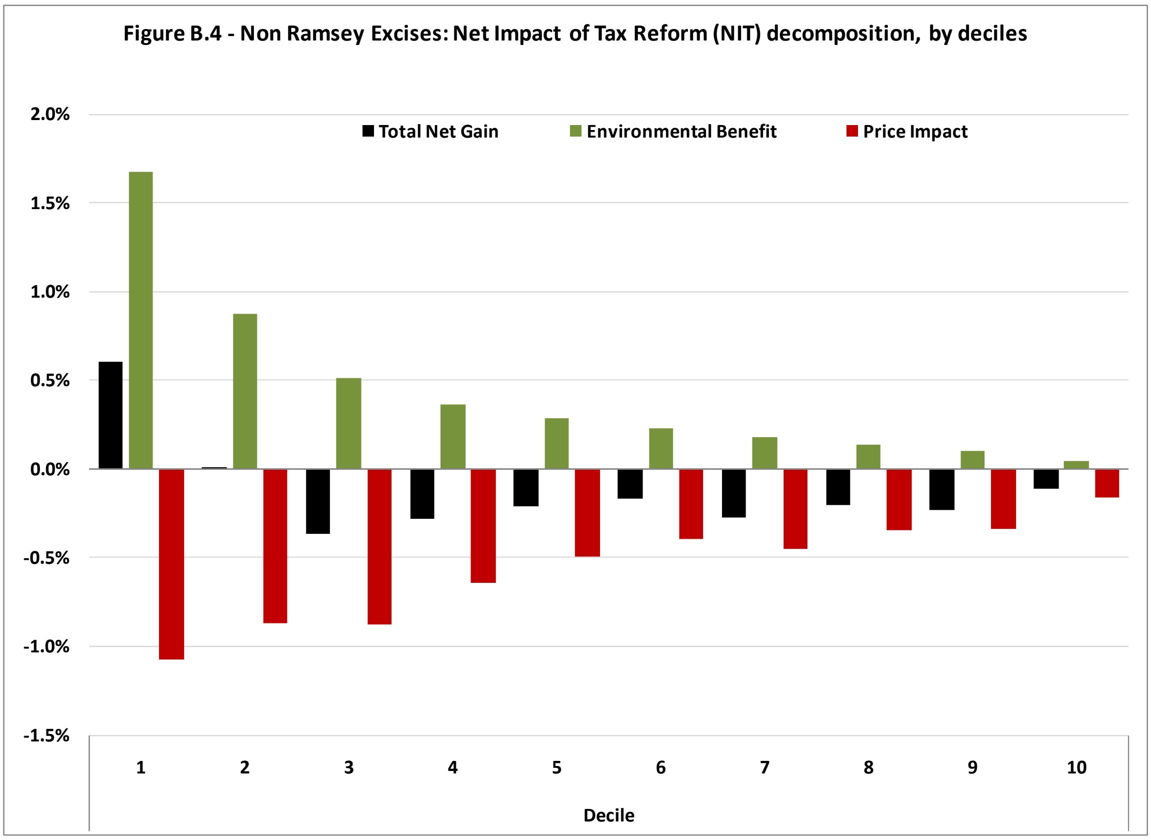


Table B.7 summarizes the estimation of expression (10) of section 3.1.4 to approximate the distributional impact of the tax reforms. It decomposes total net gains in effects of price impacts due to taxes and due to environmental gains (explained by prices changes only due to tax changes), across deciles, for all reforms (Non-Ramsey, see Table A2; Ramsey and Ramsey with political constraints, see Table A3). Non Ramsey excises on energy products that turn into environmental objectives give rise to small net losses equivalent to 1.2% of household expenditure given that environmental gains (4.4% of household expenditure) do not compensate for the effects of price increases (-5.6% of household expenditure). The poorest 10% benefit from reform but the largest share of losses are concentrated in deciles 3 to 5 indicating that reform will need compensatory transfers for low income families.

Table B7

Bolivia: Distributional impact of tax reforms, by deciles

	Decile										
	1	2	3	4	5	6	7	8	9	10	Total
Case I: Non Ramsey Excises											
Total Net Gain	**0.60%**	**0.01%**	**-0.36%**	**-0.28%**	**-0.21%**	**-0.17%**	**-0.27%**	**-0.20%**	**-0.23%**	**-0.11%**	**-1.23%**
Environmental Benefit	1.68%	0.88%	0.51%	0.37%	0.28%	0.23%	0.18%	0.14%	0.10%	0.05%	4.41%
Price Impact	-1.07%	-0.87%	-0.88%	-0.65%	-0.49%	-0.40%	-0.45%	-0.34%	-0.34%	-0.16%	-5.64%
Case II: Ramsey Excises											
Total Net Gain	**-0.31%**	**-0.75%**	**-1.05%**	**-0.91%**	**-0.71%**	**-0.64%**	**-0.71%**	**-0.61%**	**-0.59%**	**-0.35%**	**-6.62%**
Environmental Benefit	3.31%	1.73%	1.02%	0.72%	0.56%	0.45%	0.35%	0.28%	0.20%	0.09%	8.71%
Price Impact	-3.62%	-2.48%	-2.07%	-1.64%	-1.27%	-1.08%	-1.07%	-0.89%	-0.79%	-0.44%	-15.33%
Case II: Ramsey Excises with Political Constraints											
Total Net Gain	**13.33%**	**6.31%**	**1.45%**	**0.64%**	**0.18%**	**-0.30%**	**-0.65%**	**-0.84%**	**-1.19%**	**-1.20%**	**17.74%**
Environmental Benefit	19.56%	10.23%	6.00%	4.26%	3.30%	2.64%	2.08%	1.63%	1.21%	0.56%	51.47%
Price Impact	-6.23%	-3.92%	-4.55%	-3.62%	-3.13%	-2.94%	-2.73%	-2.47%	-2.39%	-1.76%	-33.73%



A final discussion of the particularities of our Bolivian case-study is illustrated in Box BB1 and it relates to the interplay between informality, urban vs. rural households and the room for LPG-Biomass substitution.

Box BB1

Informality, environmental costs of biomass and the need of multiple instruments

Biomass is a prime contributor to environmental costs in our estimates of Annex C and it has the feature that is an untaxed good. Our modeling strategy for the reform towards environmental taxes has been interpreted as a shift of the non-uniform component of taxes on energy from the current status-quo situation to one where environmental costs play a a central role in determining excises. Even in the simplest possible framework we have found three problems with biomass and taxes that are particularly compounded in the case of Bolivia. One is the prevalence of informality in the case of Biomass, which is traded in informal markets in urban Uruguay or Argentina, but in the case of Bolivia is also directly collected by rural households. Second, is the existence of subsidies to certain energy goods in the form of lower producer prices, a fact that occurs extensively in Argentina and Bolivia but that in this case is compounded by the fact that a large subsidy is given to LPG which is a key substitute of biomass as it is registered in the changes in the energy balances of the last 20 years. Third, is the interplay of distributional impacts in all three countries, but that in the case of Bolivia is compounded by the fact that subsidies of LPG are deviated to the non-urban poor while the rural poor is not reached due to its *reliance on biomass. This is reinforced by the fact that not only pays higher prices for LPG (due to transport costs).*

Figure BB1 shows the distribution by deciles in urban (right panel) and rural (left panel) households of the energy goods for cooking and heating. The red bars show the share of LPG which is the dominant fuel in urban households –regardless the income decile- while the green bars show the share of biomass, which is dominant in –particularly poor- rural households. Other competing fuels are Natural Gas (blue bars) particularly for the urban rich and "guano" (animal waste) (in orange bars) particularly for the rural poor.

Figure BB1
LPG vs. Biomass in household consumption in Urban and Rural Bolivia across deciles , 2009

Urban households **Rural households**

Figure BB1 is a motivating piece of evidence on the limitation of using taxes to promote fuel savings or interfuel substitution with environmental concerns. The use of lower taxes to LPG to accommodate the fact that biomass is untaxed will be a poor instrument as it will deviate resources to urban households which already have substituted away biomass. It will also have very poor distributive (or rather a regressive) impact. A better solution to the problem is to explore the use of multiple instruments[1] to help the rural poor to advance in their substitution towards LPG. This can be done by subsidies or rebates that amount to introducing two part tariffs. But rebates need not be related only to lump sum vouches for LPG purchases (that for instance compensate for the higher costs of transport) but also targeted at the purchase of durables that may be one of the cost that prevent switching towards LPG.

[1] See for example Fullerton and Wolverton (2005) and Parry (2011).

4. Main conclusion and policy implications

In this paper we have addressed the reform potential of energy environmentally related taxes in Argentina, Bolivia and Uruguay.

We first found differences in level and structure of environmentally related taxes with OECD countries but with the common feature that that energy taxes are prime contributors. Compared to the EU countries, environmental taxes in Argentina are low, measured as percentage of GDP, but its composition results similar to the European average[38]. Uruguay differs in the relative importance of different environmentally related taxes –more biased to transport taxes- but their share of GDP is close to Spain, the EU country showing the lowest ratio. Bolivia displays a percentage to GDP that more than double the one of Argentina and exceeds the European average, with a noticeable high incidence of transport taxes. The comparison of contribution of revenues from environmental taxes to total fiscal revenues reflects huge differences in general tax bases among countries in different development stages: Bolivia, in particular, with a narrower tax base than other countries, shows a considerable high share of environmental taxes on fiscal revenues; more than 2 points higher than Japan, the OECD country with the largest share.

However, the comparison of formal taxes and tax revenues hides the role of subsidies. Argentina for example has very large fiscal subsidies in the pricing of energy. Discussing current environmental taxes and environmental tax reform in Argentina cannot overlook the presence of subsidized prices. In spite that the OECD methodology we revise in Section 2 refers to taxes and does not adjust for existing explicit or implicit subsidies, when we move to modeling environmental taxes in practice we have of is paper we have integrated pre-existing distortions and fiscal subsidies that tend to drastically change the previous picture for Argentina. Subsidies in gas oil, natural gas and electricity are larger than revenue collected through excises on energy goods and are 72% of total tax revenues (including VAT) collected from energy goods. Netting out subsidies, Argentina collects energy taxes that are in current dollars just the double of those collected by Uruguay, when the GDP ratio between the two countries is more than 10 to 1. Uruguay is a very different case, as it is in general subsidy-free in energy prices. Rather, additional quasi-taxes may be embedded in the value chain of the energy sector due to higher costs of public enterprise operations that we do not consider in our analysis. Bolivia returns to the features of the argentine case due to the presence of subsidies.

[38] The predominance of energy taxes is common to most Member States.

We then move to model an energy tax reform process out a status quo and towards environmentally related excises, distinguishing between uniform and non-uniform tax components, positive and normative tax structures, and between non-Ramsey and Ramsey specifications. This allows us to decompose tax wedge margins into a uniform component due to general (VAT) indirect taxation and a set of non-uniform excises. The non-uniformity of taxes and tax wedge-margins observed in the status quo is modeled trough a simple positive model of taxes, which has underlying observed characteristics of goods as implicit parameters in the observed structure. The normative non-uniformity of excises is modeled with the introduction of environmental costs. Thus a tax reform towards environmental taxes is seen as a reformulation of the non-uniform tax component from a positive to a normative definition. We do so in two main versions. The first one (called Non Ramsey) does not pay attention to price-elasticities and just evaluate the impact of such a substitution. The second is a Ramsey-type exercise in pure form and also with a variety that incorporates political constraints embedded in the above mentioned implicit parameters observed in the status-quo. We obtain simple results for the tax formulas that involve environmental levies, but also discuss extensions and limitations of the model.

We implement the model after some effort to estimate local and global environmental costs related to energy consumption. We follow a detailed methodology that uses relates local and global pollutants with energy products, to determine for each product and each sector of the economy injury determination which links the injury to the release of pollutants and damage determination which involves valuing the injury in monetary terms. Compared to other estimates used in recent exercises of efficient environmental taxation of some fuels (such as Parry and Strand (2010) for Chile) our methodology arrives at comparable values in the case of gasoline, but larger values in the case of diesel (Gas Oil) in Argentina and Uruguay, which turn out to be responsible for much environmental damage and also for the qualitative and quantitative results of our exercises. In general our estimates tend to show quite larger values for local environmental costs and relatively smaller values for global ones. We do not incorporate other externalities (e.g. transport) apart from environmental costs in the evaluation of tax reform. These are substantially higher in the estimates of Parry and Strand (2010) for Chile. We do not include these externalities because we believe they will blur the role of environmental costs in the resulting tax structures and because we assume that other instruments will tackle them better than fuel taxes (Parry, 2011). We acknowledge that this qualifies some of our results (particularly that current gasoline excises are too high if environmental costs are factored in) if these other instruments are not available.

In terms of results we find that a rebalancing of fuel taxes (where gasolines and electricity taxes fall and diesel and other fuels taxes goes up) is present in the three countries. This result is robust to the range of price-demand elasticity and environmental cost parameters. Other taxes also adjust depending on environmental costs, pre-existing taxes and producer price distortions. Very low (distorted) status-quo prices magnify the jump in taxes that incorporate environmental costs, because these are large in comparison to a very low base. Natural gas in Argentina is one clear example, while electricity does not share such feature because environmental taxes should be zero. Biomass should face high taxes but it trades in informal markets and faces no taxes, suggesting the need for alternative instruments. Adjusting taxes on substitutes is not an efficient (or equitable) response as the case of Bolivia illustrates.

