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The duality of taxes and tradable permits: A survey with applications in Central and Eastern Europe

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ABSTRACT Economic instruments such as taxes and tradable permits have been promoted as efficiency improving policies in the transition economies of Central and Eastern Europe and elsewhere. The little noticed potential for a symmetric equity impact from the two instruments in a world without distortions is first discussed. A specific policy option is suggested in which existing environmental taxes in Central and Eastern Europe can be increased without imposing additional financial burdens in industry if appropriate tax credits are provided. Second, conditions in Central and Eastern Europe are identified that reduce the change of efficiency losses in a general equilibrium setting when distortions exist. The trade-off between efficiency and equity in such a setting is found to depend on country-specific parameters and to be reduced if: (1) a cost-effective policy is implemented, (2) environmental assets can be distributed prior to privatization, and (3) government expenditures can decline.

1. Introduction

A relatively common approach to environmental improvement exists in the transition economies of Central and Eastern Europe. The common elements of concern to this paper include a pollution tax system, permitted pollution levels, and concern about the viability of firms. Modifications to the tax system, the implementation of tradable permits, or mixed (two-tier) tax and trade systems have been suggested to improve economic efficiency in the region (see for example, Moldan, 1995; Stavins and Zylicz, 1995; Farrow and Bluffstone, 1995; Farrow, 1997). This paper focuses on the implicit distribution of environmental assets as it affects the efficiency of

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environmental policies. The paper proceeds in section 2 by reviewing the applicability to Central and Eastern Europe of the distributional symmetry between equally efficient taxes and tradable permits as discussed or implied by Mumy (1980), Pezzey (1992) and Farrow (1995) in a first-best world with no distortions. In section 3 the paper builds on recent work by Bovenberg and de Mooij (1994), Bovenberg and Goulder (1996), Goulder (1995), Parry (1995, 1996), Goulder, Parry, and Burtraw (1996), Fullerton (1996), and Fullerton and Metcalf (1997) to investigate new concerns about a trade-off between efficiency and equity in a general equilibrium setting. Characteristics both general and specific to Central and Eastern Europe are seen to reduce recent concern about the welfare-reducing potential of some distributions of environmental assets.

2. Efficiency and equity

The existing environmental tax systems in Central and Eastern Europe have been reviewed by Klarer (1994), Anderson and Fiedor (1997), Kozeltsev and Markandya (1997), and Vincent and Farrow (1997). They conclude that the effective pollution tax rates in Central and Eastern Europe tend to be too low to be consistent with the quantity goals of environmental policy. For instance, SO_2 charges per ton in Russia are slightly over $1; above $37 in the Czech Republic; and highest in Poland at about $83. Poland is recognized as having significantly higher pollution taxes than other countries in the region (Anderson and Fiedor, 1997) although even these are noted as being 'far below the theoretically efficient level. . . . to meet policy objectives' (Stavins and Zylicz, 1995: 5). What behavioral effect exists from pollution taxes in 5 of 11 Central and Eastern European countries is declining over time due to the lack of indexation of taxes (Vincent and Farrow, 1997). In general, however, political effort in Central and Eastern Europe to raise the level of taxes is resisted on the grounds that pollution taxes high enough to have a larger behavioral effect might adversely effect the economic situation of many enterprises (Klarer, 1994; Kozeltsev and Markandya, 1997). This section summarizes and extends work on pollution tax credits. Such credits can alter the distributional impact of a higher tax level and so reduce concern about the financial impact of taxes. Links to the distributional impact of tradable permits and to existing policies on temporary tax credits are also investigated.

Default tax and permit policies differ in their financial effect on stakeholders. This can have a significant impact on the political support, and hence the political economy, of alternative policies. Default tax policy taxes all units of pollution and leads to a large monetary transfer to the government. Default tradable permit policy as implemented in the US allocates permits to existing firms which avoids the large transfer to the government. These distributional differences cause industry to create a large barrier to the implementation of behaviorally relevant pollution tax rates. Yet in Central and Eastern Europe, in contrast to the US, the pollution tax system is one of the stronger components of the system and provides a plausible building block for more effective policies.

Changing the default assumption for taxes can address two issues of

major concern in Central and Eastern Europe: (1) raising pollution tax rates to behaviorally relevant levels, and (2) doing so without extracting so much in taxation that socially expensive closures result. Related proposals have been discussed in the North American literature by Mumy (1980), Pezzey (1992), and Farrow (1995). The existence of environmental taxes in Central and Eastern Europe may make such proposals more relevant than in North America where such a foundation does not exist.

