Domestic Tax Reforms under Consumption-Generated Pollution and Revenue Constraint

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Abstract
In recent years, an increasing number of countries gradually relies more on the use of domestic taxes, e.g., consumption taxes or VATs, for raising government tax revenues. This paper revisits the question of reforming the structure of consumption taxes in the presence of consumption-generated pollution, and identifies sufficient conditions under which such a tax reform improves welfare with and without a binding government revenue constraint.

Keywords: Consumption tax reforms, Consumption generated pollution, Welfare, Government tax revenues

H23: Environmental Taxes and Subsidies

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1. Introduction

Tax reforms have been a central policy issue both in theory and practice over the past few decades. An important issue of the relevant literature is that of establishing sufficient conditions under which indirect tax reforms, or moving taxes towards uniformity, improves welfare without, however, eroding government tax revenue. This concern becomes even more important for revenue strained developing economies. Achieving these two goals, countries are able to attain a so-called “double-dividend”. That is, a tax system which improves welfare and ensures at least constant, if not higher, government tax revenues.

By now, a sizeable literature has addressed the aforementioned issues. In particular, within the context of open economies, two popular types of trade and/or domestic tax reforms have been examined. First, a policy of revenue-neutral reforms in trade taxes and/or in commodity taxes (e.g., Abe (1995), Michael et al. (1993), Anderson (1999), Keen and Ligthart (2002), Lahiri and Nasimi (2005). Second, a reform of trade taxes accompanied by appropriate changes in domestic taxes so that consumer or producer prices are held constant, e.g., see Hatzipanayotou et al. (1994), Emran (2005), Emran and Stiglitz (2005).

A recent and relatively small literature relates tax reforms to environmental pollution. Pollution, whether it is attributed to production or consumption of final goods, entails adverse utility effects, which then needs to be accounted for when evaluating the welfare and government revenue implications of reforming a country’s structure of indirect taxes. Studies, such as Copeland (1994), and Turunen-Red and Woodland (2004) have focused on constructing welfare improving reforms of trade and environmental taxes without, however, accounting for revenue considerations. Beghin and Dessus (1999), examine the implications of reforms in trade and

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1 For example, international institutions, e.g., GATT/WTO, the IMF and the World Bank, encourage governments to reform their indirect tax structure, moving away from trade taxes, such as tariffs and export taxes to other forms of taxation such as income taxes, consumption taxes and VATs. For example, in a recent study for Pakistan, Lahiri and Nasimi (2005) find that the share of sales taxes in total tax revenue increased from 13 percent in 1990-91 to 35 percent in 2001-02, while the share of international trade taxes decreased from 39 percent to 10 percent during the same period.

2 Earlier literature on trade and domestic tax/subsidy reform policies, without a binding government revenue constraint include, among others, Hatta (1977a, 1977b), Fukushima (1979), Diewert et al. (1989).
environmental policies on welfare and the level of pollution emissions, under the
coststraint of non-decreasing government tax revenue. Hatzipanayotou et al. (2004)
examine the “double-dividend” implications of a number of multilateral
environmental policy reforms in a two-country model of production generated cross-
border pollution and of simultaneous provision of private and public sector pollution
abatement. In all these studies, pollution is considered a by-product of production.
But, utility can be adversely affected also by pollution emissions emanating from
consumption activities, e.g., car use, cigarettes, aerosol sprays, etc. To the best of our
knowledge only a limited number of studies has, thus far, related the issue of tax
policy reforms to consumption generated pollution. Beghin et al. (1997), abstracting
from tax revenue considerations, examine the welfare implications of environmental,
in a reciprocal dumping model with consumption generated pollution demonstrate,
among other things, that a revenue neutral reform of increasing consumption taxes
and reducing tariffs is strictly Pareto improving.

The purpose of this paper is to identify, in the presence of consumption
generated pollution, consumption tax reforms that improve welfare and keep
government revenue constant. To achieve this goal, we build a small open economy
general equilibrium model with consumption generated pollution. The structure of
indirect taxes consists only of consumption taxes. Within this context, we identify the
conditions under which specific consumption tax reforms improve welfare with and
without government budget constraint.

