

# Optimality of relaxing revenue-neutral restrictions in Green tax reforms

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## Abstract

Green Tax Reforms [GTR] have been initially devised as a policy proposal to tackle simultaneously several political goals, such as accomplishing environmental objectives together with lesser tax distortions requiring tax revenue recycling. Yet, recent fiscal stress episodes in many developed countries have defied this view. In this paper, we assess the convenience of revenue-neutral restrictions in GTR on efficiency basis. Usual revenue-neutral conditions impose on policymakers additional constraints that may restrain welfare gains. Our conclusions may provide theoretical support for the third generation of GTR (calling for a departure from revenue-neutral conditions on GTR), as well as some recent legal European experiences.

**Keywords:** green tax reforms; revenue neutrality; optimal taxation

**JEL Codes:** H23, Q48

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## 1. Introduction

Environmental and fiscal issues are increasingly among the top priorities on the policy agenda in many developed countries. On the one hand, fiscal stress episodes in some European countries subsequent to the economic and financial crisis hit in most OECD countries in such a way that “consolidating the public finances is an important challenge for many countries” (OECD, 2012). On the other hand, sizeable global trends like “intensified global competition for resources” and “increasing environmental pollution” may be identified in the realm of the natural resources domain (energy, non-energy minerals, biomass, etc.)<sup>1</sup>. Some policy initiatives have been proposed to tackle both objectives simultaneously, as is the case of Green Tax Reforms [hereafter GTR]. This is the case of the nationally based GTR implemented in Europe in the last two decades.<sup>2</sup> More recently, the European Commission once again launched<sup>3</sup> a GTR proposal (European Commission, 2011).

Strictly speaking, GTR consists of setting environmental taxes and then recycling the revenue by reducing distorting taxes in order to improve the efficiency of the tax system, thus keeping the government budget unchanged.<sup>4</sup> However, alternative recycling procedures can be devised. In fact, there exists a new wave on GTR schemes with extra revenues recycled for fiscal consolidation (see for instance, Gago et al’s

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<sup>1</sup> See for instance “Global megatrend 7: Intensified global competition for resources” and “Global megatrend 10: Increasing environmental pollution” in the series of global megatrends published by the European Environment Agency (EEA, 2011). The acknowledgement of this reality represents one of the main fundamentals for the Green Growth initiative under the auspice of the OECD. <http://www.oecd.org/greengrowth/>

<sup>2</sup> For instance, Denmark, Germany, Finland, Norway, Sweden, Netherlands and the UK.

<sup>3</sup> There was a previous GTR proposal in 1992.

<sup>4</sup> We agree with Dresner et al. (2006): “The most common definition of ETR [GTR], which we also adopt here, is the use of the revenue from environmental taxes to reduce distortionary taxes, in particular, taxes on labour.”

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2014 survey). That is certainly an appealing idea<sup>5</sup> in the current troubled times for developed economies facing a scenario of economic crisis and growing public deficits, when new policy strategies are needed to recover economic growth and stabilise public budgets.<sup>6</sup> The interest in considering environmental taxes to accommodate global trends (i.e., environmental and fiscal issues) is the idea that they might play an important role in easing political constraints regarding the reform of public budgets (calling for spending cuts and tax increases).<sup>7</sup> In that context, environmental and energy-related taxes might become “the lubricating oil”<sup>8</sup> that makes a fiscal or public budget reform possible.<sup>9</sup>

Nonetheless, some researchers might be reluctant towards any departure from revenue-neutral GTR (budget-neutrality adjustments), considering such a departure as something undesirable for the general goal of efficiency improvements of the tax system. Realpolitik, however, may regard the departure from revenue-neutral conditions as an unavoidable cost<sup>10</sup> for policymaking (subject to fiscal stress episodes, perceived impacts on competitiveness and low-income groups).

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<sup>5</sup> Interestingly, a special issue in *Energy Policy* (vol. 34, 2006) was devoted to the social and political responses to ecological tax reform in Europe. This issue is beyond the scope of this piece of research. An interesting presentation to these issues can be found in the introduction to the special issue by Dresner et al. (2006).

<sup>6</sup> A policy brief by OECD (2010) summarises this issue as follows: “the scale of the challenge of restoring sound public finances in many countries is likely to require discretionary tax increases. [...] Enacting tax reforms may be difficult unless reforms are seen to be both necessary and fair. This is likely to apply as much to environmentally related taxation (e.g., to reduce emissions of greenhouse gases) as other taxes”.

<sup>7</sup> The burden from environmental taxes is becoming an important source of revenue in some countries. Hagemann (2012) attributed as high as 1.8% of GDP to the contribution of greenhouse gas emission charges as part of fiscal consolidation in most European countries.

<sup>8</sup> “The lubricating oil that makes possible a tax reform” in Bovenberg and Goulder (2002)’s words.

<sup>9</sup> The bill “Fiscal Measures for Environmental Sustainability” (“Ley 15/2012 de medidas fiscales para la sostenibilidad energética”) endorsed by the Spanish Government in 2012 may represent a very good example.

<sup>10</sup> The benefits of a neutral-revenue GTR represents an opportunity cost in terms of efficiency: policymakers devote extra revenues to fiscal consolidation (by reducing the share of public deficit and

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In this paper, we assess the convenience of revenue-neutral restrictions in GTR on efficiency basis. Our results provide theoretical support to the *third generation of GTR* (Gago et al., 2014), which proposes giving up revenue-neutral constraints and designing GTR schemes with extra revenues recycled to fiscal consolidation, as well as some recent legal European experiences (such as Sweden, the UK, Ireland and Spain). In the following section, we present the new generation of GTR. Section 3 presents our methodology, and section 4 develops the main theoretical analysis. Finally, we summarise the main conclusions and policy implications in section 5.