The distributional symmetry between taxes and permits can be investigated through an application of the lump sum distribution of taxes in a first-best world. Consider a policy in which an annual fixed tax credit is introduced at the same time that pollution taxes are increased. The higher tax combined with a tax credit changes the incentives without necessarily changing the amount of money paid by the firm. Define q_t and q_0 as current and base year emissions, t as the tax rate, and $\mathbf{a}(0 \leq \mathbf{a} \leq 1)$ as a revenue parameter. Then the net tax is computed as

$$\text{Net tax} = tq_t - \mathbf{a}tq_0$$

$$= tq_t - \text{constant} \quad (1)$$

$$= t(q_t - \mathbf{a}q_0) < \text{or} > 0 \text{ as } (q_t - \mathbf{a}q_0) < \text{or} > 0 \quad (2)$$

Several implications emerge. Equation (1) implies that the lump sum credit does not alter the marginal incentive to reduce emissions as is well known. The marginal incentive is the tax rate. It is this property that can lead to a least cost solution in a single tax system. Note that the tax 'credit' is not a loan but is an offsetting accounting entry that reduces the taxes paid by the firm. However, equation (2) indicates how the revenue portion of the tax can be set by the decision maker by choosing **a**, the revenue parameter.

The current tax policy default is that **a** equals zero. In this case the property right in the environmental asset is entirely assigned to the government providing revenues equal to tq_t. If **a** is set to 1 then no revenue is raised at the current level of emissions and the environmental asset is implicitly distributed to the firm. With **a** at a non-zero level, the government is acting as a broker who will tax emissions over a threshold ($\mathbf{a}q_0$) at rate t but who will give a tax credit on emissions under the threshold (note this requires positive income to generate positive taxes so that entry and exit conditions may not be dramatically altered.) The choice of **a** clearly determines the distributional impact and is of great importance to politicians. In a first-best world with no other distortions, what is important for economic efficiency is that *however* **a** is set, it merely defines the distributional effect.

Several additional issues are of potential concern to economists and to policy makers including: (1) the potential for equivalent distributional impacts between grandfathered permits and tax credits, (2) the existence of cost neutral tax increases, (3) permanent versus temporary and partial tax credits, and (4) the implications for the number of firms in the industry. Each of these is considered in turn.

Dual distributional effect between grandfathered permits and tax credit

Implicit above is that lump sum tax credits can be distributionally equivalent to tradable permits when the permits are distributed to the current

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polluters, perhaps recognizing historical use of the environmental property right. Under appropriate conditions, the lump sum distribution can equal the economic value of such grandfathered tradable permits. Consider a tax system and a tradable permit system that are dual to each other in the sense that the tax, t, and the equilibrium price of a permit, p, are equivalent and, therefore, so are the relevant quantities controlled. When permits are given to existing polluters, say in value equal to pq_i, it would be possible to define a tax credit that exactly matches the initial value of the permits, namely tq_i. The distributional effects of both taxes and permits would then be equivalent.

Cost neutral tax increase

In the economic conditions of Central and Eastern Europe, there is concern about additional transfer of income away from firms. While politicians may choose the lump sum credit to be of any amount, some stakeholders may wish to design the tax credit to have no impact on the cash flow of the firm at the base amount of pollution. Consider the new, higher tax rate as t', the old rate to be t and other terms as above. The tax credit required to achieve a cost neutral increase in pollution taxes, before any optimal response to the higher rates, can be simply computed as

$$\text{Initial new taxes} - \text{old taxes} = 0$$

$$\text{requires } (t'q_0 - c) - tq_0 = 0$$

$$(t' - t)\, q_0 = c$$

Clearly, neutrality can be defined with respect to quantities other than q_0 such as the legally permissible level of pollution.

Permanent versus temporary or partial tax credits

The above structure defined a constant, annual lump sum tax credit. This is only one possible form. Continuing the parallel between tax credits and grandfathered permits, it is possible to design tax systems that add a time dimension to the tax or to the tax credit. The parallel to phasing out or reducing quantities in tradable permits can be mimicked by increasing the tax. Shifting the value of the property right granted over time, a design not normally considered in the tradable permits literature, is a more common concern with tax credits. The lump sum tax credit can drop to zero at some point which would be a temporary tax credit that effectively seizes the property right at a point in time. If the tax credit is not conditional on environmental performance, neither a permanent nor a temporary credit would be expected to impact the firm's decision to invest in environmental control. This may be viewed as economically desirable where the firm has better information about the rate of return across internal investment opportunities.

In at least Hungary and the Czech and Slovak Republics, a temporary but conditional tax credit is allowed with the current pollution tax system. In the Czech and Slovak Republics the credit is a fixed fraction of the tax bill and continues only for the time that an environmental investment is occurring which creates the conditionality of the credit. In contrast to an

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unrestricted credit, a conditional and temporary credit does affect the decision of whether or not to invest in pollution control. It is possible to think of this credit as compensating for an implicit price of pollution, the tax, that is too low to induce some investment behavior. The conditional tax credit makes it more likely that investments will be undertaken but may distort the firm's decision making with respect to other investment opportunities due to the conditionality of the credit.

