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Tax Reform and the Environment in Developing Economies: Is a Double Dividend Possible?

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Abstract

We reconsider some analytical arguments on the double dividend, focusing on the small open developing economy case. Compared with the large, mature industrial economies usually considered, such economies differ in several respects, including the structure of tax revenues, commodity pricing and sectoral factor intensities. While a double dividend from environmentally-motivated taxes is not assured, the range of conditions for its existence seems broader than usually implied. Empirically, the scope for achieving both environmental improvements and diminished excess burden in developing economies may be greater as a side-effect of the reform of existing taxes than from imposition of explicit environmental taxes.

JEL Classifications: Q28, O13, F18.

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Contents

1. Introduction

In the past decade, environmental economists have responded to the challenge of designing economically acceptable and politically feasible environmental tax policy by arguing that under some circumstances, a "green" tax may contribute more than merely environmental benefits. A major innovation has been the observation that in addition to reducing pollution, the revenue raised by a green tax in a tax-distorted economy may make possible the revenue-neutral reduction of other distortionary taxes, thus increasing the efficiency of the tax system (Pearce; Repetto *et al.*). The essence of the argument is simple. Distortionary taxes reduce welfare, and an uncorrected externality is itself a distortion. The revenue-neutral combination of a green tax at the Pigovian rate (i.e., that at which polluting firms fully internalize external costs), together with the reduction of a distorting tax, will both reduce environmental damage and increase the efficiency of the tax system as a whole.[1] The environmental 'dividend' of the green tax is supplemented by an economic 'dividend' due to reduced excess burden; accordingly, this is frequently referred to as the 'double dividend' argument.

The robustness of the double dividend hypothesis has been questioned. In particular, it has been observed that in an economy distorted by pre-existing taxes, imposing a green tax at the Pigouvian rate may result in the exacerbation of those distortions, and thus yield less revenue than in the first-best case. As a result the magnitude of the second dividend may be small—and could even be negative under some assumptions. In the latter case the welfare reduction from efficiency losses may even be so large as to outweigh any imputed gain from the recycling of the environmental tax. In other words, there may be no second dividend after all, or at the very least, the costs of imposing the environmental tax may be such that its socially optimal rate will never reach the Pigouvian level (Bovenberg and de Mooij; Bovenberg and Goulder).

In this paper we reconsider the likely effects of environmental taxes and of the environmental effects of tax reform in the specific context of a small open developing economy. We contend that while a double dividend from environmental taxation can never be assured, the range of conditions for its existence and efficacy in developing economies may be considerably broader than the current literature appears to imply. Finally, we argue that in industrializing economies, the greatest scope for improvements both in environmental quality and the efficiency of the tax system may arise from the imposition of explicit green taxes, but rather as a side-effect of

[1] The idea of joint revenue and environmental benefits has become firmly, if not rigorously, established in the minds of many developing country policy makers. In May 1997, the Thai government proposed to address an impending budget deficit by introducing several new taxes, several of which were defended on the grounds both of revenue and of environmental benefits.

the reform of existing tax systems. The paper concludes with a brief illustration based on data from Thailand.

2. Distortions and environmental taxes in theory

2.1 Theoretical context

In a first-best world, revenues from taxes on environmental and other negative externalities would be sufficient to fully finance public spending, with no need for distortionary taxes. Each environmental tax would be set at the Pigovian rate, that is, the rate that equates its marginal social benefit with its marginal social cost. In practice, of course, other taxes are necessary to achieve desired levels of government expenditure. The double dividend argument then runs as follows. The imposition of an environmental tax will reduce emissions from the taxed industry and earn revenue for the government. The extra revenue can be used to reduce the rate of an existing distortionary tax, the usual example being a wage-based income tax. Social welfare will thus be increased by the reduction in pollution, and also by the revenue-neutral reduction in the distortionary tax.

There is a theoretical problem with this argument, however. Environmental and other taxes may have negative interactions not clearly recognized in the early double dividend literature, with the effect that the revenue-neutral cut in the distortionary tax made possible by the green tax is less than might have been expected. With an upward-sloping labor supply curve, the real wage reduction caused by increased commodity prices will reduce labor supply and this erosion (narrowing) of the base of the labor tax will require an increase in the income tax rate if revenue-neutrality is to be maintained. A recent paper by Fullerton and Metcalf summarizes the implications of neglecting to count the price-increasing effect of the green tax:

> ...pollution taxes raise the cost of production and thus raise the break-even price of output. This effect *reduces* the real net wage, which offsets the *increase* in the real net wage made possible by using the revenue to reduce the labor tax rate. Under certain simplifying assumptions that represent a reasonable approximation, the two effects exactly offset (1997, p.7; see also Goulder 1995:279).

