ASOCIACION ARGENTINA
DE ECONOMIA POLITICA

ANALES | ASOCIACION ARGENTINA DE ECONOMIA POLITICA

XLVII Reunión Anual

Noviembre de 2012

ISSN 1852-0022
ISBN 978-987-28590-0-8

WORKABLE ENVIRONMENTALLY RELATED ENERGY TAXES

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Workable environmentally related energy taxes[#]

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Resumen

Se modela un proceso de reforma de impuestos a energéticos que, partiendo de la situación vigente, incorpora un componente de daños ambientales. Se distingue entre impuesto uniforme y no uniforme, estructuras impositivas positivas y normativas, y se adopta una especificación *non-Ramsey*. Se simula el ejercicio para Argentina, Bolivia y Uruguay, encontrando que debería haber un rebalanceo de impuestos, dominado por naftas y gas oil. Hay significativas ganancias ambientales, e impactos fiscales positivos e importantes. La corrección en las distorsiones pre-existentes en los precios de energéticos en Argentina y Bolivia genera un impacto distributivo negativo; mientras que resulta positivo en Uruguay.

Códigos JEL: H23, Q40, Q51

Abstract

We model an energy tax reform process out of a status quo and towards environmentally related excises, distinguishing between uniform and non-uniform tax components, positive and normative tax structures, and adopting a non-Ramsey specification. We implement the model for Argentina, Bolivia and Uruguay and find a rebalancing of fuel taxes, where gasoline and diesel are main drivers. Environmental gains of the reform are significant, while fiscal impacts are positive and large. The tax reform has a positive distributive impact in Uruguay, while large pre-existing price distortions tend to produce negative impacts in Argentina and Bolivia.

JEL Codes: H23, Q40, Q51

[#] This paper is a based on a report written with the support of the Latin American and Caribbean Research Network of the IDB as a background paper to the Project “The Future of Taxation in Latin America”. An earlier draft proposal was presented at a Seminar in Washington in August 3, 2011. We thank our discussants Jack Mintz and Jon Strand, as well as Eduardo Lora, Sebastian Miller, Ian Parry and Teresa Ter Minassian for useful comments and suggestions. We also thank Sebastian Miller for further comments to a first draft. The usual disclaimer applies.

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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, Leicester and Smith, 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 costs 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.

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 Braathen (2005) shows), in Latin America, and in the three countries of this study (Argentina, Bolivia and Uruguay).[2] In a related and extensive report (Navajas et. al., 2011), we found differences in level and structure of ERT with OECD countries but with the common feature 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. 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.[3]

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 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 this paper. 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 a pre-existing set of fiscal instruments in search of a new rationale. 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

[1] See also Sandmo (2000, 2010) and Parry (2011) on the scope of taxes, and Stavins (2007) and Smith (2011) for recent briefings to the field.

[2] See also Ekins (1999) for a survey on the European experience on environmental taxes; and Oliva Pérez et.al.(2011) for a discussion on the potential use in Latin America.

[3] 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.

revenue raising concerns and the interplay of political economy constraints that are already embedded in the observed status quo.

In section 2 we set our analytical framework starting from the observed status quo of uniform indirect taxes and non uniform energy taxes and assuming that existing energy excises are (and will remain) “non-Ramsey” (i.e. do not introduce demand price elasticities into explaining the current structure).[4] We distinguish between a positive formulation (related to the observed status quo) from a normative formulation (related to the reform 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. 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 that critically depend on environmental costs of energy products. Within this reference model we obtain in section 2 an easily representation of a tax reformulation of energy taxes towards ERT, develop formulas to assess the fiscal impact (i.e., changes in fiscal revenues) of the reformulation of energy taxes as ERT and include a net benefit analysis of environmental gains. We also extend the assessment to account for the distributional impact of tax reforms.

The estimation of environmental (local and global) costs of energy are discussed in section 3. We follow a detailed methodology that relates local and global pollutants with energy products so as to determine -for each product and each sector of the economy- injuries and damages valued in monetary terms. Compared to other estimates used in recent exercises of efficient environmental taxation of fuels (e.g. 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 congestion or road use) apart from environmental costs in the evaluation of tax reform. These are high –relative to environmental damage- in the estimates of Parry and Strand (2010) for Chile. We do not include these externalities because 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 (see Parry, 2011). [5]

After setting the framework, we move on in section 4 to implement it for the cases of Uruguay, Argentina and Bolivia. We do so in a sequence of steps that proceeds from evaluating the basic data set, estimating tax structures, computing fiscal revenues, and environmental and distributive impacts. We use data on market quantities, consumer and producer prices and own estimates of (local and global) environmental costs associated with each product. Finally section 5 draws our main conclusions and policy implications of the paper as well as the suggested extensions in other dimensions that deserve further study.