3 In their model there is a binding government revenue constraint through which public sector pollution
abatement is financed by using a fraction of emission tax revenue collected from the private producers.
4 Generally speaking, within this literature, the meaning of a trade-environment “double-dividend”
pertains to the reform of trade and environmental taxes which improve welfare and reduce both trade
and environmental distortions without eroding government tax revenues.
5 Another strand of the literature, not however relevant for the present paper, examine economic
implications of consumption generated pollution, e.g., Copeland and Taylor (1995), Perrings and
Ansuategi (2000).
6 Here, in the absence of other distortions, e.g., international trade impediments, or of other policy
instruments, consumption taxes serve as environmental taxes directly targeting consumption generated
pollution. Moreover, our focus, for analytical purposes, on consumption generated pollution, should not
be taken as undermining the real world relevance of production generated pollution, especially in LDCs
(e.g., the pollution haven hypothesis). However, consumption generated pollution may be an equally
notable feature of these economies. For example, Beghin et al. (1997) note that substantial levels of
toxic emissions arise from the final consumption of chemicals and non-electrical energy, and from post
consumption waste. Moreover, as noted by Kayalica and Kayalica (2005), the Brundtland Report
(WCED, 1987) considers consumption-driven pollution of biosphere as an important threat to the
environmental sustainability of development.
2. The Model

We consider a small open, perfectly competitive economy which produces and consumes $K + 1$ internationally traded goods. There are $K$ types of pollutants associated with the consumption of these goods. Good zero is the *numeraire* good, whose price equals 1 and its consumption it is assumed not to generate any pollution. The country is endowed with the inelastic supply of $M$ primary factors, denoted by the vector $\mathbf{v}$, which are used in the production of all goods.

As noted above, pollution is modeled as a by-product of consumption. We assume that the consumption of each commodity generates a different type of pollutant, denoted by $z_j$, $j = 1, 2, ..., K$. For convenience in the analysis to follow, we assume that one unit of consumption $c_j$ generates one unit of the corresponding type of pollutant $z_j$.

The country is a price taker in world commodity markets. Thus, international commodity prices of all goods are fixed and assumed to equal unity, and are given by the price vector $p^* = (1, 1, ..., 1)$, a $(1 \times K)$ vector of unit-scalars. Producer prices are equal to the world prices. Restrictions, however, exist in the form of consumption taxes on the polluting consumptions. Thus, for the $j^{th}$ commodity let $p_j = 1 + \tau_j$ be the domestic consumer price, where $\tau_j$ denotes the specific consumption tax levied on the $j^{th}$ commodity. No taxes of any type are levied on the *numeraire* good $(0)$.\(^8\)

The economy’s production side is represented by the country’s Gross Domestic Product (GDP) function, $R(p^*, \mathbf{v})$, which captures the economy’s maximum revenue from domestic production of the internationally traded goods. The GDP function is denoted as:

$$R(p^*, \mathbf{v}) = \max_y \left\{ p^* y : (y_0, y, z) \in T(\mathbf{v}) \right\},$$

where $y_0$ and $y = (y_1, y_2, ..., y_K)$, respectively, denote the outputs of the *numeraire* and of all other goods, and $(y_0, y, z)$ is the set of feasible output and pollution combinations given by the economy’s aggregate technology set $T(\mathbf{v})$. For the rest of

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7 In the literature of indirect tax reforms, the assumption of a small open economy (i.e., no terms of trade effects) is, by and large, a standard one to facilitate the analysis.

8 Emran (2005) notes that more than one commodity can be untaxed, which then serve as a composite *numeraire* good.
the analysis, since the vectors of producer prices $p^*$ and of factor endowments $\bar{v}$ remains unchanged, the GDP function is denoted by $R$. A prime (') denotes a transposed vector or matrix.