The existence of the second (fiscal) dividend thus depends on whether the *revenue recycling effect* (the benefits of using green tax revenues to cut other tax rates) outweighs the *tax interaction effect*—that is, the additional distortion created by the interaction of the green tax with existing taxes.[2] A revenue-neutral rise in the environmental tax may be associated with a rise, a fall or no change in the overall efficiency of the tax system; that is, a double dividend cannot be expected as a matter of course.

Numerical results of simulation exercises with general equilibrium models support the analytical findings, and motivate the conclusion that

> ...environmental taxes *typically* exacerbate, rather than alleviate, preexisting tax distortions—even if revenues are employed to cut preexisting distortionary taxes...In the presence of preexisting distortionary taxes, the optimal pollution tax typically lies below the Pigouvian tax, which fully internalizes the marginal social damage from pollution. Intuitively, the collective good of environmental quality competes directly with other collective goods (Bovenberg and de Mooij, p.1085; italics added; see also the conclusion to Bovenberg and Goulder 1996).

The current literature thus offers little scope for optimism about the possibility of a double dividend from green taxes. If such taxes are set high enough to achieve meaningful reductions in emissions, they may cause significant exacerbation of existing distortions in the tax system. Policy makers will then be forced to trade off the goal of a cleaner environment against other policy targets. Importantly, the seriousness of the problem increases with the degree to which the tax system is initially distorted, since the greater the initial distortion, the greater the social cost of imposing a new tax.[3] By implication, the less flexible is the tax system, the smaller is the probability that the socially optimal rate of a green tax will approach the Pigovian rate.

The double dividend debate provides a reminder of the importance of a general equilibrium approach to evaluating the welfare implications of tax policies. However, the roles played by specific structural features of double dividend models are not always fully articulated.[4] The empirical focus of this literature (on carbon taxes in large industrialized economies) motivates specific assumptions about the nature of the tax instrument and the price-setting capacity of the polluting industry. An emissions tax discourages production, and its effect is passed on in the form of higher consumer prices for the good produced in the polluting industry. Moreover, in analytical models at least, intersectoral differences in overall tax incidence and factor intensity are regarded as negligible. The general applicability of these assumptions is an unresolved empirical question. In the next paragraphs we consider likely differences in the analysis of an environmental tax under some alternative assumptions. The settings to be highlighted are arguably representative of a middle-income developing economy, such as one of the East Asian "newly industrializing economies" (NIEs).

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[2] *Revenue recycling effect* and *tax interaction effect* are terms introduced by Goulder (1995).

[3] This point is established empirically in Bovenberg and Goulder, who compare optimal carbon tax rates in a fully optimized tax system with those in a system in which some tax rates are fixed at suboptimal levels (see p.993).

[4] If an environmental tax is imposed to replace command-and-control (CC) measures, there will always be a double dividend since a tax at a rate that matches the environmental and price effects of the CC instrument will raise revenue that can be used to offset reductions in other taxes (Fullerton 1997). In addition, tax revenues formerly used to finance CC will be released for other purposes.

2.2 International trade and commodity price formation

The first point concerns the assertion that a green tax is passed on in the form of a price increase. In a competitive industry this can only occur if the price is not constrained by the availability of substitutes, whether from the domestic economy or abroad. In the case of energy the endogenous price assumption seems reasonable, but this may not be so for many other commodities in which polluting production is a domestic policy issue. Fertilizer and some other heavy and chemical industries producing relatively undifferentiated products, with pollution as a by-product, fall into this category. Unless trade is restricted, the border price acts as a limit price for domestic producers, and a tax on their output will reduce returns to sector-specific factors such as fixed capital rather than being passed on to buyers. If the Law of One Price (LOP) holds, a tax on polluting production will result only in lower domestic output and higher imports of the taxed good.

In general equilibrium with LOP, a green tax on a polluting production process will increase revenues and have no domestic price effects, so long as the tax and trade response have negligible effects on activity in other sectors. If LOP does not hold, domestic prices can be raised by an amount governed by the elasticity of substitution between imported and domestic goods. Analytical models stating that the tax is *fully* passed on in prices are dealing with the special case of a non-traded good.

There may still be a tax interaction effect if domestic output or profits earned in the polluting industry are subject to a tax, so the existence of a double dividend is not assured merely because output prices do not rise.[5] In general equilibrium, however, a complete assessment of the double dividend will also depend on intersectoral factor market responses.

2.3 Intersectoral tax incidence and factor intensity differentials

Existing analytical carbon tax models incorporate a rather special treatment of the real wage effect of an environmental tax. Since labor taxes (or equivalently, price increases or consumption taxes that reduce the real net wage) are implicitly applied to labor employed in all sectors, in these models the representative consumer faced with a reduction in real net wages will respond by opting for more leisure. The reduction in labor supply narrows the base of the income tax or its equivalent, and is the cause of doubts about the double dividend. However, this neglects inter-industry variation both in the use of the polluting good and in the intensity of labor use. Carbon taxes on energy industries are clearly unusual in that their effects are felt by a very broad range of industries, but even these taxes can be expected to have differential cost effects depending on the energy-intensity of production processes. It goes without saying that an environmental tax on some other type of good might have a major impact on costs in some sectors, and no direct effect at all on others.