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[4] In Navajas et.al. (2011) we also model comprehensively Ramsey structures, with and without political constraints and 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. Direction of tax reform tests show robustness of our results to different parameter values, while simulations show that the non-Ramsey formulation used in this paper is preferable to a Ramsey one in terms of implementation, transparency and welfare impacts of tax and price changes that originates in efficiency objectives that work through price elasticities and are unrelated to environmental costs.

[5] 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. However, simulations performed to include constraints representing these other externalities suggest that our results concerning fiscal and distributional impacts do not change qualitatively.

2. Modelling strategy for workable reform analysis

The modelling strategy is an adaptation of an indirect tax model to cope with data limitations that we usually face in the countries studied. 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 in a larger report in Navajas et.al. (2011).

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) 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 as:

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

The observed margins m_i will be the sum of a uniform component for all n commodities in the economy[6] 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 will be given 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-. However, as the non-uniformity of energy excises may also depend on the interplay of demand price-elasticities for each

[6] 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.

good, -which introduction is in itself a quasi normative ingredient, representing basic Ramsey taxation (i.e. efficiency)-, we simplify adopting a "non-Ramsey" formulation of the Z_i. Technical details behind the derivation of tax formulas can be found in Appendix 1 and more extensively in Navajas et.al. (2011).

Status-quo and reform

Assume that the Z_i are determined by factors different from efficiency reasons and that demand price-elasticities have not been considered in the observed status quo. In this case 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^P (where supra indices P stands for positive)

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

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 (that we call 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^P parameters in expression (3) Becker's numbers (following Becker, 1983).[7]

The normative representation allows for a straightforward interpretation of tax reform or reformulation considering environmental objectives, which is to move from the above Z_i^P to the ones that come from introducing environmental costs associated to energy products. That is, we define Z_i^N (where N stands for normative):

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

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. $T_i^N = K_i(1+t)/\lambda$ (specific only) and $\tau_i^N = K_i.(1+t)/\lambda.p$ (ad-valorem-only). In both cases, it can be seen that computing tax rates is straightforward as they depend on parametric

[7] In Navajas et.al. (2011) we further compare the implicit characteristics θ_i with the so-called distributional characteristics of energy goods (d_i). 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. 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 models with distributional objectives. See Sandmo (2000) for the use of distributional characteristics within environmental tax models. See also Hettich and Winner (1984) and Porto (1996) for modelling positive tax structures.

(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).

Revenue impact

To assess the revenue impact of tax reform we define tax revenue impacts as changes that come from computing margins and prices in expression (4), as shown in expression (5) below. Defining the status as "0" and in the reformed scenario as "J" we simply write:

$$R^j = \sum_{i=1}^{n-1} m_i^j . q_i^j . X_i^j \quad \text{and} \quad R^0 = \sum_{i=1}^{n-1} m_i^0 . q_i^0 . X_i^0 \qquad (5)$$

Quantities after reform are computed according the constant elasticity assumption as

$$X_i^j = \exp\{\log X_i^0 - \eta_i .[\log q_i^j - \log q_i^0]\} \text{ with estimates taken fron Navajas et.al. (2011)}$$

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 involves an increase of prices of widespread energy inputs that in turn will impact on the prices of non-energy goods.[8] 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.[9]

Distributional impact

Finally, tax reforms induced by the normative case 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 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)

$$IP^j = \sum_{h=1}^{H} \sum_{i=1}^{n} \alpha_i^h . \frac{q_i^j - q_i^0}{q_i^0} \qquad \text{where } \alpha_i^h = \frac{x_i^h . q_i^0}{Y^h} \qquad (6)$$

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 are final prices after reform. 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

[8] 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).