Turning to the demand side of this economy, it consists of identical households who consume the $K+1$ commodities. Households utility is positively affected by consumptions, but it also adversely affected by the consumption generated pollution. A representative household’s preferences are captured by the expenditure function $E(1, p, z, u)$ denoting the minimum expenditure on private goods, at consumer price vector $p$ and vector of pollutants $z$, achieving a certain level of utility $(u)$. The $E(1, p, z, u)$ function is non-decreasing and concave in $p$. That is, $E_{p_j} = \partial E / \partial p_j$ is the compensated demand for good $(j)$, 9 and $E_{pp}$ is a $(K \times K)$ negative semi-definite matrix. The expenditure function is increasing in $z$ and $u$. 10 In particular, the derivative $E_{z_j}$ of the expenditure function captures the marginal damage caused by the pollutant $z_j$, and thus it represents the household’s marginal willingness to pay for its abatement (e.g., see Copeland, 1994). Since we assume that one unit of consumption generates one unit of the corresponding type of pollutant $z_j$, the latter is defined as $z_j = E_j(1, p, z, u)$.

The government’s tax revenue $(T)$ is lump-sum distributed to domestic households and it equals the consumption tax revenue. That is,

$$T = \tau' E_p (p, z, u) = \sum_{j=1}^{K} \tau_j E_{p_j} (p, z, u), \quad (1)$$

where $E_p$ is the vector of compensated demand functions, and recall that for the untaxed numeraire good, $\tau_0 = 0$. Since consumption tax revenue is lump-sum distributed to domestic households, the country’s income-expenditure identity

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9 The compensated demand and supply functions for the numeraire good are respectively, $E_{p_0}$ and $R_{p_0}$.

10 The $E(.)$ function is increasing in $z$ since an increase in any type of pollutant is assumed to harm the households utility. Therefore, to attain a given level of utility, $u$, private spending on consumption must rise. Moreover, $E_u (= \partial E / \partial u)$ denotes the reciprocal of the marginal utility of income.
requires that private spending on goods must equal income from production plus income from consumption taxes. That is,

\[ E(p, z, u) = R + \sum_{j=1}^{K} \tau_j E_{p_j}(p, z, u). \]  

(2)

Changes in the small open economy’s welfare are due to changes in the levels of consumption and of consumption generated pollutants. Thus, differentiating equation (2), and recalling the definition for \( z_j \) we obtain:

\[ E_u du = -(E_z - \tau) dE_p = -\sum_{j=1}^{K} \left(E_{z_j} - \tau_j\right) dE_{p_j}, \] 

since by assumption the numeraire good is untaxed and its consumption does not generate pollution. Changes in the compensated demand for the \( j^{th} \) good \( (dE_j) \) are given by

\[ dE_{p_j} = E_{p_j,p_j} d\tau_j + \sum_{j=1}^{K} E_{p_j,z_j} dz_j + E_{p_j,u} du \] 

(4)

where subscripts on the functions \( E_{p_j,p_j}, E_{p_j,z_j}, E_{p_j,u} \) denote partial derivatives of the function \( E_{p_j} \). For example, \( E_{p_j,p_j} = \partial E_{p_j} / \partial p_j \). In equation (4) and for the rest of the analysis we assume, that private goods and clean environment are independent in consumption, i.e., \( E_{p_j,z_j} = 0 \).\(^{11}\) Moreover, \( E_{p_j,p_i} > 0(< 0) \) if the \( j^{th} \) and \( i^{th} \) goods are substitutes (complements) in consumption, and \( E_{j,u} \) is positive assuming that the \( j^{th} \) good is normal in consumption. The properties of the expenditure function, i.e.,

\[ \sum_{j=0}^{K} p_j E_{p_j,p_j} = 0 \] 

give \( E_{p_j,p_j} = -(p_0 / p_i) E_{p_0,p_j} - \sum_{j=0}^{K} (p_j / p_i) E_{p_j,p_j} \). \(^{11}\) Note that \( p_k = 1 + \tau_k, k = j, i \), and by the reciprocity conditions \( E_{p_k,p_j} = E_{p_j,p_k} \). Using the