In the Czech Republic, a credit equal to 40 per cent of the existing taxes can be received during the time of construction and lasting until operation. Proposals exist to raise the credit to 90 per cent. Such projects can take several years. How large is this form of a tax credit in comparison to the fixed, permanent credit described above? Fixed period annuities that take into account tax cost savings, tax credits, fixed costs, and operating costs can be used to estimate the value of the incentive. As an example, a five-year temporary tax credit at a 15 per cent rate of discount is worth about 53 per cent of an infinite permanent tax credit (calculations available from author). If regulations allow only a fraction of the taxes to be received as a credit, then the present value changes proportionally. The existing policy in the Czech Republic provides a 40 per cent credit which, given the above conditions, is worth 21 per cent (0.53*0.4) of the value of a full and permanent credit.

Tax credits and the number of firms

Some economists such as Baumol and Oates (1988) and Spulber (1985) have indicated concern about the long-run implications of lump sum credits. While efficient entry conditions may not be affected when entering firms pay the full marginal tax, the central concern is that granting property rights to the firm could reduce efficient exit from the industry. This could occur because existing firms earn higher profits (rent) from the credit than without the credit and thus inefficiently exit the industry. Pezzey (1992) has discussed how the firm could be theoretically compensated for its environmental asset holdings if it exits the industry and Mumy (1980) suggests that the financial incentives could be traded. However, even accepting the theoretical possibility of inefficient exit with some kinds of tax credit programs, a second question is its relevance to policy. Just as econometricians should ask both whether a variable is statistically significant and also whether its magnitude is important to decision making, so too one can ask how empirically relevant is the issue to the choice of economic instruments in a policy setting.

Issues that decrease the importance of long-run inefficient exit are:

> In Western economies, there does not seem to be significant evidence that cost-increasing environmental regulations have caused highly polluting, resource-based firms to exit the industry (Tobey, 1990; Cropper and Oates, 1992; van Beers and Van den Bergh, 1997) and only weak evidence that more 'footloose' industries have relocated (van Beers and Van den Bergh, 1997). Given some symmetry of financial impact on decision making, it may be unlikely that rents would significantly prevent exit. Furthermore, the possibility of exiting one industry but

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transferring a firm's valuable assets to another industry through acquisition of the firm is another possibility that can reduce exit inefficiency.

In Central and Eastern Europe where employment and firm survival during the transition are major social issues, the potential theoretical result of more firms surviving on the margin is likely to be viewed as a desirable design element of the policy.

A new literature on entry and exit decisions under uncertainty and irreversibility suggests that firms may be slower to enter and also slower to exit than previously modeled based on net present value criteria (Dixit and Pindyck, 1994; Dixit, 1992). To the extent that price and other market-based uncertainty is a driving force in Central and Eastern Europe, then the influence of environmental controls is likely to be less important in the exit decision.

3. Efficiency versus equity

The presumption in the preceding section is that there are no efficiency impacts from lump sum distributions in a first-best world without distortions in the economy. A rapidly growing literature (e.g., Bovenberg and de Mooij, 1994; Goulder, 1995; Parry, 1995, 1996; Goulder, Parry, and Burtraw, 1996; O'Riordan (ed.), 1997; and Fullerton and Metcalf, 1997) deals with a general equilibrium setting in which pre-existing taxes may alter the efficiency results of previous analyses. These latter results may be especially important to countries in Central and Eastern Europe which seek to adopt economic instruments on the presumption that they will automatically increase efficiency. This section first investigates the interaction between efficiency and equity in a general equilibrium setting with a distortion. Second, conditions in Central and Eastern Europe are investigated that might mitigate the potential reduction in welfare.

General equilibrium analysis with an existing distortion

The efficiency impact of granting valuable assets to firms is the core of the new general equilibrium literature on the public finance implications of instrument choice. This new literature currently draws strong policy recommendations regarding the choice of instruments and the way in which they are implemented. While the welfare change from distributionally equivalent policies, such as grandfathered permits and tax credits, appears to be equal in the partial equilibrium literature, whether *any* welfare gain occurs with grandfathered permits or tax credits is now in question. The literature indicates that efficiency gains importantly depend on the distribution of environmental assets. Consequently equity is not independent from efficiency.