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

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:

$$EB^j = \sum_{h=1}^{H}\sum_{i=1}^{n}\frac{K_i.\bar{x}_i}{Y^h}\frac{(X_i^0 - X_i^j)}{X_i^0} \quad \text{where} \bar{x}_i = \frac{X_i^0}{H} \qquad (7)$$

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 (6) and (7) can be expressed as the net impact of a tax reform (NIT), using the definition of elasticity as $\eta_i=-(\Delta X_i/X_i).(\Delta q_i/q_i)$:

$$NIT^j = EB^j - IP^j = \sum_{h=1}^{H}\sum_{i=1}^{n}[\frac{K_i.\bar{x}_i.\eta_i}{Y^h} - \alpha_i^h].\frac{(q_i^j - q_i^0)}{q_i^0} \qquad (8)$$

The estimated value of (8) 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 (5) 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 (8) 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 reform. 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. Environmental costs of energy consumption

Methodology

As energy products (EP) are 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[10] 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[11]. 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

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

[11] 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).

include basically health care costs and productivity losses until the recovery (or death)[12]. 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 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.

Differences with recent estimation procedures

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 Navajas et.al (2011) for details of 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. 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

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

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 view, there are doubts in the literature on whether global environmental costs (i.e. related to CO2 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.[13]

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[14], 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[15]. 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 CO2 respectively, and they compute in the benchmark case a 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 or exclusively dollars per mile; 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).

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[13] Jon Strand commented in a 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.

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

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

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, that are much lower than in Santiago are more important for diesel than for gasoline.

4. Application to Uruguay, Argentina and Bolivia

Our database set is quite large and is described in detail in Appendix II. We construct data sets for observed prices with and without taxes (including some corrections when distortions due to subsidies occur in Argentina and Bolivia)[16] 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. Estimates of the marginal costs of raising public funds are assumed in a simple fashion according the simple grammar of our model.

The sequence of summary results presentation is the following. We show our results for non-Ramsey energy environmental taxes as compared to the status quo, in Table X1 (X=U,A and B standing for Uruguay, Argentina and Bolivia). Then we estimate (in Tables X2) tax revenue impacts comparing the results with the status-quo and with simulations for Ramsey taxes (as performed in Navajas et.at. 2011). We do the same for the estimated changes in environmental costs after reform (in Table X3). Finally, we present results (in Table X4) of our evaluation of the distributional impact.

4.1. Uruguay

Table U1 shows the results of the non-Ramsey excise case.

[16] We make corrections for gas oil, electricity and natural gas for Argentina, and gasolines, gas-oil and LPG for Bolivia. See Navajas (2006) and Cont et.al. (2011 for an account of the genesis and evolution of energy subsidies in Argentina.

Table U1							
Uruguay: Non Ramsey Environmentally Related Excises							
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%

Source: Navajas et.al (2011)

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).[17] 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 U1. 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.

Table U2 shows an estimation of the revenue impact of the reform of energy taxes towards ERT comparing the status quo with the non-Ramsey specification adopted in section 2 and also with simulations of Ramsey taxes performed in Navajas et.al (2011).

[17] Our analysis of the correspondence of the implicit characteristics of goods (θ_i) with distributional characteristics (d_i) show some strong (but not perfect) correlation between both parameters, suggesting that distributional concerns are one driver of the Becker's numbers.

Table U2

Uruguay: Impact of ERT Reform on Tax Revenues

Data for 2010 in millions of US dollars

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

Source: Navajas et.al (2011)

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 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. As expected, the move towards Ramsey excises (column 3) 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 U3 we show the level of environmental costs in the status quo and after reform, again for our reference case of Non-Ramsey taxes against the status quo and a Ramsey simulation.

Table U3

Uruguay: Estimated environmental costs before and after reform

in million dollars

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

Source: Navajas et.al. (2011)

As in the case of the fiscal impact, we do not consider biomass in the estimates. Both cases (non Ramsey and 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 tax reforms. Table U4 summarizes the estimation of expression (8) 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 our reference case of Non-Ramsey taxes and for the case of Ramsey taxes.

Table U4						
Uruguay: Distributional Impact of Tax Reforms, by deciles						
	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%	
	Decile					**Total**
	6	7	8	9	10	
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%

Source: Navajas et.al. (2011)

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[18]. On the other hand, gasoline 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. In turn, Ramsey taxes have a negative distributional impact due to larger price increases (see Navajas et.al.2011 for further details).

4.2 Argentina

Table A1 shows the results for our reference model of non-Ramsey excises. Columns (A) and (B) reproduce the reference tax wedge margin and its non-uniform component Z_i^P that we call Becker's numbers. These are to be compared by the so-called Sandmo's (Z_i^N) numbers in column (D) capturing the additive environmental cost component ($K_i/\lambda.q_i^N$) shown in expression (4). The comparison of the normative Z_i^N with the positive Z_i^P 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.

