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Equity and efficiency in the Clinton energy tax proposal

Some early thoughts from first principles

Gary W. Yohe

Preliminary, theoretic review of the BTU based energy tax proposed by the Clinton administration suggests that its output effects can be justified on environmental grounds; that its potentially perverse substitution effects should be expected to be small and easily corrected by subsequent policies; that its deviation from revenue maximizing energy tax rates should not be too damaging; and that its revenue can more than cover any equity provisions directed at the lower end of the income distribution.

Keywords: Clinton; Energy; BTU tax

The energy tax component of the Clinton Economic Plan, a programme which calls for applying a growing proportional tax to the BTU content of all sources of energy, raises the usual litany of equity and efficiency issues.[1] This short note is offered as a quick, initial overview of the scope of these issues based upon some first principles of applied microeconomic theory. Inasmuch as adjustments to the earned income tax credit for low income families and individuals have also been proposed to eliminate any increased tax burden which might otherwise fall upon these people, the comments recorded here will, in fact, focus primarily on efficiency, touching only tangentially upon some secondary equity implications.[2]

There are, in particular, at least two direct efficiency issues to be considered: the relative efficacy of a BTU tax in achieving stated, although clearly secondary environmental and energy conservation objectives; and its relative efficacy in achieving its primary objective – raising some of the additional tax revenue required to ameliorate the problem of the federal deficit. The first section of this note will offer some initial insight on the first question, drawing heavily on a simple, partial equilibrium model of production in a competitive industry. The second section will contrast the Clinton proportional BTU tax against standard Ramsey efficiency taxes before some concluding remarks offer some qualitative judgements.

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Efficiency in achieving environmental objectives

The simplest context within which to begin to consider the efficient internalization of the external environmental cost of energy consumption builds directly upon the standard model of a competitive industry which produces some positively valued good. Denote that good y, and let its benefit be recorded along some schedule $B(y)$. Assume further that good y is produced from capital, assumed to be available at some constant price denoted by r, and an assortment of energy sources denoted E_i for $i = 1, \ldots n$.[3] Let each E_i be available in varying quantity along individual cost schedules $c_i(E_i)$, let α_i represent the BTU content of energy E_i, and let γ_i and η_i represent, respectively, the pollution content of E_i for two different types of pollution (denoted z_1 and z_2). Assume, as well, that the social costs of these two pollutants are quantified along two distinct schedules denoted $S_i(z_i)$ for $i = 1, 2$; and let the production of y be described fully by a production function of the form

$$y = f\{K, (\alpha_1 E_1 + \ldots + \alpha_k E_k), (\alpha_{k+1} E_{k+1} + \ldots + \alpha_n E_n)\} \quad (1)$$

where f {–,–,–} has all of the usual properties.[4]

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Notice that energy enters the production function for y in terms of the total BTU content of the chosen energy mix in two separate arguments. Distinct energy sources located within either argument are thus assumed to be perfect substitutes (with their relative BTU contents determining their constant marginal rates of technical substitution), but substitution between distinct sources located in two different arguments need not be perfect.[5]

If the industry were somehow to internalize the external cost of its two pollutants, it would operate in a way which achieved the social optimum. Denoting that optimum by the vector $(y^*, K^*, E_1^*, \ldots, E_n^*)$, the competitive industry would maximize

$$B\,[f\{K, (\alpha_1 E_1 + \ldots + \alpha_k E_k), (\alpha_{k+1} E_{k+1} + \ldots + \alpha_n E_n)\}] - rK - \Sigma c_i(E_i) - S_1[\Sigma \gamma_i E_i] - S_2[\Sigma \eta_i E_i]$$

so that the appropriate first order conditions which characterized the vector $(y^*, K^*, E_1^*, \ldots, E_n^*)$ would simply set the marginal benefit product of each input equal to its true marginal cost. Using traditional notation, the optimum would solve the usual system of $(n+1)$ equations in $(n+1)$ unknowns:

$$B'\,[y^*]\,f_K\{^{*,*,*}\} = r \tag{2}$$

$$\alpha_i B'\,[y^*]\,f_{1E}\,\{^{*,*,*}\} = c_i'\,(^*) + \gamma_i S_1'\,[^*] + \eta_i S_2'\,[^*] \text{ for } i = 1, \ldots k \tag{3}$$

$$\alpha_i B'\,[y^*]\,f_{2E}\,\{^{*,*,*}\} = c_i'\,(^*) + \gamma_i S_1'\,[^*] + \eta_i S_2'\,[^*] \text{ for } i = (k+1), \ldots, n \tag{4}$$

The asterisk notation in Equations (2), (3) and (4) indicates that each of the identified marginal functions must be evaluated at the social optimum.