Issues related to optimal taxation, such as structured by Sandmo (1975), and the potential substitution of less-distorting environmental taxes for more distorting taxes on other inputs like labor, popularized by Repetto *et al.* (1992), are two driving forces in the general equilibrium literature on environmental taxation. The newer literature questions whether efficiency gains can occur unless environmental taxes are collected (or quotas sold)

and the revenue recycled to reduce other types of taxes. A sample conclusion from this literature is:

> If the marginal environmental benefits from pollution reductions are below a certain threshold value, then any amount of pollution abatement through non-revenue policies like emission quotas (*or tax credits*) is efficiency reducing. (Goulder, Parry, and Burtraw, 1997, terms in parentheses added)

The basic question asked by the new literature is whether introducing an economic instrument, such as taxes or tradable permits (quotas), provides an increase in efficiency when:

1 pre-existing taxes on labor are used to fund the government provision of public goods,
2 economic instruments are either used to raise revenue (a default tax, or auctioned permits) or not (tax credits, grandfathered permits),
3 general equilibrium conditions exist in a perfectly competitive economy,
4 labor supply is responsive to tax rates,
5 government expenditures are constrained to be constant.

The central tenor of the literature is that unless revenue is raised from the environmental policy and used to offset labor taxes, then environmental policies may not increase efficiency. The loss in efficiency is caused by higher prices, declines in production, reduced labor use, and higher labor taxes to maintain the existing level of government expenditures. The result, as in Bovenberg and Goulder (1996), Fullerton and Metcalf (1997), Goulder, Parry, and Burtraw (1997), and Parry (1995) is that efficiency may actually decline from a non-revenue raising policy.

The relevance to Central and Eastern Europe of these results can be discussed by identifying four cases: (1) differences in economic characteristics, (2) the cost effectiveness of alternative policies, (3) incomplete privatization, and (4) unconstrained government expenditures. The following sections investigate these cases by first taking the results of Fullerton and Metcalf (1997) as given and then by modifying some of the assumptions.

The trade-off between efficiency and equity

In the spirit of Bovenberg and de Mooij (1994), Fullerton and Metcalf (1997) develop a general equilibrium model to analyze the impact of alternative environmental policies on consumer welfare. The model maximizes consumer utility in an economy given various production, budget, and government revenue constraints. Consumers receive satisfaction from market goods (X and Y), leisure (L_h), a public good (G) that is provided by government expenditures, and environmental quality that is negatively affected by emissions (Z). Goods X, Y, and G are produced using labor, and also pollution in the case of good Y. Constraints on the macroeconomy are the total amount of labor (L), and a requirement (relaxed in this paper) that the public good is produced at a constant level which requires government expenditures to be maintained. Policy parameters of

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the system include a pre-existing tax on labor (t_1) and a tax on profits (t_π). Among several economic parameters, sensitivity tests of simulations presented later also emphasize the marginal social damages from pollution, μ, and the elasticity of labor supply.

Total satisfaction in the system is maximized subject to an aggregate consumer budget constraint. Changes in the optimum, based on total differentiation, are investigated after making use of the additional constraints and conditions for profit maximization in the private sector. The reader is referred to Fullerton and Metcalf for the full derivation of their results. One result expresses the rate of change in national welfare as a function of the rate of change in the output of a pollution-producing good, $\hat{Y}$. Equation (3) below reproduces a key result where the left-hand side is the monetary value of the change in utility measured as a proportion of total income—the proportional change in welfare. On the right-hand side of equation (3), the two terms in the brackets identify the economic gain and loss when a pollution tax is imposed on the economy. The second term, involving μ, is the benefit obtained from lowering pollution which depends on marginal social damages and the proportion of the externality-producing good in the economy, Y/L. A decline in pollution exerts an unambiguously positive impact on welfare through this term. However, the first term, involving t_π and the size of the labor market distortion, Δ, exerts an offsetting negative impact on welfare. The negative impact results from change in labor supply caused by the general equilibrium distortion in prices that is exacerbated by increases in the price of polluting good. Whether welfare increases or decreases depends on the relative magnitude of the two terms

$$\frac{dU}{\lambda L} = \{t_1 (1-t_\pi)\Delta - \mu (Y/L)\} \hat{Y} = -\psi \hat{Y} \tag{3}$$

where U is utility, the measure of welfare,

λ is marginal utility of income,

L is total labor, also interpreted as national income,

t_1 is the rate of labor tax,

t_π is the rate of profit (rent) tax,

Δ a complex function of parameters of the system representing the size of the labor supply distortion from taxes

μ the marginal social damage from pollution,

Υ the pollution producing good with $\hat{Y}$, the rate of change: dY/Y,

ψ interpreted as an elasticity, the impact of a per cent change in the polluting good, on a percentage measure of welfare; its sign indicates the direction of welfare change.