[18] 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.

Table A1									
Argentina: Non Ramsey Environmentally Related Excises									
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	(G) % Price Change		
							(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

Table A2 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).

Table A2

Argentina: Impact of ERT Reform on Tax Revenues

Data for 2010 in millions of US dollars

products	Status-quo 2010				non Ramsey taxes			
	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	Ramsey taxes			
	Fiscal Revenues (1)	of which: Excises	Subsidy (2)	Net balance (1) - (2)
Transport	12643	9591	0	12643
Standard Gasoline (92 RON)	109.8	67.1	0.0	109.8
Special Gasoline (92-95 RON)	1901.6	1157.8	0.0	1901.6
Premium Gasoline (97 RON)	608.2	381.3	0.0	608.2
Aerokerosene (Jet Fuel)	430.3	140.5	0.0	430.3
Aeronafta (propeller)	4.5	1.4	0.0	4.5
Gas Oil (*)	9467.1	7772.3	0.0	9467.1
Vehicle NG (GNC) (*)	121.9	70.7	0.0	121.9
Households	1168	709	0	1168
LPG	211.4	128.5	0.0	211.4
Kerosene	37.8	29.9	0.0	37.8
Natural gas (residential and commercial) (*)	399.9	271.5	0.0	399.9
Electricity (residential and commercial) (*)	519.2	279.2	0.0	519.2
Industry	1449	709	0	1449
Diesel Oil	24.4	20.9	0.0	24.4
Fuel Oil	463.0	298.4	0.0	463.0
Natural gas (*)	612.6	295.4	0.0	612.6
Electricity (*)	349.4	93.9	0.0	349.4
TOTAL	15261	11009	0	15261

Source: Navajas et.al. (2011)

Table A2 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 energy 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.[19] 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

[19] 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.

fiscal revenues increase in more than 5 billion dollars, or more than 60%. As expected, Ramsey taxes have an additional 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 A3 shows the changes in levels associated with the reforms.

Table A3

Argentina: Estimated Environmental costs before and after Reform

in million dollars

products	*Status Quo*		**non Ramsey taxes**		**Ramsey taxes**	
	Local	*Total*	*Local*	*Total*	*Local*	*Total*
Transport	**10759**	**11214**	**8087**	**8463**	**7768**	**8130**
Standard Gasoline (92 RON)	58.9	65.2	59.4	65.8	59.4	65.8
Special Gasoline (92-95 RON)	953.8	1056.6	990.8	1097.7	970.0	1074.5
Premium Gasoline (97 RON)	252.2	279.4	269.9	299.1	258.5	286.4
Aerokerosene (Jet Fuel)	0.0	33.0	0.0	32.6	0.0	31.2
Aeronafta (propeller)	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***
Vehicle NG (GNC) (*)	***79.6***	***96.3***	***41.2***	***49.8***	***39.5***	***47.7***
Households	**263**	**455**	**168**	**247**	**161**	**233**
LPG	11.6	30.8	10.7	28.7	9.8	26.1
Kerosene	18.8	19.9	17.4	18.5	15.9	16.9
Natural gas (residential and commercial) (*)	***143.4***	***313.3***	***49.9***	***109.1***	***45.6***	***99.5***
Electricity (residential and commercial) (*)	***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
Industry	**319**	**551**	**266**	**436**	**256**	**418**
Diesel Oil	26.1	26.9	18.3	18.8	17.5	18.0
Fuel Oil	231.5	265.2	199.6	228.7	191.2	219.0
Natural gas (*)	***46.0***	***242.1***	***32.7***	***171.9***	***31.3***	***164.6***
Electricity (*)	***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
TOTAL	**11342**	**12220**	**8521**	**9146**	**8185**	**8782**

Source: Navasa et.al. (2011)

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 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, Table A4 summarizes the estimation of expression (8) 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. Table A.4 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.

Table A4
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%	
	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%

Source: Navajas et.al. (2011)

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%.[20] 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 A.3, Gas-Oil is the main driver behind environmental gains.

4.3 Bolivia

Table B1 shows the results of the non-Ramsey tax reform for Bolivia.

[20] 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.