Now suppose that the same industry were to face a proportional BTU tax (at rate T per BTU) along with a vector of environmentally motivated, energy specific taxes $(t_1, \ldots, t_n)$. First principles of competitive markets would then imply immediately that the industry would effectively maximize

$$B[f\{K, \alpha_1 E_1 + \ldots + \alpha_k E_k), (\alpha_{k+1} E_{k+1} + \ldots + \alpha_n E_n)\}] - rK - \Sigma c_i(E_i) - \Sigma T\alpha_i E_i - \Sigma t_i E_i$$

New first order conditions reveal that the industry would still work to set the marginal benefit product of each input equal to its marginal cost, but the cost side would now reflect governmentally imposed, tax based additions to private cost. The resulting equilibrium, denoted $(y', K', E_1', \ldots, E_n')$, would then solve:

$$B'\,[y']f_K\{-', -', -'\} = r \tag{5}$$

$$\alpha_i B'\,[y']f_{1E}\{-',-',-'\} = c_i'\,(-') + \alpha_i T + t_i \text{ for } i = 1, \ldots, k \tag{6}$$

$$\alpha_i B'\,[y']\,f_{2E}\{-', -', -'\} = c_i'\,(-') + \alpha_i T + t_i \text{ for } i = (k+1), \ldots, n \tag{7}$$

These conditions are, by virtue of the mechanics of long-run competitive equilibria, similar to the conditions recorded in Equations (2) – (4), but they are clearly not exact duplicates.

The alternative first order conditions recorded in Equations (5) – (7) would, however, match Equation (1) if

$$t_i^* = \gamma_i S_1'\,[^*] + \eta_i S_2'\,[^*] \text{ for } i = 1, \ldots, n \tag{8}$$

and

$$T^* = 0 \tag{9}$$

and so, of course, their solutions would then match. Equations (8) and (9) therefore reveal that optimality could be achieved by a vector of effluent charges (a well known result) even when more than one type of pollutant is involved (a less well understood result).[6] The charges set for each type of energy would be set appropriately if they simply and accurately reflected the total marginal social cost of their combined emissions (evaluated at the optimal level of emissions, of course).

Equations (8) and (9) also suggest that any positive BTU tax T accompanied initially by a vector of source specific pollution charges (taken for the moment to be zero) could be modified for all sources of energy by charging $t_i' = t_i^* - \alpha_i T$ for $i = 1, \ldots, n$; but that is not the point. These modified taxes need not even be positive, but that is also beside the point. The issue at hand is assessing the relative efficiency of some positive T in the absence of any adjustment in the various t_i.[7]

Notice, in this regard, that the import of the n equations recorded in Equations (6) and (7) is that appropriate environmental taxes would create both output and substitution effects on energy consumption – conservation in the use of energy, *per se*, and substitution out of relatively more polluting sources of energy and into relatively less polluting sources. The solutions identified in the n equations recorded in Equations (8) and (9) simply show how this could be accomplished. Relying, as the Clinton Economic Plan does, on a BTU tax whose effect will be distributed differentially across energy sources by

BTU content rather than polluting potential might therefore create perverse substitution effects even as it produces an output effect in the appropriate direction. To the extent that relatively more efficient energy sources with high BTU character might be relatively less polluting, a BTU tax might cause second order substitution away from those cleaner energy sources; to the extent that this happened not to be the case, of course, substitution inspired by the BTU tax would push relative energy mixes in the appropriate direction – quite by accident. The direction and size of these substitution effects is, of course, an empirical question which deserves some attention.