## 2. A new generation of GTR.

An extensive literature on GTR and the double dividend hypothesis exists.<sup>11</sup> The double dividend hypothesis provides the main theoretical support for implementing GTR. It postulates that green reforms deliver two dividends: an improved environment plus fiscal efficiency gains when extra revenues are “recycled”<sup>12</sup> by reducing some other distorting taxes. A line of research<sup>13</sup> has aim to integrate the double dividend literature within the realm of optimal taxation<sup>14</sup> by analysing (*i*) the optimal environmental taxation in the presence of other taxes; and (*ii*) under what conditions a “double dividend” is indeed an outcome. For this strand of the literature, the interest

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extra debt on total budget) instead of recycling options through lower distorting taxes (e.g., lower fiscal burdens on labor income).

<sup>11</sup> See for instance Speck et al (2011), Giménez and Rodríguez (2010), Goulder (2013) or Gago et al (2014).

<sup>12</sup> By “revenue recycling” we mean a revenue neutral-revenue GTR.

<sup>13</sup> See for instance the seminal work of Sandmo (1975), and others such as Bovenberget et al (1996), Ligthart and van der Ploeg (1999), Kim (2002) and Ballard et al (2005). For a general survey, see for instance Bovenberg and Goulder (2002).

<sup>14</sup> Most of the optimal taxation literature is concerned with the characterization of an optimal tax system, which also accounts for correcting external effects present in the economy (see for instance the seminal work by Sandmo, 1975).

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has mostly hinged on the deviations of the optimal environmental taxation from the Pigouvian norm.

Concerning policy implementation, this literature recognises that policymakers usually depart from a non-optimal tax system and that any fiscal reform aiming to improve social welfare is bounded by socioeconomic constraints. The purpose of the double dividend literature<sup>15</sup> has been to provide an operative and implementable tax reform that involves environmental improvements and efficiency gains of the fiscal system (see for instance Bovenberg 1999). Siegmeier et al (2015) consider that climate change economics and public finance “typically overlooks” and “neglects sizeable interactions of carbon pricing with other fiscal policy instruments”.

Besides, there may be some shortcomings in the pathway of research findings translating into policy (e.g., in order to consolidate public deficits or to attract special interest groups to lobby in favor of regulations). Thus, when scientific arguments and political forces meet, some departures from the original revenue-neutral GTR scientific arguments may arise. The European Commission [EC] launched a GTR proposal in April 2011 (European Commission, 2011a) that represents what happens at the boundary of science and policy (real policymaking constraints as opposed to theoretical model restrictions). The EC proposal includes a 20 euros/tnCO<sub>2</sub> carbon tax and a 9.6 euros/GJ energy tax. The EC pursues several objectives: (i) to contribute to growth and employment by shifting taxation from labor to consumption; and (ii) to promote energy efficiency and consumption of more environmental friendly products. The EC’s proposal aims to complement the existing EU Emissions Trading System (EUETS) by

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<sup>15</sup>Proposals in this literature, however, are surrounded by some controversies (see for instance Giménez and Rodríguez, 2011).

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applying a carbon tax to sectors that are out of its scope (transport, households, agriculture and small industries) plus an energy tax,<sup>16</sup> then counterbalancing some actual EUETS weakness.<sup>17</sup>

The EC's GTR proposal, however, leaves open the use of increased tax revenues: the EC recommends reducing labor taxes, but countries are allowed to use the revenues for fiscal consolidation (European Commission, 2011a). Accordingly, the European Environment Agency published a Staff Position Note (Andersen et al., 2013) addressing the role for environmental fiscal reform in Portugal. This note claims a "dynamic approach to revenue-neutrality" under the current circumstances calling for fiscal consolidation.<sup>18</sup>

Recent fiscal stress episodes in the Eurozone are only some examples of new constraints faced by policymakers to design a comprehensive fiscal system that also considers environmental taxes. Gago et al (2014) review GTR designs on the grounds of the latest political experiences. These authors distinguish three generations of GTR. The first two generations, implemented from the very beginning of the 90's, "would differ in both the guiding energy tax schemes and revenue-recycling procedures". Additionally, these authors identify a recent third generation of GTR that does imply "revenue swaps but to provide additional funding for the public sector". Accordingly, this new generation of non-neutral-revenue GTR is prone to use of increased tax revenues for fiscal consolidation.

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<sup>16</sup> See for instance Rodríguez and Labandeira (2010) for more details on the EUETS design.

<sup>17</sup> The European Commission launched an open debate on options for structural reform of the EU ETS. More details in <http://ec.europa.eu/clima/policies/ets/reform/>

<sup>18</sup> Similar arguments can be found in OECD (2010): "the prospective need for fiscal consolidation increases the presumption that environmental objectives like reducing greenhouse gas emissions should be addressed through measures that rise revenues".

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Some examples of this relaxation on the revenue-neutral condition at the time of GTR implementation also may be found in recent legislation released by several European countries, such as Sweden (2002), UK (2006), Ireland (2010) and Spain (2012)<sup>19</sup>, as well as several European Commission’s proposals already mentioned.