Fiscal impacts and environmental gains of the tax reform exercises are significant in all countries, particularly more in Argentina and Bolivia if subsidies are eliminated. As much of the exercise is driven by changes in transport fuels such as Gas Oil (Diesel Oil), they tend to explain a great part of fiscal revenues and environmental gains. For the same reason, double dividend effects do not seem to come by, because of price increases of widespread energy inputs (gas oil for transport) are triggered by the reform exercise. The distributional impact of the exercise is evaluated combining the effect -across income deciles- of price increases due to taxes with the effect of environmental gains (due to consumption quantities of energy reduced as a consequence of tax changes) which are assumed to be distributed uniformly across households. Given that the tax reform raises transport fuels, we allow for the effect of an increase in public transport, which adds to the negative price effect while not adding to environmental gains. We find that distributional impacts of reform critically depend on its type (Non-Ramsey vs. Ramsey) and on allowing for the distribution of environmental benefits, since price effects are in general negative. Non Ramsey tax reforms have a positive distributional impact in Uruguay (due to both positive environmental and also price effects) and in Argentina (which pre-existing distortions make room for large negative price effects along with large environmental gains both concentrated in Gas Oil and Natural Gas) but negative in Bolivia. Ramsey tax reforms have negative distributive impacts in all countries even allowing for the distribution of environmental gains.

This study has enlarged our previous understanding of the topic both in terms of modeling and policy implications. We found that decomposing taxes into uniform and non-uniform components and studying the effects of an environmentally related tax reform as a change in the non-uniform component simplifies the setting and allows for better testing of alternative specifications of models. We found results that tend to make Non-Ramsey type reforms much preferable to Ramsey type ones, which are the ones that seem to be suggested in conventional formats in the literature (e.g. Sandmo, 2000). Non-Ramsey formulations are more transparent and therefore easy to implement as they help at adding a non-uniform excise component (what we have termed Sandmo's numbers) that is related to environmental costs, into uniform (e.g. VAT) taxes. They also avoid the problem of Ramsey-type formulations that are obliged to treat explicitly efficiency objectives that work through price-elasticities and therefore introduce additional changes in taxes that have nothing to do with environmental costs. For example, in all cases above, Ramsey-type formulations provoke tax increases in electricity (due to inverse price elasticity effects) even if electricity has no environmental costs. Beyond this we favor the introduction of multiple instruments as they can help at coping with other externalities, with the informality features of LAC tax systems and with negative distributional and competitive impacts. The case biomass deserves a closer look (in several countries of LAC) paying attention to these interactions. Other areas that deserve further research are a closer and more focalized estimation of environmental costs that separate into urban and non urban or rural impacts as well as into the distributional incidence of those costs.

In our view, environmentally related taxes are going to be an increasing part of the future of taxation in LAC as the interplay of the pricing of energy and carbon will become more accepted and implemented in our countries. This will probably leave local environmental costs to be dealt with in combination with other instruments. Fiscal revenue impacts of environmentally related energy taxes largely depend on internalizing local costs into fuel taxes and on their revenue-raising role in most LAC countries, a fact that is interrelated to the cost of raising public funds. Our study suggest that large fiscal impacts are associated with larger taxes in widely used energy goods that, for the same reason, are going to transfer price increases to the economy, thus undoing extra fiscal gains (associated with the double dividend hypothesis) and also having visible distributive and competitive impacts.

Annex A

Modelling the structure of energy ERT

Assumptions and initial setting

The simplest "starting" model assumes an economy of H homogeneous households with n goods (an aggregate good x_0 and n-1 goods that in principle are all potentially responsible of external effects). Households maximize utility from consumption and suffer from a "consumption externality" (a la Diamond (1973)) that stems from aggregate consumption of energy. We assume a fixed labor supply and a linear technology of production with competitive firms (which implies that producer prices are parametric). The government raises revenues through indirect taxes to finance (an assumed fixed) expenditure G (which decision is ignored). The welfare function of this economy is written alternatively as

$$W^P = \Phi(q, Y) \qquad \text{(A1)}$$

$$W^N = H.V(q,Y) - \sum_{j=1}^{n-1} K_j . X_j(q,Y) \qquad \text{(A1')}$$

Where $W^P = \Phi(q, Y)$ is the objective function of a political elite that depends on a vector of consumer prices q and income Y. This represents the positive case. In the normative case in (A1') we have the utilitarian case, represented by H.V(q, Y) (the sum of the indirect utility function of the representative household), where we further add the term Σ $K_j.X_j$ which captures the disutility to society coming from aggregate consumption of the n-1 goods causing environmental costs, where K_j is the disutility to society of the consumption of good X_j.

Final or consumer prices are defined as $q_i = p_i.(1+t)+T_i$ and come from producer prices p, a general uniform ad-valorem tax t (defined on the aggregate consumption good x_0 and applied to energy goods as well) and a specific non-uniform tax component Ti applied only to energy goods. Thus, energy goods taxes are non-uniform because of the T_i component.[39].

Modelling tax structures in both positive and normative formulations, requires that the government chooses taxes (t, T_i) so as to maximize (A1) or (A1') subject to the budget constraint below (A2) (which by aggregation is compatible with the zero profit condition of firms and market clearing in all markets).

$$R = \sum_{i=0}^{n} (t.p_i + T_i).X_i(q,Y) - R_0 \geq 0 \qquad \text{(A2)}$$

[39] This setting can be easily adapted to particular real-world settings with both ad-valorem and specific components

where R_0 is the revenue constraint (required to finance G). For simplicity, we assume separability between all goods to neglect cross-price elasticities effects and reducing information requirements.

The government problem becomes easily characterized by the choice of taxes (t, T_i) to maximize the auxiliary function $L = W^J(.) + \lambda.R(.)$ $J = P, N$ where λ is the Lagrange multiplier associated with the budget or revenue constraint. We assume that the general uniform tax (t) is chosen with reference to the tax on the aggregate good x_0. From first order conditions (and assuming interior solutions) with respect to instruments t_i for all i we obtain (given $\partial q_0/\partial t_0 = p_0$, $\partial q_i/\partial T_i = 1$ by definition):

Positive model

(choice of $t = t_0 \quad \forall i$)

$$\frac{\partial \Phi}{\partial q_0}.\frac{\partial q_0}{\partial t_0} + \lambda..(t_0.\frac{\partial X_0}{\partial q_0}.\frac{\partial q_0}{\partial t_0} + X_0) = 0 \qquad \text{(A3)}$$

(choice of T_i)

$$\frac{\partial \Phi}{\partial q_i}.\frac{\partial q_i}{\partial T_i} + \lambda..((t.p_i + T_i).\frac{\partial X_i}{\partial q_i}.\frac{\partial q_i}{\partial T_i} + X_i) = 0 \qquad \forall i = 1,\ldots n \qquad \text{(A3')}$$

Normative Model

(choice of $t = t_0 \quad \forall i$)

$$H.\frac{\partial V}{\partial q_0}.\frac{\partial q_0}{\partial t_0} + \lambda..(t_0.\frac{\partial X_0}{\partial q_0}.\frac{\partial q_0}{\partial t_0} + X_0) = 0 \qquad \text{(A4)}$$

(choice of T_i)

$$H.\frac{\partial V}{\partial q_i}.\frac{\partial q_i}{\partial T_i} - K_i.\frac{\partial X_i}{\partial q_i}.\frac{\partial q_i}{\partial T_i} + \lambda.((t.p_i + T_i).\frac{\partial X_i}{\partial q_i}.\frac{\partial q_i}{\partial T_i} + X_i) = 0 \qquad \forall i = 1,\ldots n \qquad \text{(A4')}$$

In the positive model, we assume that $\partial\Phi/\partial q_i = -\theta_i.X_i$, expressing the marginal disutility for the political elite of an increase in the price of the good i. The θ_i parameters (normalizing to $\theta_0 = 1$) are called "implicit" characteristics of goods. In the normative model we make use of the Roy's identity ($\partial V/\partial q_i = -\alpha.x_i(q.Y)$ where $\alpha = 1$ is the marginal utility of income). In both cases, manipulating we can derive tax formulas for each i=0,...n goods for both positive and normative formulations.

Positive Model

$$m_0^P = \frac{q_0 - p_0}{q_0} = \frac{\lambda - \theta_0}{\lambda.\eta_0} \qquad \text{(A5)}$$

$$m_i^P = \frac{q_i - p_i}{q_i} = \frac{\lambda - \theta_i}{\lambda.\eta_i} \qquad \text{(A5')}$$

Normative Model

$$m_0^P = \frac{q_0 - p_0}{q_0} = \frac{\lambda - 1}{\lambda.\eta_0} \qquad \text{(A6)}$$

$$m_i^P = \frac{q_i - p_i}{q_i} = \frac{\lambda - 1}{\lambda.\eta_i} + \frac{K_i}{\lambda.q_i} \qquad \text{(A6')}$$

Expression (A5') is similar to Becker's (1983) formulation of positive indirect taxes arising from pressure groups. We restrict this model for empirical purposes by forcing the tax-wedge margins m_i of the positive model to coincided with observed, status quo tax-wedge margins. Normative, optimal energy taxes (expression (A6')) in this simplest framework enter as an additive term to the standard optimal indirect tax formula (Sandmo 1975; 2000). (See also that $(\lambda-1)/\lambda+1/\lambda=1$, so it can be seen as a weighted sum of efficiency and environmental effects). Computing these formulae even from the simplest model require data on the parameter $\lambda=1/(1-m_0.\eta_0)$ (representing the marginal cost of funds to the public sector), demand price elasticities, and an estimation of the environmental cost (per unit of consumption and as a percentage of the end user price). Also, since (A.6') is not a closed-form expression, care must be taken on possible loops (that can be neglected in the simplest case of assumed constant elasticities). Thus the empirical application proceed using estimates of those parameters (or in the case of the price-elasticity an interval of likely values if available estimates are poor and estimates from meta-analysis are considered).

Non Ramsey tax structures

Both positive and normative models above incorporate efficiency objectives and therefore are varieties of a simple Ramsey-type setting (that may be termed Ramsey-Becker and Ramsey-Pigou-Sandmo) and, therefore, tax wedge margins depend on price-demand elasticities. In section 3.1 we start the analysis of environmentally related tax reform looking at a case where demand-elasticities are not considered. Rather, the structure of indirect taxation proceeds from a pre-existing uniform tax on all goods, upon which a set of excises on energy goods is added.

We define the structure of taxation by the sum of a uniform and a non-uniform component that add-up to complete the tax wedge margin:

$$m_i = \frac{q_i - p_i}{q_i} = \frac{t}{1+t} + Z_i \qquad \text{for all } i = 1,\ldots, n-1 \qquad \text{(A7)}$$

The uniform component t/(1+t) comes from expressions (A5) (with $\theta_0=1$)[40] and (A.6). The non-uniform component changes according we consider the positive or normative formulation. In the positive model, and given that price-elasticities heterogeneity is not considered, we have (with $\eta_i = \eta_0$ for all i) from (A5'):

[40] Given the fact that a uniform indirect tax (VAT like) has been implemented we take, without loss of generality, the implicit characteristic of the aggregate good (0) as unity.

Case IP : Non - Ramsey Positive Model

$$m_i^{IP} = \frac{q_i^{IP} - p_i}{q_i^{IP}} = \frac{\lambda - 1}{\lambda.\eta_0} + \frac{1-\theta_i}{\lambda.\eta_0} = \frac{\mathrm{t}}{(1+\mathrm{t})} + \frac{1-\theta_i^I}{\lambda.\eta_0} \qquad \text{for all i} = 1,\ldots,\text{n - 1} \qquad \text{(A8)}$$

$$Z_i^{IP} = \frac{1-\theta_i^I}{\lambda.\eta_0}$$

Case IN : Non - Ramsey Normative Model

$$m_i^{IN} = \frac{q_i^{IN} - p_i}{q_i^{IN}} = \frac{\lambda - 1}{\lambda.\eta_0} + \frac{K_i}{\lambda.q_i^{IN}} = \frac{\mathrm{t}}{(1+\mathrm{t})} + \frac{K_i}{\lambda.q_i^{IN}} \qquad \text{for all i} = 1,\ldots,\text{n - 1} \qquad \text{(A9)}$$

$$Z_i^{IN} = \frac{K_i}{\lambda.q_i^{IN}}$$

Both positive and normative tax structures are decomposed between uniform (t/(1+t)) and non-uniform (Z_i) components. The Z_i's in the positive model correspond to what we term Becker's numbers, while in the normative model, correspond to what we call Sandmo's numbers.