The question of whether or not the size of the output effect to be created by the Clinton BTU tax is appropriate on environmental grounds is also a complicated empirical question that has not yet been addressed. It is interesting to note, however, that the original Nordhaus estimate of the efficient carbon tax for the USA would increase the current price of gasoline by two or three cents a gallon – clearly in the ballpark of the 1993 BTU tax proposed in the Clinton Economic Plan.[8] Adding uncertainty and non-linearity to his cost–benefit calculus increases its effect on gasoline to six to seven cent range, but those estimates lie close to the proposed BTU tax for 1996.[9] Both of these efficient carbon taxes would have to increase over time at the rate of interest to meet their intertemporal allocation objectives.[10] That is not yet part of the Clinton Economic Plan, but casual reference to the few studies which have tried to judge the efficient shadow price of carbon emissions suggests that the initial Clinton tax rates are not out of line with the secondary environmental objectives which they were designed to support.

Efficiency in raising revenue

The BTU tax idea is not, however, primarily an environmentally motivated initiative. Its main purpose is, instead, to raise revenue for the federal government. The second efficiency question therefore arises: does a proportional BTU tax minimize the dead weight loss of the resulting market distortions? Answering this question is complicated by existing market distortions and other factors, but some preliminary insight can be drawn quickly by looking at the usual efficient Ramsey tax solutions to the efficiency problem before those complications muddy the analytical and empirical waters. Recall, to that end, that efficient Ramsey taxes, t_i, added to the prices of all of the sources of energy, p_i, would have to satisfy

$$\frac{t_i}{p_i} = k \left\{\frac{1}{\epsilon_{di}} + \frac{1}{\epsilon_{si}}\right\} \quad (10)$$

where ϵ_{di} and ϵ_{si} represent the price elasticities of demand and supply, respectively, for each of the E_i – the n sources of energy noted in the production function of Equation (1).[11]

Now suppose, for the sake of argument, that all of the E_i were perfect substitutes (ie assume that the last two arguments of the production function could be collapsed into one). In that case, Equations (6) and (7) would collapse to

$$\alpha_i B' [y^s] f_E\{-^{s}, -^{s}) = c_i' (-^{s}) \text{ for } i = 1, \ldots, n \quad (11)$$

in the absence of any environmental or BTU taxes. A base BTU price, P_{BTU}, could then be defined by

$$P_{BTU} \equiv B' [y^s] f_E\{-^{s}, -^{s})$$

so that Equation (11) would read:

$$\alpha_i P_{BTU} = c_i'(-^{s}) \text{ for } i = 1, \ldots, n \quad (12)$$

The non-tax equilibrium prices of all employed sources of energy would therefore be proportional to P_{BTU}, and the various α_i would represent the constants of proportionality.

Any proposed BTU tax at some rate $T > 0$ would, in this case, apply proportionately to each energy source, and the proportional increase in the price of each and every source would be $[T/P_{BTU}]$. Imposing such a tax would alter the employment of each type of energy, but the percentage change in quantity along the demand curve would match the percentage change in quantity along the supply curve for every E_i. Equation (10), the efficiency condition, would therefore hold only if

$$\frac{2k\{d\ln(E_i)\}T}{P^2_{BTU}} = \frac{\alpha_i T}{\alpha_i P_{BTU}} \quad (13)$$

for all $i = 1, \ldots, n$; ie efficiency would be achieved if

$$\{d\ln(E_i)\} = P_{BTU} T/2k \text{ for all } i = 1, \ldots, n \quad (14)$$

Equation (14) holds, in words, that all equilibrium quantities must change proportionately if efficiency is to be achieved by the proposed BTU tax – a condition which could be satisfied if all sources of energy were perfect substitutes.

What would happen, though, in the more likely case in which all of the various types of energy were not perfect substitutes? It follows from Equation (13) and its more general form in Equation (10) that the Clinton BTU tax would overtax some sources of energy relative to their corresponding Ramsey efficiency taxes, and undertax others. It is clear from Equation (10), more specifically, that a proportional BTU tax would undertax energy sources which were relatively inelastically supplied and/or inelastically demanded. Conversely, a BTU tax would overcharge energy sources which were relatively elastically supplied and demanded.