In general equilibrium, there may be additional effects to consider. If some sector directly affected by a tax is large in relation to factor markets, for example, then a change in its activities might alter some factor prices. In that case all sectors will experience relative factor cosst changes and will adapt their own production plans and input demands accordingly.

In a diversified economy with limit pricing on at least some goods, sectoral differences in the incidence of the environmental tax will cause labor and other mobile factors to migrate among sectors. Whether real net wages rise or fall, and thus whether the tax base expands or contracts as a result depends – among other things – on the relative labor-intensity of the declining and expanding sectors.

To see this, consider the simplest case of a small open economy with two industries, one producing a 'clean' good and the other a polluting good. Each industry uses labor and capital, both of which are mobile between sectors; there is an initial tax on labor income. Suppose that the LOP or some other mechanismconstrains the price of the clean sector output, and choose the polluting good as *numéraire* with a price of 1. With a green tax at rate t, the net producer price of this good is $1/(1+t)$. When the green tax rate is increased, will real wages rise or fall? The tax increase is equivalent to a fall in the relative producer price of the polluting good, so output declines, and some labor and capital migrate to the clean sector . By the Stolper-Samuelson theorem, when the tax is increased, the real price of the factor used relatively intensively in the polluting industry must fall, and that of the other factor must rise. If the polluting industry is relatively capital-intensive, a tax on its output will cause real wages to *increase.* Under revenue-neutrality, if the green tax revenues are used to cut the labor tax rate, the real net wage increase is even greater. In this example, a green tax that affects industry costs asymmetrically causes the base of the labor tax to increase so long as the labor supply curve is not backward-bending . The tax interaction effect, in other words, is *positive*, and the double dividend is assured.

Of course, the Stolper-Samuelson real wage prediction is less unambiguous in a world of many factors and sectors (it continues to hold in an average sense, however). The key point is that the environmental tax may affect not only labor supply (through the real net wage, as in the 'standard' models) but also labor demand, through changes in the relative profitability of industries. The importance of the labor demand effect depends on the magnitude of sectoral

[5] The tax has environmental implications at a global level that are not dealt with here. Whether *global* pollution increases or falls depends, in part, on whether the production process in the domestic economy is more or less

differences both in the incidence of the pollution tax and in factor intensity. The model to be developed later in this paper demonstrates that the demand effect identified above is more likely to be influential when intersectoral factor intensity variation is high, a distinctive feature of developing economies .

2.4 Green taxes vs. "green" tax reforms

Analytical double dividend models concentrate, for good empirical reasons, on the example of a labor or other income tax as the source of a distortion. Some additional insights can be obtained by broadening the set of fiscal instruments that might be altered as the result of revenues from the green tax. In developing economies, trade taxes—which are commodity-specific and thus highly distorting—are far more important sources of revenue than in industrialized economies. In the late 1980s, taxes on trade made up an average of 29.4% of government revenues in developing countries, as compared with only 2.8% in industrialized countries. Income and social security taxes made up 64.2% of revenues in industrial economies but only 35.1% in developing economies (Agenor and Montiel, p.29). In Thailand, a representative NIE, average revenue from personal income taxes in 1991-5 was only 11% of total revenue; the average share of import duties was 19% (Bank of Thailand). In general, tax systems in developing countries are more highly distortionary, in part because of their heavier reliance on trade taxes. This raises the potential for environmental taxes to achieve simultaneous improvements in environmental quality and in the efficiency of the tax system.

The deeper point about import tariffs, however, is that in contrast to a typical tax on production or factor use, these policies *promote* production in targeted industries. To increase a tariff is to increase the overall distortion of the tax system, and also, in the case of polluting industries, to increase the production of emissions. Conversely, tariff reduction means lower production and emissions in those industries, with the net revenue result dependent on the original form of the trade policy instrument and the effects of liberalization on output in protected and other sectors, as well as on concomitant changes in other tax revenues. It is intuitively clear that under some circumstances, tariff reduction or other forms of policy liberalization in such highly distorted tax systems could deliver environmental quality improvements in addition to reduced excess burden— the double dividend.

This discussion of differences in commodity pricing rules, in intersectoral factor intensities and in tax systems is intended to inform an investigation of the double dividend in a typical small, open industrializing economy. Parts of the discussion seem to indicate a somewhat less pessimistic

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polluting than that in the country(ies) from which imports are sourced.

outlook for the double dividend in such an economy. Among points we have raised, intersectoral variation in tax incidence and factor intensity, and the presence of narrow-based distorting taxes such as tariffs are potentially the most significant. We examine their implications briefly in the next section before turning, in sections 4 and 5, to an informal examination of tax reform in developing countries and of relevant data from the Thai economy.