Ramsey tax structures

The Ramsey structures defined in formulas (A5)-(A5') and (A6)-(A6') lead naturally to non-uniform tax structures that are not consistent with an observed characteristic of the tax system we evaluate, namely that there is a pre-defined uniform tax on all commodities that is complemented (rather than superseded) by a non-uniform structure of excises. In the Ramsey formulation, as stated above, both components of the tax wedge margin are non-uniform, as can be seen from expressions (A5') and (A.6'). Thus, taxes may become non-uniform for reasons (efficiency) different from the positive or normative reasons that motivate non-uniformity of excises.[41]

Despite this breaking of uniformity embedded in Ramsey tax structures, computing is a straightforward application of expressions (A5') and (A6'), which –at the same time- can easily accommodate, for the sake of comparison or benchmarking, the separation

[41] Moreover, under plausible circumstances the tax-wedge margin of some goods may be lower than the uniform rate (t/(1+t)) which is a nuisance, as it imply a negative Z_i –despite the fact that there are associated environmental costs-. The reason for this outcome is not difficult to explain and is associated with the constraint to achieve a given revenue constraint that is embedded in Ramsey taxation. Assume that there is one energy good –typically diesel oil (gas oil) in the cases we study- that has a large environmental cost and initially a relatively low tax wedge. A Ramsey-like reform will imply a large increase in the price and in the tax wedge of such a good, and correspondingly a large increase in revenues. To stabilize revenues, the Ramsey program will "seek" to reduce revenues elsewhere and it will do so particularly in energy goods will relatively low environmental costs. The magnitude of such a rebalancing could be such that interior solutions may imply a negative tax wedge (i.e. a subsidy) for some goods. As this result goes against reasonable policy, one possibility is to constraint the taxes of these goods to be no lower than the uniform tax rate (t). Another possibility, which is the one chosen in this paper, is to avoid restricting the exercise to stabilize revenues and compute instead Ramsey tax formulas with a assumed marginal cost of public funds (λ), which makes revenues endogenous to the new tax structure.

between uniform and non-uniform components of tax wedge margins as defined above in expression (A7). Versions of the positive and normative models are the stated as:

Case IIP: Ramsey Positive Model

$$m_i^{IIP} = \frac{q_i^{IIP} - p_i}{q_i^{IIP}} = \frac{\lambda - 1}{\lambda.\eta_i} + \frac{1-\theta_i^{II}}{\lambda.\eta_i}$$

$$= \frac{\mathrm{t}}{(1+\mathrm{t})} + [\frac{\lambda - 1}{\lambda.\eta_i} - \frac{\mathrm{t}}{(1+\mathrm{t})}] + \frac{1-\theta_i}{\lambda.\eta_0} \qquad \text{for all i} = 1,\ldots,\text{n - 1} \qquad \text{(A10)}$$

$$Z_i^{IIP} = [\frac{\lambda - 1}{\lambda.\eta_i} - \frac{\mathrm{t}}{(1+\mathrm{t})}] + \frac{1-\theta_i}{\lambda.\eta_0}$$

Case IIN: Ramsey Normative Model

$$m_i^{IIN} = \frac{q_i^{IIN} - p_i}{q_i^{IIN}} = \frac{\lambda - 1}{\lambda.\eta_i} + \frac{K_i}{\lambda.q_i^{IIN}} =$$

$$= \frac{\mathrm{t}}{(1+\mathrm{t})} + [\frac{\lambda - 1}{\lambda.\eta_i} - \frac{\mathrm{t}}{(1+\mathrm{t})}] + \frac{K_i}{\lambda.q_i^{IIN}} \qquad \text{for all i} = 1,\ldots,\text{n - 1} \qquad \text{(A11)}$$

$$Z_i^{IIN} = [\frac{\lambda - 1}{\lambda.\eta_i} - \frac{\mathrm{t}}{(1+\mathrm{t})}] + \frac{K_i}{\lambda.q_i^{IIN}}$$

Once again, both positive and normative tax structures are decomposed between uniform (t/(1+t)) and non-uniform (Z_i) components. The first terms in the Z_i's of both positive and normative model have an identical form, which indicates de departure from tax uniformity due to efficiency. The second terms of the Z_i's are again, respectively, Becker's numbers and Sandmo's numbers.

Marginal tax reforms

Even within the simplest model, optimal taxes have both problems of measurement and of representing a reasonable benchmark, if what we observe as a tax structure reflects political economy issues as it normally happens in Latin America with fuel prices associated with public transport such as diesel vis-avis gasoline (where the simple "glimpse" referred to above normally reflects under-taxation of the former and over-taxation of the later). To cope with the problems associated with measuring, invoking and implementing an optimal tax structure, the literature of the direction of marginal tax reforms (initiated by Guesnerie (1977), Ahmad and Stern (1984) and others; see also Myles (1995, Ch.6)) provides a simple way to evaluate a tax structure "out-of-the-optimum" and recommend directions of reform. Given that the starting point is not an optimum set of taxes, in each one of the first order conditions the "numbers" λ will not be identical and differ among themselves. Defining each λ_i at the starting point, we have:

$$\lambda_i = -\frac{\partial W/\partial t_i}{\partial R/\partial t_i} = \frac{1-(K_i/q_i).(-\partial X_i/\partial q_i).(q_i/X_i)}{1-(t_i/q_i).(-\partial X_i/\partial q_i).(q_i/X_i)} = \frac{1}{1-(t_i/q_i).\eta_i} + \frac{-(K_i/q_i).\eta_i}{1-(t_i/q_i).\eta_i} \qquad \text{(A12)}$$

Where λ_i is the marginal cost of public funding from tax i ($MCPF_i$) and again can be decomposed into efficiency and environmental effects. The values of λ_i can be computed from observed taxes and prices and estimates of demand price-elasticities and environmental unit costs. They provide a simple characterization of which energy goods are over or under taxed in relation to the rest and suggest a line of reform. The robustness of the reform direction can be tested against the sensitivity to different parameters on which we may be uncertain.

Heterogeneous agents

In a world of heterogeneous agents the normative formulation is changed to account for the fact that distributional impacts are important. A simple and straight modification of the welfare function (A1') is the following

$$W = \sum_h \sigma^h . V(q, Y^h) - \sum_{j=1}^{n-1} K_j . X_j(q, Y) \qquad \text{(A1'')}$$

Agents are heterogeneous in income (not in preferences). Optimal taxes in this setting are expressed as :

$$\frac{q_i^{IIIN} - p_i}{q_i^{IIIN}} = \frac{\lambda - d_i + \eta_i.(K_i/q_i)}{\lambda.\eta_i} =$$

$$= \frac{\lambda - d_i}{\lambda.\eta_i} + \frac{(K_i/q_i)}{\lambda} \qquad \text{(A13)}$$

where

$$d_i = \sum_h \beta^h . \frac{x_i^h}{X_i} \qquad \beta^h = \frac{\partial W}{\partial V^h} . \frac{\partial V^h}{\partial Y^h} = \sigma^h . \alpha^h \qquad \text{(A14)}$$

The d_i are so-called distributional characteristics, β^h is the social marginal utility of income of household h which are a product of welfare weights and the private marginal utility of income. Estimation of all theses parameters require further specification of welfare or utility functions (such that β^h can be estimated from household income) and the use of micro-data from Household expenditure surveys. While this methodology can in principle be implemented for consumer goods, it has serious implementation difficulties when energy products are inputs. This will happen for almost all energy products, except for those goods (such as natural gas and electricity) where market data allows us to separate household consumption. In the case of fuels for transport, for example, the separation between quantities sold to households and to firms (in the transport, commercial, industrial and, important for our case countries, the agricultural sector) cannot be identified. Thus we will not evaluate the case of taxes T_i that incorporate distributional characteristics.

Restating equity concerns

In the framework describe above it may seem an unfortunate terminology to call "positive" a model that may include distributional concerns (if the θ_i's are such that they depend on distributional impacts of price or tax changes) and "normative" a model that does not include them. One practical way out of this tension can be to check if the θ_i's are correlated with the distributional characteristics of goods (d_i), in particular for some critical energy goods that are going to be key participants in the rebalancing of taxes. If they are, then it would be possible to readapt expression (A11) above by introducing the "recovered" θ_i's estimated previously in the positive model. This will cushion the change in taxes and move the normative tax structure closer to the status-quo than in the case of (A11). Of course, the introduction of the θ_i's will also introduce some political constraints that may (come from pressure groups and) not necessarily be related to distributional equity. We call this version a Ramsey Model with political constraints.

Case IIIN: Ramsey Normative Model with political constraints

$$m_i^{IIIN} = \frac{q_i^{IIIN} - p_i}{q_i^{IIIN}} = \frac{\lambda - \theta^{II}}{\lambda.\eta_i} + \frac{K_i}{\lambda.q_i^{IIIN}} =$$

$$= \frac{\mathrm{t}}{(1+\mathrm{t})} + [\frac{\lambda - \theta^{II}}{\lambda.\eta_i} - \frac{\mathrm{t}}{(1+\mathrm{t})}] + \frac{K_i}{\lambda.q_i^{IIIN}} \qquad \text{for all i} = 1,\ldots,\text{n - 1} \qquad \text{(A11)}$$

$$Z_i^{IIIN} = [\frac{\lambda - \theta^{II}}{\lambda.\eta_i} - \frac{\mathrm{t}}{(1+\mathrm{t})}] + \frac{K_i}{\lambda.q_i^{IIIN}}$$

Annex B
Database on quantities, prices and taxes

ARGENTINA

1) Household expenditure microdata:
"Encuesta Nacional de Gasto de los Hogares 1996/97" *(National Household Expenditure Survey).* Coverage: Metropolitan Area only (Great Buenos Aires). The distributions of energy goods (electricity, natural gas, LPG, vehicular NG, gasolines and gas oil) consumption across households were estimated retrieving quantities from household expenditure and current average prices for the time of the survey. Public transport expenditures (urban and inter-urban railroad and road transport) expenditure was also retrieved from the micro-data.

2) Energy consumption:
a. ***Liquid fuels (Standard, Special and Premium Gasoline, Gas Oil, Diesel Oil, Kerosene, LPG, Jet Fuels)***: aggregate sales to domestic market were collected from the "Tablas dinámicas" database, prepared by the Argentine Secretaría de Energía (Secretary of Energy[42]).
b. ***Electricity:*** Electricity consumption data were gathered from the Secretary of Energy's Historical Electricity Data Base[43] and the electricity wholesale market operator's (CAMMESA) "Informe Anual 2010"[44].
c. ***Natural Gas:*** Natural gas consumption data were collected from the ENARGAS ("Ente Nacional Regulador del Gas") Operative Statistics data base[45].

Memo items: Biomass quantities were estimated from the Argentine National Energy Balances[46] and other secondary sources.

3) Energy prices:
a. ***Liquid fuels (Standard, Special and Premium Gasoline, Gas Oil, Diesel Oil, Kerosene, LPG, Jet Fuels)***: end-user domestic market prices were collected from the "Tablas dinámicas" base, prepared by the Argentine Secretaría de Energía (Secretary of Energy, see footnote 1). Import parities and ex-refinery values were obtained from Montamat y Asociados[47].
b. ***Electricity:*** For consumer prices, we used the wholesale market seasonal prices including the corresponding taxes. Regarding producer prices, we estimated the annual deficit of the wholesale market operator and added it to the wholesale market price.
c. ***Natural Gas:*** Consumer prices are reference basin prices established by Secretaría de Energía (according to Resolutions 1070/2008 and 1417/2008) and also include

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[42] *http://energia3.mecon.gov.ar/contenidos/verpagina.php?idpagina=3300*
[43] *http://energia3.mecon.gov.ar/contenidos/verpagina.php?idpagina=3140*
[44] *http://portalweb.cammesa.com/MEMNet1/Documentos%20compartidos/VAnual10.pdf*
[45] *http://www.enargas.gov.ar/DatosOper/Indice.php*
[46] *http://energia3.mecon.gov.ar/contenidos/verpagina.php?idpagina=3366*
[47] *http://www.montamat.com.ar/*

the corresponding (annual average) fee due to the Bolivian Natural Gas Imports Trust Fund created by National Government Decree n° 2067/2008.

***Memo items**:* Biomass prices have been estimated from commercial sources.

4) Environmentally Related Taxes:

a. ***Liquid Fuels and Natural Gas Excise Tax***: In August 1991, the Argentine Congress passed the Law nº 23.966[48] (*Impuesto sobre Combustibles Líquidos y Gas Natural*, henceforth ICLG), which imposes a levy upon domestic transactions -sales or donations- involving liquid fuels and several other hydrocarbon derivatives. Specific tax rates are 70% for Standard Gasoline; 62% for Special, Premium and Natural Gasolines, and Virgin Naphtas; 19% for Kerosene, Diesel Oil and Fuel Oil; and 16% for Vehicle Natural Gas (GNC). The main source for ICLG Revenues for the year 2009 is the Ministry of Economy[49].

b. ***Motor Vehicle Excises***: Under the Argentine Federal Regime, Provinces tipically levy taxes on vehicle ownership. Tax rates and payment schemes vary according to provinces. In particular, tax rates are also heterogeneous among vehicles, depending upon make and model, year of registration, weight, origin, specific purpose, etc. Aggregate (nation-wide) motor vehicle excise revenues were calculated in CIAT (2010): *"Observatorio de la Recaudación Tributaria nº 4"*.

c. ***Motor Vehicle and Vehicle parts Tariffs***: Motor vehicles (and its components as well) are subject to customs duties as long as they come from outside MERCOSUR (trade between common market partners is exempt). Revenues in this category were estimated based on COMTRADE imports statistics and MERCOSUR's common external tariffs for the corresponding chapters of the Harmonized System.

BOLIVIA

1) Household expenditure microdata:

"Encuesta de Hogares 2009" *(Household Living Conditions Survey).* Coverage: Country-wide. The distributions of energy goods consumption across households (electricity, LPG, natural gas, biomass, gasolines and diesel oil) were estimated retrieving quantities from household expenditure in fuel used for cooking purposes and current average prices for the time of the survey. Public transport (urban and inter-urban railroad and road transport) expenditure was also retrieved from the micro-data.

2) Energy consumption data:

a. ***Liquid fuels (Special and Premium Gasoline, Diesel Oil, Kerosene, LPG, Jet Fuels, Vehicular NG)***: aggregate sales to domestic market were gathered from the "Anuario

[48] *http://infoleg.gov.ar/infolegInternet/verNorma.do?id=365*

[49] *http://www.mecon.gov.ar/sip/basehome/dir1.htm*

Estadístico[50]" report series, prepared by the Bolivian Agencia Nacional de Hidrocarburos (National Hydrocarbons Agency).
b. ***Electricity:*** Domestic market electricity consumption data were collected from the "Anuario Estadístico[51]" report series published by the Bolivian "Superintendencia de Electricidad"
c. ***Natural Gas:*** Domestic market natural gas consumption data were obtained from the "Anuario Estadístico" report series (see footnote 9).

Memo items: Biomass quantities were estimated from the Bolivian National Energy Balances[52] prepared by "Ministerio de Hidrocarburos y Energía" (Ministry of Hydrocarbons and Energy).

3) Energy prices data:
a. ***Liquid Fuels (Special and Premium Gasoline, Diesel Oil, Kerosene, LPG, Jet Fuels, Vehicular NG)***: domestic market consumer prices are those sanctioned by Resolución Administrativa n° 1558/2010 of the Bolivian Agencia Nacional de Hidrocarburos (National Hydrocarbons Agency). Producer prices were calculated using INE[53] (Instituto Nacional de estadísticas) trade statistics and other official sources.
b. ***Electricity:*** For consumer prices, we used the wholesale market seasonal prices including the corresponding taxes. See "Comité Nacional de Despacho de Carga" (CNDC[54]) website.
c. ***Natural Gas:*** Consumer prices were obtained from the national YPFB "Boletín Estadístico" Report Series[55].