Expanding the discussion well beyond the boundaries of the simple model presented in the first section, end-use demand for energy should be relatively inelastic in the short to medium term, during which time finding even limited opportunities for substitution might be difficult or even impossible, and for uses which tend to be necessities in every day life. Problems of undertaxation may therefore fade over time as opportunities for substitution expand and the efficient tax falls toward the base case proportional tax; in fact, a qualitative case might be made that energy sources are relatively perfect substitutes over the long term so that the efficiency qualities noted in the preceding analysis might eventually apply quite nicely.

Meanwhile, and to the extent that necessities display relatively low price elasticities, inefficient undertaxation would buy some improved equity. Families and individuals with low incomes tend to spend higher proportions of their incomes on necessities; and if these necessities were, by virtue of their energy content, undertaxed relative to their Ramsey efficient rate, then the potential regressivity of the energy tax would be diminished. This may, indeed, be why estimates show that a surprisingly small proportion of the revenue collected would be required to eliminate any additional burden for lower income families and individuals; but care needs to be taken that this amelioration of the equity issue does have a price. It comes at the cost of reducing the tax induced price incentives for people who might otherwise look more vigorously for substitutes because their energy source of choice faces an inefficiently light tax burden.

The demand for energy employed as a factor of production of some other good is a derived demand which would be relatively price inelastic if, among other things, there were a limited availability of substitutes in the production process, the marginal productivity of energy in that process could be expected to increase rapidly as employment fell, and/or the demand for the final product were price inelastic. The favourable equity implications of the last circumstance have just been discussed. The first two circumstances point to similar equity improvements, because they suggest that producers who see energy, either in general or from a specific source, as essential to their operation would face taxes which were lower than their corresponding Ramsey efficiency taxes. The Clinton proposal would, in other words, confront firms and employers who have little room in which to manoeuvre in their attempt to reduce the burden of the tax on their profitability with smaller than efficient taxes – again, an equity gain achieved only at the expense of some reduced incentive to respond.

Some concluding remarks on context and next steps

This brief note has, as advertised, offered only a small first step in understanding the ramifications of the BTU tax component of the proposed Clinton Economic Plan. More detailed analyses which address the equity and efficiency issues identified here will certainly be forthcoming from researchers across the USA and, indeed, from around the globe. These studies will take more general equilibrium approaches and incorporate explicitly the complications of market structure, existing and proposed environmental controls, geographical and economic distributions of income and incidence and so on. The simplistic modelling recorded here does, however, have a role to play in framing some of the more important questions and providing some preliminary, qualitative insight which is, as it turns out, quite reassuring.

There is, for example, reason to believe that the size of the tax is justifiable on environmental grounds, even before a coherent environmental programme is articulated. Its output effects do, in particular, seem to conform well to the modest output effects which would accompany the carbon based abatement responses to the threat of greenhouse induced global warming that recent analyses have supported on efficiency grounds. Its second order substitution effects might be all wrong, but correcting their effect on the overall energy mix of the economy could easily become the foci of subsequent policy initiatives designed to provide additional economic incentives for investment in efficient medium- to long-term fuel switching. Incentives of this sort may, in fact, be more politically feasible if they do not have to bear simultaneously the burden of covering the cost of inspiring conservation (the output effect already handled by the BTU tax) *and* adjustment in the energy mix.

It would also appear, at first glance, that deviations in the effective tax rates to be applied to various sources of energy from their maximally efficient, revenue raising settings should not be too damaging. They will exist, particularly over the short to medium term, but they can be expected to err systematically on the side of equity. The BTU tax proposal thereby gains some increased measure of social and political palatability without resorting to increasing estimates of the surprisingly small tax expenditure required to eliminate its underlying regressive tendencies.