The political implementation of this third generation of GTR seems to have taken the initiative to break with the *neutral recycling of environmental revenues* maxim, but it lacks sound theoretical support. This analysis falls on the boundary realm of the optimal taxation and the double dividend literature. However, the role of revenue-neutral constrains on GTR in the very achievement of an optimal fiscal system has been hardly addressed as long as most literature is “largely focusing on revenue-neutral carbon tax swaps to fund marginal rate cuts in distortionary taxes” (Rausch, 2013). Following the line of reasoning set out by the third generation of GTR, Rausch (2013) has analysed, within an applied general equilibrium model calibrated for the United States, whether a carbon pricing policy may be socially desirable if it is combined with a fiscal policy aimed at reducing public debt instead of revenue-neutral carbon tax swaps. That policy “implies a relaxation of future public budgets as debt repayment results in lower future interest obligations”, which introduces an intergenerational view on the tax recycling and GTR debate. That piece of research represents one example of providing numerical support to devote revenues from

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<sup>19</sup> The Spanish law *Fiscal Measures for Environmental Sustainability (Ley 15/2012 de medidas fiscales para la sostenibilidad energética)* provides the most recent example of this trend. This law introduces energy and environmental-related tax reforms without revenue recycling considerations: new taxes on hydropower production and nuclear waste generation, increased rates on consumption of hydrocarbons for cogeneration and electricity production (coal, natural gas, light fuel oils), and a new tax levied on the production of electricity (uniform for all producers including renewable sources). The Spanish government forecasted an increase of as much as 2.729 million euros of additional fiscal revenues devoted to fiscal consolidation.

1 climate instruments to finance existing public spending. Yet, it lacks a formal treatment  
2 on the robustness of its findings and therefore cannot be derived any general  
3 conclusion.  
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7 Thus, departing from a non-optimal fiscal system, it is worth exploring whether  
8 the implementation of non-neutral-revenue GTR results in higher economic and  
9 welfare outcomes as opposed to neutral-revenue GTR (the first two GTR generations).  
10 The purpose of this piece of research is to analyse the role played by revenue-neutral  
11 restrictions on GTR in achieving an outperforming fiscal system in comparison with an  
12 alternative no-neutral-revenue GTR scheme (according to the third-generation wave).  
13 This paper addresses this issue in a parametrized model. Initially, we consider a fiscal  
14 system that do not include any environmental tax for whatever reason, yet designed  
15 optimally. Then, policymakers decide to implement a revenue-neutral-revenue GTR  
16 subsequent to recognise the existence of a pollutionary externality, as a result of voter  
17 demands, or as a policy tool in order to accomplish any international environmental  
18 agreement.<sup>20</sup> Would the resulting tax menu, now the environmental tax considered, be  
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41 This paper illustrates that the answer is (likely) to be negative. The reason is that  
42 green tax reforms impose on policymakers an additional constraint, namely, to recycle  
43 the revenues from the environmental tax by alleviating existing distorting taxes by  
44 keeping the total budget unchanged. Next, we develop our arguments along our  
45 simple model.  
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56 <sup>20</sup> Think for instance of the 2014 bilateral U.S.-China agreement setting targets for CO<sub>2</sub> emissions out to  
57 the year 2030. The United States will reduce its CO<sub>2</sub> emissions to 27 percent by 2025, approximately,  
58 below the 2005 levels; the Asian giant, however, does not commit itself to any specific value of  
59 emissions, but rather the country's emissions will peak by 2030.  
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### 3. The benchmark model

Consider a static economy, so there are neither savings nor capital accumulation, with two types of agents: households and firms. There are a number of perfectly price-taker competitive firms producing two goods with labour  $N$  (the only required input): good  $X$  is produced with a dirty technology that has pollution  $E$  as a byproduct, while good  $Y$  is produced with a clean technology. Both technologies exhibit constant returns of scale, so the production functions are linear for both goods,  $X = F(N_x) = AN_x$  and  $Y = F(N_y) = DN_y$ . We will assume pollution is proportional to production  $E = \Lambda(X) = \frac{B}{A}X$ . We denote the price of good  $X$  by  $P_x$  and the price of good  $Y$  by  $P_y$ . The price of good  $X$  is normalized to one, i.e.  $P_x = 1$ .

There also exist  $H$  identical households, who are the owners of the firms, and each endowed with 1 unit of time (e.g., a year) that are allocated between working time  $n^h$  and leisure time  $l^h$ . Labor compensation  $w^h$  and government transfers  $T^h$  are sources of income for any household  $h$ . Households enhance welfare by enjoying leisure time  $l^h$  and consuming a composite private good  $c^h$ , a combination of the produced goods purchased by the household,  $x^h$  and  $y^h$ . In addition, pollution  $E$  produced by firms affects each household's welfare negatively. Each household's preferences are represented by a twice-continuously differentiable utility function, and we will take from Parry *et al* (1999) the following parametrized function  $U^h(c^h, l^h, E) = [\alpha_1 c^\rho + \alpha_2 l^\rho]^{1/\rho} - \phi(E)$  with  $c^h = \text{Ln}\{[x^h]^{\beta_x}[y^h]^{\beta_y}\}$ , where  $\phi()$  is an increasing and concave function that represents disutility from pollution. For simplicity, we will assume the following parameterization for the disutility from

pollution  $\phi(E) = \phi E$ . To compute the equilibrium analytically, we choose  $\rho = 1$ , set  $\beta_y = (1 - \beta_x)$  and  $\alpha_2 = (1 - \alpha_1)$ , and reparameterize  $\alpha \equiv \alpha_1$  and  $\beta \equiv \beta_x$ .

In the decentralized competitive equilibrium without a market for pollution, competitive firms do not care about the externality and each household takes the amount of pollution as given. As a result, agents' self-interest leads each agent to equate their private marginal rate of substitution (and transformation) among goods and resources to relative prices. Consequently, there would be too much pollution as it is free.