The equity and efficiency trade-off in the choice of economic instruments is caused by the presence of a profit tax, t_π. That term is a tax on fixed factors (rent) in the zero profit equilibrium so that $1 - t_\pi$ is the fraction of

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rent that a producer is allowed to keep. As the welfare change is a function of the initial allocation of property rights to the government or to the firm based on the rent that is taxed away, t_π, there is a clear trade-off between equity and efficiency.

The magnitude of the two key terms depends on several parameters of the economic system. Fullerton and Metcalf (1997), in part following Parry (1995) and others, substitute plausible empirical values from the United States into equation (3) to evaluate the relative importance of the two terms (see the appendix for a summary of values used). They conclude that for most point values, economic instruments that do not raise revenue to reduce other taxes will lead to a decline in welfare. For cases where they find welfare increasing with less than full taxation of rent, their sensitivity tests indicate what they consider to be implausibly large values of marginal social damages that would be necessary to reach that result. Indeed, a concern for the size of the marginal social damage has been a focus of Goulder, Parry, and Burtraw (1997).

Sensitivity of the sign of the welfare change to parameter levels is investigated further in several ways. The first approach investigates the break-even point for allocating rent between government and industry for the base set of parameters; the second systematically evaluates the uncertainty in parameters using Monte Carlo simulation methods.

The efficiency and equity trade-off defined by equation (3) can be used to identify the break-even point, *ceteris paribus*, where lower profit taxes cause the sign of the welfare impact to change. Using the base parameter assumptions of Fullerton and Metcalf, welfare is increased only if the private sector is allowed to keep at most 40 per cent of the rent. Taking their results as given, it suggests that policy entrepreneurs can only give industry 40 per cent or less of the rent to reach agreement with the private sector and still expect to have some increase in efficiency in the economy.

More generally, all parameter values, instead of only t_π, can be allowed to vary. Once the sensitivity of the welfare change to the various US parameters is understood, it can be determined if key parameter values more relevant to Central and Eastern Europe can lead to a modified conclusion,

Monte Carlo simulations were carried out to investigate the effect of uncertainty on parameter values. In general, a triangular distribution was specified with the most likely value being the one used by Fullerton and Metcalf and the range being that discussed in their text as supported in the literature (see appendix). Where only the end points of the range were provided, a uniform distribution was used. The result of 1,000 simulations for each of ten different levels of the profit tax rate resulted in figure 1 where the 95 and 100 per cent bounds of the simulations of each tax value are plotted.[1] The vertical axis measures the proportional change in welfare from a 1 per cent change in the output of the polluting good, the term psi (ψ), of equation (3). For instance, when the rent is entirely taxed away (t_π equals 1) welfare is increased in all simulations. While this is consistent with the results of Fullerton and Metcalf, the simulations for other values

[1] The program Crystal Ball was used in the simulation.

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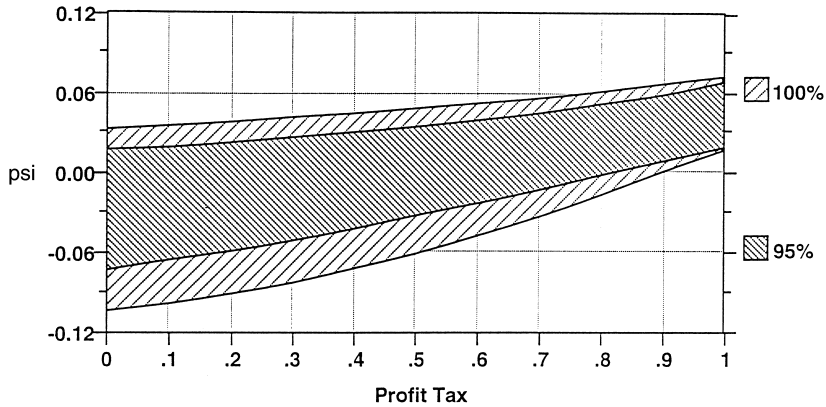

Figure 1. *Simulation results: Elasticity of welfare and profit tax rates*

of the profit tax are more complex. For any value of t_π there is a significant chance that welfare will incerase. When rents are entirely given to the private sector, t_π equals zero, there is a 20 per cent change of welfare increasing given the initial parameters of the model. As some rent is taxed away, welfare is more likely to increase. Sensitivity analysis of the Monte Carlo simulation, based on the percentage of the variation of the outcome explained by changes in the parameter, indicates that at low levels of the profit tax, the labor supply elasticity and the marginal social damages, in that order, are the most important variables and together explain about 90 per cent of the variations in the outcome. As more rent is captured by the government, the priority of the variables is reversed. Other variables have a much smaller effect on the variations in the outcome.