[1]The details of the plan announced immediately after the State of the Union Address in February 1993 called for a BTU tax which would have the effect of, eg increasing the prices of a gallon of gasoline, a gallon of home heating oil, and one million cubic feet of natural gas on 1 July by roughly 2.5 cents, 2.75 cents and 8.75 cents respectively. Over the longer term, the plan proposed further that the tax grow over time so that, three years later, it will have tripled – adding 5 cents, 5.5 cents and 17.5 cents to the original effective tax rates. See 'The energy tax', *Time Magazine*, Vol 141, No 9, 1 March 1993, p 25.

[2]This adjustment would, by administration accounts, involve a tax expenditure of slightly less than 14% of the total revenue to be collected by the energy tax: see 'The energy tax', *Time Magazine*, Vol 141, No 9, 1 March 1993, p 25. This percentage conforms well with the estimated tax expenditure required to eliminate the regressivity of modest carbon taxes which have roughly the same initial effect on (eg) the price of gasoline and home heating oil but which grow much more slowly – albeit for a much longer time. See B. Schillo, L. Giannarelli, D. Kelly, S. Swanson and P. Wilcoxen, *The Distributional Impacts of a Carbon Tax*, US EPA Report, Energy Policy Branch, Washington, 1992 for a review of the distributional implications and tax recycling options for a modest carbon based tax from three models: the Jorgenson–Slesnick–Wilcoxen model, DRI's CES/DECO model and the Urban Institute's TRIM2 model.

[3]Capital here serves simply as the representative non-energy factor of production. Without loss of generality in what follows, only one such factor is required; it is modelled here as simply as possible with perfectly elastic supply.

[4]Assume, in fact, that all of the schedules have the usual properties: positive but declining marginal benefits and marginal products with positive and increasing marginal costs. The pollutants can interact, of course, but allowing for that interaction by recording a single social cost function in two pollution variables would add no insight for present purposes and come at the expense of considerable notational complexity.

[5]Again, it is enough to have two sources of energy which are not perfect substitutes.

[6]See A. Kneese and C. Schultz, *Pollution, Prices, and Public Policy*, The Brookings Institution, Washington, 1975, or T. Tietenberg, *Environmental and National Resource Economics*, 3rd edn, Harper Collins, New York, 1992, Chapter 14. These sources cover the single pollutant case. Confusion about how to deal with multiple pollutants can be found throughout much of the early global warming literature.

[7]In more thorough studies, the initial environmentally based taxes might reflect such things as applicable, existing effluent charges, the shadow prices of existing emissions standards or best available technology constraints, the market price of pollution licences, and so on. This discussion takes all of that as given and unchanged.

[8]See W. Nordhaus, 'To slow or not to slow: the economics of the greenhouse effect', *Economic Journal*, Vol 101, 1991, pp 920–937; and W. Nordhaus, *Rolling the DICE: An Optimal Transition Path for Controlling Greenhouse Gases*, Cowles Foundation Discussion Paper No 1019, Yale University, New Haven, CT, 1992.

[9]See G. Yohe, 'Sorting out the facts and uncertainties in economic response to the physical effects of global climate change', in J. Darnstadter, ed, *Assessing Climate Change Risks: Implications for Research and Decisionmaking*, Resources for the Future, Washington, forthcoming 1993 and B. Garvey and G. Yohe, *Incorporating Uncertainty and Nonlinearity into the Calculus of Efficient Response to the Threat of Global Warming*, Wesleyan University mimeo, Middletown, CT, October 1992.

[10]The taxes are, in the Nordhaus, Garvey, Yohe work, really scarcity rent shadow prices attributable to efficient limitations of cumulative carbon emissions through the year 2050. Dynamic efficiency therefore holds that they must increase at the rate of interest: this is a long standing, standard result. See H. Hotelling, 'The economics of exhaustible resources', *Journal of Political Economy*, Vol 39, 1931, pp 137–175.

[11]See P. Diamond and J. Mirrlees, 'Optimal taxation and public production, II: tax rules', *American Economic Review*, Vol 61, 1971, pp 261–278 for a relatively modern treatment of the fundamentals; or F. Ramsey, 'A contribution to the theory of taxation', *Economic Journal*, Vol 37, 1927, pp 47–61 for the original paper in this area. See also J. Stiglitz, *Economics of the Public Sector*, Norton, New York, 1986, Chapter 19 for a textbook treatment.