3 Efficiency and welfare gains from trade tax liberalization

3.1 A simple model

In this section we construct and analyze a simple general equilibrium model of tax reform and economic welfare in a small open economy. Pollution is a byproduct of production in one sector. The structure of the model is motivated by the recent experience of the group of developing economies known as newly industrializing economies (NIEs), and specifically by that of the Thai economy. In that country, recent tax reform initiatives have emphasized the reduction of import tariffs and the corresponding expansion of broad-based taxes, most notably a national value-added tax (VAT) begun in 1992. These reforms are typical of tax changes in the NIEs in recent years. We take this stylized case— an economy with existing trade taxes and a VAT— as our starting point and examine the economic effects of a further revenue-neutral tariff reduction. To ensure comparability with the double dividend literature, our other assumptions about economic structure and behavior match those of Bovenberg and de Mooij.

Imagine an open economy in which two goods are produced, an import-competing good (M) and an exportable (C). The economy is small in relation to world markets, so base commodity prices are determined through trade rather than through domestic demand and supply. There is a single representative consumer who supplies labor, assumed to be the only factor in elastic supply. Utility is gained from consumption of private goods (M and C) and two public goods, government expenditure (G) and environmental quality (E). Labor, used only in production of M and C, is homogeneous and the labor market clears across the two sectors at a common wage. We assume for simplicity that only M production generates emissions (E).[6] We assume emissions to be produced in fixed proportion to output, so $E = E(M)$; $E' < 0$, $E'' = 0$.

Producers face border prices P_m and P_c, adjusted by the rate of any taxes on trade. For simplicity, we choose units so that $P_m = P_c = 1$. The M sector is protected by a tariff, so producers in that sector face domestic price $p_m = 1+t$. Producers in the C sector face price $p_c = P_c = 1$. Consumer prices are equal to producer prices plus a value-added tax (VAT), applied at a uniform

[6] This assumption is made for analytical convenience only. We briefly discuss other sectoral distributions of emissions later in the paper.

rate h to domestic consumption of each good (since there are no intermediate goods, the VAT is equivalent to a sales tax). Consumers thus pay $q_c = (1+h)$ for the exportable, and $q_m = (1+t)(1+h)$ for the importable.

The two private goods are produced by profit-maximizing firms using labor and sector-specific factors, with CRS technology. Aggregate revenue is given by the GNP function $r(\mathbf{p},\mathbf{v})$, where $\mathbf{v}$ is a vector of factor endowments including the mobile factor, labor (L). By Shephard's lemma, $\partial r(\mathbf{p},\mathbf{v})/\partial p_i = r_i(\mathbf{p},\mathbf{v})$ is the domestic supply of good i, and $\partial r(\mathbf{p},\mathbf{v})/dL = w^L(\mathbf{p},\mathbf{v})$ is the competitive equilibrium wage (in practice, since we deal only with labor market changes, $\mathbf{v} = L$ and henceforth we suppress the superscript on w). Since we will make use of them shortly, it is convenient to note here some relevant second-order properties of the revenue function as follows. The response of wages to commodity price changes is given by $\partial^2 r(\mathbf{p},\mathbf{v}) / dL\partial pj = \partial w / \partial pj = r_{lj}$. The sign of this derivative depends on relative factor intensity. In the simplest case of two factors and two sectors, r_{lj} is positive for the sector that is relatively labor-intensive. By Stolper-Samuelson, in such a sector a rise in the output price raises real returns to the relatively intensively used factor, i.e., the wage. Lastly, we note that $\partial^2 r(\mathbf{p},\mathbf{v}) / dL^2 = \partial w / \partial L = r_{ll} < 0$ is the wage response to an increase in the size of the labor force.

Our assumptions on consumer preferences follow Bovenberg and de Mooij. The representative consumer obtains utility from consumption of private and public goods and leisure. By choice of units the consumer is endowed with one unit of labor, so consumption of leisure is 1-L. Households do not consider the environmental implications of their own consumption of M. The utility function is thus written:

$$U = U(u(C, M), 1\text{-}L, G, E). \tag{1}$$

Suppose utility to be weakly separable in private and public goods, which individuals take to be fixed in supply. Suppose further that the labor supply decision is a function of the real net wage and that it is separable from decisions about the consumption of other goods, so:

$$L = L(w / \pi) \qquad L_w > 0, \tag{2}$$

where $\pi(\mathbf{q})$ is a consumer price index such that $\pi = q_m^{\alpha} q_c^{1-\alpha}$, where α is the share of purchases of M in total household expenditures. We can represent the consumer's optimization problem with respect to private goods by an expenditure function $e(\mathbf{q},u)$. By Shephard's lemma, $\partial e(\mathbf{q},u)/\partial q_i =$

$e_i(\mathbf{q},u)$ is the compensated demand for good i, and $\partial e(\mathbf{q},u)/\partial u = e_u$ is the marginal utility of a unit of consumption.

