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Abstract

This paper examines how a monopolist's production and emission decisions and its incentives to evade emission taxes are affected by the degree of consumers' environmental awareness. Producing a low-emission eco-friendly product is costly for the monopolist with the marginal production cost being an inverse function of the level of emission. Consumers cannot verify the environmental attributes of the product (except for reading the labels!). Heterogeneous consumers are characterised by an environmental awareness parameter proportional to the emission level that is distributed uniformly over a certain range. In this framework, we find several strong results. **First**, regardless of any emission taxes, the monopoly emission level declines and approaches the social optimal as consumers become more environmentally conscious although green consumerism alone cannot guarantee the socially-optimal level of emission. **Second**, even with a perfectly observable emission level, the (2nd best) optimal tax can be higher, equal or lower than the Pigouvian tax (in contrast to Barnett (1980)) depending upon the degree of consumers' awareness. **Third**, higher the degree of awareness, stronger is the deterrent effect of audit strategies on the monopolist's incentives for tax evasion. A strong policy implication emerges from our analysis: given the government's budget constraint, resources should be allocated to promoting environmental awareness rather than to costly auditing. **JEL codes: D42; H23; H26; L12**

Introduction and Motivation

Environmental protection is a priority and challenge for most countries today. Most economic activities generate negative externalities that producers often do not internalize. Environmental taxes are common policy instruments for regulating environmental quality. Today, consumers are becoming increasingly environmentally conscious with many indeed differentiating products according to their environmental attributes, choosing the products that are associated with a lower emission level. Producing a low-emission/high-quality product however can be costly for the monopolist. A profit-maximising polluting monopolist therefore faces certain dilemmas: should he choose a more environmentally-friendly low-emission production technology with high production costs to stimulate demand and pay lower emission taxes, or should he choose an inferior high-emission technology to save on production costs but pay higher taxes and face lower demand? Moreover, will the monopolist try to achieve the best of both worlds by claiming to have produced output with an eco-friendly technology in an attempt to boost consumers' demand and evade taxes whilst saving on production costs? These are the issues we address in this paper. So far, authors (e.g. Macho-Stadler & Perez-Castrillo (2006), Sandmo (2002)) have examined audit strategies and compliance behaviour when firms may evade environmental taxes, but none has analysed how consumers' preferences on environmental attributes can have an impact on the efficacy of such strategies upon firms' behaviour.

The Model

Consumers

- Utility function: $U = v - \theta e - p$; $\theta \sim [\underline{\theta}, \bar{\theta}]$; $F(\theta)$; $f(\theta)$;
- θ : environmental awareness parameter
- $\hat{\theta} = \frac{v-p}{e}$: **Threshold level of awareness** such that the proportion of population buying the good (i.e. demand) is: $\theta^d = \int_{\hat{\theta}}^{\bar{\theta}} f(\theta) d\theta$.

The Monopolist

- $c(e)$: The marginal cost of production with $c'(e) < 0$, $c''(e) > 0$; $e \in R^+$
- The monopoly profit: $\pi = [p - c(e)]\theta^d$
- Plays a *two-stage game* where chooses e in stage 1 and p in stage 2. Solve backwards.
- Stage 2**: $p(e) = (v + c(e) - e\theta)$; $\hat{\theta}(e) = \frac{1}{2e}\{v - c(e) + e\theta\}$; $\partial \hat{\theta}(e)/\partial e \geq (<) 0$.
- Stage 1**: $-c'(e_m) = \hat{\theta}(e_m)$: **e is chosen such that the marginal reduction in the marginal cost equals the threshold level of awareness.**

Remark: Higher the degree of *minimum* level of awareness, lower is the equilibrium level of emission i.e. greener is the technology used i.e. $\partial e^*/\partial \underline{\theta} < 0$ (follows from the SOC).

Benchmark I: A social welfarist's problem

The welfarist sets $p = c(e_s)$ and maximises aggregate consumers' surplus (CS) net of a societal damage function $b(E)$, $b'(E) > 0$, $b''(E) > 0$; $E = e_s \theta_s^d$ is the aggregate emission i.e.

$$\max_{e_s} \{CS - b(E)\}$$

Proposition. When societal damages are taken into account, monopoly equilibrium level of emission is higher than the socially optimal level. Furthermore, higher the minimum level of awareness (as captured by $\underline{\theta}$), closer is the equilibrium monopoly level of emission to the socially optimum one. If however the societal damages are **not** considered separately, then the equilibrium level of monopoly emission is socially optimal.