A weak empirical basis exists for adapting parameters to the setting of Central and Eastern Europe. However, the distribution of some parameters can be adjusted based on limited information to provide an indication of results. In particular, tax rates, environmental damages, and the proportion of the polluting industry are adjusted from their earlier levels to characterize an economy more like those of Central and Eastern Europe. Each parameter is discussed briefly below.

The large size of the remaining goverment sector in Central and Eastern Europe requires significant tax revenues. This size is also revealed by median social security and other labor taxes of 47 per cent on gross wages as paid by employers (Business International, 1994.) Other taxes affecting labor include income taxes in some countries and value added taxes that often vary by commodity but which are frequently about 20 per cent (Business International, 1994.) These rates are significantly higher than those in the US and would act to reduce the welfare gain. The range for the labor tax is increased to between 0.5 and 0.75 in the composite simulation for Central and Eastern Europe from the US values of 0.35 to 0.5. Profit taxes are already significant in most Central and Eastern European countries with a median rate of 35 per cent. (Business International, 1994). The value added tax also adds to the implicit profit tax. These existing profit

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taxes indicate that governments would capture a significant part of the rent generated by environmental property rights. Consequently the profit tax rate is treated as a variable with a range from 0.15 to 0.5 for the adjusted simulation.

Marginal environmental damages from polluting industries could be expected to be higher in Central and Eastern Europe given the low existing level of pollution control and corresponding higher ambient levels of pollution in some locations. This may be mitigated somewhat by recent declines in production and by population densities. The range of the marginal damage from pollution per unit of polluting output is almost doubled from the US simulation to a range of 0.2 to 0.5 in the adjusted simulation although this is almost solely a judgmental sensitivity test (see, for example, Pearce, 1993:52; Hertzman (1995). Finally, the share of national output that produces pollution is increased from the US example to a range of 0.25 to 0.5. This is based on the share of output from industries that are generally thought to be polluting such as: power generation, manufacturing, mining, and transportation. These adjustments increase the welfare gain from reducing pollution.

The early stages of the labor markets in Central and Eastern Europe such as surveyed by Commander and Coricelli (1995) and Camara (1997) provide little evidence on labor market elasticities. General equilibrium modelers in the area such as Hare, Revesz, and Zalai (1993), Breuss and Tesche (1993), and Morris, Revesz, and Zalai (1997) have often assumed labor supply elasticities of zero but note the emerging nature of the labor markets. Consequently other parameters in the adjusted simulation remain based on US estimates.

The result of the composite simulation for an economy more typical of Central and Eastern European conditions is that when environmental rents are taxed at the current rate of the tax on profits, pollution reductions result in welfare increases in only 10 per cent of the simulation trials. The mean value of the profit tax in the adjusted simulation was 32 per cent. These results, despite both welfare-increasing and welfare-decreasing parameter changes compared to US values, are somewhat more cautious than the previous results. In the US results, a scenario with a 30 per cent profit tax has a 35 per cent change of increasing welfare. However, because of the weak empirical basis for the parameters of the system, the results should be considered merely suggestive while indicating the importance of country-specific quantitative policy analysis when alternatives are being considered.

Several alternatives exist for more country-specific analyses. Analysts could continue the application of the Fullerton and Metcalf approach. Alternatively, more complex general equilibrium models can be used. Morris, Revesz, and Zalai (1997) forecast the decline in aggregate economic activity in Hungary from higher environmental taxes when labor taxes are reduced to maintain government revenue. Their results indicate that a decline in various air emissions of about 10 to 50 per cent from uncontrolled levels is associated with a 0.5 to 1 per cent decline in economic activity. In the context of the model discussed here, the decline in activity is the negative valued term stemming from changes in the labor market.

However, the value of the environmental improvement is not considered nor is the impact of alternative policies compared, an important issue discussed below.

Comparing policy alternatives: The importance of cost effectiveness

The general equilibrium literature on environmental taxation focuses on pre-existing distortions in other markets without considering the full range of policy alternatives for environmental control. In many cases policies already exist to reduce pollution. In practice, various kinds of technological limitations or performance standards will be considered as regulatory policies.[2] It is useful to investigate whether the importance given to cost effective instruments in the partial equilibrium analysis of regulations carries through to the general equilibrium analysis of regulations. Although the general importance of cost effectiveness can be assessed, some specific policy comparisons (as between economic instruments and command and control policies) cannot be explicitly evaluated in the Fullerton and Metcalf model due to the homogeneity of producers.

In the context of the general equilibrium model, cost effectiveness is relevant to the extent that alternative policies have differential impacts on the cost of pollution control. Consider a policy choice either between an existing regulation and a new proposal or between two new proposals. How does the general equilibrium impact of the more cost effective policy, *e*, compare to the impact of the more costly policy, *c*? Both policies are designed to achieve the same reduction in pollution and so the welfare impact of choosing between policies *e* and *c* is reduced to the difference between the negative impact on the labor market.