\(^{11}\) The assumption that the demand for private goods is independent of the environmental quality is often made in the literature (i.e., Bovenberg 1999, Beghin and Dessus 1999). For example, this would be the case if the utility function is quasi-linear, e.g., \( u(c, z) = \overline{u}(c) + \lambda z \), where \( \lambda \) is a constant parameter. Clearly, in this case goods and clean environment are independent in consumption.
above properties, and substituting equation (4) into (3), changes in welfare due to small changes in consumption taxes are given as follows:

\[
Adu = -\sum_{j=1}^{K} \left( E_{z_j} - \tau_j \right) E_{p_j} \, d\tau_j = \left[ \sum_{j=1}^{K} (s_i - s_j) p_j E_{p_j} + s_i E_{p_i} \right] d\tau_i, \tag{5}
\]

where \( A = E_u + \sum_{j=1}^{K} (E_{z_j} - \tau_j) E_{p_j}, \) which is positive for stability. It represents the general equilibrium inverse of the marginal utility of income; inclusive of feedback via consumption taxes and pollution (see Beghin et al., 1997). The term \( s_k = (E_{z_k} - \tau_k) / p_k, \) is positive (negative) depending on whether the \( k^{th} \) pollutant is under (over-) taxed. We say that the \( k^{th} \) pollutant is under (over-) taxed according to whether \( (E_{z_k} - \tau_k) > 0 (< 0). \) Therefore, the ratio \( s_k \) gives the rate of under- or over-taxation of the \( k^{th} \) consumption generated pollutant as a fraction of the \( k^{th} \) good’s consumer price. For the rest of the analysis, this ratio is called the rate of under-taxation of pollution of the \( k^{th} \) consumption pollutant when \( s_k > 0, \) and the rate of over-taxation of pollution of the \( k^{th} \) consumption pollutant when \( s_k < 0. \) Note that \( s_0 = ((E_{z_0} - \tau_0) / p_0) = 0. \)

Equation (5) can be used for the discussion of the welfare implications of movements of rates of under-taxation or over-taxation of pollution towards uniformity via reforms in consumption taxes. These consumption tax reforms are first examined assuming that government revenue considerations are not accounted for, and second assuming that the government revenue constraint is a binding one.

3. Movement of rates of under (over-) taxation of pollution towards uniformity.

As reviewed in the introduction there is, by now, a notable literature on the welfare and government implications of commodity tax, tariffs and consumption taxes, reforms. The innovation of this paper in regards to this literature is that it

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12 If the numeraire good were also assumed polluting and taxed, the right-hand-side of equation (5) would be written as \( \sum_{j=1}^{K} (s_i - s_j) p_j E_{p_j}. \) Thus the assumption of an untaxed and non-polluting numeraire commodity, if anything, makes the results less straightforward to interpret.
considers these effects when the consumption of the taxed goods also entails the emission of harmful to the environment pollutants, which in turn adversely affect the utility of households. Moreover, observing the right-hand-side of equation (5) one notes that here, due to the presence of consumption generated pollution, reforms of environmental (consumption) taxes are such that the rates of under (over-) taxation of pollution, i.e., \((s_i - s_j) > 0(<0), \forall j\), are moved towards uniformity. Such reform exercise, however, makes no implication about whether the actual consumption tax rates also move towards uniformity. This observation is in contrast to the standard literature on indirect tax reforms whereby such policies aim at bringing the actual tax rates towards uniformity.

In light of the above, we examine the welfare implications of moving the rates of under-taxation of pollution towards uniformity via reforms in consumption taxes. Specifically, we examine the welfare implications of decreasing (increasing) the consumption tax on the commodity with the lowest (highest) rate of under-taxation or over-taxation of pollution, first, without a government revenue constraint, and second, under the assumption of such a binding revenue constraint.

3.1 Reforms of consumption taxes without a binding revenue constraint

For the purposes of our analysis we use the following definitions:

**Definitions:** Let \( H_i \) be the compound commodity consisting of all other goods including the numeraire commodity, except of the \( i^{th} \) taxed commodity, and let \( H^{0}_i \) be the compound commodity consisting of all other goods except of the numeraire and the \( i^{th} \) taxed commodities.

