TECHNICAL APPENDIX:
AN ECONOMIC ANALYSIS OF NEW UPSTREAM EMISSIONS REQUIREMENTS FOR PIPELINE APPROVALS

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This Appendix is based on several sources including Weitzman (1974), Charles (2010) and Weyl (Weyl).

If regulators know exactly how the future will unfold, equally stringent price and quantity regulations can easily be shown to be formally equivalent. Complications arise however when compliance costs and private demand are *uncertain* and regulations *endure* over several periods. Uncertainty implies that regulators are unable to perfectly predict today what the actual compliance costs of, say, carbon prices or quantity regulations will be at a given point in the future. Further, once policy-makers commit to a particular policy (e.g., a carbon tax), it tends to have inertia and remains unchanged for several years. These two factors – uncertainty and policy rigidity – break the equivalence between price and quantity regulation. Weitzman (1974) demonstrated that there are merits and demerits to each instrument under a given set of conditions. This Appendix formally demonstrates that for managing CO_2 emissions when there is uncertainty and policy rigidity, a carbon tax is strongly preferred to rejecting a pipeline based on emissions.

Assume a linear marginal private value function, which reflects that joint market surplus of

producers and consumers. Denote this as $MS(q)$, which is a function of q, the regulated activity (i.e., emissions). This function is tantamount to an inverse excess demand function. The $MS(q)$ function takes the form:

$$MS(q) = p^* - a(q - q^* - \varepsilon)$$

where p^* (equilibrium price), q^* (equilibrium quantity) and a (inverse elasticity of excess demand) are known. ε is uncertain but is assumed to be a mean zero, noise term. This function maintains the property that excess demand functions slope downward. Emissions, q, generate social costs. Let the marginal social costs, MSC, be known with certainty[1] and given by:

$$MSC(q) = p^* + b(q - q^*)$$

The regulator wants to select q to maximize social welfare. Denote this choice q^{**} which is found by equating MS to MSC:

$$\begin{aligned} p^* - a(q - q^* - \varepsilon) &= p^* + b(q - q^*) \\ q^{**} &= q^* + \left(\frac{a}{a+b}\right)\varepsilon \end{aligned}$$

If the regulator makes an error and selects q instead of q^{**}, the deadweight loss is given by the Harberger triangle: $\frac{1}{2}(a+b)(q - q^{**})^2$.

The regulator now has two options. It can treat prices as fixed and set a quantity regulation or it can determine an optimal tax over fixed quantities. The optimal quantity, option one, is found by setting $q = q^*$ which is equal to the expectation of q^{**} (i.e., $\mathbf{E}[q^{**}]$) . For option two, the regulator sets a price, $\tilde{p}$, such that:

$$\begin{aligned} p^* - a(q - q^* - \varepsilon) &= \tilde{p} \\ q &= q^* + \frac{p^* - \tilde{p}}{a} + \varepsilon \end{aligned}$$

Recall that the socially optimal level of q is $q^{**} = q^* + \left(\frac{a}{a+b}\right)\varepsilon$. But due to the uncertainty in compliance costs and private demand, there will be an "error" when establishing either a price or quantity regulation. The error from selecting q^* equals $-\left(\frac{a}{a+b}\right)\varepsilon$ with a deadweight loss of $^1/_2(a\varepsilon)^2$. Likewise the error from setting $\tilde{p}$ is[2] $\left(\frac{b}{a+b}\right)\varepsilon$ with a deadweight loss of $^1/_2(b\varepsilon)^2$.

The regulator should opt for the regulation that generates the smallest error. Within this simplified model, this size of the error – i.e., the deadweight loss – depends on whether a or b is larger.

Notes

[1]Weitzman (1974) demonstrates that this assumption is without loss of generality.

[2]This is because $q^{**} - (q^* + \varepsilon) = \left(\frac{a}{a+b}\right)\varepsilon$.

References

Charles, K. (2010). Environmental economics, 2nd ed. *Oxford University Press*.

Weitzman, M. L. (1974). Prices vs. quantities. *The review of economic studies 41*(4), 477–491.

Weyl, G. Course note on prices v. quantities.