### 3.1. The decentralized equilibrium allocation with public intervention

To mitigate the pollutionary externality, public intervention maybe needed. Consider there exists a benevolent government that maximizes households welfare by choosing a menu of taxes  $\{t_E, t_c, t_w\}$ , where  $t_E$  is a tax on each unit of pollution emitted,  $t_c$  is a tax on consumption, and  $t_w$  is a tax on income. For convenience, we denote the tax ratio  $\tau = \frac{1-t_w}{1+t_c}$ . The tax revenue finances an exogenous public expenditure and the excess of burden is transferred back to households as a lump-sum subsidy, i.e.  $\{T^h\}_{h=1}^H$ . For simplicity, we assume that the public expenditure is zero<sup>21</sup>.

To the extent there is a tax on emissions, competitive firms take into account the externality. The functional forms assumed greatly simplifies the labour market equilibrium by setting the real wages at the infinitely elastic demand  $\frac{w}{P_x} = A - \frac{t_E}{P_x} B$ , and the consumption goods price ratio equals to  $\frac{P_y}{P_x} = \frac{A}{D} - \frac{B t_E}{D P_x}$ .

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<sup>21</sup>Alternatively, we can reinterpret transfers  $T^h$  as a measure of all the value generated from public expenditure.

Each household  $h$  maximizes his welfare subject to the budget constraint

$$(1+t_c)\left[x^h + \frac{P_y}{P_x}y^h\right] = (1-t_w)\left[\frac{w}{P_x}(1-l^h) + T^h\right],$$

taking the real wage  $w/P_x$  as given. Finally, the government budget constraint is balanced as long as the tax revenue is evenly given back to households  $T^h$ , i.e.,

$$\sum_{h=1}^H T^h = \frac{t_E}{P_x} E + t_c \sum_{h=1}^H \left[x^h + \frac{P_y}{P_x} y^h\right] + t_w \sum_{h=1}^H \left[\frac{w}{P_x}(1-l^h) + T^h\right].$$

The competitive equilibrium with public intervention and a menu of taxes  $\{t_E, t_c, t_w\}$  is described by demand and supply functions, the market clearing conditions and government budget constraint. This allows us to find the equilibrium allocations:

$$l^h(\tau, t_E) = 1 - \frac{\alpha}{1-\alpha} \frac{\tau}{A} (A - t_E B \beta), \quad (1)$$

$$(x^h(\tau, t_E), y^h(\tau, t_E)) = \left( \beta \frac{\alpha}{1-\alpha} \tau (A - t_E B), (1-\beta) \frac{\alpha}{1-\alpha} D \tau \right), \text{ and} \quad (2)$$

$$T^h(\tau, t_E) = \frac{\alpha}{1-\alpha} (A - t_E B) \left[ 1 - \tau \frac{(A - t_E B \beta)}{A} \right] \quad (3)$$

for each household  $h$ ; and,

$$(X(\tau, t_E), Y(\tau, t_E)) = \left( \beta \frac{\alpha}{1-\alpha} H \tau (A - t_E B), (1-\beta) \frac{\alpha}{1-\alpha} D H \tau \right) \quad (4)$$

$$(N_x(\tau, t_E), N_y(\tau, t_E)) = \left( \beta \frac{\alpha}{1-\alpha} \frac{H}{A} \tau (A - t_E B), (1-\beta) \frac{\alpha}{1-\alpha} H \tau \right) \quad (5)$$

and,

$$E(\tau, t_E) = \beta \frac{\alpha}{1-\alpha} \frac{B H}{A} \tau (A - t_E B). \quad (6)$$

### 3.2. The optimal tax menu

The equilibrium allocations allow us to define the individual *utility function* for each household  $h$  as a function of the tax menu

$$U^h(\tau, t_E) = U^h(c^h(\tau, t_E), l^h(\tau, t_E), E(\tau, t_E)) = K_0 + \alpha \ln[K_1 \tau(A - t_E B)^\beta] - \frac{\alpha}{A} \tau(A - t_E B \beta) - \phi \left( \frac{\beta \alpha}{1 - \alpha} \frac{BH}{A} \tau(A - t_E B) \right),$$

with  $K_0 = (1 - \alpha)T$  and  $K_1 = \frac{\alpha}{1 - \alpha} \beta^\beta [(1 - \beta)D]^{1 - \beta}$ . The *aggregate social welfare function* becomes  $U(\tau, t_E) = \sum_{h=1}^H \alpha_h U^h(\tau, t_E)$ , where  $\alpha_h$  is the household weights.

Since all households are identical, we take the value  $\alpha_h = 1$  for all  $h$ .

A benevolent government will choose the optimal taxation menu  $\{\tau^*, t_E^*\}$  that maximizes *aggregate social welfare function*; that is,

$$\max_{\tau, t_E} U(\tau, t_E) = \max_{\tau, t_E} \sum_{h=1}^H U^h(\tau, t_E).$$

First order conditions -i.e.  $\partial U^h(\tau^*, t_E^*) / \partial \tau = 0$  and  $\partial U^h(\tau^*, t_E^*) / \partial t_E = 0$  - determine the optimal tax menu:

$$\begin{aligned} \tau^* &= 1 \\ t_E^* &= \frac{A}{B} \frac{\Omega}{1 + \Omega}, \end{aligned} \quad (7)$$

with  $\Omega = \phi BH / (1 - \alpha)$ , so that the competitive equilibrium allocations at the optimal tax menu are given by (1)-(6) for  $\{\tau^*, t_E^*\}$ . The optimal tax menu in this simple economy results in zero distorting taxes, together with a positive environmental tax that internalize the negative externality. See Figure 1 for a numerical example illustrating the welfare level (point A) achieved by this optimal tax menu.