Then, using the above definitions, the following proposition lays out sufficient conditions for welfare improving consumption tax reforms required for moving the rates of under-taxation or over-taxation of pollution towards uniformity.

**Proposition 1:** Assume the existence of consumption generated pollution, and that the rate of under-taxation of pollution in the consumption of the \( i^{th} \) good is the highest. Then, increasing the consumption tax on this good, so that its rate of under-taxation of pollution falls to the level of the second highest under-taxation rate, improves
social welfare if the $i^{th}$ good is a substitute in consumption with the compound commodity $H_i$. If the $i^{th}$ good is the taxed commodity with the lowest rate of under-taxation of pollution, then decreasing the consumption tax on this good, so that its rate of under-taxation of pollution rises to the level of the second lowest under-taxation rate, improves welfare if, in consumption, the $i^{th}$ good is a substitute with the compound commodity $H_i^{0}$, and a complement with the numeraire good. If, however, the $i^{th}$ good is the taxed commodity with the highest rate over-taxation of pollution, then decreasing the consumption tax on this good, so that its rate of over-taxation of pollution falls to the second highest rate of over-taxation, improves welfare if the $i^{th}$ good is a substitute with the compound commodity $H_i$.

According Proposition 1, in the presence of consumption generated pollution, there are some key conditions for a welfare improving reform of consumption taxes so as the rates of under-taxation of pollution move towards uniformity. First, the compound substitutability between the taxed polluting consumption good and its respective compound commodity. Specifically, the $i^{th}$ commodity is a substitute in consumption to the compound commodity $H_i(H_i^{0})$ if an increase in the price of the $i^{th}$ good raises the compensated demand for the compound commodity. Second, the relationship between the rates of under-taxation of pollution between commodities. Assuming that the rate of under-taxation of pollution for the $i^{th}$ good is the highest, then, $(s_i - s_j) > 0$ for every $j$. In this case, increasing the consumption tax on this good improves welfare if the $i^{th}$ good is a substitute in consumption with the compound commodity $H_i$. In the case where the rate of under-taxation of pollution for the $i^{th}$ good is the lowest, (i.e., $(s_i - s_j) < 0$ for every $j$), then reducing the consumption tax on this good improves welfare if the $i^{th}$ good is not only a substitute in consumption to its respective compound commodity $H_i^{0}$, but also it is a complement to the numeraire good (i.e., $E_{p,p_0} < 0$). Finally, in the case where the $i^{th}$ good has the

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13 If the $i^{th}$ good is a pair-wise substitute with all other goods, then it is also a substitute with the composite consumption commodity $H_i$ or $H_i^{0}$, but not vice versa (e.g., see Hatta 1986, Michael et al. 1993).
highest rate of over-taxation of pollution (i.e., $s_i < 0$ and in absolute terms is the highest for all the over-taxed commodities), then decreasing its consumption tax improves welfare if the \( i^{th} \) good is a substitute in consumption with the compound commodity \( H_i \).

Intuitively, the above results can be interpreted as follows. Take the case whereby the \( i^{th} \) good exhibits the highest (lowest) rate of pollution under-taxation, thus it is the good associated with the most (least) distorted, i.e., pollution emitting, consumption pollution. Then, increasing (decreasing) the environmental tax on this good so that its rate of under-taxation of pollution falls (rises) to the second highest (lowest) rate, aims at bringing the consumption generated pollution distortions towards uniformity. This result depends on the relationship in consumption between the good with the highest (lowest) rate of under-taxation of pollution, and of all other goods, i.e., the compound and \( numeraire \) goods. Thus, assuming substitutability in consumption between the good with the highest (lowest) rate of under-taxation of pollution, an increase (decrease) in the environmental (consumption) tax on this good so that its rate falls (rises) to the second highest (lowest) rate of under-taxation of pollution, reduces (raises) its consumption and pollution distortion and raises (reduces) the consumption and pollution distortion of the compound good. In a similar manner, complementarity between the good exhibiting the lowest rate of under-taxation of pollution and the \( numeraire \) good, guarantees that a decrease in the environmental tax on the former commodity, so that its rate of under-taxation of pollution reaches the second lowest rate, increases its consumption and pollution emissions, increases the consumption of the non-polluting \( numeraire \) good, and thus moves consumption generated pollution distortions towards uniformity. An analogous argument holds when the \( i^{th} \) good exhibits the highest rate of over-taxation of pollution, and the environmental tax on this good is reduced in such a way that, assuming substitutability in consumption between this good and the compound commodity, its rate of over-taxation of pollution reaches the second highest rate.