*Memo items:*Biomass consumer prices were collected from commercial sources.

4) Environmentally Related Taxes:
a. ***Hydrocarbons Special Tax****:* Law 843 (1997) created the "*Impuesto Especial a los Hidrocarburos y Derivados*" which taxes imports and domestic sales of liquid fuels and several other hydrocarbon derivatives. Specific tax rates in local currency units per liter are determined periodically by Bolivian *Superintendencia de Hidrocarburos* (hydrocarbons regulatory authority). LPG and residential kerosene are exempt from the tax. The main source for IEHD revenues for the year 2009 is the Bolivian National Tax System (SIN[56]).
b. ***Motor Vehicle Excises***: Law 843 also created the "*Impuesto a la Propiedad de Vehículos Automotores*", which taxes motor vehicle ownership. As usual, tax rates vary

[50] *http://www.anh.gob.bo/index.php?option=com_content&view=category&layout=blog&id=939&Itemid=69*
[51] *http://www.ae.gob.bo/node/70*
[52] *http://www.hidrocarburos.gob.bo/sitio/index.php?option=com_docman&Itemid=136*
[53] *http://apps.ine.gob.bo/comex/Main*
[54] *www.cndc.bo/home/index.php*
[55] *http://www.ypfb.gob.bo/index.php?option=com_content&view=article&id=169&Itemid=166*
[56] *http://impuestos.gob.bo/*

according to several motor vehicle characteristics. The source for these tax revenues for 2009 is the *Registro Único para la Administración Tributaria Municipal* (RUAT[57]).
c. ***Motor Vehicle and Vehicle parts Tariffs***: We considered tariffs corresponding to transport material (Chapter 87, Harmonized System) imports. Revenue data in this category were collected from *Aduana Nacional de Bolivia* (Bolivian Customs[58]).

URUGUAY

1) Household expenditure Microdata:
"Encuesta Nacional de Gasto e Ingresos de los Hogares 2005-2006" *(National Household Expenditure Survey).* Coverage: Country-wide. The distributions of energy goods consumption across households (electricity, LPG, kerosene, biomass, gasolines and diesel oil) were estimated retrieving quantities from household expenditure in energy goods and current average prices for the time of the survey. Public transport (urban and inter-urban railroad and road transport) expenditure was also retrieved from the micro-data.

2) Energy consumption data:
a. ***Liquid Fuels (Special, Super and Premium Gasoline, Gas Oils, Kerosene, LPG, Jet Fuels)***: aggregate sales[59] to domestic market were collected from the Uruguayan Dirección Nacional de Energía (DNE, National Energy Authority).
b. ***Electricity:*** Domestic market electricity consumption[60] was also gathered from DNE.
c. ***Natural Gas:*** Domestic market annual natural gas consumption[61] data are those informed by DNE in its webpage.

Memo items: Biomass quantities were estimated from the Uruguayan National Energy Balances[62] prepared by DNE.

3) Energy prices data:
a. ***Liquid Fuels (Special, Super and Premium Gasoline, Gas Oils, Kerosene, LPG, Jet Fuels)***: average domestic prices[63] (by city and fuel) were collected from the DNE site.
b. ***Electricity:*** For consumer prices, we used the wholesale market seasonal prices including the corresponding taxes, available at the wholesale market operator ADME webpage[64].
c. ***Natural Gas:*** Energy Component in tariff schedules were collected from the distribution firms' websites: GASEBA[65] and CONECTA[66].

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57 *http://www.ruat.gob.bo/*
58 *http://www.aduana.gob.bo/*
59 *http://www.miem.gub.uy/portal/agxppdwn?5,6,245,O,S,0,545%3BS%3B1%3B159*
60 *http://www.miem.gub.uy/portal/agxppdwn?5,6,249,O,S,0,568%3BS%3B1%3B163*
61 *http://www.miem.gub.uy/portal/hgxpp001?5,6,246,O,S,0,MNU;E;72;4;76;1;MNU*;
62 *http://www.miem.gub.uy/portal/hgxpp001?5,6,235,O,S,0,MNU;E;72;1;73;2;MNU*
63 *http://www.miem.gub.uy/portal/hgxpp001?5,6,240,O,S,0,MNU;E;72;2;75;1;MNU*;
64 *http://adme.com.uy/*
65 *http://www.montevideogas.com.uy/cathome_30_1.html*

Memo items: Biomass prices have been estimated from commercial sources.

4) Environmentally Related Taxes:

a. ***Specific Domestic Tax (IMESI)***: this levy taxes domestic sales and imports of liquid fuels (gasolines, jet fuels, kerosene, diesel and gas oil). Specific tax rates are determined periodically by the Uruguayan Executive Branch. Liquid fuels pricing policy is set by the *Administración Nacional de Combustibles, Alcoholes y Portland* (ANCAP[67]), which is the primary source of prices and taxes data for this study.

b. ***Motor Vehicle Excises***: Motor vehicle excises are collected by Subnational Governments, and as in the other two countries tax rates are variable. Aggregate revenue data for the year 2009 were collected from the Uruguayan Ministry of Economy and Finance[68].

c. ***Motor Vehicle and Vehicle parts Tariffs***: As in the case of Argentina, revenues in this category were estimated based on COMTRADE imports statistics and MERCOSUR's common external tariffs for the corresponding chapters of the Harmonized System.

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[66] *http://www.conecta.com.uy/tarifas.php*

[67] *http://www.ancap.com.uy/*

[68] *http://www.mef.gub.uy/portada.php*

Annex C

Estimation of environmental damages attributable to energy products

Overview of the method

As energy products (EP) is responsible for the direct emission and secondary formation of several pollutants, local air pollution and global climate changes are among the main negative externalities associated to their use. To estimate the social costs of these externalities, the methodology applied in this study follows what is known by policy analysts as "integrated assessment", using a "damage function" approach. It is a multidisciplinary, multi-step modeling process, involving injury determination, quantification of effects, and damage determination, using data and models drawn from government institutions and the academic literature. Injury determination links the injury to the release of pollutants; quantification of effects determines in physical terms the reduction in natural resources services; and damage determination involves valuing the injury in monetary terms.

The method adopted estimates the magnitude of the damages attributable to different EP and activity sectors. This is a major difference with the few previous aggregate (Cifuentes et al 2005, Conte Grand et al 2002) or sectoral (Rizzi 2008) studies on Latin American countries, and a very relevant one for environmental taxation purposes.

The approach employed in this work for the three countries studied parallels a simple but robust method developed by the World Bank in collaboration with the World Health Organization and the Pan American Health Organization (Lvovsky et al, 2000). This method allows the assessment of EP-consumption related environmental costs relatively fast and reasonable, even if the local information is incomplete.

The first step in the process of valuation of environmental effects is to attribute emissions of different pollutants to the use of each EP (each EP consumed by each economic sector). Pollutants considered are PM10, SO2, NOX and CO2, and except for PM10, this information is provided (or can be estimated) by the national reports submitted to the United Nations Framework Convention on the Climate Change (UNFCCC) containing emissions inventory of Greenhouse Gases –GHG- (Fundación Bariloche 2005, SEADS 2008, MMAyA 2009, MVOTMA 2010). As regards to PM10 emissions, not included in the emissions inventories, the approach suggested is through standard emissions factors applied to the amount of a particular EP consumed by each category of sources within a sector. It requires disaggregated information of consumption of EP (including quality specifications) contained in the energy balance sheets of each country and/or the emissions inventories.

The following step to assess responsibility for local environmental damage to the use of each EP by sector is to estimate to what extent the respective emissions contribute to the deterioration of air quality, taking into account exposure levels. To do so, a simple dispersion model with limited data requirements (climate conditions and area) is adopted. Given the local character of these damages, estimations are focused on major urban cities. To do so, the dispersion model must be run with the emissions generated at these centers, which are approximated[69] through the estimated respective consumption of EP (car fleet, population, power plants, etc.).

Given the changes in air quality attributable to different EP, different categories of damages can be assessed. The effects of local air pollution due to the use of EP are diverse and numerous, but the ones of highest concern are the adverse consequences they can have for the health of human beings. Non-health damages include reduction of visibility, soiling and material damage.

To calculate health impacts, it is applied the "avoided costs" methodology which has been broadly used in environmental economic valuation studies in the world (World Bank 1994; EPA 1999; EC 1999; Cesar et al 2000; Lvovsky et al 2000; Cifuentes et al 2005; Rizzi 2008, among others). It starts with the application of the doses-response (D-R) functions that link variations in the concentration of pollutants in the air to probable impacts on health (premature mortality, respiratory affections, etc.). While it would be ideal to use local D-R functions, the very few epidemiological studies in developing countries causes that D-R functions of international studies are adopted (e.g., Schwartz 1993; Pope 2004). The application of selected D-R functions (for the values of changes in the concentration of pollutants attributable to each EP) to the demographic data of the countries studied, makes it possible to estimate cases of premature deaths and the occurrence of various pathologies associated with these pollutants.

Converting health impacts to economic values requires the use of unit economic values for mortality and morbidity. For the former, the Value of a Statistical Life can be measured using the Human Capital (HC) approach (present value of earnings lost as a result of premature death) or alternatively by the Willingness to Pay (WTP) of a population to reduce certain types of risk to which it is exposed, based on contingent valuation or hedonic pricing[70]. For morbidity, its valuation can also be based on the approach of the WTP to avoid symptoms caused by pollution related illnesses, or alternatively, on the Cost of Illness (CI), which include basically health care costs and productivity losses until the recovery (or death)[71]. Given that HC and CI approaches capture only partially the unit economic values for mortality and morbidity, it is adopted WTP of avoiding different risks. When national measures of WTP are not available, as it is the situation for the countries studied, it is usual to "transfer" U.S. and European estimations adjusted by the relative GDP per capita and WTP-income elasticity.

With regard to the valuation of the local damage other than health, such as damage to buildings, dirt from clothing and monuments, reducing visibility, etc., the lack of local estimations makes it also usual the "transference" of WTP values obtained in other

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[69] The emissions inventories correspond to the national level.

[70] The former is considered a lower bound of the latter since it uses foregone future incomes as the valuation vehicle, but does not include the subjective value people assign to life (in terms of consumption, leisure, etc.). In fact, studies in the United States suggest that WTP estimates are 8 to 20 times those under the HC approach (Viscusi, 1993).

[71] Again, CI is considered a lower bound of WTP as the former only includes the price reduction of getting health (Azqueta, 1994).

studies, which are expressed in a certain amount per unit change in the concentration of a particular pollutant, adjusted by differences in GDP per capita and WTP-income elasticity for environmental goods.

In addition to local environmental impacts, the use of EP has effects on global climate change, which generates potential damages in the long run, although there is still great uncertainty about its scope and consequences. In spite of this, most studies adopt a global damage function used to derive a corresponding shadow price of marginal CO2 emissions, but with a wide range of values (Parry and Strand 2010). Based on a lower to central marginal damage cost per metric ton carbon, and taking into account CO2 emissions associated with each EP, it is possible to estimate the value of the global damage per unit of EP consumed.

The aggregation of health, non-health and global damages allows estimating the magnitude of the environmental damages attributed to different EP (per unit of use) and activity sectors.

Estimating the environmental damage for Uruguay, Argentina and Bolivia

<u>Emissions</u>: In the cases of Uruguay and Argentina, for each EP use, the model employs the emissions of CO2, NOX and SO2 by source from the last emissions inventory submitted to the UNFCCC, corresponding to years 2004 and 2000, respectively (MVOTMA, 2010; Fundación Bariloche, 2005). The same studies report the consumption of each EP by different sources. Standard emissions factors for PM10 compiled from the literature (Table AC1, at the end of this Annex) are used to estimate particulates emissions (PM10). As in most cases these emissions factors depend on EP quality (ashes and sulfur content), technical information from national authorities (ANCAP, 2011; Secretaría de Energía, 2006) has been obtained for the quality data required.

Last emissions inventory presented by the Government of Bolivia corresponds to years 2002 and 2004 (MMAyA 2009), but it releases too aggregate data for the purpose of this study. Even when the previous inventory -for year 2000- (Ministerio de Desarrollo Sostenible y Planificación, 2003) does not present the full detailed information required -i.e., emissions of CO2, NOX and SO2 by source and EP, and consumption of each EP by different sources-, it has been possible to get reasonable estimations using additional information, mainly provided by the energy balance sheet. As in the estimates for Uruguay and Argentina, standard emissions factors (Table AC1) were used to calculate PM10 emissions, while technical information on EP quality was obtained from the inventory.

National results on emissions and consumption are adjusted to estimate the corresponding ones to Montevideo (Uruguay), Buenos Aires (Argentina) and La Paz (Bolivia). Data of geographical GDP is used as factor adjustment on Industry and Commerce, percentage of housings for Residential, and percentage of vehicle fleet for Transport. Tables C1U (Uruguay), C1A (Argentina) and C1B (Bolivia) show the estimated emissions of CO2, NOX, SO2 and PM10 by source and EP (rows 2 to 5), and the consumption of different EP by source (row 6).