The structure of this model mirrors those used in the analytical double dividend literature except in two respects: all goods are traded, with their prices determined in international rather than domestic markets and with tariffs as well as domestic taxes; and sectors are heterogeneous in terms of the labor-intensity of production. Distortions arise from three sources: two tax instruments, and an environmental externality associated with the production of M. The VAT affects consumers' decisions only, whereas the trade tax affects decisions by both consumers and producers. Excess burden associated with the tariff thus has two components, arising from the misallocation of resources in both production and consumption.[7]

The government earns revenues from the tariff and the VAT and spends these on provision of the public sector good. Its budget constraint is:

$$G = tz_m(\mathbf{p},\mathbf{q},L,u) + h\sum_i e_i(\mathbf{q},u)q_i \qquad i=C,M, \qquad (3)$$

where e_i is domestic consumption of good i, as defined above, and $z_m = (e_m - r_m)$ is net imports of M. A revenue-neutral set of tax reforms is found by setting dG=0 and solving to obtain:

$$\left.\frac{dh}{dt}\right|_{dG=0} = -\left(\frac{\mu + h\alpha}{1+t}\right), \qquad (4)$$

where μ is the ratio of imports (valued at producer prices) to total consumer expenditure, and α is the share of expenditures on M to total expenditure (see Appendix for derivation). Other than in exceptional circumstances, $|dh/dt| < 1$, so for a given change in t, a smaller proportional change in the VAT rate is required to maintain constant government expenditures.

The aggregate budget states that the total value of private expenditures equalthe value of private goods production plus tax revenue. Using (1), write the budget constraint as:

$$e(\mathbf{q}, u) = r(\mathbf{p}, L) + G. \qquad (5)$$

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[7] Notice that since the value of E does not alter production functions and affects all consumers equally, the environmental externality functions in a way analogous to the VAT. A more general model would allow for both productin and consumer effects to be heterogeneous. Sources of heterogeneity could be related to technology on the production side, and to a variety of phenomena including spatial differences, on the consumer side. Thus, for

Since factor market clearing is assured by labor mobility, (3) and (5) fully describe the general equilibrium of our simple economy. Satisfaction of these conditions ensures that trade is also in balance, by Walras' law.

If M production is the chief source of environmental concern then it is apparent that in this economy, reducing the tariff will deliver an environmental benefit. The tariff reduction will serve the same environmental purpose as a green tax. Then the question is whether reducing the tariff could also reduce excess burden, thus yielding the double dividend. By the theory of the second-best, there is no guarantee that reducing the rate of a distorting tax will result in a net increase in welfare. Since the tariff is an important source of government revenue, there is a concern that by reducing it, the efficiency of the tax system will be diminished in a way analogous to that described by Bovenberg and de Mooij for the carbon tax case, i.e., that trade liberalization and the accompanying increase in the VAT required for revenue-neutrality will result in increased excess burden through a narrowing of the tax base.

In this model the change in excess burden can be measured by a revenue-neutral change in welfare from consumption of the private goods, inclusive of the effects of any change in labor supply. Totally differentiating (1), using the price definitions to obtain $dq_m = (1+h)dt + (1+t)dh$ and $dq_c = dh$, and collecting terms gives a comparative static measure of welfare change (defined over M, C, G and L) for the representative consumer:

$$e_u du = -[z_m + e_m h]dt - [e_c + e_m(1+t)]dh + r_L dL + dG, \qquad (6)$$

where $e_u = \partial e(\cdot)/\partial u$, and subscripts on e and z denote derivatives as earlier defined. When the government budget remains balanced (dG=0), a rise in one tax rate must be matched by a decrease in the other. Whether welfare rises or falls depends on whether these tax changes increase or reduce excess burden, and also on whether labor supply rises or falls. Labor supply in turn will depend not only on the real wage effect of a change in the CPI, but also, as was observed in Section 2, on endogenous changes in the *nominal* wage as labor is reallocated among sectors in response to changes in relative producer prices. Will welfare rise or fall, and by how much, when labor market adjustments are taken into account? This is the question we must answer in order to establish whether or not a double dividend is possible in this model.

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example, urban residents may care more about pollution occurring in urban areas than about pollution affecting rural areas.

3.2 The labor market

In earlier environmental tax models, the labor market response to a revenue-neutral tariff change depends on overall labor supply response to a change in the real net wage. In this model of a diversified economy the real net wage change also depends on shifts in labor demand that occur as the result of changes in the relative profitability of sectors. When sectors of varying factor intensity respond to relative price changes, aggregate labor demand— and thus nominal wage pressures— may rise or fall.[8]