Table B1									
Bolivia: Environmerntally Related Non Ramsey Excises									
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	(G) % Price Change		
							(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	0.12	0.00	0.35	0.23	0.04	0.06	36.1%	*0.0%*	*36.1%*
Electricity	0.12	0.00	0.12	0.00	0.04	0.04	0.0%	*0.0%*	*0.0%*
Wood	0.00	-0.12	0.86	0.74	0.03	0.21	601.1%	*0.0%*	*601.1%*
Industry									
Natural Gas	0.12	0.00	0.29	0.18	0.06	0.08	25.5%	*0.0%*	*25.5%*
Electricity	0.12	0.00	0.12	0.00	0.06	0.06	0.0%	*0.0%*	*0.0%*
Wood	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.

Fiscal revenue impacts of the tax reforms for Bolivia are shown in Table B2. 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 official and other sources). 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 B2								
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	0.4	*0.0*	0.0	0.4	1.5	*1.2*	0.0	1.5
Electricity	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	4.9	*0.0*	0.0	4.9	13.4	*9.2*	0.0	13.4
Electricity	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**
	Ramsey excises							
	Fiscal Revenues (1)	***of which: Excises***	**Subsidy (2)**	**Net balance (1) - (2)**				
Transport	**505**	***377***	**0**	**505**				
Special Gasoline (*)	***130.3***	***73.7***	***0.0***	***130.3***				
Premium Gasoline (*)	***0.6***	***0.3***	***0.0***	***0.6***				
AV Gas (*)	***0.7***	***0.2***	***0.0***	***0.7***				
Jet Fuel (+)	***13.7***	***5.0***	***0.0***	***13.7***				
Diesel Oil (*)	***329.8***	***274.8***	***0.0***	***329.8***				
Vehicular NG	29.9	*22.7*	0.0	29.9				
Households	**69**	***38***	**0**	**69**				
LPG (*)	***45.8***	***26.0***	***0.0***	***45.8***				
Kerosene	0.9	*0.6*	0.0	0.9				
Natural Gas	1.9	*1.6*	0.0	1.9				
Electricity	20.5	*10.3*	0.0	20.5				
Industry	**29**	***14***	**0**	**29**				
Natural Gas	14.7	*10.7*	0.0	14.7				
Electricity	14.6	*3.7*	0.0	14.6				
TOTAL	**603**	***429***	**0**	**603**				
(*) Goods with fiscal subsidies								

Table B3 refers to the change in environmental costs associated with the tax reforms.

Table B3						
Bolivia: Estimated Environmental costs before and after Reform						
in million dollars						
products	*Status Quo*		**non Ramsey taxes**		**Ramsey taxes**	
	Local	*Total*	*Local*	*Total*	*Local*	*Total*
Transport	**557**	**618**	**350**	**390**	**342**	**381**
Special Gasoline (*)	***84.6***	***107.6***	***57.2***	***72.8***	***57.2***	***72.8***
Premium Gasoline (*)	***0.3***	***0.4***	***0.2***	***0.3***	***0.2***	***0.3***
AV Gas (*)	***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***
Diesel Oil (*)	***456.7***	***482.6***	***279.0***	***294.9***	***271.7***	***287.2***
Vehicular NG	15.9	23.9	13.2	19.8	12.8	19.2
Households	**140**	**152**	**139**	**149**	**138**	**148**
LPG (*)	***2.5***	***9.0***	***1.6***	***5.6***	***1.5***	***5.3***
Kerosene	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
Electricity - Households	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
Industry	**254**	**273**	**254**	**272**	**254**	**272**
Natural Gas - Industry	0.2	10.7	0.2	9.1	0.2	8.9
Electricity - Industry	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
TOTAL	**951**	**1043**	**743**	**810**	**735**	**801**

(*) Goods with fiscal subsidies

Turning into the evaluation of the distributional impacts of tax reforms, Table B.4 summarizes the estimation of expression (8) 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 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 B4
Bolivia: Distributional Impact of Tax Reforms, by deciles

	Decile 1	2	3	4	5
Case I: Non Ramsey Excises					
Total Net Gain	**0.60%**	**0.01%**	**-0.36%**	**-0.28%**	**-0.21%**
Environmental Benefit	1.68%	0.88%	0.51%	0.37%	0.28%
Price Impact	-1.07%	-0.87%	-0.88%	-0.65%	-0.49%
Case II: Ramsey Excises					
Total Net Gain	**-0.31%**	**-0.75%**	**-1.05%**	**-0.91%**	**-0.71%**
Environmental Benefit	3.31%	1.73%	1.02%	0.72%	0.56%
Price Impact	-3.62%	-2.48%	-2.07%	-1.64%	-1.27%