Table C1U. Montevideo: EP Consumption, Emissions and Changes in Concentration of Pollutants								
	Emissions from EP use (kton)				Consump.	Changes in Concentration (ug/m³)		
Sources	CO2	NOX	SO2	PM10	(kton)	NOX	SO2	PM10
Transport Use								
Gasoline	324,36	2,72	0,43	0,08	106,47	6,76	1,06	0,49
Gas oil	521,34	6,69	2,65	1,98	164,82	16,62	6,58	5,78
Commercial Use								
LPG (Supergas)	0,33	0,00		0,00	0,11	0,00	0,00	0,00
LPG (Propane Gas)	4,45	0,00		0,00	1,53	0,01	0,00	0,00
Manufactured Gas	2,87	0,00		0,00	0,81	0,01	0,00	0,00
Querosene	0,19	0,00	0,00	0,00	0,06	0,00	0,00	0,00
Gas oil	54,15	0,05	0,28	0,18	18,00	0,12	0,70	0,47
Fuel oil	14,75	0,03	0,28	0,01	4,69	0,08	0,70	0,04
Natural Gas	14,75	0,03		0,01	4,55	0,02	0,00	0,00
Wood		0,03	0,28	0,01	7,16	0,03	0,07	0,13
Residential Use								
LPG (Supergas)	91,81	0,07		0,00	31,90	0,17	0,00	0,01
LPG (Propane Gas)	0,75	0,00		0,00	0,26	0,00	0,00	0,00
Manufactured Gas	3,46	0,00		0,00	0,98	0,01	0,00	0,00
Querosene	10,31	0,01	0,01	0,01	3,29	0,02	0,03	0,03
Gas oil	1,25	0,00	0,02	0,00	0,42	0,00	0,04	0,01
Fuel oil	35,50	0,08	0,68	0,02	11,30	0,19	1,69	0,10
Natural Gas	35,50	0,08		0,02	3,78	0,01	0,00	0,00
Wood		0,08	0,68	0,02	450,21	1,39	4,49	8,02
Coal	7,67	0,01	0,00	0,00	0,43	0,00	0,00	0,03
Industrial (and Construction) Use								
LPG (Supergas)	2,11	0,00		0,00	0,73	0,00	0,00	0,00
LPG (Propane Gas)	5,18	0,01		0,00	1,78	0,00	0,00	0,00
Gasoline	0,42	0,00	0,00	0,00	0,14	0,00	0,00	0,00
Natural Gas	99,78	0,07		0,00	49,18	0,03	0,00	0,00
Querosene	1,97	0,00	0,00	0,00	0,63	0,00	0,00	0,00
Gas oil	16,22	0,01	0,09	0,04	5,39	0,01	0,04	0,02
Fuel oil	260,15	0,57	5,03	0,55	83,31	0,23	2,05	0,29
Petroleum Coke	2,45	0,00	0,02	0,02	0,85	0,00	0,01	0,01
Coal	2,58	0,01	0,02	0,02	0,83	0,00	0,01	0,01
Manufactured Gas	2,58	0,01		0,02	0,06	0,00	0,00	0,00
Wood		0,01	0,02	0,02	249,86	0,07	0,41	0,73
Other solid biomass	14,35	0,06	0,00	0,00		0,03	0,03	0,00
Oil Refinery Use								
Fuel oil	117,26	0,26	2,26	0,25	37,55	0,10	0,92	0,07
Gas oil	3,72	0,00	0,02	0,01	1,24	0,00	0,01	0,00
LPG (Supergas)	1,32	0,00		0,00	0,44	0,00	0,00	0,00
Natural Gas	19,76	0,09		0,00	8,84	0,03	0,00	0,00
Gas Fuel	180,53	0,16		0,00	51,13	0,07	0,00	0,00
Refinery Gas	93,64		5,91	0,00	26,52	0,00	2,41	0,07
Gas Plant								
Gasoline	0,61		0,00	0,00	0,19	0,00	0,00	0,00
Power Plant Use								
Gas oil	258,63	1,10	1,31	0,10	86,51	0,17	0,20	0,01
Fuel oil	635,85	1,77	12,28	0,23	203,63	0,27	1,87	0,08

Source: authors' calculations based on MVOTMA (2010) and Lvovsky (2000)

<u>From emissions to changes in air quality</u>: To establish the link between the absolute change in ambient concentrations of pollution and the emissions from each sector, the dispersion model proposed by Lvovsky et al (2000) was applied, which takes into account the height emissions are released, meteorological data (wind speed and

atmospheric stability) and the area of each city[72]. In this study, residential, institutional, commercial and transport users are considered low level sources; industries as medium level sources and energy industries as high level sources. Tables C1U, C1A and CIB (rows 7 to 9) illustrate the contribution of different EP uses to changes in ambient conditions for the cities studied, measured by variations in the concentration of different local pollutants in the air (ug/m^3).

Table C1A. Buenos Aires: EP Consumption, Emissions and Changes in Concentration of Pollutants

Sources	Emissions from EP use (kton)				Consump. (kton)	Changes in Concentration (ug/m³)		
	CO2	NOX	SO2	PM10		NOX	SO2	PM10
Transport Use								
Gasoline	1528,65	14,07	0,32	0,36	506,86	32,17	0,72	1,82
Diesel oil	3266,10	32,60	2,29	10,39	1039,01	74,54	5,24	26,15
Diesel oil (train)	56,55	1,38	0,04	0,17	16,50	3,16	0,09	0,47
Natural Gas	487,95	3,33	0,00	0,01	241,72	7,61	0,00	0,25
Commercial Use								
LPG	15,20	0,02	0,00	0,00	5,27	0,04	0,00	0,00
Diesel oil	49,40	0,04	0,04	0,10	15,69	0,10	0,08	0,24
Fuel oil	21,40	0,05	0,07	0,01	6,80	0,11	0,16	0,03
Natural Gas	540,80	0,44	0,00	0,01	267,65	1,00	0,00	0,05
Residential Use								
LPG	289,10	0,22	0,00	0,00	100,55	0,50	0,00	0,03
Querosene	26,80	0,02	0,02	0,03	8,46	0,05	0,04	0,06
Natural Gas	1397,60	1,18	0,00	0,03	691,83	2,69	0,00	0,14
Wood	89,90	0,11	0,39	0,58	83,33	0,26	0,89	1,37
Coal	76,30	0,08	0,00	0,64	25,20	0,18	0,00	1,47
Industrial (and Construction) Use								
LPG	6,08	0,01	0,00	0,00	2,11	0,00	0,00	0,00
Natural Gas	1041,20	1,33	0,00	0,02	422,78	0,54	0,00	0,02
Diesel oil	20,88	0,04	0,02	0,04	6,04	0,02	0,01	0,02
Fuel oil	74,40	0,16	0,24	0,14	21,36	0,07	0,10	0,06
Coal coke	16,48	0,05	0,00	0,09	3,69	0,02	0,00	0,04
Coal	11,60	0,00	0,07	0,11	4,34	0,00	0,03	0,05
Refinery Gas	5,84	0,00	0	0,00	2,43	0,00	0,00	0,00
Wood	30,96	0,03	0,14	0,10	13,63	0,01	0,06	0,04
Energy industries								
Diesel Oil	34,60	0,16	0,03	0,03	9,80	0,03	0,00	0,01
Fuel oil	278,70	0,58	0,88	0,19	52,47	0,10	0,15	0,04
LPG	1,00	0,00	0,00	0,00	0,36	0,00	0,00	0,00
Natural Gas	2964,80	4,37	0,00	0,05	1467,59	0,74	0,00	0,03
Coal	130,20	0,31	0,57	1,24	48,57	0,05	0,10	0,21
Refinery Gas	119,70	0,00	0,00	0,00	49,83	0,00	0,00	0,00
Wood	1334,00	0,01	0,58	0,87	123,70	0,00	0,10	0,15

Source: authors' calculations based on Fundación Bariloche (2005) and Lvovsky (2000).

[72] Following Lvovsky et al (2000), as SO2 and NOX also contribute to ambient levels of fine particulates, PM10 concentrations were increased by 3% and 4% of SO2 and NOX concentrations, respectively.

Table C1B. La Paz: EP Consumption, Emissions and Changes in Concentration of Pollutants								
	Emissions from EP use (kton)				Consump. (kton)	Changes in Concentration (ug/m³)		
Sources	CO2	NOX	SO2	PM10		NOX	SO2	PM10
Transport Use								
Gasoline	171,19	1,64	0,15	0,04	56,22	23,97	2,16	1,62
Diesel oil	222,09	2,39	0,38	0,84	70,24	34,91	5,48	13,88
Natural Gas	6,66	0,05	0,00	0,00	3,31	0,67	0,00	0,03
Residential and Commercial Use								
Natural Gas	1,96	0,00	0,00	0,00	0,97	0,02	0,00	0,00
LPG	70,19	0,11	0,00	0,00	24,17	1,55	0,00	0,08
Querosene	2,99	0,00	0,00	0,00	0,95	0,04	0,06	0,02
Gasoline	0,86	0,01	0,00	0,00	0,28	0,12	0,01	0,01
Wood		0,14	0,34	0,53	75,91	2,11	4,93	8,00
Industrial (and Construction) Use								
Natural Gas	111,14	0,19	0,00	0,00	55,22	0,09	0,00	0,00
Coal	1,20	0,00	0,00	0,01	0,45	0,00	0,00	0,00
Petroleum Coke	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Lubricants	0,18	0,00	0,00	0,00	0,12	0,00	0,00	0,00
Paraffin	3,70	0,00	0,00	0,00	2,12	0,00	0,00	0,00
LPG	1,32	0,00	0,00	0,00	0,45	0,00	0,00	0,00
Fuel oil	0,08	0,00	0,00	0,00	0,02	0,00	0,00	0,00
Diesel oil	16,73	0,01	0,03	0,01	5,29	0,01	0,01	0,00
Querosene	2,64	0,00	0,00	0,00	0,84	0,00	0,00	0,00
Gasoline	2,63	0,03	0,00	0,00	0,86	0,01	0,00	0,00
Biomass		0,35	0,16	1,76	251,85	0,16	0,07	0,82
Energy Industries								
Natural Gas	150,53	0,39	0,00	0,00	74,79	0,03	0,00	0,00
Liquid Fuel Refinery	2,18	0,01	0,00	0,00	0,62	0,00	0,00	0,00
Refinery Gas	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Lubricants	0,02	0,00	0,00	0,00	0,01	0,00	0,00	0,00
LPG	0,02	0,00	0,00	0,00	0,01	0,00	0,00	0,00
Diesel oil	7,17	0,06	0,01	0,00	2,27	0,00	0,00	0,00
Querosene	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Gasoline	0,48	0,00	0,00	0,00	0,16	0,00	0,00	0,00
Biomass		0,04	0,05	0,09	13,07	0,00	0,00	0,01
Mining and Metallurgy								
LPG	0,26	0,00	0,00	0,00	0,09	0,00	0,00	0,00
Fuel oil	0,02	0,00	0,00	0,00	0,01	0,00	0,00	0,00
Diesel oil	3,84	0,01	0,01	0,00	1,21	0,00	0,00	0,00
Querosene	0,05	0,00	0,00	0,00	0,01	0,00	0,00	0,00
Gasoline	0,34	0,00	0,00	0,00	0,11	0,00	0,00	0,00

Source: authors' calculations based on Ministerio de Desarrollo Sostenible y Planificación (2003) and Lvovsky (2000).

Health effects of air pollution: To measure the health impacts of changes in air pollution attributed to different EP and uses, dose-response functions (Table AC2) - which relate variations in the concentration of pollutants in the air (last three rows of Tables C1U, C1A and C1B) to probable impacts on health- are applied to the demographic parameters of Montevideo, Buenos Aires and La Paz. Respective results are shown in Tables C2U, C2A and C2B (row 2). For valuation purposes, the base monetary parameters for each health effect adopted (row 3) are those suggested by Lvovsky et al (2000) and unitary income elasticity is assumed. Tables C2U, C2A and C2B illustrate the unit values for each health effect corresponding to the three cities assessed (row 4) and the health costs due to EP use (row 5).

Table C2U. Montevideo: Health effects and costs from EP use				
	Cases (Population: 1,34 mill.)	WTP (Unit value in USD) for GDP USD 1000	WTP (Unit value in USD) for Montevideo GDP (USD 12000)	Health costs (000 USD)
Premature deaths	134	74.346	892.152	119.179
Chronic bronchitis	520	8.949	107.389	55.888
Respiratory hospital admissions	212	194	2.327	493
Asthma attacks	28802	3	35	999
Emergency room visits	4160	6	69	289
Restricted activity days	782341	2	29	22.835
Lower respiratory illnesses in children	6868	2	24	166
Respiratory symptoms	2489886	2	24	60.333
Cough days	104	2	24	3
Chest discomfort days	192997	2	28	5.314
Total (000 USD)	265.499			

Source: authors' calculations based on Table C1U, local information and Lvovsky (2000).

Table C2A. Health effects and costs from EP use				
	Cases (Population: 2,89 mill.)	WTP (Unit value in USD) for GDP USD 1000	WTP (Unit value in USD) for Buenos Aires GDP (USD 11000)	Health costs (000 USD)
Premature deaths	604	74.346	817.806	494.356
Chronic bronchitis	2231	8.949	98.440	219.623
Respiratory hospital admissions	909	194	2.133	1.939
Asthma attacks	123473	3	32	3.927
Emergency room visits	17832	6	64	1.134
Restricted activity days	3353858	2	27	89.734
Lower respiratory illnesses in children	29444	2	22	654
Respiratory symptoms	10674017	2	22	237.092
Cough days	75	2	22	2
Chest discomfort days	138216	2	25	3.489
Total (000 USD)	1.051.948			

Source: authors' calculations based on Table C1A, local information and Lvovsky (2000).

Table C2B. La Paz: Health effects and costs from EP use				
	Cases (Population: 0,79 mill.)	WTP (Unit value in USD)		Health costs (000 USD)
		for GDP USD 1000	for La Paz GDP (USD 2000)	
Premature deaths	104	74.346	148.692	15.455
Chronic bronchitis	385	8.949	17.898	6.883
Respiratory hospital admissions	186	194	388	72
Asthma attacks	25212	3	6	146
Emergency room visits	3641	6	12	42
Restricted activity days	578089	2	5	2.812
Lower respiratory illnesses in children	9149	2	4	37
Respiratory symptoms	1839830	2	4	7.430
Cough days	51	2	4	0
Chest discomfort days	52320	2	5	240
Total (000 USD)	33.117			

Source: authors' calculations based on Table C1B, local information and Lvovsky (2000).

<u>Local non health damage</u>: Valuation of non health effects for local population is based on WTP (expressed per person and ug/m3) estimated through several international studies (Lvovsky et al, 2000). These values are shown in the first panels of Tables C3U, C3A and C3B and correspond to US income level of 1990 (USD 21790).