As noted earlier, in general equilibrium the wage is determined both by producer prices (which determine labor demand) and by the consumer's labor supply decision, which depends on consumer prices. When tax policy changes alter producer and consumer prices we have, from (2):

$$dL = L_w \left(\frac{w}{\pi} dw - \frac{w}{\pi^2} d\pi \right) \tag{7}$$

Solution values in terms of the policy variables can be most readily be found by converting variables from levels to proportional changes (denoted by italics, e.g. $\hat{L} = dL/L$). Expression (7) then becomes

$$\hat{L} = \varepsilon_s(\hat{w} - \hat{\pi}) \tag{8}$$

where ε_s is the elasticity of labor supply with respect to the real wage. We next seek expressions for $\hat{w}$ and $\hat{\pi}$. For the proportional change in the CPI, using the definition of $\pi(q)$ and $\hat{p}_m = T\hat{t}$, $\hat{p}_c = 0$ for proportional changes in producer prices, we obtain:

$$\hat{\pi} = H\hat{h} + \alpha T\hat{t} \tag{9}$$

where $H = h/(1+h))$ and $T = t/(1+t)$, and α is the expenditure share of the importable good. For wages, from the second-order condition of the GNP function we have:

$$\hat{w} = \varepsilon_{lm} T\hat{t} + \varepsilon_{ll}\hat{L}, \tag{10}$$

where ε_{lm} is the elasticity of the wage with respect to p_m, and $\varepsilon_{ll} < 0$ is the elasticity of the wage with respect to labor supply. The sign of ε_{lm} depends, in this model, on whether the M sector is more or less labor-intensive than the C sector; it is positive is M is the labor-intensive sector, and negative otherwise. A value of this parameter close to zero indicates that factor intensities are similar across sectors.

[8] Of course, other characterizations of the labor market are reasonable in developing country settings; for a discussion of the Thai case see Coxhead and Jiraporn 1999.

Substituting (9) and (10) into (8) and collecting terms, we arrive at a solution for labor supply response to policy changes:

$$\hat{L} = \varepsilon\left[\left(\varepsilon_{lm} - \alpha\right)T\hat{t} - H\hat{h}\right] \tag{11}$$

where $\varepsilon = \varepsilon_s/(1-\varepsilon_s\varepsilon_{ll}) > 0$ is the general equilibrium labor supply elasticity. Expression (11) distinguishes labor supply effects between supply and demand sides as follows. Labor supply is diminished by increases in the VAT rate, and by the tariff if $\alpha > 0$; these are real wage effects from the demand side. However, the tariff also causes the protected industry to expand, and this may increase or reduce the nominal wage, depending on whether it is M or C that is the relatively labor-intensive sector. By assumption so far it is C, so $\varepsilon_{lm} < 0$. In that case a tariff increase (reduction) unambiguously causes labor supply to diminish (expand), for a given value of $\hat{h}$.

Whether a tariff increase increases or reduces overall labor supply depends not only on workers' labor supply responses to real wages, but also on the reallocation of labor between industries which are more or less labor-intensive. Converting the expression for a revenue-neutral VAT change (4) to proportional changes, we obtain:

$$\hat{h} = -T\left(\frac{\mu + h\alpha}{h}\right)\hat{t} \tag{12}$$

By substitution into (11) and collecting terms:

$$\hat{L} = \varepsilon T\left[\varepsilon_{lm} - \left(\frac{\alpha - \mu}{1 + h}\right)\right]\hat{t} \tag{13}$$

The first term within square brackets is the factor-intensity effect discussed earlier. Suppose that $\varepsilon_{lm} \approx 0$, that is, that factor intensity differences between sectors are small. Then the second term, which captures the relative impact of labor market influences from the supply and demand sides, dominates . A tariff rise will result in increased labor supply if the labor demand effect (measured by μ) outweighs the real wage effect (α)— and vice versa.

We can now evaluate the net welfare impact of a revenue-neutral tariff change. Convert (6) to proportional changes of variables:

$$\hat{y} = -T[\alpha - \gamma]\hat{t} - H\hat{h} + \omega\hat{L}, \tag{14}$$

where γ is the value of production of M expressed as a fraction of y. Using (12) to eliminate $\hat{h}$ and collecting terms:

$$\hat{y} = -T\left(\frac{\alpha}{1+h} - \gamma - \frac{\mu}{1+h} - \omega\hat{L}\right)\hat{t}. \qquad (15)$$

Whereas α is defined in terms of consumers' prices, both γ and μ are defined in terms of producer prices. Since $q_i = p_i(1 + h)$ for i=M,C, it follows that $\alpha - (1+h)\gamma = (1+h)\mu$, or the difference between consumption and production of M, valued in a common set of prices, is equal to imports of M valued in the same prices. Using this in (15),

$$\frac{\hat{y}}{\hat{t}} = -T\left(H\mu - \omega\frac{\hat{L}}{\hat{t}}\right). \qquad (16)$$

This shows that the welfare effect of a tariff increase is unambiguously negative as long as $\hat{L}/\hat{t} < 0$. Finally, substituting the expression for $\hat{L}$ shown in (13), noting that $(\alpha-\mu)/(1+h) = H\mu$, we arrive at the general equilibrium expression for the welfare effect of a tariff change, with revenue-neutral alteration of the VAT rate:

$$\frac{\hat{y}}{\hat{t}} = -T\big(H(1+\omega\varepsilon)\mu - \omega\varepsilon\varepsilon_{lm}\big) \qquad (17)$$

As long as $\varepsilon_{lm} < 0$, this expression is unambiguously negative. A shift in the tax base from a less to a more distorting tax reduces welfare, except possibly when the sector benefiting from increased protection is highly labor-intensive. Conversely, a tariff reduction will increase welfare. In either case, the welfare change is larger, the more elastic is the labor supply curve and the larger is labor's share of national income; similarly, the effect is larger when the M sector is large in relation to the economy. Finally, the effect is greater when initial tax rates are high, since T and H then take larger values.

