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Effective Carbon Taxes and Public Policy Options: Insights from India and Pakistan

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I. INTRODUCTION

During our work in the early 1980s on the applications of modern public finance methods to the context of developing countries, we focused initially on the sub-continent, starting with India, but then initiating a more complete assessment for Pakistan. We use the intuition from our work from the early 1980s on the description and evaluation of indirect tax systems (see Ahmad and Stern, 1984, 1991) to examine issues that have become prominent more recently. These relate to the design and implementation of environmental taxes, as well as substituting for ad hoc levies that seek to mop-up revenue gains from declining oil prices in recent months. Thus, fiscal space has been created that could provide the impetus for the introduction of a "carbon tax." In this paper, we assess appropriate instruments for "carbon taxation" in terms of the carbon content of different goods and activities. It is also possible to evaluate the effects on people in different circumstances, and show possibilities for compensating "losers". A further important issue in India concerns which level of government might be responsible for the administration of the tax. In this effort, we follow the distinguished tradition of Amaresh Bagchi, who was intimately involved in tax policy design, including the political acceptability of options and in designing intergovernmental fiscal systems, for India and other developing countries.

In this paper, we take as given the need for public action on climate change (see Stern, 2007), and that carbon taxation is one of the key instruments for influencing both behaviour of consumers and producers. The calculations also illustrate the eventual effects on prices of a scheme based, for example, at least in part on a quota-cum-trading scheme linked to upstream activities, such as electricity generation or steel production. Section II examines methods for designing and implementing effective carbon taxes. In Section III we ask whether the states/provinces or the center should administer the tax. We also raise some political economy issues concerning gainers and losers, and possible compensation measures for poor people. Section IV concludes.

II. Effective Carbon Taxes

The establishment of a carbon tax or excise for environmental purposes could be achieved by an import duty/excise on petroleum products or coal. This will work through the production structure and affect the prices of goods that use the inputs that are subjected to tax. In addition whether the tax is administered by the center on imports or/and domestic production, or by the states at the final stage, as would be required under the constitutional arrangements that prevail in the subcontinent, would affect the revenue prospects not just of the level of government that levies the tax, but also of other levels of government. In this paper, we build on the concept of "effective taxes" that we developed in order to assess cascading taxes that characterized the tax systems of India and Pakistan in the 1980s.

A model of effective taxes

The structure for both taxes and subsidies is often complicated and they can apply to intermediate as well as final goods. As most carbon taxes involve the taxation of intermediate goods, such as petroleum, kerosene, gas or coal, a full assessment requires the estimation of the effects of this taxation on the prices of all other goods—hence the effective taxes that arise from any form of carbon tax. This not only permits an assessment of the different commodities on which the tax might be levied, but also permits an analysis of the incidence of the tax on households in different circumstances.

Studies of the incidence of indirect taxes and subsidies based on household consumption data require the knowledge of the component of the price of a final good, which might be attributed to a change in the tax on any specific good or class of goods. Further, an evaluation of proposals for changes in taxes would also utilize, in principle, this information since the government would need to know the consequences for revenue of changes in purchases of different goods resulting from the changes being considered.

Let us review the model of effective taxes presented in Ahmad and Stern (1991). We begin with a simple closed economy Leontief model. All purchasers of a good pay a price inclusive of tax. We write the vector of prices faced by producers who are buying an input as *p* and the vector of prices received by a producer selling the good as p^p , the difference is the tax incurred at the production stage. Consider a simple input-output model of production with fixed input-output matrix *A*, gross output vector *x* and net output vector *z.* The inputs are *Ax* and

$$z = x - Ax = (I - A)x \tag{1}$$

Competitive pricing conditions for this model are:

$$p^{p'} = p'A + y', \tag{2}$$

where primes denote row vectors and *y* is the vector of value-added by industry (which we assume for the moment to be fixed). If *t* is the tax vector, then

$$p' = p^{p'} + t', \tag{3}$$

from (2) and (3) we have

$$p' = t'(I - A)^{-1} + y'(I - A)^{-1}. \tag{4}$$

We define the effective tax vector t^e *as*

$$t^{e'} = t'(I - A)^{-1}, \tag{5}$$

and prices in the absence of taxes, the 'basic' or shadow price vector $p^{b'}$ as