Equation (4) below represents a variation of the first term in equation (3). It is the difference in (negative) impact on the labor market from each policy.[3] Define the relation between the pollution control cost with the two policies as $P^e = \theta P^c$ where $0 < \theta < 1$. The differential labor market impact, while holding government expenditures constant, is

$$\frac{dU^e}{\lambda L} - \frac{dU^c}{\lambda L} = t_1 \Omega \{(1-t_\pi^e) \hat{P}^e - (1 - t_\pi^c) \hat{P}^c\} \tag{4}$$

where

Ω is a set of parameters defining the impact on the labor market,

$\hat{P}$ is the rate of change of price of pollution (equal to marginal cost).

Substitute $\hat{P}^e = \theta \hat{P}^c$ and for the moment assume $t_\pi^e = t_\pi^c$, then

$$\frac{dU^e}{\lambda L} - \frac{dU^c}{\lambda L} = \{t_1 (1 - t_\pi)\Omega \hat{P}^c\}(\theta-1) \tag{5}$$

[2] Fullerton and Metcalf (1997) investigate a technological policy of controlling pollution per unit of output with the somewhat surprising outcome that the first units of control do not impose any costs on the economic system. Moving away from the initial units controlled, however, begins to impose a larger cost on the economy.

[3] Insert equation 19 from Fullerton and Metcalf, linking changes in labor to price, with equation 9, and assume that the change in pollution is the same with either policy so that pollution changes net out in the change in welfare.

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For the same level of taxation, t_π^e equal to t_π^c, the change in welfare from choosing the more cost effective instrument is welfare improving and proportional to the savings in cost. The general equilibrium change is equal to $\theta - 1$ (a negative number) times the (negative) general equilibrium impact of the more costly policy. As $\theta - 1$ is the proportional cost savings, the importance of savings in a partial equilibrium context carries through to the general equilibrium setting, noting that cost effectiveness is to be defined as the impact on the relevant price. While additional research may add to the generality of this conclusion, the relevance for Central and Eastern Europe is that cost effectiveness remains critical to the economic choice between policy alternatives. Furthermore, such cost savings provide the basis for potential negotiation on distributional issues.

Privatization

The potential for continued privatization of the economy in Central and Eastern Europe is one of the distinguishing features of the economies in transition. Privatization provides an opportunity to address the efficiency and equity issues raised in the general equilibrium literature. While the extent of the privatization process varies by country and sector, many large stationary sources of air or water pollution remain to be privatized. If an industry is not yet privatized, then another avenue exists for a government to collect rent from pollution tax credits or grandfathered quotas. If governments in Central and Eastern Europe define tax credits or quotas prior to privatization, then the expected rents become part of the asset value of the firm. Such values are expected to be capitalized into the purchase price paid by the buyer and received by the government when the firm is privatized. Selling the firm in a market transaction can capture a significant amount if not all of the rent given the firm through tax credits or grandfathered permits. Consequently the negative results of the general equilibrium literature may not be relevant when privatization is still in the future and economic instruments are defined prior to privatization.

Allowing government expenditures to change

A common practice in the general equilibrium literature is to hold government expenditures constant by imposing the constraint that dG equals 0, where dG is the change in government expenditures. A major policy decision such as holding government expenditures constant is not, however, the responsibility of the analyst except as a sensitivity analysis. In fact, the very process of privatization is a reduction in the size of government expenditures. Removing the requirement to maintain government expenditures reveals an important economic trade-off that was previously obscured. The result of removing the constraint is to introduce a new parameter, the marginal social benefit of government labor. Fullerton and Metcalf cite their first major result as

$$\frac{dU}{\lambda} = t_1 dL - \mu\, dZ \tag{6}$$

where Z is the amount of pollution, other terms as defined previously.

This result makes intuitive sense. The first term is the loss from adjusting

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taxes to make up for lost government tax revenue when labor declines. The second term is the gain from improved environmental conditions.

This equation changes when government spending is not held constant in the theoretical model. It can be shown that removing the government constraint still leads to a positive term (damages avoided from pollution) and a negative term (general equilibrium cost), but the interpretation of the negative term is quite different. The revised equation, when government expenditures are not held constant, becomes[4]

$$\frac{dU}{\lambda} = \gamma dL_G - \mu\, dZ \tag{7}$$

where L_G is labor in the government sector, γ is the marginal social product of labor in the government sector, other terms as previously.