Benchmark II - emission taxation with perfect observability

With the (per unit) tax rate $t > 0$ on the **perfectly observable emission level**, the monopoly profit is

$$\pi = [p - c(e)]\theta^d - te$$

- Stage 1**: Same as before
- Stage 2**: Now, $-c'(e_m) > \hat{\theta}(e_m)$. Hence, we show (using the SOCs)

Proposition. In the presence of a per-unit tax on the emission level, the monopolist chooses a **greener** technology whereby it lowers the level of emission compared to the no-tax scenario. Furthermore, we have,

Proposition. The second best optimal tax rate t is *different* from the Pigouvian tax rate for a competitive firm and can either be larger or smaller than the Pigouvian tax rate, depending upon the degree of environmental awareness of consumers.

Comment. The above result, which is in contrast to Barnett (1980) that shows that the 2nd best tax rate for the monopoly is *always* lower than the Pigouvian tax rate, therefore signifies the role that the degree of environmental awareness plays here.

Emission taxation with imperfect observability

In the absence of auditing and penalty, when the emission level is **unobservable**, the monopolist will invariably have the **incentive to misreport e** . To see that, let

- e_r : The monopolist's reported level of emission so that $e_r < e_m$ (true level). Then
- For consumers: $U = v - \theta e_r - p$
- The **threshold level of θ** (and hence the demand) now depends on e_r : $\hat{\theta}_r = \frac{v-p}{e_r}$
- The monopoly profit: $\pi = [p - c(e)]\theta_r^d - te_r$
- Stage 2** (price sub-game): $p(e, e_r) = (v + c(e) - e_r\theta)$; $\hat{\theta}_r(e, e_r) = \frac{1}{2e_r}\{v - c(e) + e_r\theta\}$,
 $\frac{\partial \hat{\theta}_r(e)}{\partial e} > 0$; $\frac{\partial \hat{\theta}_r(e)}{\partial e_r} < 0$ [previously ambiguous: price effect vs θ effect]
- Stage 1** (emission sub-game): $\max_{e, e_r} \pi = [p - c(e)]\theta_r^d - te_r$

Since $\frac{\partial \pi}{\partial e} > 0$; $\frac{\partial \pi}{\partial e_r} < 0$ (monotonically), we have:

Proposition. In the absence of auditing and penalty, the monopolist will always choose the worst technology (excessive amount of emission) and report minimum emission level.

Tax evasion, auditing and penalty

- α : audit probability (random auditing with perfect observability)
- $z(e - e_r)$: penalty function {depends on the extent of evasion}, $z'(\cdot) > 0$, $z''(\cdot) > 0$.

Stage 1 monopoly problem:

$$\max_{e, e_r} (1 - \alpha)\{[p(e, e_r) - c(e)]\theta_r^d - te_r\} + \alpha\{[p(e, e_r) - c(e)]\theta_r^d - te - z(e - e_r)\}$$

Proposition. (i) equilibrium value(s) of e (and e_r) are now different from benchmarks 1 and 2 values, with $\partial e_r/\partial \alpha > 0$; $\partial e_r/\partial t < 0$. Furthermore, as the level of awareness of the *least* aware consumer increases, (i) the deterring effects of audit on misreporting becomes stronger, and (ii) the impact of t on misreporting becomes smaller i.e.

$$\frac{\partial}{\partial \theta} \left(\frac{\partial e_r}{\partial \alpha} \right) > 0; \frac{\partial}{\partial \theta} \left(\frac{\partial e_r}{\partial t} \right) < 0$$

Remark. Given that auditing is costly and the government has a budget constraint, the authority should spend resources to raise environmental awareness amongst consumers instead of on costly auditing.

Conclusions

In this paper, we have shown that the degree of environmental awareness has strong implications with regard to how a polluting monopolist chooses to produce. Whilst consumers' awareness alone cannot guarantee the socially optimal level of emission, more the consumers become environmentally aware, the higher is the incentive for the monopolist to choose a greener technology. The effectiveness of the emission tax rate, which is usually different from the Pigouvian tax rate, is further enhanced by the consumers' degree of awareness especially in the presence of a monopolist's incentives to evade taxes. Therefore, raising environmental awareness turns out to be a better policy option for the government in place of costly auditing.

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