## 4. The new equilibrium after a GTR is implemented.

The advocates for green tax reforms heavily rely on the efficiency gains. The total gains or losses in aggregate welfare after implementing a green tax reform could be measured as the difference between the aggregate welfare received after the reform with respect to the initial aggregate welfare. Thus, an increase aggregate welfare would justify its implementation. Analytically, we can compute the new allocations before and after implementing a neutral-revenue GTR.

### 4.1. The departure point in real policymaking.

Consider initially that the government has never set an environmental tax for whatever reasons, so  $t_E^0 = 0$ . Besides, suppose that the available or existing taxes are set at its optimal taxation level, i.e., the constrained-optimal taxation scheme by applying the Ramsey rule with  $t_E^0 = 0$ . Then, the benevolent government chooses the optimal tax  $\tau$  that maximizes *aggregate social welfare function*, that is

$$\max_{\tau, t_E} U(\tau, t_E) = \max_{\tau, t_E} \sum_{h=1}^H U^h(\tau, t_E), \text{ s.t. } t_E = 0.$$

In our simple model, the Ramsey rule tax ratio is found from the first order condition

$\partial U^h(\tau^{**}, 0) / \partial \tau = 0$ ; that is,

$$\tau^{**} = \frac{1}{1 + \Omega\beta},$$

so that the competitive equilibrium allocations are given by (1)-(6) for  $\{\tau^{**}, 0\}$ . Observe that, the constrained-optimal distorting tax ratio (with  $t_E^0 = 0$ ) is lower than the

1 optimal tax ratio,  $\tau^{**} = 1/(1 + \Omega\beta) < 1 = \tau^*$ , which entails that whether the consumption  
 2 tax ( $t_c^{**}$ ) or the income tax ( $t_w^{**}$ ) -or both- are higher than its optimal level. See Figure 1  
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 5 for a numerical example illustrating the welfare level (point C) achieved by the  
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#### 4.2. The implementation of a neutral-revenue green tax reform.

Later on, the government decides the tax menu must be modified by implementing a neutral-revenue GTR<sup>22</sup> (following the first and second generation's designs of GTR). This neutral-revenue GTR consists strictly on setting an environmental tax  $t_E^{GR}$  and recycling the environmental revenues to reduce distorting taxes  $\tau^{GR}$ , keeping the government budget balanced (i.e., keeping the household transfers at their initial level):

$$\sum_{h=1}^H T^h(\tau^{GR}, t_E^{GR}) = \sum_{h=1}^H T^h(\tau^{**}, 0). \quad (8)$$

In this case, setting any environmental tax  $t_E^{GR}$  entails the following level of the distorting tax ratio:

$$\tau(t_E^{GR}) = \frac{A(\tau^{**} A - t_E^{GR} B)}{(A - t_E^{GR} B\beta)(A - t_E^{GR} B)}. \quad (9)$$

Observe that, as asserted by the advocated of GTR, any environmental tax  $t_E^{GR}$  assured that the pollutionary externality is mitigated and, after subsequently implementing a revenue-neutral-revenue GTR, the level of distorting taxes is alleviated as the tax ratio

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<sup>22</sup>For instance, after recognizing the existence of a pollutionary externality, because voter demands or as a policy tool in order to accomplish any international environmental agreement.

1 is higher, i.e.,  $\tau^{GR} < \tau^{**}$ .<sup>23</sup> Accordingly, there exist a myriad of GTR for which the choice  
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 3 of the environmental tax  $t_E^{GR}$  may accomplish diverse constraints (e.g., optimal tax  
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 5 prescriptions, Pigouvian norm or any other political constraint). Any of these neutral-  
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 7 revenue GTR equilibrium allocations are then given by (1)-(6) for  $(\tau^{GR}, t_E^{GR})$  for each  
 8  
 9 given environmental tax  $t_E^{GR}$ . See Figure 1 for a numerical example showing the  
 10  
 11 welfare level achieved by every neutral-revenue GTR's proposal (green thick line).  
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### 19 **4.3. Is full recycling the better way?**

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 22 In this section, we explore the role played by neutral-revenue GTR in achieving  
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 24 an optimal taxation menu when departing from a tax menu with no previous  
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 26 environmental considerations. The initial tax scheme  $\{\tau^{**}, 0\}$  was found in section 4.1;  
 27  
 28 we have assumed that the tax ratio  $\tau^{**}$  was chosen to maximize citizens' welfare in  
 29  
 30 such a way that the benevolent government designs a tax system without being aware  
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 32 to correct a pollutionary externality (constrained by  $t_E^{**} = 0$ ). Then, we presented the  
 33  
 34 implementation of a neutral-revenue GTR in section 4.2, setting any given  
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 36 environmental tax  $t_E^{GR}$ .  
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 44 Results from section 4.2 allow us to find the environmental tax that maximizes  
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 46 the social welfare, a tax reform that will be referred to as the *optimal neutral-revenue*  
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 48 *GTR* (see Figure 1, point B). We will follow the literature of optimal taxation by  
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 50 considering that the benevolent government will choose the optimal taxation menu  
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57 <sup>23</sup>This would be true provided  $\lim_{t_E^{GR} \rightarrow 0} d\tau(t_E^{GR})/dt_E^{GR} > 0$ , which is only verified in our illustration  
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 59 provided  $\Omega < 1$ . So it is not expected to be generally true for any value of the calibrated parameters.  
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1  $\{\tau^{GR*}, t_E^{GR*}\}$  that maximizes *aggregate social welfare function* subject to the  
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 3 government budget is balanced; that is,

$$4 \max_{\tau^{GR}, t_E^{GR}} U(\tau^{GR}, t_E^{GR}) = \max_{\tau, t_E} \sum_{h=1}^H U^h(\tau^{GR}, t_E^{GR}) \text{ subject to (8).} \quad (10)$$