The change in welfare is still composed of two terms. The welfare-enhancing impact of reducing pollution remains the same. But what is the cost? Interpreting γ as the marginal social benefit of government labor, the first term is the opportunity cost of reducing government labor defined as the product of the decline in government labor and the marginal social benefit of government labor. The sign and size of the term is debatable as there is not an economically necessary presumption that the government is operating at the optimal level and there is significant policy concern about the marginal benefits of governmental labor.

Removing the constraint that government expenditures stay the same thus rephrases the cost of pre-existing distortions in the model. The cost of the environmental improvements carried out by the private sector are the lost uses of government labor funded by the tax revenue. Depending with whom you are speaking and in what country, the government 'cost' element might be considered positive or negative and it may be difficult to refute either proposition without further research. The first term might then either reinforce the welfare gains of reducing pollution or offset some of the gains as in the previous analyses of the private labor market. Consequently the negative results of the general equilibrium literature need not apply if governmental expenditures are unconstrained. The potential for government labor to be less productive in Central and Eastern Europe could indicate that the general equilibrium cost of transferring rents to the private sector are smaller.

4. Conclusion

In Central and Eastern Europe, pre-existing conditions somewhat favor tax

[4] To obtain the result from Fullerton and Metcalf, expand the definition of G from NL_G to $h(NL_G)$ to represent a non-linear governmental production function of the public good. Then their equation (5) without $dG = 0$ has a new term, $U_G h' N dL_G$. Define γ as $U_G h' N/\lambda$ to be the marginal social benefit of government labor (parallel to the definition of marginal social damages from pollution.) This results in an intermediate expression for the change in welfare of $dU/\lambda = t_1 dL - \mu dZ + (\gamma - 1)dL_G$. Note that since $P_x = P_L = 1$, then $t_1 dL = t_1 P_L dL =$ lost government revenue. Without $dG = 0$, the amount of labor lost in government (since there is no capital in the model) is the lost revenue divided by the wage. Then $t_1 dL = dL_G$. Substitute this result into the intermediate welfare expression to obtain equation (7) above.

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systems over trading. The distributional impacts of pollution taxes or trading, which are usually thought to favor trading, can be made equal through the use of tax credits. The general equilibrium analysis of environmental taxation in the presence of distorting taxes does reveal a more complex picture than without distortions. In general equilibrium, equity and efficiency impacts are seen to interact. The latter part of this paper suggests that the partial or whole allocation of environmental property rights to firms, including any associated rent, may not be as questionable as the current literature suggests. While an analysis of parameters adjusted to be more like the economies of Central and Eastern Europe indicates some initial caution at existing levels of labor and profit taxes, the following issues all appear to strengthen the conditions under which grants of property rights to the private sector can lead to welfare improvement:

1 choosing among cost effective policies,
2 future privatization, and
3 lack of a constraint to maintain government expenditures.

These issues are however, far from closed. To the extent that environmental economic policy advisors seek to practice a modified Hippocratic Oath: 'Above all, Do Not Reduce Efficiency', there is a demand to clarify the conditions under which economic instruments improve efficiency compared to what actually and potentially exists.

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Appendix: Parameter assumptions

Fullerton and Metcalf (1997) review applicable research to determine the range of US values reported in the literature for various parameters. Most likely values are then selected with other cases also being investigated. Appendix table A1 identifies the parameter definition, the range, the selected value used by Fullerton and Metcalf, the distributions used for the US, and the distributions used for the composite Central and Eastern European simulations reported in the main body of the text.

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Table A1. *Simulation assumptions*

Parameter	*Low value*	*Selected value*	*High value*	*Distribution in simulation*	*Distribution in simulation*
	Fullerton and Metcalf	Fullerton and Metcalf	Fullerton and Metcalf	US	Composite Central and Eastern Europe
Marginal labor tax rate	0.35	0.40	0.50	Triangular (0.35, 0.40, 0.50)	Uniform (0.15, 0.75)
Profit tax (equity) rate)	0	0.4	1.0	Ten separate simulations from 0 to 1	Uniform (0.15, 0.5)
Marginal environmental damage (proportion of value of polluting output)	0.1	0.1 in base case, 0.3 sensitivity	0.3	Uniform (0.1, 0.3)	Uniform (0.2, 0.5)
Labor supply elasticity (uncompensated)	0	0.1 in base case, 0.3 sensitivity	0.3	Uniform (0, 0.3)	Uniform (0, 0.3)
Aggregate income elasticity	−0.1	−0.2	−0.3	Triangular (−0.1, −0.2, −0.3)	Triangular (−0.1, −0.2, −0.3)
Pollution producing goods as a proportion of total production	0.15	0.15		Uniform (0.15, 0.25)	Uniform (0.25, 0.5)
Elasticity of substitution in consumption		1.0		Triangular (0.75, 1, 1.25)	Triangular (0.75, 1, 1.25)