$$p^{b'} = y'(I - A)^{-1}. \tag{6}$$

The i^{th} component of t^e is the amount government revenue would change if there were a unit change in the final demand for a good. This is the formal definition of the effective tax: if the final demand vector is z and government revenue R, we have

$$t_i^e = \frac{\partial R}{\partial z_i}; \text{ and}$$

$$t^{diff'} = t^{e'} - t' \quad (7)$$

which measures the difference between the effective tax, t^e and the nominal tax *t.* Thus, t^{diff} indicates the extent to which inputs are taxed. The overall level of taxation of inputs in the economy is given by t^{diff} times the final demand vector *z* or

$$\begin{aligned} t^{diff}.z &= t^{diff'}(I-A)x \\ &= t^{e'}(I-A)x - t'(I-A)x \\ &= t'(I-A)^{-1}(I-A)x - t'x + t'Ax \\ &= t'Ax \end{aligned} \quad (8)$$

Alternatively, we can see this last measure of the taxation of inputs as simply a decomposition of the total tax payment:

$$\begin{aligned} t.x &= t'(I-A)x + t'Ax \\ &= t.z + t'Ax \end{aligned} \quad (9)$$

Into tax on final demand, *t.z,* and tax on intermediate goods $t'Ax$.

While t^{diff} measures the extent to which inputs are taxed in the model, it does not indicate any costs associated with distortions of choice of technique resulting from taxation of inputs since all coefficients are fixed. Further changes in factor prices and pure profits have been assumed away, since we have a single factor and zero profits.

The assumption of fixed coefficients could be relaxed as follows. If we assume that each industry has a single output (no joint production) and there are constant returns to scale, we may write $c_i(p,w)$ as the minimum cost of producing good *i*, when input prices are *p* and the single factor has price *w*. If we choose the single factor as numeraire we may write the vector of costs as a function *c(p)* of *p* only. The most efficient way of producing each good can be defined simply in terms of the technique which gives the minimum quantity of the factor directly and indirectly required in production and these minimum costs, γ are the prices of the non-substitution theorem. We then have:

$$\gamma = c(\gamma) \tag{10}$$

And

$$\gamma' = y'(\gamma)(I - A(\gamma))^{-1} \tag{11}$$

Where $y(\gamma)$ is the vector of factor requirements per unit of output for each industry and $A(\gamma)$ and the input-output matrix at prices γ. Notice that γ and *A* now depend on prices where they were previously fixed and that

$$(A(p))_{ij} = \frac{\partial c_i}{\partial p_j} \tag{12}$$

from the standard properties of the cost function.

When we have taxation of sales, producers receive a price p^p but pay *p* for inputs. Thus in equilibrium, generalizing equation (2) above,

$$p^p = c(p)\,. \tag{13}$$

The differences between prices with and without taxation is $p-\gamma$ which may be written using (3), (10) and (13)

$$p - \gamma = c(p) - c(\gamma) + t \tag{14}$$

$$\geq t'(I - A(p))^{-1} \tag{15}$$

Using the concavity of the cost function and (12). Thus,

$$p' - \gamma' \geq t'(I - A(p))^{-1} \tag{16}$$

Since $(I - A(p))^{-1}$ is we assume a non-negative matrix. The implication is that the effective tax estimated empirically using input-output tables at current prices *underestimate* the price-raising effect of the taxes. The reason is that the fixed coefficients assumption ignores the rise in prices associated with the reorganization of inputs from those associated with $A(\gamma)$, which minimize resource costs, to *A(p).*

We can illustrate this point by writing a decomposition of the overall price rise as:

$$p' - \gamma' = t'(I - A(p))^{-1} + (p^{b'} - \gamma') \tag{17}$$

Which comes from (4), (5), (6) remembering that A is now a function of p. Thus the price rise is made up from the effective taxes and the increase in the vector of resource costs of production, $p^{b'} - \gamma'$, which we know is non-negative from (16) or from the property that γ' is the vector of minimum resource costs. Similarly, the increase in the costs of production at market prices associated with the tax is:

$$p^{p'} - \gamma' = t^{diff\,'} + (p^{b'} - \gamma') \tag{18}$$

An obvious measure of the resource cost of the input taxation per unit of output is simply $(p^{b'} - \gamma')$ where:

$$p^{b'} = y'(p)(I - A(p))^{-1} \tag{19}$$

And γ' is given by (11). This would be combined with a measure of output shifts in a calculation of overall losses.[1] For marginal changes, one would be interested in the rate of change of $p^{b'}$ with respect to taxes. This may be derived as follows: from (4), (5) and (6)

$$p^{b'} = p' - t^{e'} \tag{20}$$

Thus,

$$\frac{\partial p^{b'}}{\partial t} = \frac{\partial p'}{\partial t} - \frac{\partial t^{e'}}{\partial t} \tag{21}$$

where $\frac{\partial p'}{\partial t}$ is the matrix with the ij[th] element $\frac{\partial p_j}{\partial t_i}$. From (3), (12) and (13) we have

$$\frac{\partial p'}{\partial t} = (I - A)^{-1} \tag{22}$$

and from (5), (21) and (22) we have:

$$\frac{\partial p^{b'}}{\partial t} = -t'(\partial \bar{A})\bar{A}' \tag{23}$$

where $\bar{A}$ is $(I - A)^{-1}$ with ij[th] element $\bar{a}_{ij}$, $\partial\bar{A}$ is the derivative of $\bar{A}$ with respect to prices *p*—it is a tensor with kjl^{th} element α_{kjl} equal to $\frac{\partial \bar{a}_{kj}}{\partial p_l}$, and the ij[th] element of the rhs of (23) is $-\sum_{k,l} t_k \alpha_{kjl} \bar{a}_{il}$.

[1] For very small taxes, the extra costs associated with taxes would be second order (essentially from the envelope theorem), but not necessarily for larger taxes.

Flexible coefficients

One of the objectives of the taxation of "carbon" is to induce both producer and consumer responses, and while the fixed coefficient assumption is convenient for the estimation of effects on consumers, in terms of both welfare and shifts in demand patterns, it would be useful to incorporate more flexible assumptions concerning the production structure. Both $(p^{b'} - \gamma')$ and its marginal version (23) depend on the *change* in input-output coefficients, since it is the shift in these that is causing the resource cost. We know that the total loss $(p^{b'} - \gamma')$ is positive for each good, although this will not necessarily be true for the marginal. The calculation of these losses poses problems, however, since we observe *A(p)* and not the input-output matrix $A(\gamma)$ and do not know the rate of change of A with respect to prices. One could compute $A(\gamma)$ or the derivative of A with a general equilibrium model of the production side which involved flexible coefficients, but then a large part of the answer would be from the assumption of functional forms and invention of parameters and is unlikely to be available at the level of disaggregation of the standard input-output matrices. We examine here the problem of calculating $\frac{\partial p_j}{\partial t_i}$ and $\frac{\partial w_k}{\partial t_i}$, where we have flexible coefficients in production. Again, we assume a competitive closed economy with constant returns to scale and no joint production. We could write the cost of production on good *j* as $c_j(p, \omega)$, where all purchasers of inputs buy at prices *p*, and ω_k is the purchasers' price of factor *k* –the sellers' price $(w_k = \omega_k - \tau_k)$. The prices received by producers p^p differs from *p* through the vector of taxes *t*. Thus

$$p = p^p + t$$

where

$$p^p = c(p, \omega)$$

and

$$p = c(p, \omega) + t$$

Transposing and differentiating with respect to the tax, t_i we have

$$\frac{\partial p_j}{\partial t_i} = \sum_k \frac{\partial c_j}{\partial p_k}\frac{\partial p_k}{\partial t_i} + \sum_m \frac{\partial c_j}{\partial \omega_m}\frac{\partial \omega_m}{\partial t_i} + \delta_{it} \tag{24}$$

In matrix form:

$$\Delta = \Delta A + WB + I \tag{25}$$

Where $(\Delta)_{ij} = \frac{\partial p_j}{\partial t_i}$, $(A)_{kj} = \frac{\partial c_j}{\partial p_k}$, $(B)_{mj} = \frac{\partial c_j}{\partial \omega_m}$, and $(W)_{im} = \frac{\partial \omega_m}{\partial t_i}$.