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 8 Since the *government budget balanced* condition (8) states a functional  
 9 relationship between the tax ratio and the environmental tax  $\tau(t_E^{GR})$ , as shown by  
 10 equation (9), we can alternatively find the optimal environmental tax by maximizing  
 11  
 12  $\max_{t_E^{GR}} U(t_E^{GR}) = \max_{t_E^{GR}} U(\tau^{GR}(t_E^{GR}), t_E^{GR})$ , to find that

$$13 \quad t_E^{GR*} = \frac{A}{B} \frac{\Omega}{1 + \Omega}$$

14  
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 17 is a root of the first-order conditions  $dU(t_E^{GR}) / dt_E^{GR} = 0$ , so that the optimal tax ratio  
 18  
 19 becomes

$$20 \quad \tau_E^{GR*} = \tau(t_E^{GR*}) = \left( 1 + \frac{\Omega\beta}{1 + \Omega(1 - \beta)} \right) \left( 1 - \frac{\Omega\beta(1 + \Omega)}{1 + \Omega\beta} \right).$$

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 22  
 23 See Figure 1 for a numerical example illustrating the maximum welfare level (point B)  
 24 achieved by a neutral-revenue GTR. Observe that the *optimal neutral-revenue GTR* (as  
 25 represented by point B) represents a Pareto efficient improvement, because the initial  
 26 tax scheme  $\{\tau^{**}, 0\}$  is also an feasible menu at the maximization problem (10). But, is  
 27 this neutral-revenue GTR tax menu  $\{\tau^{GR*}, t_E^{GR*}\}$  really optimal? Does it represent the  
 28 best target for policymakers?

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The answer to this question is negative as long as the optimal neutral-revenue GTR does not represent the best target available for policymakers  $\{\tau^*, t_E^*\}$ . This conclusion might jeopardize those arguments from proponents of implementing any neutral-revenue GTR. This conclusion may be illustrated in two alternative ways (see



1 Figure 1). For instance, the final tax ratio will not be the optimal one,  $\tau(t_E^{GR*}) \neq \tau^*$ ,  
 2  
 3 even if the neutral-revenue GTR implements the optimal environmental tax,  $t_E^{GR*} = t_E^*$ .  
 4  
 5 And vice versa, the final environmental tax will not be the optimal one,  $t_E^{GR**} \neq t_E^*$ , even  
 6  
 7 if the neutral-revenue GTR is set at the optimal tax ratio (i.e.,  $\tau(t_E^{GR**}) = \tau^*$ ). Observe in  
 8  
 9 our illustration at Figure 1 that this neutral-revenue GTR tax menu  $\{\tau^*, t_E^{GR**}\}$ , with  
 10  
 11  $\tau(t_E^{GR**}) = \tau^*$ , entails households that are worse off, in welfare terms, with respect the  
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 13 equilibrium allocation for the initial tax menu with no previous environmental  
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 15 considerations  $\{\tau^{**}, 0\}$ .  
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23 We may conclude that (i) a neutral-revenue GTR does not turn a non-optimal tax  
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 25 system into an optimal one; and, therefore, (ii) the optimal tax menu  $\{\tau^*, t_E^*\}$  will  
 26  
 27 never be achieved after implementing a neutral-revenue GTR (see Figure 1). The  
 28  
 29 reason stems from the core of the neutral-revenue GTR proposal: the revenue from  
 30  
 31 environmental taxation is recycled to alleviate distorting tax rates *constrained to keep*  
 32  
 33 *the public budget unchanged*, according to equation (8).  
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39 Worst of all, there might be a range of environmental tax rates for which a  
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 41 neutral-revenue GTR decreases households' welfare. For that range of environmental  
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 43 tax rates the households would be better off in an economy with no environmental  
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 45 taxes. In our illustration (see Figure 1), this is the case for high enough environmental  
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 47 taxes whose corresponding tax ratio after implementing a neutral-revenue GTR is  
 48  
 49 higher than  $\bar{\tau}^{GR} = \bar{\tau}^{GR}(\bar{t}_E^{GR})$ , with  $U(\bar{\tau}^{GR}(\bar{t}_E^{GR}), \bar{t}_E^{GR}) = U(\tau^{**}, 0)$ . That is, a revenue  
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 51 recycling scheme does not accomplish the GTR goal of increasing welfare by obtaining  
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 53 a less distorting tax system, at least for a range of environmental taxes.  
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3 In terms of our model, the initial per capita transfers  $T^h(\tau^{**}, 0)$  for each  $h = 1, \dots$   
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5  $H$  must remain constant after implementing a revenue-neutral GTR, i.e.  
6  
7  $T^h(\tau^{GR}, t_E^{GR}) = T^h(\tau^{**}, 0)$  for any household  $h$ . These transfers, however, do not need to  
8  
9 match those corresponding to the optimal taxation scheme, i.e.,  $T^h(\tau^*, t_E^*)$ . In fact, the  
10  
11 key element for this paper's main conclusions is that the level of transfers  $T^h$  is a  
12  
13 monotonically decreasing function for both arguments (i.e.,  $\tau$  and  $t_E$ ). Thus, in light of  
14  
15 Figure 1, the transfers in an optimal tax scheme,  $T^h(\tau^*, t_E^*)$  must be lower than those  
16  
17 after implementing a neutral-revenue GTR ( $T^h(\tau^{GR}, t_E^{GR}) = T^h(\tau^{**}, 0)$ ) because it allows  
18  
19 for a better tax-rate adjustment towards its optimal level. Accordingly, a neutral-  
20  
21 revenue GTR provides too many transfers to households (i.e., results in a suboptimal  
22  
23 high level of public expenditure).