	Decile 6	7	8	9	10	*Total*
Case I: Non Ramsey Excises						
Total Net Gain	**-0.17%**	**-0.27%**	**-0.20%**	**-0.23%**	**-0.11%**	**-1.23%**
Environmental Benefit	0.23%	0.18%	0.14%	0.10%	0.05%	4.41%
Price Impact	-0.40%	-0.45%	-0.34%	-0.34%	-0.16%	-5.64%
Case II: Ramsey Excises						
Total Net Gain	**-0.64%**	**-0.71%**	**-0.61%**	**-0.59%**	**-0.35%**	**-6.62%**
Environmental Benefit	0.45%	0.35%	0.28%	0.20%	0.09%	8.71%
Price Impact	-1.08%	-1.07%	-0.89%	-0.79%	-0.44%	-15.33%

Source: Navajas et.al. (2011)

5. 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 have modeled 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, following a non-Ramsey specification. 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 a simplified fashion that does not pay attention to price-elasticities and just evaluate the impact of such a substitution. We obtain simple results for the tax formulas that involve environmental levies, but also compare our resuls with simulations of Ramsey taxes.

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.

References

Ahmad, E. and N. Stern (1984) "The Theory of Reform and Indian Indirect Taxes", Journal of Public Economics, 25, pp. 259-98.

Azqueta D. (1994), Valoración económica de la calidad ambiental, Madrid: Mc Graw-Hill.

Barde J.P. and N. Braathen (2005), "Environmentally Related Levies", Chapter 5 in Cnossen S., Theory and Practice of Excise Taxation: Smoking, Drinking, Gambling, Polluting and Driving. Oxford: Oxford University Press.

Baumol W. and W. Oates (1988), The Theory of Environmental Policy, second edition, Cambrige University Press.

Becker G. (1983), "A Theory of Competition Among Pressure Groups for Political Influence", Quarterly Journal of Economics, vol.96, pp.371-400

Cesar, H. et al (2000), "Economic valuation of improvement of air quality in the metropolitan area of Mexico City", Working document IVM-W00/28 +W00/28 Appendices.

Cifuentes, Luis A., A. Krupnick, R. O'Ryan and M.Toman (2005). "Urban Air Quality and Human Health in Latin America and the Caribbean." Working Paper, InterAmerican Development Bank, Washington, DC.

Cont W., P. Hancevic and F. Navajas (2011), "Energy populism and household welfare", 34th IAEE International Conference, June 20, 2011, Stockholm School of Economics, Sweden. http://www.hhs.se/IAEE-2011/Program/

Conte Grand M. (2002), "Impacts of GHG Mitigation on Local Air Pollution in the Buenos Aires Metropolitan Area: Valuation of Human Health Effects", Chapter 3, Final Report IES: Integrated Environmental Strategies Program Co-Control Benefits Analysis Project for Argentina (National Renewable Energy Laboratory and U.S. Environmental Protection Agency).

Cremer H., N Gahvari y F. Ladoux (2003), "Environmental taxes with heterogeneous consumers: an application to energy consumption in France", Journal of Public Economics, vol 87, pp.2791-2815.

Diamond, P. (1973) "Consumption Externalities and Imperfect Corrective Pricing", Bell Journal of Economics, 4, pp. 526-38.

EC (1999), "ExternE: Externalities of Energy, Vol.7: Methodology 1998 Update", European Commission, Directorate General XII: Science, Research and Development.

Ekins P. (1999), "European environmental taxes and charges: recent experience, issues and trends", Ecological Economics 31 (1999) 39–62

EPA (1999), "Final Report to Congress on Benefits and Costs of the Clean Air Act, 1990 to 2010", EPA 410-R-99-001.

Fullerton D., A. Leicester and S. Smith (2010) "Environmental Taxes", Chapter 5 in Institute for Fiscal Studies (2010), The Mirrlees Review. Reforming the tax system for the 21st century. London. http://www.ifs.org.uk/mirrleesReview

Fundación Bariloche (2005), "Inventario de Emisiones de Gases de Efecto Invernadero de la República Argentina. Año 2000", Tomos II y Tomo IV.

Guesnerie, R. (1977) "On the Direction of Tax Reform", Journal of Public Economics, 7, pp. 179-202.

Hettich W. y S. Winner (1984), "A Positive Model of Tax Structure", Journal of Public Economics, vol.24, pp.

Kanbur S. Y G. Myles (1992), "Policy Choice and Political Constraints", European Journal of Political Economy, vol.8, pp.1-29.