Note that *A* is the familiar input-output matrix, since $\frac{\partial c_j}{\partial p_k}$ is simply the input of good k into industry j at unit production levels. Similarly, *B* is a matrix of factor requirements. Thus,

$$\Delta = (I - A)^{-1} + WB(I - A)^{-1} \tag{26}$$

Equation (25) establishes that the results for fixed coefficients extends to flexible coefficients. The effective tax t^e calculated using the existing *A* no longer reflects the price differential between the equilibrium with and without taxation, but the important feature is the rate of change of prices with respect to the tax, and that is given by $(I - A)^{-1}$ both with flexible and with fixed coefficients for intermediate goods.

Open Economy

We can extend the analysis to the open economy by distinguishing between domestically produced goods and their prices using superscript d, and imported goods by the superscript m; as before the producer price is indexed by the superscript p. the buyer's price is the producer price plus the tax. Thus,

$$p^m = p^* + t^m$$

And

$$p^d = p^{pd} + t^d$$

Where p^* is the exogenous world price of the import and t^m and t^d are taxes on imports and domestically produced goods respectively. Thus

$$p^d = c^d(p^d, p^m, \omega) + t^d \tag{27}$$

And

$$\Delta^d = \frac{\partial p_j^d}{\partial t_i^d} = \sum_l \frac{\partial c_j^d}{\partial p_l^d}\frac{\partial p_l^d}{\partial p_i^d} + \sum_f \frac{\partial c_j^d}{\partial \omega_f}\frac{\partial \omega^f}{\partial t_i^d} + \delta_{ij} \tag{28}$$

$$\Delta^m = \frac{\partial p_j^d}{\partial t_k^m} = \sum_r \frac{\partial c_j^d}{\partial p_r^d}\frac{\partial p_r^d}{\partial t_k^m} + \sum_f \frac{\partial c_j^d}{\partial \omega_f}\frac{\partial \omega^f}{\partial t_k^m} + \frac{\partial c_j^d}{\partial p_k^m} \tag{29}$$

where (28) and (29) are analogous to (24). And corresponding to (25):

$$\Delta^d = \Delta^d A^d + W^d B + I$$

and

$$\Delta^m = \Delta^m A^d + W^m B + A^m \tag{30}$$

Where:

$A^d = \left(\frac{\partial c_j^d}{\partial p_l^d}\right)$ is the domestic input-output matrix, giving the coefficients of domestic goods into domestic production;

$A^m = \left(\frac{\partial c_j^d}{\partial p_k^m}\right)$ is the matrix of imported goods into domestic production;

W^d is the matrix of factor price responses to the taxation of domestic inputs; and
W^m is he corresponding factor price matrix for taxes on imported goods .

Finally,

$$\Delta^d = (I - A^d)^{-1} + W^d B(I - A^d)^{-1} \text{ and}$$

$$\Delta^m = A^m (I - A^d)^{-1} + W^m B(I - A^d)^{-1} \qquad (31)$$

Thus, in the fixed coefficients case, equations (31) reduce to give the overall effective tax

$$t^{e'} = t^{d'} (I - A^d)^{-1} + t^{m'} A^m (I - A^d)^{-1} \qquad (32)$$

Simply put, the contribution of a domestic excise on carbon-related goods which falls on domestic production alone, is given by the first term on the rhs of (32), and that of import duties on the vector of imports that feed into domestic production (second term on the rhs of (32). The effects are additive. The effects of a sales tax levied regardless of origin are also given by (32) as these work in part by affecting prices of domestically produced goods and in part through imported inputs that feed into domestic production.

Directions of reform

The effective taxes resulting from the imposition of a carbon tax need to be assessed. For a given revenue requirement, one could ask about the effects of the alternatives (e.g., central excises on petroleum, gas, coal products; plus import duties/central sales tax; or final sales taxes or VAT imposed by the states/provinces) and mechanisms by which the choices might be made. The first step is to evaluate the effective taxes, as we have described above. One of the key elements in the policy design is the effect on households in different circumstances. This is the second step, and we outline the methods below.