24  
25 To sum up, a GTR with full recycling of extra revenues restricts the benevolent  
26  
27 government choices so as to dismiss the best targets otherwise available for  
28  
29 policymakers. The key issue for this negative result is that policymakers cannot achieve  
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31 the optimal taxation menu by implementing a tax reform that imposes a constant  
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33 public budget (in terms of our model, a transfer pattern set at its initial level).  
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35 Therefore, a relaxation on this full recycling condition may provide better economic  
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37 outcomes (closer to the best target).  
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## 50 **5. Conclusions and Policy Implications**

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52 Environmental and energy-related taxes are usually regarded by both  
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54 policymakers and economists as promising instruments for easing political constraints.  
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56 On the one hand, they may raise sizeable revenues to confront fiscal stress episodes in  
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1 some European countries, facing a scenario of economic crisis and growing public  
2 deficits. On the other hand, they may reinforce existing energy efficiency policies  
3 aiming to improve energy security (on price uncertainty and in the geopolitics realm)  
4 and environmental impacts. However, some academics might be reluctant to any  
5 departure from revenue-neutral GTR (budget neutrality adjustments) as something  
6 undesirable for the general goal of efficiency improvements of the tax system:  
7 policymakers should not devise environmental and energy-related taxes as a pretext to  
8 raise extra revenue.  
9

10  
11 In this paper, we have assessed the convenience of revenue-neutral restrictions  
12 in GTR on efficiency basis. Our results provide theoretical support to the third  
13 generation of GTR, which proposes to give up revenue-neutral constraints and to  
14 design GTR schemes with extra revenues recycled to fiscal consolidation. It advocates  
15 for a “dynamic approach to revenue-neutrality”, and thus it is aligned with statements  
16 from the European Environment Agency and the European Commission. Similar  
17 arguments can be found in statements from the OECD (2010), such as “the prospective  
18 need for fiscal consolidation increases the presumption that environmental objectives  
19 like reducing greenhouse gas emissions should be addressed through measures that  
20 rise revenues”. Those recommendations have been implemented in some recent legal  
21 European experiences.  
22

23  
24 Concerning policy recommendation, a main consequence of this work is that  
25 introducing additional taxes to mitigate market failures should lead policymakers to  
26 fully reconsider the tax menu and not to self-restriction of recycling schemes on green  
27 tax revenues (e.g., by keeping the existing level of public expenditure).  
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Several final comments are in order. First, we are assuming (for modelling convenience) that the departure point for policymakers is an optimal taxation system without any environmental consideration (thus, without environmental taxes).<sup>24</sup> Once the environmental tax is introduced, a neutral-revenue GTR is unable to transform an inefficient tax system into an optimal one (or even one closer to being optimal). However, if we realise that real-world politicians are constrained by multiple restrictions —e.g., distributional concerns, vote restrictions, international commitments— the usual starting point for policymakers used to be a suboptimal tax system. This observation makes the achievement of any optimal tax menu after implementing a neutral-GTR even more unlikely.

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Second, although our paper recommends giving up the neutral recycling scheme of GTR to enhance the efficiency of the tax scheme, our findings do not represent straightforward support for increased government expenditures funded with new revenue from environmental taxation. A result in our simple model shows that it could easily be the reverse: an optimal tax system would require a decrease, instead of an increase, in government expenditure (i.e., a lower transfer amount to individual agents). Of course, our simple model presents a static setting with public expenditure restricted to consumption of goods (comprising governmental transfers to households), so there is no government provision of goods and services (such as education, health, R&D, etc.) that increases present and future individuals' welfare, as no positive externalities exist from goods produced by the public sector in our model. If so, it would be necessary to redesign a tax menu to internalize these positive

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<sup>24</sup> This tax menu without any environmental tax exists because of a specific reason (lack of knowledge of environmental impacts, etc.). Thus, with complete information, we should say it is not an optimal tax system as long as any environmental externality is absent (see section 4.1).

externalities (and then, to fund these government expenditures). But the main message of this paper related to the suboptimal accomplishment, in welfare terms, of implementing revenue-neutral GTR will (very likely) remain. It should be kept in mind that the objective of this work is not to present a complete analysis of the third generation of GTR in the realm of optimal taxation, but instead just to present theoretical support against revenue-neutral constraints on GTR to achieve an optimal taxation menu.

