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A general equilibrium cost-benefit rule for green certificates

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I derive a basic result on assessing the welfare effects of green certificates in a general equilibrium setting. The result is developed and extended in forthcoming papers (e.g. Johansson & Kriström (2016)).

Assume a smooth perfect market economy, with two types of electricity producers, D and G. A certificate system entails that $100k, k \in [0,1]$ of total electricity production $Q = q^D + q^G$ must originate from G, so that $q^G = kQ$. D needs to buy certificates (but both needs to have them)[1]. Let $s \in \Re_1^+$ be the price of a certificate. Let π^i and c^i, i=D,G be profit and cost-functions with the usual properties.
Firms maximize

$$\pi^D = pq^D - c_D(q^D) - ksq^D \quad (1)$$
$$\pi^G = pq^G - c_G(q^G) + (1-k)sq^G \quad (2)$$

With the stated assumptions the solutions are interior. Summing these we find that the system is financed within the firms.

Households own the firms, and we simplify by having one household with smooth indirect utility function $V(p,m)$, $m = \pi^D + \pi^G$; a numeraire good is suppressed. Income is only from profits, it really does not add anything to add a perfect labor market (the cost-benefit rule will be the same).

Define $\lambda = \frac{\partial V}{\partial m}$, i.e. the marginal utility of money. We then obtain this basic result on the welfare impacts of perturbing the system in general equilibrium:

Proposition 1. $\frac{dV}{\lambda} = -sQdk$

Proof. Follows by total differentiation of V □

All market effects net out, so this is a general equilibrium measure. Consequently, the cost of marginally changing the quota is the change in k times the value of total electricity consumed, valued by the certificate price. This result extends directly to the non-marginal case, see Johansson & Kriström (2016)

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[1]There are many ways to model a certificate system, I follow Widerberg (2011). Johansson & Kriström (2016) uses a different set-up, focussing specifically on the Swedish-Norwegian system. The basic result is the same, although the latter approach is convenient for extensions to the non-marginal case and for public finance issues, etc.

for a much more elaborate analysis and Johansson & Kriström (2015) for the theory of welfare measurement in general equilibrium settings.

As an example, consider increasing the current quota in the Swedish-Norwegian from k=0.231 to k=0.241. Using only the Swedish numbers of Q=90 Twh and a current certificate price of about 130 SEK per MWh, we get a cost of about 117 MSEK. Implicitly, there is a significant transfer from consumers to holders of certificates (in the Swedish case, almost 3 Billion SEK). This transfer is moot in the current model, since there is only one household.

1 References

Johansson, P.-O. & Kriström, B. (2016) Social Benefits and Costs of Arbitrary-Sized Changes in Green Certificate Schemes, Forthcoming Working Paper, CERE.

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Widerberg, A. (2011) Essays on Energy and Climate Policy – Green Certificates, Emissions Trading and Electricity Prices. Economic Studies, 201, Department of Economics, University of Gothenburg