We use the concept of the welfare loss associated with an increase in the i[th] tax sufficient to raise Rs.1 in revenue (see Ahmad and Stern, 1984). This welfare loss, λ_i, is defined as:

$$\lambda_i = \frac{-\dfrac{\partial V}{\partial t_i}}{\dfrac{\partial R}{\partial t_i}} = \frac{\sum_h \beta^h x_i^h}{X_i + \sum_{j=1}^{n} t_j^e \dfrac{\partial X_j}{\partial p_i}} \qquad (24)$$

Where the numerator $-\frac{\partial V}{\partial t_i}$ is the social loss associated with an increase in the price of the ith good—and is the money measure of the loss to household *h*, x_i^h, aggregated across households using welfare weights, β^h; where x_i^h is the consumption of commodity *i* by household *h* (*h* = 1, 2,…..H; *i* = 1,2,….n). X_i is the total consumption of commodity *i*, $\frac{\partial X_j}{\partial p_i}$ is the matrix of demand derivatives, and t_j^e is the effective tax on good j.

One example of a structure for the welfare weights, β^h, would be to use a formula as follows:

$$\beta^h = \left(\frac{I^1}{I^h}\right)^e \qquad (25)$$

Where I^1 and I^h are the expenditures per capita of the poorest household group and household *h* respectively, and *e* can be interpreted as an inequality aversion parameter. For *e* = 0, we have all β^h equal to one or zero inequality aversion, and *e* = 5 begins to approach concern only for the poorest household group.

The effects of different assumptions concerning inequality aversion can change the desired options for reform. It is interesting that in the empirical evaluation of the directions of reform in Pakistan (see Ahmad and Stern 1984 and 1991), as inequality aversion increases, the housing, fuel and light category becomes the most attractive sector for additional taxation, given the relatively low (in proportional terms) expenditures of poor people on these items. In this case, both the theory of reform and environmental considerations point to higher taxation of carbon-intensive goods.

It should be noted that in the Pakistan case for data from the 1980s, the category "housing, fuel and light" contains a composite grouping of commodities, dictated by the consideration that demand responses for a finer grouping were not available, and that these may bear in different ways on the poorest households. The carbon-related components bore an effective tax of .35 for petroleum products, 0.21 for electricity, and 0.57 for gas—referring to the direct and indirect tax element in the price of each good—covering all types and sources of taxation (duties, excises and sales tax) that were levied at that time. In the Indian case, demand elasticities were available for the “fuel and light” grouping, and the composite effective tax for this category was 0.27 for roughly the same period.

Interestingly, similar calculations for India showed that the λ_i for “fuel and light” remained high for all levels of inequality aversion (low ranks at all levels of ε—see Table 2). The differences in ranking in relation to Pakistan may be due to the fact that “housing” was not included in this category. While these numbers are used as illustrations of method, it is likely that changes in consumption patterns in India, with the greater use of automobiles by the middle and upper income groups will likely have changed the rankings towards those in Pakistan.

It is not desirable for the tax rates on roughly similar items within a group of commodities to vary significantly, in order to prevent substitution effects and avoidance, even tough one might wish to tax less heavily, for example, the types of fuel consumed more heavily by poor people. Thus, the issue of the impact of any tax measures relating to carbon taxation, and identification of compensatory measures for the poorest is likely to be critical in any assessment of different options.

Table 1 Pakistan: ranks for λ_i

ε	**0**	**0.5**	**1.0**	**2.0**	**5.0**
1. Wheat	**10**	**4**	**1**	**1**	**1**
2. Rice	**7**	**7**	**6**	**6**	**7**
3. Pulses	**8**	**5**	**3**	**2**	**2**
4. Meat Fish, Eggs	**13**	**13**	**13**	**13**	**13**
5. Milk and Products	**11**	**11**	**10**	**10**	**11**
6. Vegetables, fruits and spices	**12**	**12**	**11**	**11**	**9**
7. Edible Oils	**1**	**1**	**4**	**4**	**4**
8. Sugar	**3**	**3**	**5**	**5**	**5**
9. Tea	**5**	**2**	**2**	**3**	**3**
10. Housing, fuel and light	**2**	**6**	**8**	**9**	**10**
11. Clothing	**6**	**8**	**9**	**8**	**8**
12. Other foods	**9**	**9**	**7**	**7**	**6**
13. Other non-foods	**4**	**10**	**12**	**12**	**12**

Source: Ahmad and Stern (1991)