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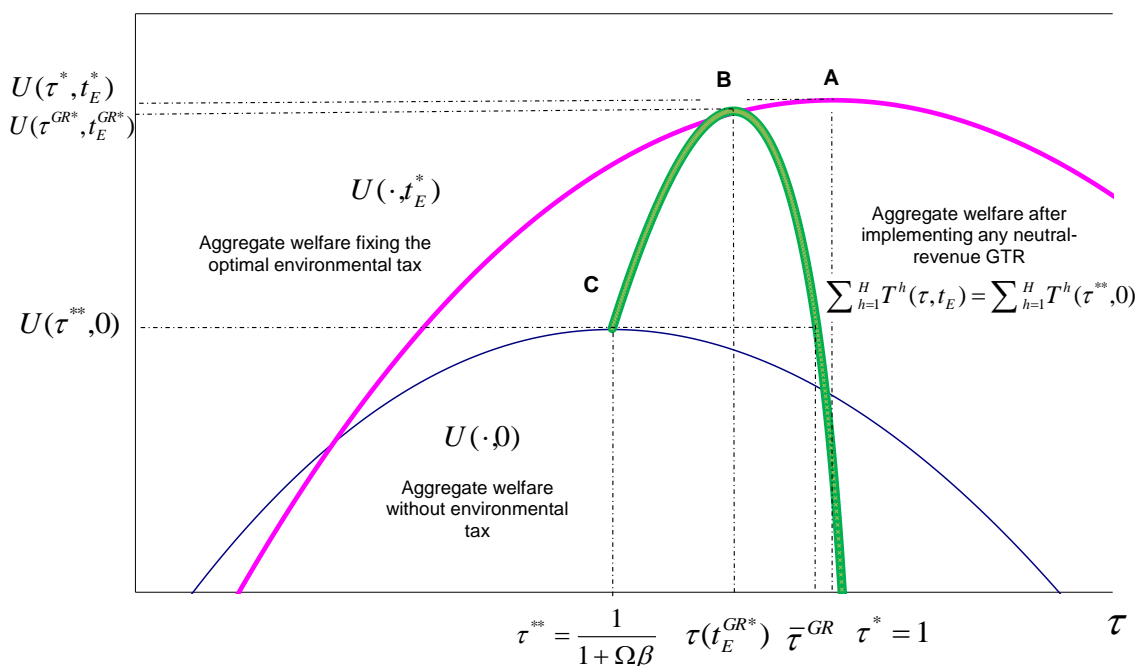
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Note: A numerical example to illustrate the reasoning in section 4.



**Figure 1. Welfare levels for alternative tax menus.**

The vertical axis represents the aggregate households' welfare for each tax rate  $\tau$  (horizontal axis). We picture three functions: (i) the social welfare function  $U(\tau, 0)$  where no environmental tax is considered ( $t_E = 0$ ) (represented by the blue line), a function that reaches a maximum at C for  $\tau^{**} = 1/(1 + \Omega\beta)$ ; (ii) the social welfare function  $U(\tau, t_E^*)$  fixing the environmental tax at its optimal level  $t_E^*$  (represented by the pink line), a function that reaches a maximum at A for  $\tau^* = 1$ ; and (iii) the value of the social welfare function after implementing any neutral-revenue GTR starting from the distorted tax system  $(\tau^{**}, 0)$ , that is by setting any environmental tax and then reducing the tax ratio observing the neutral constraint (8). Point B represents the maximum welfare achieving for a GTR, i.e. whenever  $t_E^{GR*}$  is chosen. The parameterization for this numerical illustration is the following:  $\alpha = 0.3$ ,  $\beta = 0.2$ ,  $A=1.021$ ,  $B=0.7$ ,  $D=1$ ,  $H=2.5$ ,  $\phi = 0.1$ , and  $T=1$ .

## TECHNICAL APPENDIX

### A.1. Optimal Tax Problem: First order conditions

$$\frac{\partial U^h(\tau^*, t_E^*)}{\partial \tau} = \frac{\alpha}{\tau} - \frac{\alpha}{A} (A - t_E B \beta) - \phi \frac{BH}{A} \frac{\alpha \beta}{1 - \alpha} (A - t_E B) = 0$$

$$\frac{\partial U^h(\tau^*, t_E^*)}{\partial t_E} = \frac{\alpha \beta}{(A - t_E B)} - \frac{\alpha \beta}{A} \tau - \phi \frac{BH}{A} \frac{\alpha \beta}{1 - \alpha} \tau = 0$$

### A.2. Derivative of equation (9)

$$\frac{d\tau(t_E^{GR})}{dt_E^{GR}} = \tau(t_E^{GR})(-B) \left[ \frac{1}{\tau^{**} A - t_E^{GR} B} - \frac{\beta}{A - t_E^{GR} B \beta} - \frac{1}{(A - t_E^{GR} B)} \right]$$

with  $\tau^{**} = 1/(1 + \Omega\beta)$ , then as  $t_E^{GR}$  approaches to 0, the derivative is positive provided  $\Omega < 1$ .

### A.3. Optimal tax menu at the neutral-revenue GTR Problem: First order condition

$$\begin{aligned} \frac{d\mathbf{U}(t_E^{GR})}{dt_E^{GR}} &= (A - t_E^{GR} B) \frac{d\tau(t_E^{GR})/dt_E^{GR}}{\tau(t_E^{GR})} \left\{ \frac{1}{A - t_E^{GR} B} - \frac{\tau}{A} \left[ \frac{A - t_E^{GR} B \beta}{A - t_E^{GR} B} + \Omega\beta \right] \right\} - \\ &- B\beta \left\{ \frac{1}{A - t_E^{GR} B} - \frac{\tau}{A} [1 + \Omega] \right\} = 0 \end{aligned}$$

Observe that both brackets are identical provided

$$\frac{A - t_E^{GR} B \beta}{A - t_E^{GR} B} + \Omega\beta = 1 + \Omega.$$

That is, a root of  $d\mathbf{U}(t_E^{GR})/dt_E^{GR}$  is  $t_E^{GR*} = \frac{A - \Omega}{B(1 + \Omega)}$ .