Lvovsky, K.; G. Hughes; D. Maddison; B. Ostro; D. Pearce (2000), "Environmental Costs of Fossil Fuels. A Rapid Assessment Method with Application to Six Cities", World Bank Environment Department.

MMAyA (2009), "Segunda Comunicación Nacional del Estado Plurinacional de Bolivia ante la Convención Marco de las Naciones Unidas sobre Cambio Climático".

MVOTMA (2010), "Uruguay: Tercera Comunicación Nacional a la Conferencia de las Partes en la Convención Marco de las Naciones Unidas sobre el Cambio Climático".

Myles G. (1995), Public Economics, Cambridge: University Press.

Navajas F. (1995) ,"Impuestos Ambientales Óptimos y la Tributación Diferencial de las Naftas con o sin plomo", en A. Porto (ed.), Finanzas Públicas y Economía Espacial en honor de Horacio Núñez Miñana, FCE-UNLP.

Navajas F. (2006), "Estructuras Tarifarias Bajo Stress", Económica (UNLP), Año LII, Nº1-2, pp.77-102.

Navajas F. (2009), "Engel Curves, Household Characteristics and Low-User Tariff Schemes in Natural Gas", Energy Economics, vol.31, 1,pp. 162-168.

Navajas F., M. Panadeiros and O. Natale (2011), "Environmentally related energy taxes in Argentina, Bolivia and Uruguay", http://mpra.ub.uni-muenchen.de/37829/

Navajas, F. and A. Porto (1994) "Budget Shares, Distributional Characteristics and the Direction of Tax Reform", Economics Letters, 45, 4, August.

Newbery D. (2005), "Why Tax Energy?. Towards a More Rational Energy Policy", Cambridge Working Papers in Economics CWPE 0508

Oliva Pérez N., A. Rivadeneira; A. Serrano and S. Carrillo (2011), "Impuestos Verdes:

¿Una herramienta para la política ambiental en Latinoamérica?", http://library.fes.de/pdf-files/bueros/quito/08160-20110603.pdf

Parry I. (2011), "Comments on Environmental Taxes in LAC", mimeo ppt, IDB Seminar on Environmental Taxes in Latin America and the Caribbean, Washington, August 3.

Parry I. and K. Small (2004), "Does Britain or the United States Have the Right Gasoline Tax?", Disc. Paper 02-12 Rev. Resources for the Future, Washington.

Parry, I. and J. Strand (2010), "International Fuel Tax Assessment: An Application to Chile", Discussion paper, Resources for the Future, Washington, DC.

Pope, C. A. III, R. T. Burnett, et al. (2004). "Cardiovascular Mortality and Long-Term Exposure to Particulate Air Pollution: Epidemiological Evidence of General Pathophysiological Pathways of Disease." Circulation 109: 71-77.

Porto A. (1996), “Determinantes Económicos y Políticos de una Estructura Tributaria”, Serie Seminarios 1/1996, Instituto y Universidad Torcuato Di Tella.

Rizzi, L. (2008). “Costos Externos del Transporte Automotor Vial en la Región Metropolitana de Santiago”, Departamento de Ingeniería de Transporte, Pontificia Universidad Católica de Chile.

Sandmo, A. (1975) "Optimal Taxation in the Presence of Externalities", Swedish Journal of Economics, 77, pp. 86-98.

Sandmo A. (2000), The Public Economics of the Environment, Oxford University Press.

Sandmo A. (2011), “Commentary by Agnar Sadmo” in Fullerton D., A. Leicester and S. Smith (2010), op.cit.

Schwartz, J. (1993), “Air Pollution and Daily Mortality in Birmingham, Alabama”; American Journal of Epidemiology.

SEADS (2008), “Segunda Comunicación Nacional de la República Argentina a la Convención Marco de las Naciones Unidas sobre Cambio Climático”.

Smith S. (2011), Environmental economics: A very short introduction, Oxford University Press.

Stavins R. (2007), “Environmental economics”, NBER working paper Nº13575, November.

Viscusi K.W. (1993), "The Value of Risks to Life and Health", Journal of Economic Literature, Vol.31, Issue 4.

World Bank (1994), “Estimating the Health Effects of Air Pollutants: A Method with an Application to Jakarta”, World Bank Policy Research Department, Public Economics Division, Policy Research Working Paper No.1301, May.

Appendix I

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 $\Sigma\ K_j.X_j$ 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.[21].

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).