### 3.2 Reforms of consumption taxes with a binding revenue constraint

In this section we consider movements of the rates of under (over-) taxation of pollution towards uniformity via reforms in consumption taxes, but now allowing for the government revenue constraint to be binding. Indirect tax reform programs are
hardly ever considered realistic, unless they account for their fiscal or government revenue implications. With this in mind, we now assume constant government revenue, and we examine the welfare implications of the aforementioned consumption tax reforms.\footnote{Movements of consumption taxes towards uniformity under constant government revenue, but without pollution considerations, are examined among others by Michael \textit{et al.} (1993), Keen and Ligthart (2002).}

Totally differentiating equation (1), the government budget constraint with respect to changes in the consumption tax on the \(i^{th}\) good, using equation (4) and the properties of the expenditure function, and noting that \(dT = 0\), after some algebra we obtain:

\[
\delta du + \left[ (1 + \tau_i (1 - \eta_{i0}))E_{p_i} + \sum_{j \neq i} (\tau_j - \tau_i)E_{p_j/p_i} \right] \frac{d\tau_i}{1 + \tau_i} = 0 ,
\]  

(6)

where, \(\delta = \sum_{j=1}^{n} \tau_j E_{p_i/p_j}\) and it is positive assuming that goods are normal in consumption; \(\eta_{i0} = (p_0/E_{p_i})E_{p_i/p_i}\) is the compensated demand elasticity of the \(i^{th}\) good with respect to the price of the numeraire. Equations (5) and (6) are now used to examine the welfare implications of the changes in the consumption tax on the \(n^{th}\) good, and the required adjustment in the consumption tax rate on the \(i^{th}\) good in order to maintain government revenue constant. To facilitate the analysis, we rewrite equations (5) and (6) as follows:

\[
Adu - p_i^{-1}B_i d\tau_i = p_n^{-1}B_n d\tau_n , \quad \text{and}
\]

(7)

\[
\delta du + p_i^{-1}\Gamma_i d\tau_i = -p_n^{-1}\Gamma_n d\tau_n ,
\]  

(8)

where,

\[
B_i = \sum_{j \neq i, k} p_j p_k (s_k - s_j)E_{p_j/p_k} + s_k p_k E_{p_k/p_i}, \quad \Gamma_k = (1 + \tau_k (1 - \eta_{k0}))E_{p_k} + \sum_{j \neq i, k} (\tau_j - \tau_k)E_{p_j/p_k} ,
\]  

\[k = i, n.\]

Recall again that for the numeraire good \(\tau_0 = 0\). Equations (7) and (8) contain three unknowns, namely, \(u, \tau_i\) and \(\tau_n\). To derive sufficient conditions for improving welfare of movements of the rates of under (over-) taxation of pollution towards
uniformity via reforms in consumption taxes, we treat as endogenous the level of welfare \((u)\) and one of the two tax rates, e.g., \(\tau_i\), while the other tax rate, \(\tau_n\), is treated as exogenous. In doing so, equations (7) and (8) give:

\[
\begin{bmatrix}
A & -p_i^{-1}B_i \\
\delta & p_i^{-1}\Gamma_i
\end{bmatrix}
\begin{bmatrix}
du \\
d\tau_n
\end{bmatrix}
=
\begin{bmatrix}
p_n^{-1}B_n \\
-p_n^{-1}\Gamma_n
\end{bmatrix}
d\tau_n.
\]  