In an economy initially distorted by a tariff and a broad-based tax, the aggregate welfare impact of a *reduction* in the tariff will depend on two responses. First, the reduction in this highly distortionary tax will increase welfare by reducing the excess burden associated with resource misallocation by both producers and consumers. This is the effect captured by the first term within brackets in (17). Second, in addition to increasing real net wages, the tariff reduction will also cause some labor to move out of import-competing industries, an effect captured in the second term. These changes will unambiguously increase labor supply, thus broadening the base of the consumption tax, so long as the import-competing industries are important in relation to the economy as a whole *and* employ relatively capital-intensive technologies. Conversely, labor supply may decline if the real wage effect is small and the protected industries are relatively labor-intensive.

By contrast with the carbon tax examples, we have identified a set of cases in which an increase in the efficiency of the tax system accompanied by a reduction in environmental damage is beyond doubt for a wide range of parameter values. A key difference is that we have modeled an economy in which technologies, emissions and tax incidence are all distinct for different sectors. This hereogeneity makes it possible to identify a tax reform that reduces emissions and also reduces excess burden.

4. Some data and observations from Thailand

The foregoing discussion provides a foundation for thinking about the environmental implications of tax reforms in the NIEs, and in particular for asking whether a double dividend can feasibly be expected from recent reforms, or from those that might be contemplated.

The model developed in section 3 examined tariff reform in an economy with existing tariffs and a sales tax or VAT. As we noted, the two major tax reform initiatives undertaken in Thailand in recent years are trade liberalization and the expansion of the sales tax base, through introduction of a VAT in 1992 (Warr and Nidhiprabha). Environmental taxes, while widely discussed, do not play a significant role in either environmental or fiscal policy at present. Most current environmental policy takes the form of command-and-control measures, either regulating emissions or, in some cases, determining the location of new industrial plants.

In our model we assumed, for heuristic purposes, that the import-competing sector was the more emissions-intensive and thus that any reform resulting in reduced output of that sector would have a beneficial environmental effect. Data from Thai manufacturing industries are consistent with the model's assumptions. Table 1 shows that protected import-competing industries are very heavily represented in the top echelon of polluting industries in Thailand, according to broad measures of industrial emissions (this observation is consistent with the characteristics of protected industries in developing economies; see Birdsall and Wheeler 1992, and Lucas et al;. 1993). Moreover, import-competing sectors are less labor-intensive than the economy-wide average, so a contraction by these industries can be expected to result in robust labor demand (and wage) growth as other industries expand. Thus the prospects for trade liberalization to raise welfare, conventionally defined, *and* to reduce the growth rate of industrial emissions in Thailand and in similar developing countries appear strong.[9]

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[9] The question of the net environmental effect of the change remains unresolved, however. Emissions will undoubtedly fall along with output in sectors where protection declines, but the resulting movement of resources into other sectors and expansion of overall economic activity may cause a net increase in emissions. Whether the net change in emissions is positive or negative remains an empirical question.

Among the import-competing sectors, several stand out as having both exceptionally high emissions and above-average effective protective rates. Some examples are provided in Table 2. The coincidence of high protection and high emissions strongly suggests that even if the environmental benefits of a general trade liberalization are in doubt (the resulting expansion of the economy could increase overall emissions), selective reductions in trade barriers might significantly reduce emissions.

In the current policy climate, imposition of green taxes analogous to carbon taxes in wealthy countries seems a distant prospect. However, in protected industries, an identical effect can be achieved by reducing existing protective tariffs. Tariff reduction, a move consistent with the overall thrust of development policy in Thailand and most other industrializing economies, could also benefit the economy by reducing the costs of achieving environmental protection through command-and-control mechanisms. This illustrates a more general point about the relative merits of market-based versus regulatory instruments: all standard environmental policies generate a tax interaction effect, but only some produce a partial offset through the revenue-recycling effect (Fullerton; Parry, Williams and Goulder).

5. Conclusions

The new models of environmental taxation inject a healthy note of skepticism into discussions of the benefits of environmental taxation. By locating environmental tax policies in the general equilibrium context of government revenue constraints and the efficiency of raising taxes to fund provision of public goods, the public finance approach to environmental taxes has forced a more rigorous assessment of the prospects for a double dividend from green taxes. However, the pessimism that emerges from analytical explorations of the carbon tax issue does not imply that there will always — or even *typically*— be a tradeoff between increases in economic efficiency and in environmental quality.