Table C3U. Montevideo: Nonhealth local damage from EP use				
Base values for nonhealth local effects (for a GDP of USD 21790) per person per ug/m3 (USD)				
	Total	Visibility	Soiling	Corrosión
PM10		1,448	0,905	
SO2				0,45
NOX				0,2
Montevideo: Base values for nonhealth local effects per ug/m3 (000 USD)				
	Total	Visibility	Soiling	Corrosión
PM10	1784	1073	712	
SO2	411			411
NOX	183			183
Montevideo: Nonhealth local costs from EP use (000 USD)				
	Total	Visibility	Soiling	Corrosión
PM10	29298	17613	11685	0
SO2	9567	0	0	9567
NOX	4833	0	0	4833
Total (000 USD)	43698			

Source: authors' calculations based on Table C1U, local information and Lvovsky (2000).

Panels 2 of the same Tables illustrate these international values adjusted to the population and GDP of the cities considered, assuming the following income elasticities: for visibility, 1; for soiling, 0.9 and for corrosion, 0.65. Applying these values per ug/m3 of each pollutant to the respective changes in their concentrations attributed to EP use, the estimated local non health damages are obtained.

Table C3A. Nonhealth local damage from EP use				
Base values for nonhealth local effects (for a GDP of USD 21790) per person per ug/m3 (USD)				
	Total	Visibility	Soiling	Corrosión
PM10		1,448	0,905	
SO2				0,45
NOX				0,2
Buenos Aires: Base values for nonhealth local effects per ug/m3 (000 USD)				
	Total	Visibility	Soiling	Corrosión
PM10	3526	2113	1414	
SO2	834			834
NOX	371			371
Buenos Aires: Nonhealth local costs from EP use (000 USD)				
	Total	Visibility	Soiling	Corrosión
PM10	115535	69215	46320	0
SO2	6475	0	0	6475
NOX	45961	0	0	45961
Total (000 USD)	52436			

Source: authors' calculations based on Table C1A, local information and Lvovsky (2000).

Table C3B. La Paz: Nonhealth local damage from EP use				
Base values for nonhealth local effects (for a GDP of USD 21790) per person per ug/m3 (USD)				
	Total	Visibility	Soiling	Corrosión
PM10		1,448	0,905	
SO2				0,45
NOX				0,2
La Paz: Base values for nonhealth local effects per ug/m3 (000 USD)				
	Total	Visibility	Soiling	Corrosión
PM10	188	105	83	
SO2	75			75
NOX	33			33
La Paz: Nonhealth local costs from EP use (000 USD)				
	Total	Visibility	Soiling	Corrosión
PM10	4609	2570	2039	0
SO2	959	0	0	959
NOX	2132	0	0	2132
Total (000 USD)	7.699			

Source: authors' calculations based on Table C1B, local information and Lvovsky (2000).

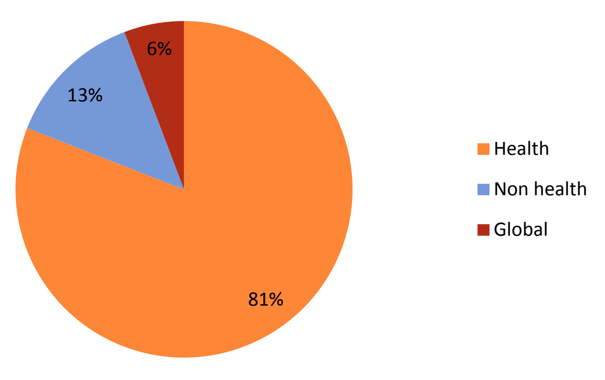
Global damage: As pointed before, estimations of the shadow price of marginal CO2 emissions are controversial, and it means a wide range of values calculated. Parry and Strand (2010) refer that most studies use market discount rates and damages estimated are around USD 5- USD 20/ton of carbon, but damages that emerge from studies that use below market rates, are in the order of USD 80/ton of carbon. In this study, the extreme value of USD 20/ton is adopted, which nevertheless seems conservative when considering a non market discount rate. Given this value and the C content of different EP, it is estimated the global damage per ton associated to each one (Table AC3).

Total damage: As valuation of local damages estimated through the methodological approach adopted in this study are associated to changes in the concentration of different local pollutants, and it has also been estimated the variation in air quality attributed to each EP use, it is possible to calculate local damage by EP and by sector. (For an illustrating case, see Box C1). Concerning to global damage, the damage costs per unit of EP (Table AC3) applied directly to EP use data allows also the estimation of global damage due to each EP and sector.

- Uruguay

Table C4U shows that the social costs of environmental impacts assessed in this study for Montevideo City total USD 328 million, 0.9% of GDP of Uruguay or 2% of the local GDP. Health damages account for the largest portion of total costs (81%), while local non health damages represent 13% and global damage 6% (Figure C1U).

Figure C1U. Montevideo: Environmental damages from EP use, by damage category (%)



Source: authors' calculations based on Table C4U

Box C1. Illustrating estimates: gas oil for transport use in Uruguay

As for gas oil used by vehicles in Uruguay -to illustrate how to arrive at the exact costs-, the 2004 emissions inventory reports that the 445 kton of this fuel consumed are responsible for the release of 18.07 kton of NOX and 7.15 kton of SO2. Applying the PM10 emission factor (Table CA1) corresponding to Diesel engine suggested by Lvovsky et al (2000) to the amount of gas oil consumed yields 5.35 kton of emissions of PM10. As these figures correspond to the whole country, they were adjusted to estimate the corresponding ones to Montevideo City according to the share of the fleet (cars and trucks) with diesel engines registered in that area out of the nationwide total (37%). This procedure gives the estimates of emissions of NOX, SO2, PM10 and consumption of gas oil (transport sector) for Montevideo City of 6.69 kton, 2.65 kton, 1.98 kton and 165 kton, respectively, shown in Table C1U.

To establish how these emissions of pollutants contribute to their concentration in the air of Montevideo, the dispersion model proposed by Lvovsky et al (2000) with the coefficients corresponding to low level sources was applied*. The resulting PM10 concentrations were increased by 3% and 4% of SO2 and NOX concentrations, respectively, to take into account that SO2 and NOX also contribute to ambient levels of fine particulates. According to this methodology, gas oil burned by vehicles in Montevideo causes 16.6 ug/m^3 of ambient level concentration of NOX, 6.6 ug/m^3 of SO2 and 5.8 ug/m^3 of PM10 (last rows of Table C1U).

The application of the dose-response functions shown in Table AC2 to these changes in concentration of SO2 and PM10 attributed to the use of gas oil by vehicles, allows the estimation of probable different impacts on health due to this fuel use. Combining these results with the monetary unit values for each health effect corresponding to Montevideo City, yields the health costs caused by gas oil consumed by motor vehicles (USD 93.055.000). These results are shown especially in Table C2Ua (and the total health cost in Table C4U), as it has been presented only for the aggregate in Tables C2U, C2A and C2B, but not for each fuel use.

Table C2Ua. Montevideo: Health effects and costs from use of gas oil (transport use)

	Cases (Population: 1,34 mill.)	WTP (Unit value in USD) for GDP USD 1000	WTP (Unit value in USD) for Montevideo GDP (USD 12000)	Health costs (000 USD)
Premature deaths	47	74.346	892.152	41.937
Chronic bronchitis	183	8.949	107.389	19.666
Respiratory hospital admissions	75	194	2.327	174
Asthma attacks	10135	3	35	352
Emergency room visits	1464	6	69	102
Restricted activity days	275292	2	29	8.035
Lower respiratory illnesses in children	2417	2	24	59
Respiratory symptoms	876148	2	24	21.230
Cough days	29	2	24	1
Chest discomfort days	54485	2	28	1.500
Total (000 USD)	93.055			

Non health local effects attributed to the consumption of gas oil for motor vehicle purposes are estimated multiplying the unitary values expressed per person and ug/m3 of each pollutant shown in Table C3U to the estimated changes in concentration of NOX, SO2 and PM10 caused by this fuel use, and it totals USD 16.044.000 (Table C4U).

Finally, global impacts provoked by gas oil used in Montevideo (transport use) result from combining a damage cost of USD 16.5 per ton of this fuel with the total consumed of it in this city (165 kton), which amount USD 2.720.000.

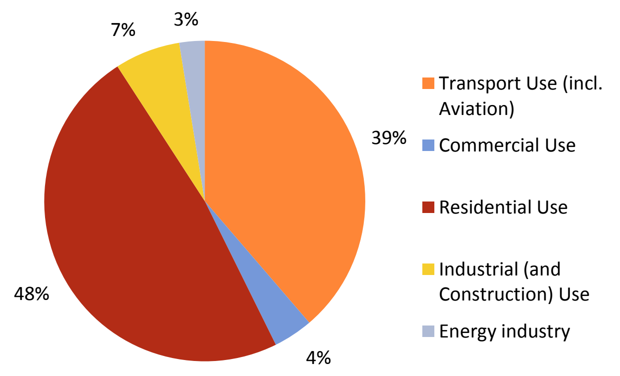
(*) The meteorological frequency factor parameters used in the model were f_{11}: 0.0; f_{12}: 0.2; f_{13}: 0.2; f_{14}: 0.1; f_{21}: 0.0; f_{22}: 0.0; f_{23}: 0.2; f_{24}: 0.0; f_{31}: 0.0; f_{32}: 0.1; f_{33}: 0.0. Following Lvovsky et al (2000), the results of the model were calibrated such that the predicted concentration of SO2 of the whole sources represented 70% of measured ambient concentrations.

Table C4U. Montevideo: Environmental costs from EP use (000 USD)					
Sources	Health	Local non health	Total local damage	Global damage	TOTAL
Transport Use	101104	18593	119697	4476	124173
Gasoline	8050	2549	10599	1757	12355
Gas oil	93055	16044	109099	2720	111818
Commercial Use	10498	1795	12293	502	12795
LPG (Supergas)	1	0	1	2	3
LPG (Propane Gas)	11	3	14	28	42
Manufactured Gas	6	2	8	15	22
Querosene	8	1	9	1	10
Gas oil	7592	1145	8738	297	9035
Fuel oil	821	376	1197	76	1273
Natural Gas	18	5	24	43	66
Wood	2041	262	2303	41	2343
Residential Use	131383	17531	148914	3451	152364
LPG (Supergas)	165	50	215	577	792
LPG (Propane Gas)	1	0	2	5	6
Manufactured Gas	5	2	7	18	25
Querosene	429	65	494	53	547
Gas oil	191	37	227	7	234
Fuel oil	1987	911	2897	183	3080
Natural Gas	15	4	19	35	54
Wood	128156	16413	144569	2566	147135
Coal	434	50	484	6	490
Industrial (and Construction) Use	17386	3003	20389	3578	23966
LPG (Supergas)	1	0	1	13	15
LPG (Propane Gas)	3	1	3	32	36
Gasoline	1	0	1	2	3
Natural Gas	29	8	37	461	498
Querosene	9	2	11	10	21
Gas oil	258	44	302	89	391
Fuel oil	5138	1409	6546	1350	7896
Petroleum Coke	148	21	169	12	181
Coal	143	19	162	11	174
Manufactured Gas	0	0	0	1	1
Wood	11615	1479	13094	1424	14518
Other solid biomass	41	21	62	171	233
Oil Refinery Use	3143	1675	4818	2131	6950
Fuel oil	1345	525	1870	608	2479
Gas oil	14	5	19	21	40
LPG (Supergas)	1	0	1	8	9
Natural Gas	24	9	33	89	123
Gas Fuel	57	18	75	925	1001
Refinery Gas	1701	1118	2819	480	3299
Gas Plant	0	0	0	3	3
Gasoline	0	0	0	3	3
Power Plant Use	1986	1101	3086	4700	7787
Gas oil	282	139	421	1402	1823
Fuel oil	1704	961	2665	3299	5964
Aviation (Jet fuel)				60	60
TOTAL	265499	43698	309197	18901	328099

Source: authors' calculations based on Tables C1U, C2U, C3U and AC3.

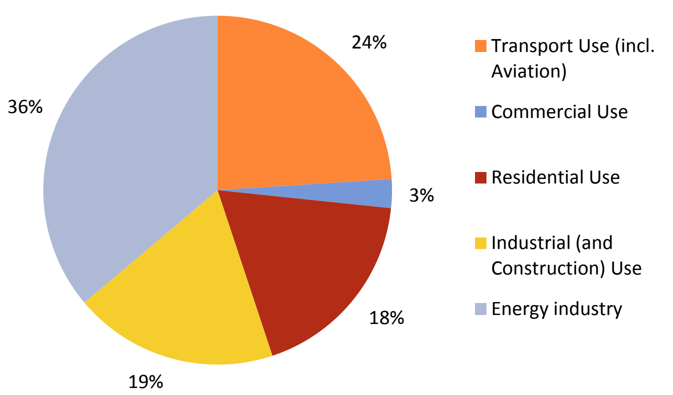
Figures C2U and C3U illustrate how different sources contribute to local and global damages in Uruguay, highlighting that the greatest part of local damages comes from households (48%) and vehicles (39%), while energy industries (36%) and transport (24%) are the main contributors to global damage.