(9)

The determinant of the left-hand-side coefficients matrix is \(\Delta = p_i^{-1}(A\Gamma_i + \delta B_i)\) and it is positive assuming that \(\tau_i\) is revenue increasing consumption tax.\(^{15}\) The system of equations (9) gives the welfare effect of a change in the consumption tax rate \(\tau_n\) as follows:

\[
\Delta \left(\frac{du}{d\tau_n}\right) = (p_ip_n)^{-1}(B_n\Gamma_i - B_i\Gamma_n).
\]  

(10)

The adjustment in the \(i^{th}\) consumption tax required to accompany the change in the \(n^{th}\) consumption tax so that government revenue is kept constant is given as follows:

\[
\Delta \left(\frac{dT_i}{d\tau_n}\right) = -p_n^{-1}(A\Gamma_n + \delta B_n).
\]  

(11)

Equation (11) indicates that increasing the consumption tax rate \(\tau_n\) reduces the consumption tax \(\tau_i\), i.e., \((d\tau_i / d\tau_n) < 0\), assuming that the \(n^{th}\) consumption tax is revenue increasing.\(^{16}\)

The following proposition summarizes the sufficient conditions, according to equation (11), ensuring a welfare improvement due to an increase in the consumption

\(^{15}\) In equations (8) and (9) treating \(du\) and \(dT\) as endogenous and \(d\tau_i\) and \(d\tau_n\) as exogenous, it can be shown that \((dT / d\tau_i) = A^{-1}p_i^{-1}(A\Gamma_i + \delta B_i)\). Thus, \((dT / d\tau_i) > 0\) requires that \((A\Gamma_i + \delta B_i)\) is positive.

\(^{16}\) Following footnote 7, it can be shown that \((dT / d\tau_n)\) is positive if \((A\Gamma_n + \delta B_n)\) is positive.
tax $\tau_n$, adjusting appropriately the consumption tax $\tau_i$, so that government revenue is held constant.

**Proposition 2:** Assume the existence of consumption generated pollution, and let the $n^{th}$ taxed commodity be characterized by the highest rate of under-taxation of pollution. Then, increasing the tax rate on the $n^{th}$ good, while decreasing the consumption tax on the $i^{th}$ good so as to keep government revenue constant, improves welfare if: (i) $\tau_n$ is the lowest consumption tax rate, (ii) the rate of under-taxation of pollution of the $n^{th}$ good is the highest and of the $i^{th}$ good is the lowest, and (iii) the $n^{th}$ and the $i^{th}$ commodities each is a substitute in consumption with its respective compound commodity, $H_n$ and $H_i^{-0}$, (iv) the $i^{th}$ good is a complement in consumption to the numeraire good, and (v) the elasticity of compensated demand for the $n^{th}$ good with respect to changes in the price of the numeraire is less than $(1 + \tau_n)/\tau_n$.

For the increase in the consumption tax $\tau_n$ to raise welfare the right-hand-side term of equation (10) must be positive. Conditions (ii) and (iii) and (iv) of Proposition 2 ensure that $B_n$ is positive and $B_i$ is negative. Conditions (i) and (iii) and (v) ensure that $\Gamma_n$ is positive. Moreover, $\Gamma_i$ must be positive, since $\Delta = p_i^{-1}(A\Gamma_i + \delta B_j)$ is positive, and $\delta$ and $A$ are positive and, by the conditions of Proposition 2, $B_j$ is negative.