Notes: The welfare loss for commodity *i*, λ_i, represents the effects on all households (using Household Survey data on consumption, and estimated demand responses) of an increase in the tax on the i^{th} good sufficient to raise a rupee of government revenue. The β^h are welfare weights on households, and ε is the inequality aversion parameter ranging from 0 to 5. A good ranked 1 would be such that a switch of taxation from it to any other good would increase welfare at constant revenue.

$$\lambda_i = \frac{\sum_h \beta^h x_i^h}{X_i + \sum_j t_j^e \frac{\partial X_j}{\partial t_i}}$$

Table 2. India: Effective taxes and rankings of welfare losses, λ_i^t,

Commodity	Effective tax, t_j^e	$\varepsilon = 0$	0.1	1	2	5
Cereals	0.052	8	7	2	2	2
Milk and dairy products	0.009	9	9	9	9	9
Edible Oils	0.083	6	6	4	4	5
Meat, fish, eggs	0.014	7	8	6	5	4
Sugar and gur	0.069	5	5	5	5	6
Other foods	0.114	4	3	3	3	3
Clothing	0.242	1	1	7	7	8
Fuel and light	0.274	2	2	1	1	1
Other non-food	0.133	3	4	8	8	7

Source: Ahmad and Stern (1991)

Notes: as for Table 1.

In order to evaluate in detail the impact on households in different circumstances, the model described above could be used together with the detailed household expenditure surveys in working out the impacts for different groups of households. This could then be used as a mechanism to provide relief, or a social safety net for the very poor, should that be deemed to be relevant. The method described above has also been used to assess the effects of carbon taxes and welfare in New Zealand (see Creedy and Sleeman, 2006).

III. WHICH LEVEL OF GOVERNMENT SHOULD ADMINISTER A CARBON TAX?

The "carbon tax" could be designed as an excise or an import duty on a range of goods/sectors (petroleum, diesel, kerosene, coal). If implemented by the Federal/central government, it could be levied at the production stage. And if made operational by the states/provinces, it would most likely be implemented at the final sales point. One could then evaluate the welfare losses from each type of instrument in deciding on which works best in relation to the relevant distributional considerations.

State and Federal Considerations

In general, the effects of central taxes and state/provincial taxes can be decomposed. In India, excises and customs were federal, and the sales taxes were provincial responsibilities. The model above can be extended as follows. The main federal options for a carbon tax would be based on either excises on production or imports. The state/provincial options relate to the sales or state-VATs in the Indian context.

The effective taxes associated with excises, imports and the sales tax are given by:

Excises: $$t^{eC}_{(ex)} = t^{C'}(I - A^d)^{-1} \quad (26)$$

Imports: $$t^{eC}_{(m)} = t^{m'}A^m(I - A^d)^{-1} \quad (27)$$

Sales: $$t^{eS} = t^{S'}(I - A^d)^{-1} + t^{S'}A^m(I - A^d)^{-1} \quad (28)$$

where t^C, t^m and t^S represent nominal per-unit rates of excise duties, imports and sales taxes. As before, A^d is the coefficient matrix for domestic inputs to domestic production, and A^m is the coefficient matrix for imported inputs into domestic production. It is assumed that imported inputs are strict complements to domestic inputs and there are fixed coefficients (in this case for simplicity).

For given increases in taxes, one can calculate the changes in effective rates through equations (29) to (31).

Excises: $$\lambda^{ex} = \frac{\sum_h \sum_i \beta^h x_i^h \Delta t^C_{i(ex)}}{\sum_i \left[X_i + \sum_i t_j^e \frac{\partial X_j}{\partial t_i^e} \right] \Delta t^{eC}_{i(ex)}} \quad (29)$$

Imports: $$\lambda^m = \frac{\sum_h \sum_i \beta^h x_i^h \Delta t_{i(m)}^C}{\sum_i \left[X_i + \sum_i t_j^e \frac{\partial X_j}{\partial t_i^e} \right] \Delta t_{i(m)}^{eC}} \tag{30}$$

Sales taxes: $$\lambda^S = \frac{\sum_h \sum_i \beta^h x_i^h \Delta t_i^S}{\sum_i \left[X_i + \sum_i t_j^e \frac{\partial X_j}{\partial t_i^e} \right] \Delta t_i^{eS}} \tag{31}$$