Figure C2U. Montevideo: Local environmental damage from EP use, sector contribution



Source: authors' calculations based on Table C4U

Figure C3U. Montevideo: Global environmental damage from EP use, sector contribution



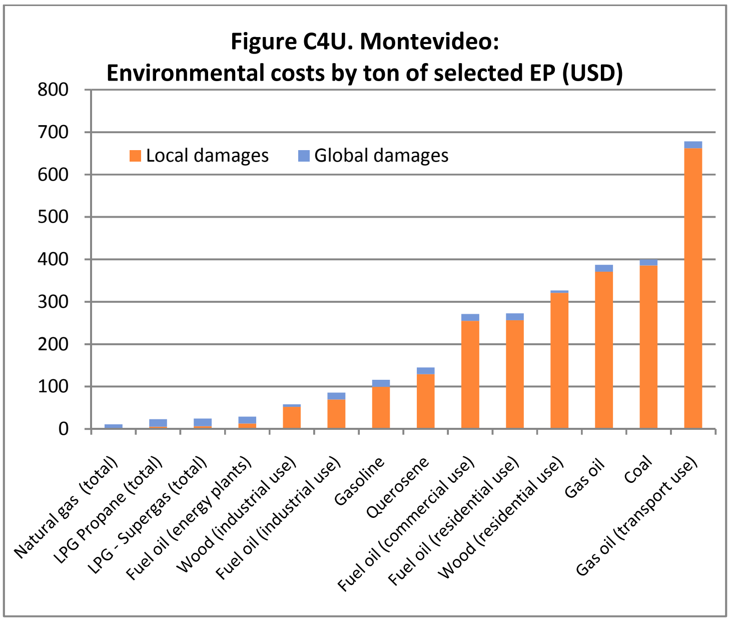
Source: authors' calculations based on Table C4U

The estimated contribution of different EP to local damages highlights the important role of gas oil for transport use and wood for residential use: they account for more than 75% out of total. The same EP, but in a much less proportion (14% each) are important contributors to global damage; however, in this case, fuel oil used in power plants is the most relevant.

Table C5U. Montevideo: Environmental costs from EP use						
	Environmental costs by EP (000 USD)			Environmental costs by ton of EP (USD)		
EP	Local damages	Global damages	Total	Local damages	Global damages	Total
Gasoline	10600	1762	12362	99,3	16,5	115,8
Gas oil (transport use)	109099	2720	111818	661,9	16,5	678,4
Querosene	514	64	578	129,0	16,2	145,2
Wood (industrial use)	13094	1424	14518	52,4	5,7	58,1
Wood (residential use)	146871	2607	149478	321,1	5,7	326,8
Other solid biomass	62	171	233	2,1	5,7	7,8
LPG - Supergas (total)	218	601	819	6,6	18,1	24,7
LPG-Supergas (residential use)	215	577	792	6,7	18,1	24,8
LPG - Supergas (commercial use)	1	2	3	9,2	18,1	27,3
LPG - Supergas (industrial use)	2	21	24	1,9	18,1	20,0
LPG Propane (total)	19	65	84	5,4	18,1	23,5
LPG Propane (residential use)	2	5	6	6,9	18,1	25,0
LPG Propane (commercial use)	14	28	42	9,1	18,1	27,2
LPG Propane (industrial use)	3	32	36	1,9	18,1	20,0
Gas oil	9286	413	9700	370,7	16,5	387,2
Gas oil (energy plants)	421	1402	1823	4,9	16,2	21,1
Fuel oil (energy plants)	2665	3299	5964	13,1	16,2	29,3
Fuel oil (residential use)	2897	183	3080	256,4	16,2	272,6
Fuel oil (commercial use)	1197	76	1273	255,1	16,2	271,3
Fuel oil (industrial use)	8417	1958	10375	69,6	16,2	85,8
Gas manufacturado (total)	15	34	48	8,0	18,1	26,1
Manufactured gas (residential use)	7	18	25	7,1	18,1	25,2
Manufactured gas (commercial use)	8	15	22	9,6	18,1	27,7
Manufactured gas (industrial use)	0	1	1	2,0	18,1	20,1
Natural gas (total)	113	629	741	1,7	9,5	11,2
Natural gas (residential use)	19	35	54	5,0	9,4	14,4
Natural gas (commercial use)	24	43	66	5,2	9,4	14,6
Natural gas (industrial use)	70	550	620	1,2	9,5	10,7
Gas Fuel	75	925	1001	1,5	18,1	19,6
Refinery Gas	2819	480	3299	106,3	18,1	124,4
Coal	816	29	845	385,8	13,8	399,6
Jet fuel	0	60	60	0,0	16,5	16,5
TOTAL	309197	18901	328099			

Source: authors' calculations based on Tables C1U and C4U

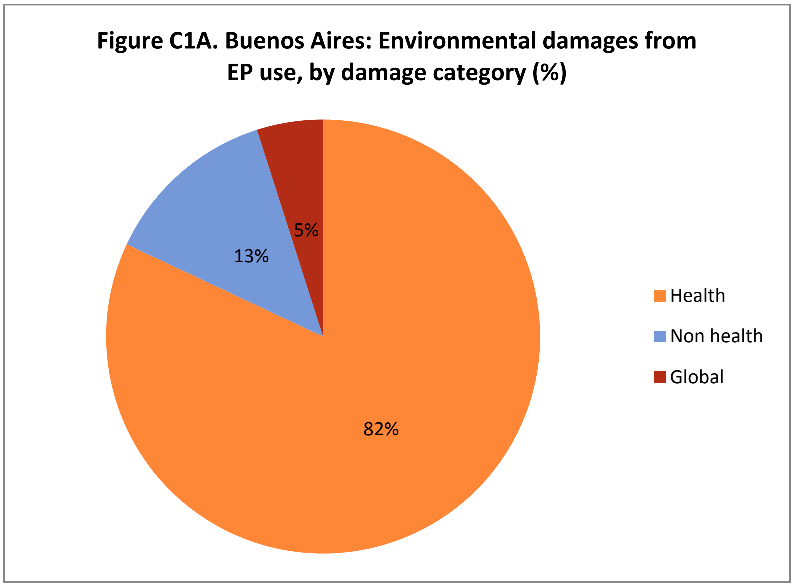
The estimated damage by EP and the consumption of them according to inventory data allows the calculation of damage per ton of each EP used (Table C5U; Figure C4U). This exercise shows that gas oil for transport is, by far, the EP with the greatest marginal damage associated (almost USD 700 per ton), while the lowest corresponds to natural gas, for any use.



Source: authors' calculations based on Table C5U

- Argentina

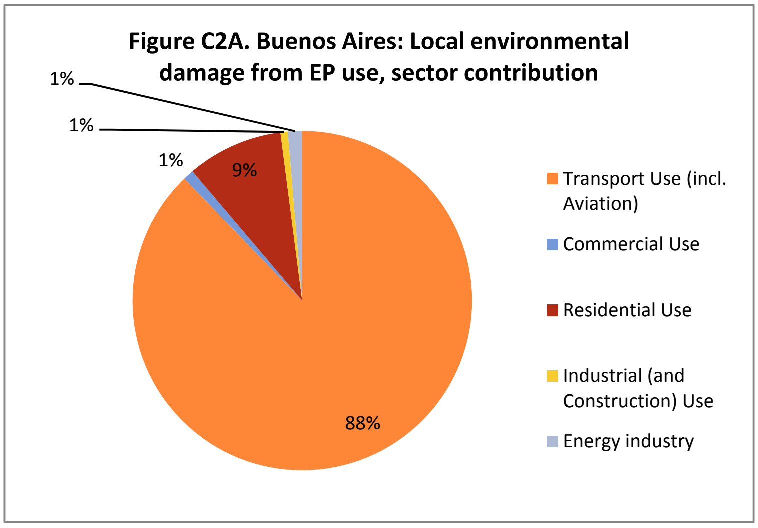
The estimated environmental costs of EP use in Buenos Aires City amount USD 1283 millions (Table C4A), nearly 0.35% of GDP of Argentina or 3.8% of local GDP. As in Lvovsky et al (2000), health impacts account for the largest portion of these costs (82%); instead, climate change damages represent (at USD 20 ton of C) only 5% out of total costs (Figure C1A).



Source: authors' calculations based on Table C4A

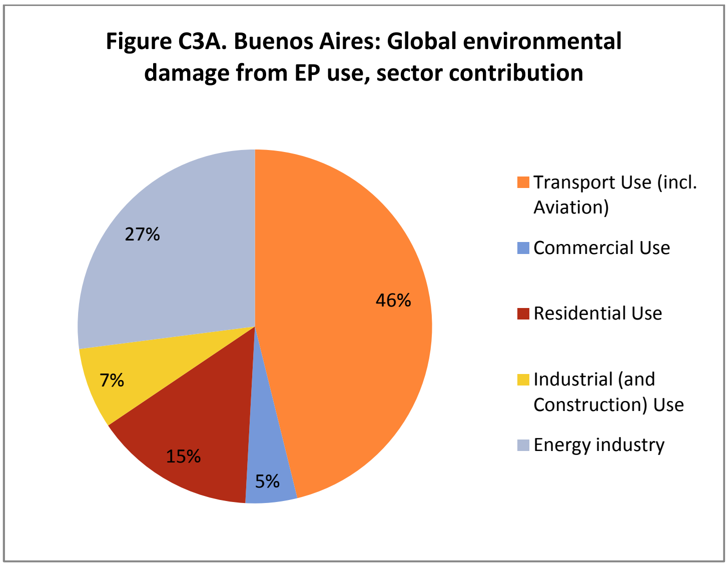
Table C4A. Buenos Aires: Environmental costs from EP use (000 USD)					
Sources	Health	Local non health	Total local damage	Global damage	TOTAL
Transport Use	921048	149790	1070838	29206	1100044
Gasoline	58612	18952	77564	8363	85928
Diesel oil	839248	124217	963465	17144	980608
Diesel oil (train)	15237	2923	18160	272	18432
Natural Gas	7950	3699	11649	2276	13925
Jet fuel				1151	1151
Commercial Use	10594	1815	12409	2985	15394
LPG	57	22	79	95	174
Diesel oil	7798	961	8759	259	9018
Fuel oil	1073	279	1352	110	1462
Natural Gas	1666	554	2220	2520	4740
Residential Use	98594	12962	111556	9294	120849
LPG	817	275	1092	1820	2912
Querosene	1972	268	2241	137	2378
Natural Gas	4414	1484	5897	6514	12411
Wood	44194	5667	49862	475	50337
Coal	47196	5268	52464	348	52812
Industrial (and Construction) Use	7408	1212	8619	4697	13317
LPG	5	2	7	38	45
Natural Gas	721	281	1002	3981	4983
Diesel oil	548	72	619	100	719
Fuel oil	2050	328	2377	346	2723
Coal coke	1251	146	1397	51	1448
Coal	1492	188	1679	60	1739
Refinery Gas	2	0	2	44	46
Wood	1339	196	1535	78	1613
Energy industries	14304	2192	16496	17114	33610
Diesel Oil	221	38	259	162	421
Fuel oil	1313	299	1612	850	2462
LPG	0	0	1	7	7
Natural Gas	1000	385	1385	13818	15203
Coal	6914	857	7771	670	8441
Refinery Gas	13	1	14	902	916
Wood	4843	612	5455	705	6160
TOTAL	1051948	167970	1219919	63295	1283214

Source: authors' calculations based on Tables C1A, C2A, C3A and AC3.



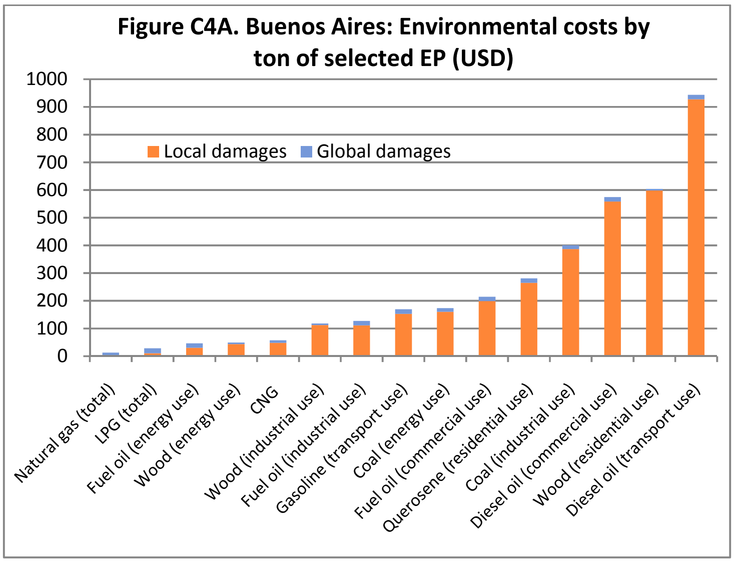
Source: authors' calculations based on Table C4A

By far, transport sector is the major contributor to local damages (88%), while the share of commercial and residential use of EP is not very important as its EP consumption is dominated by natural gas (Figure C2A). Transport also accounts for the greatest proportion of global environmental costs (46%), followed by energy industries (27%) (Figure C3A).



Source: authors' calculations based on Table C4A

These results highlight that in Buenos Aires City the heavy volume of traffic and the widespread use of diesel oil represent the main environmental problem associated to EP consumption. This petroleum product applied to transport use is responsible for nearly 75% of total estimated damages, and its social cost per ton is over USD 940 (Figure C4A and Table C5A).