Alternatively consider the case where the $n^{th}$ taxed good is burdened with the lowest consumption tax rate and exhibits the highest rate of pollution under-taxation, i.e., $s_n > 0$ and $s_n - s_j > 0, \forall j$, while the $i^{th}$ taxed good is the good with the lowest rate of pollution over-taxation, i.e., $s_i < 0$ and $|s_i| - s_j > 0, \forall j$ good that is the most over-taxed. Then, the following proposition sets sufficient conditions under which bringing the rates of under (over-) taxation of pollution towards uniformity via appropriate consumption tax reforms improves welfare while keeping government revenue constant.
Proposition 3: Let’s assume that (a) the $n^{th}$ good has the lowest consumption tax rate and the highest rate of under-taxation of pollution, and (b) that the $i^{th}$ good is the most over-taxed commodity. Then, increasing the consumption tax on the $n^{th}$ good and reducing that on the $i^{th}$ good to keep revenue constant, improves welfare if (i) the $n^{th}$ and the $i^{th}$ commodities are each substitute in consumption with its respective compound commodity, $H_n$ and $H_i$, and (ii) the $n^{th}$ good is a complement in consumption with the numeraire commodity, i.e., $E_{p_s p_i} < 0$.

Conditions (i) and (ii) of Proposition 3 ensure that $B_i$ is negative, conditions (b) and (ii) ensure that $B_n$ is positive and finally, conditions (b), (i) and (ii) ensure that $\Gamma_n$ is positive. As previously noted, $\Gamma_i$ is positive assuming the tax on the $i^{th}$ good is revenue increasing.

4. Uniform changes in consumption taxes.

Abstracting from government revenue considerations, we investigate the possibility of a welfare improving uniform increase/decrease in consumption taxes. For this we consider a change in consumption taxes by the same proportion $(0 < \lambda < 1)$ of the deviation between the marginal willingness to pay for pollution generated by consumption of the $i^{th}$ good and the existing consumption tax rate $\tau_i$ on this good. That is, let $d\tau_i = \lambda(E_{z_i} - \tau_i)$, where $d\tau_i >(<)0$ according to whether $(E_{z_i} - \tau_i) >(<)0$. That is, the tax on consumption of the $i^{th}$ polluting commodity is raised (lowered) according to whether pollution emissions are socially under (over)-taxed. Then, equation (5) can be written as:

$$Adu = -\lambda(E_z - \tau)E_{p_p}(E_z - \tau),$$

which is positive. The following proposition lays out the welfare implications of the aforementioned uniform change in consumption taxes.

Proposition 4: Let all goods be either under (over)-taxed. Then, a uniform increase (decrease) in consumption taxes proportional to the deviation between the marginal
willingness to pay for pollution generated by consumption of the \( i^{th} \) good and the tax on this good, improves welfare.

5. Concluding Remarks

Recently, an increasing number of countries, especially developing ones, after the recommendation of international institutions such as the IMF and the World Bank, gradually relies more on the use of domestic taxes, e.g., consumption taxes or VATs, for raising government tax revenues. This paper revisits the question of reforming the structure of consumption taxes in the presence of consumption-generated pollution, and identifies sufficient conditions under which such a tax reform improves welfare with and without a binding government revenue constraint.

This paper is motivated by two important issues in the theory and practice of economic policy. First, a growing concern regarding the adverse environmental implications of economic policy, in the presence of pollution generating activities, e.g., consumption generated pollution. Second, reforms of tax policies must aim not only at raising national welfare but also to either maintain constant or enhance government revenues. With this in mind, we construct a general equilibrium model of a multi-commodity small open economy where pollution is consumption generated and adversely affects households’ utility, and where the country’s tax structure comprises only consumption taxes.

We establish sufficient conditions under which specific consumption tax reforms improve welfare with and without a constant tax revenue constraint. Two types of consumption tax reforms are considered in the paper. First, that of moving towards uniformity the, what we call, rates of under (over-) taxation of pollution. The sufficient conditions for welfare improvement of this case, as are summarize in propositions 1-3, identify two features which are critical in assessing the results. One is the relationship in consumption of the commodity whose tax is changed to the compound good consisting of all other commodities, and/or to the numeraire good. The other is the relationship between i) the tax rates and ii) the rates of under (over-) taxation of pollution among the commodities. In the second tax reform program abstracting from government revenue considerations, we demonstrate that regardless of whether goods are either under (over)- taxed, a uniform increase (decrease) in consumption taxes proportional to the deviation between the marginal willingness to
pay for pollution generated by the consumption of a given good and the tax on it, improves welfare.

References


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