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

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 $L = W^J(.) + \lambda.R(.) \quad \mathrm{J = P, N}$ 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):

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

Positive model

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

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

(choice of T_i)

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

Normative Model

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

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

(choice of T_i)

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

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 this paper 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:

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

The uniform component t/(1+t) comes from expressions (A5) (with θ_0=1)[22] 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'):

$$\text{Case P : Non - Ramsey Positive Model}$$

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

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

$$\text{Case N : Non - Ramsey Normative Model}$$

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

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

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.

[22] 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.

Appendix II
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[23]).
b. ***Electricity:*** Electricity consumption data were gathered from the Secretary of Energy's Historical Electricity Data Base[24] and the electricity wholesale market operator's (CAMMESA) "Informe Anual 2010"[25].
c. ***Natural Gas:*** Natural gas consumption data were collected from the ENARGAS ("Ente Nacional Regulador del Gas") Operative Statistics data base[26].

Memo items: Biomass quantities were estimated from the Argentine National Energy Balances[27] 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[28].
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 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[29] (*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%

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[23] http://energia3.mecon.gov.ar/contenidos/verpagina.php?idpagina=3300
[24] http://energia3.mecon.gov.ar/contenidos/verpagina.php?idpagina=3140
[25] http://portalweb.cammesa.com/MEMNet1/Documentos%20compartidos/VAnual10.pdf
[26] http://www.enargas.gov.ar/DatosOper/Indice.php
[27] http://energia3.mecon.gov.ar/contenidos/verpagina.php?idpagina=3366
[28] http://www.montamat.com.ar/
[29] http://infoleg.gov.ar/infolegInternet/verNorma.do?id=365

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[30].

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 Estadístico[31]" 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[32]" 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[33] 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[34] (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[35]) website.

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[30] http://www.mecon.gov.ar/sip/basehome/dir1.htm
[31] http://www.anh.gob.bo/index.php?option=com_content&view=category&layout=blog&id=939&Itemid=69
[32] http://www.ae.gob.bo/node/70
[33] http://www.hidrocarburos.gob.bo/sitio/index.php?option=com_docman&Itemid=136
[34] http://apps.ine.gob.bo/comex/Main
[35] www.cndc.bo/home/index.php

c. ***Natural Gas:*** Consumer prices were obtained from the national YPFB "Boletín Estadístico" Report Series[36].

*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[37]).
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 according to several motor vehicle characteristics. The source for these tax revenues for 2009 is the *Registro Único para la Administración Tributaria Municipal* (RUAT[38]).
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[39]).

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[40] to domestic market were collected from the Uruguayan Dirección Nacional de Energía (DNE, National Energy Authority).
b. ***Electricity:*** Domestic market electricity consumption[41] was also gathered from DNE.
c. ***Natural Gas:*** Domestic market annual natural gas consumption[42] data are those informed by DNE in its webpage.

Memo items: Biomass quantities were estimated from the Uruguayan National Energy Balances[43] prepared by DNE.

3) Energy prices data:
a. ***Liquid Fuels (Special, Super and Premium Gasoline, Gas Oils, Kerosene, LPG, Jet Fuels)***: average domestic prices[44] (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[45].

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36 http://www.ypfb.gob.bo/index.php?option=com_content&view=article&id=169&Itemid=166
37 http://impuestos.gob.bo/
38 http://www.ruat.gob.bo/
39 http://www.aduana.gob.bo/
40 http://www.miem.gub.uy/portal/agxppdwn?5,6,245,O,S,0,545%3BS%3B1%3B159
41 http://www.miem.gub.uy/portal/agxppdwn?5,6,249,O,S,0,568%3BS%3B1%3B163
42 http://www.miem.gub.uy/portal/hgxpp001?5,6,246,O,S,0,MNU;E;72;4;76;1;MNU;,
43 http://www.miem.gub.uy/portal/hgxpp001?5,6,235,O,S,0,MNU;E;72;1;73;2;MNU
44 http://www.miem.gub.uy/portal/hgxpp001?5,6,240,O,S,0,MNU;E;72;2;75;1;MNU;
45 http://adme.com.uy/

c. ***Natural Gas:*** Energy Component in tariff schedules were collected from the distribution firms' websites: GASEBA[46] and CONECTA[47].

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[48]), 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[49].

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.

46 http://www.montevideogas.com.uy/cathome_30_1.html
47 http://www.conecta.com.uy/tarifas.php
48 http://www.ancap.com.uy/
49 http://www.mef.gub.uy/portada.php