Source: authors' calculations based on Table C5A

Table C5A. Buenos Aires: Environmental costs from EP use						
EP	Environmental costs by EP (000 USD)			Environmental costs by ton of EP (USD)		
	Local damages	Global damages	Total	Local damages	Global damages	Total
Natural gas (transport use)	11649	2276	13925	48,2	9,4	57,6
Gasoline (transport use)	77564	8363	85928	153,0	16,5	169,5
Diesel oil (transport use)	963465	17144	980608	927,3	16,5	943,8
Diesel oil (train)	18160	272	18432	1100,6	16,5	1117,1
Natural gas (commercial use)	2220	2520	4740	8,3	9,4	17,7
LPG (commercial use)	79	95	174	15,0	18,1	33,1
Diesel oil (commercial use)	8759	259	9018	558,4	16,5	574,9
Fuel oil (commercial use)	1352	110	1462	198,7	16,2	214,9
Natural gas (residential use)	5897	6514	12411	8,5	9,4	17,9
LPG (residential use)	1092	1820	2912	10,9	18,1	29,0
Querosene (residential use)	2241	137	2378	264,8	16,2	281,0
Wood (residential use)	49862	475	50337	598,3	5,7	604,0
Coal (residential use)	52464	348	52812	2081,9	13,8	2095,7
Coal (industrial use)	1679	60	1739	386,7	13,8	400,5
Natural gas (industrial use)	1002	3981	4983	2,4	9,4	11,8
LPG (industrial use)	7	38	45	3,3	18,1	21,4
Diesel oil (industrial use)	619	100	719	102,5	16,5	119,0
Fuel oil (industrial use)	2377	346	2723	111,3	16,2	127,5
Coal coke	1397	51	1448	379,0	13,8	392,8
Refinery gas (industrial use)	2	44	46	0,7	18,1	18,8
Wood (industrial use)	1535	78	1613	112,6	5,7	118,3
Coal (energy use)	7771	670	8441	160,0	13,8	173,8
Natural gas (energy use)	1385	13818	15203	0,9	9,4	10,4
LPG (energy use)	1	7	7	1,6	18,1	19,7
Diesel oil (energy use)	259	162	421	26,4	16,5	42,9
Fuel oil (energy use)	1612	850	2462	30,7	16,2	46,9
Refinery gas (energy use)	14	902	916	0,3	18,1	18,4
Wood (energy use)	5455	705	6160	44,1	5,7	49,8
Jet fuel		1151	1151		16,5	16,5
TOTAL	1219919	63295	1283214			

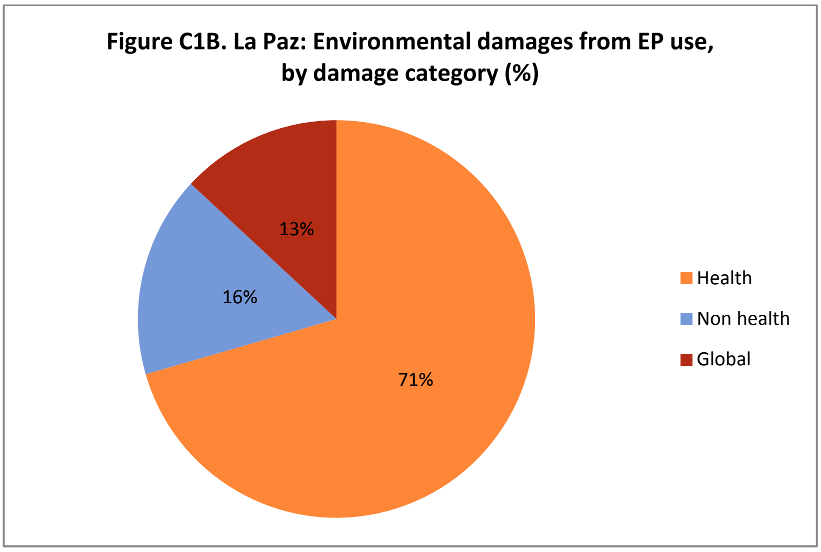
Source: authors' calculations based on Tables C1A, C2A, C3A and AC3.

- Bolivia

For La Paz, Bolivia, the environmental costs of EP use assessed in the study total USD 47 million, which represents 0,3% of national GDP and 3% of estimated local one (Table C4B). Even though health impacts are the most relevant damages, its share (71%) is smaller than in the cases of Uruguay and Argentina, while the incidence of global costs is less modest (13%). This is mostly explained by the use of a valuation approach for local costs linked to the income level (WTP), which is very low in comparison with the corresponding to others cities assessed; the values of the climate change damages, instead, are considered at a fix amount per EP by ton of consumption of each one.

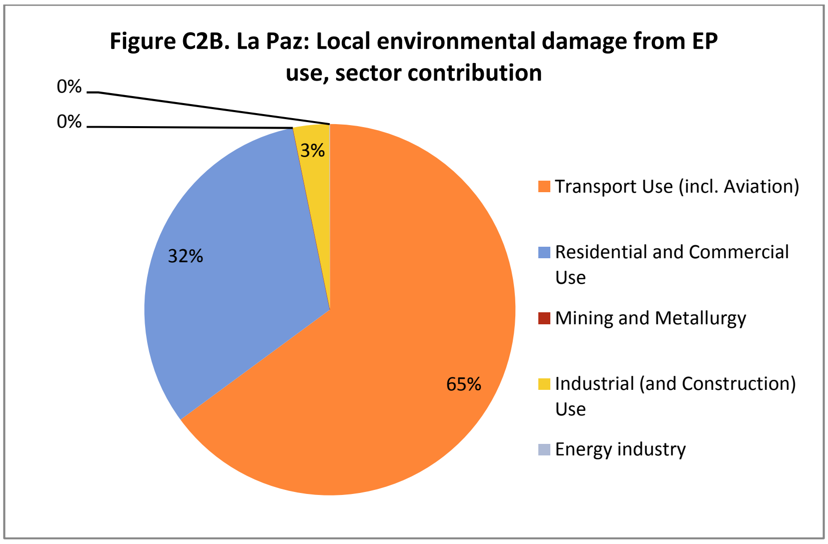
Table C4B. La Paz: Environmental costs from EP use (000 USD)					
Sources	Health	Local non health	Total local damage	Global damage	TOTAL
Transport Use	21000	5491	26492	2120	28612
Gasoline	18751	4195	22946	1159	24105
Diesel oil	2211	1268	3479	928	4407
Natural Gas	39	28	67	33	100
Residential and Commercial Use	10983	2031	13014	899	13914
Natural Gas	2	1	3	9	12
LPG	105	67	172	437	610
Querosene	23	9	32	15	47
Gasoline	13	7	20	5	24
Wood	10839	1948	12787	433	13220
Industrial (and Construction) Use	1121	173	1293	2121	3414
Natural Gas	6	4	10	518	528
Coal	5	1	6	6	12
Petroleum Coke	0	0	0	0	0
Lubricants	0	0	0	2	2
Paraffin	1	0	1	35	36
LPG	0	0	0	8	8
Fuel oil	0	0	0	0	1
Diesel oil	5	2	7	87	94
Querosene	0	0	1	14	14
Gasoline	1	1	2	14	16
Biomass	1102	165	1267	1436	2703
Energy Industries	12	3	15	827	842
Natural Gas	2	1	3	702	705
Liquid Fuel Refinery	0	0	0	10	10
Refinery Gas	0	0	0	0	0
Lubricants	0	0	0	0	0
LPG	0	0	0	0	0
Diesel oil	0	0	1	37	38
Querosene	0	0	0	0	0
Gasoline	0	0	0	3	3
Biomass	10	2	12	75	86
Mining and Metallurgy	1	1	2	24	26
LPG	0	0	0	2	2
Fuel oil	0	0	0	0	0
Diesel oil	1	1	2	20	22
Querosene	0	0	0	0	0
Gasoline	0	0	0	2	2
Aviation (Jet fuel)				160	160
TOTAL	33117	7699	40816	6150	46966

Source: authors' calculations based on Tables C1B, C2B, C3B and AC3.



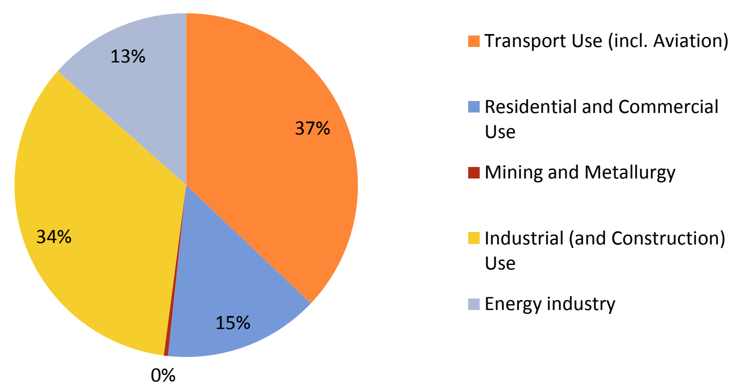
Source: authors' calculations based on Table C4B

Transport is the most relevant source of local and global pollution (65% and 37%, respectively), specially diesel-powered vehicles, and the wide use of wood by households makes residential sector a very important contributor too (Figures C2B and C3B). Industries and power plants account for a small proportion of local damage but have a great impact on global climate (47%).



Source: authors' calculations based on Table C4B

Figure C3B. La Paz: Global environmental damage from EP use, sector contribution



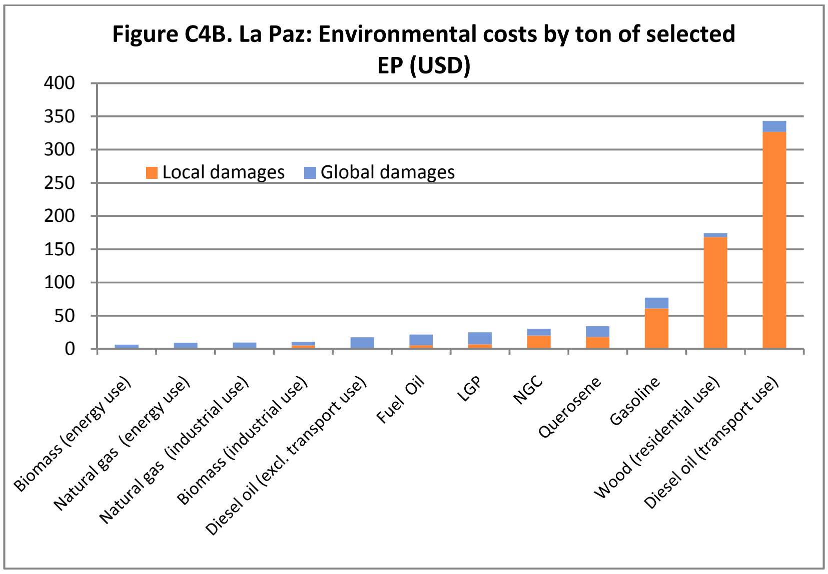
Source: authors' calculations based on Table C4B

The unit environmental cost associated to the use of diesel oil for transport is over USD 340 per ton, the highest one for Bolivia among the EP assessed; wood for residential use is in the second place, with damage per ton around USD 174 (Table C5B and Figure C4B).

Table C5B. La Paz: Environmental costs from EP use

EP	Environmental costs by EP (000 USD)			Environmental costs by ton of EP (USD)		
	Local damages	Global damages	Total	Local damages	Global damages	Total
Natural gas (total)	16	1229	1245	0,1	9,4	9,5
Natural gas (energy use)	3	702	705	0,0	9,4	9,4
Natural gas (industrial use)	10	518	528	0,2	9,4	9,6
Liquid Fuel Refinery	0	10	10	0,2	16,5	16,7
Refinery Gas	0	0	0	0,2	18,1	18,3
Lubricants	0	2	2	0,7	16,5	17,2
LPG	172	447	620	7,0	18,1	25,1
Diesel oil (total)	22955	1304	24259	290,5	16,5	307,0
Diesel oil (transport use)	22946	1159	24105	326,7	16,5	343,2
Diesel oil (excl. transport use)	9	145	154	1,1	16,5	17,6
Querosene	33	29	62	17,9	16,2	34,1
Gasoline	3501	951	4452	60,7	16,5	77,2
Paraffin	1	35	36	0,4	16,5	16,9
Fuel oil	0	0	1	5,3	16,2	21,5
CNG	67	33	100	20,1	10,1	30,2
Wood (residential use)	12787	433	13220	168,5	5,7	174,2
Biomass (industrial use)	1267	1436	2703	5,0	5,7	10,7
Biomass (energy use)	12	75	86	0,9	5,7	6,6
Jet fuel		160	160	0,0	16,5	16,5

Source: authors' calculations based on Tables C1B, C2B, C3B and AC3.



Source: authors' calculations based on Table C5B

Auxiliary tables

Table CA1. Emissions factors (EF) (kg per ton)		
	TSP	PM10
Coal		
Utility boiler	0.5*6*A	0.5*TSP (EF)
Large industrial boiler	0.5*6*A	0.5*TSP (EF)
Small industrial boiler	0.5*6*A	0.5*TSP (EF)
Household boiler	0.5*6*A	0.5*TSP (EF)
Fuel oil		
Utility boiler	0.15 * 2 * (0.38 +1.25 * S)	0.9 * TSP (EF)
Large industrial boiler	2 * (0.38 +1.25 * S)	0.8 * TSP (EF)
Small industrial boiler	3 * (0.38 +1.25 * S)	0.8 * TSP (EF)
Household boiler	3 * (0.38 +1.25 * S)	0.8 * TSP (EF)
Wood boiler	14	0.5 * TSP (EF)
Diesel engine	15	0.8 * TSP (EF)
Gasoline engine	0,8	0.9 * TSP (EF)
Natural gas (kt/PJ)		
Utility boiler	0.0001	0.0001
Large industrial boiler	0.0001	0.0001
Small industrial boiler	0.0001	0.0001
Household boiler	0.0001	0.0001

Note: A, ash content of coal, weight percent; S, sulfur content of fuel, weight percent

Source: Lvovsky et al (2000); RAINS model

Table CA2. Air pollution dose response functions (ug/ m3 change in annual mean level)		
Health effect	PM10	SO2
Mortality (% change)	0,084	
Chronic bronchitis (per 100.000 adults)	3,06	
Respiratory hospital admissions (per 100.000 population)	1,2	
Asthma attacks (per 100.000 asthmatics)	3260	
Emergency room visits (per 100.000 population)	23,54	
Restricted activity days (per 100.000 adults)	5750	
Lower respiratory illnesses in children (per 100.000 children)	169	
Respiratory symptoms(per 100.000 adults)	18300	
Cough days (per 100.000 children)		1,81
Chest discomfort days (per 100.000 adults)		1000

Source: Lvovsky et al (2000)

Table CA3. Climate change damage costs from EP use		
	Damage cost at USD 20 per ton C	per
Coal	13,8	ton
Lignite	5,7	ton
Coal gas	19,5	ton
Fuel oil	16,2	ton
Gas oil	16,5	ton
Gasoline	16,5	ton
LPG	18,1	ton
Natural gas	10,1	m3
Wood	5,7	ton

Source: Lvovsky et al (2000)

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