The case we have examined, of a *general* tax reform in a stylized small open developing economy, suggests productive paths for empirical analysis directed at evaluating the net economic benefits of environmental taxes, and the environmental benefits from general tax reform in such economies.

In the second-best world of an economy distorted both by taxes and environmental externalities, there are few predictions about the economic effects of tax policy changes— their magnitudes or even their signs— that can be made with certainty. However, continued uncertainty about the net benefits of 'green taxes'— and, importantly, the difficult political economy of their adoption and implementation— suggests that the efforts of environmental economists may be better directed towards helping design overall tax reform packages that also work towards environmental objectives rather than working backwards from environmental targets to tax reform packages. Of course, environmental quality gains achieved by these means will occur at the margin, meaning that major reductions in growth rates of most forms of pollution will still require direct interventions, polluter-pays instruments, and perhaps the establishment of markets for rights to pollute or to use depletable resources. Nevertheless, it seems that a double dividend is a very real possibility with the kinds of tax and trade policy reform currently becoming popular in developing countries, and indeed that the magnitude of such dividend may be greater than predicted by models designed for industrialized economies.

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Table 1: Protection, factor intensity and emissions data for Thai manufacturing industries

Weighted Average[a] (standard deviations in parentheses)	Import-competing (n=45)	Exporting (n=29)	Non-Traded (n=19)
Protection and factor intensity indicators			
Domestic resource cost (DRC)	2.07	0.65	—
	(0.131)	(0.024)	
Effective rate of protection (ERP)	139.39	-12.01	—
	(12.359)	(1.126)	
Nominal rate of protection (NRP)	44.06	1.22	—
	(2.685)	(0.168)	
Labor-intensity (labor cost as a fraction of total cost)	0.42	0.61	0.43
	(0.015)	(0.033)	(0.033)
Emissions indicators (see Note):			
AHTI score (linear index)	6.47	2.92	2.68
	(0.201)	(0.153)	(0.220)
IPPS rank	33.20	36.34	55.04
	(1.611)	(1.806)	(3.908)

Sources: Bank of Thailand and Hettige *et al*..

[a] Calculated using within-group weights based on value of domestic production.

Note:
AHTI = Acute Human Toxicity Index, an aggregate emissions score developed for developing countries by Hettige *et al.* The score is measured in risk-weighted pounds of Toxic Release Inventory (TRI) emissions per $1,000 of shipment value (the TRI aggregates 322 chemicals in an index developed by the U.S. Environmental Protection Authority). The IPPS (Industrial Pollution Projection System) rank is out of 74 industries (at 4-digit ISIC level) included in a data base by Hettige *et al.* Higher AHTI scores and lower IPPS ranks indicate greater emissions. These emissions measures are not based on Thai data due to unavailability; however, "the present version …can be useful as a guide to probable pollution problems [in developing countries], even if exact estimates are not possible" (Hettige *et al.*, p.7).

Table 2: Summary data for top 10 industries in IPPS rankings, by ERP

Sector	Imports (% of consumption)	NRP (%)	ERP (%)	L/K	IPPS rank	LAHTI score
Fertilizer, Pesticide & Insecticide	87	19.9	20.6	0.48	1	105.3
Natural Chemical & Fertilizer	89	12.6	9.8	0.37	1	105.3
Basic Chemicals	93	18.6	18.6	0.34	2	54.92
Tannery and Leather Finishing	27	25.9	180.9	0.69	3	30.4
Synthetic Resin	49	35.4	57.3	0.30	4	26.44
Pulp, Paper and Paperboard	47	20.9	21.4	0.16	5	21.83
Plastic Wares	41	38.9	47.6	0.57	6	17.31
Printing & publishing	9	n.d.	n.d.	0.42	8	14.93
Paper products	5	n.d.	n.d.	0.95	9	14.77
Non-ferrous Metal	73	14.4	11.6	0.56	10	13.23

Sources: As for Table 2. Note: n.d.denotes no data available.

Appendix: derivation of equation (4)

From (3), $h = (G - tz_m)/E$, where $E = e_m q_m(h,t) + e_c q_c(h)$. So

$$\left.\frac{dh}{dt}\right|_{dG=0} = \frac{-1}{E^2}\left(Ez_m + (G - tz)\frac{\partial E}{\partial t}\right)$$

Since $q_m = (1+t)(1+h)$ and $q_c = (1+h)$, $\partial E/\partial t = e_m(1+h) = e_m q_m/(1+t)$. From (3) again, $(G - tz_m) = hE$; defining the ratio of imports (valued at producer prices) to total consumer expenditure as $\mu = p_m z/E$, and the share of M in total consumer expenditures as $\alpha = e_m q_m/E$, gives the equation in the text.