Ahmad and Stern, 1984, 1991, assessed the intergovernmental model described above for the evaluation of the welfare losses from the systems for India, using a Nasse modification of the linear expenditure system, household expenditure data using the NSS surveys, and a corresponding 89-group input-output matrix. They showed that at low levels of inequality aversion, e = 0, or 0.1 say, $\lambda^m > \lambda^{ex} > \lambda^S$. In other words, were a government not particularly concerned with the welfare of the poor, it would prefer to raise revenues through a marginal increase in (state) sales taxes. This would cause less social cost per marginal rupee of revenue than an increase in excise duties, and even less than an extra rupee generated through import duties. However, even with a moderate level of inequality aversion, e = 1, the rankings are reversed, states sales taxes would cause greater welfare losses than central taxes (including excises and import duties). Thus, governments with even moderate levels of concern for the poor might prefer a carbon excise to a sales tax equivalent.

These are preliminary and general indications, and the exercise should be repeated with recent estimates and household and production data.

Political economy concerns

Concern with climate change and the externalities from greenhouse gases gives a global perspective and this is probably best seen as an issue for federal taxation. The excise/import duties route also is simple to administer and avoids the difficulties in the intra-state taxation of transactions that would arise if different states were to go for different rates of the VAT.

Moreover, it is not advisable to introduce differentiated VAT structures at the state level, as this is likely to generate potential for avoidance and difficulties in collection. Thus, administration considerations would also point to the advantages of a federal excise/import duty structure for the carbon tax.

The empirical assessment of the effective carbon taxes could then be used to help design any compensatory measures for the poorest people as might be deemed necessary by the federal or state governments. With federal collections, a sharing mechanism with states that could be used to finance compensatory mechanisms at the state level would greatly enhance the overall political-economy incentives for the central carbon tax.[2]

IV. Implementation Issues

If a carbon excise were to be chosen, for instance at the current juncture in Pakistan, it could be thought of as a mechanism to replace partially a petroleum development levy (PDL) that has been introduced for revenue purposes to mop up some revenues as the international prices of petroleum have declined. Replacing some of the PDL by the carbon tax would have no impact on prices, hence households or on production, and this suggests that an optimal time to introduce it would be under present conditions, as compensatory mechanisms described above would not be needed.

Given that a carbon tax is justified on environmental considerations, it would be appropriate not to set an ad valorem tax, but a specific tax based on quantities imported and produced domestically. This would relate the tax to the use of carbon related inputs, and also provide an assured level of revenues for the government. An additional PDL could be retained above the carbon excises, and this should be allowed to vary with international prices for insurance purposes.

[2] For a survey of intergovernmental transfer mechanisms, see Ahmad and Searle, 2006.

V. CONCLUDING REMARKS

We have pointed to the ways in which the concept of "effective taxes" and the theory of reform can be used to guide the design of carbon taxes. It can help identify the appropriate choice of commodities on which the taxes can be levied. This can then be used to identify the impact on households in different circumstances.

The methods can also be used to evaluate the design of intergovernmental responsibilities for carbon taxation. From our work on sub-continental taxation in the past, it would appear that a central excise might be the most appropriate course of action. In these cases, it is likely that administrative considerations, together with the political economy concerns, will predominate. In this case, a uniform treatment across states may be desirable. This could be achieved either by a central tax or harmonized state level taxes. In the Indian context, it would not, however, be desirable to introduce differentiation into state level VATs, and the appropriate instrument may well be a central excise.

Similar calculations would be relevant for a cap-and-trade scheme where allocation of quotas were assigned to key upstream industries and trading could then take place between enterprises. The eventual impact on prices could be calculated using similar methods. Auctioning of quotas would then provide the revenues.

The carbon tax or quota-trading scheme would, as suggested, need to be accompanied by compensatory measures for the poorest households that might be affected. These may have to be administered by state governments, and partially financed by the carbon tax or revenues from auctioning of quotas, which could also be used to finance any needed restructuring of manufacturing or other activities. In the context of falling petroleum prices, the introduction of a carbon excise would provide a painless way of introducing environmental taxation without having to set up compensatory mechanisms.

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