Self-Imposed Carbon Taxes*

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Abstract

Why have firms chosen to self-impose a carbon tax where governments have failed to act? I provide an answer to this question by highlighting a novel mechanism in which a firm can use a self-imposed carbon tax to relax the intensity of price competition with its rivals, making it a profitable strategy. The mechanism I highlight does not depend on the self-imposed carbon tax shifting demand or yielding marketing benefits (e.g., making the firm's products more attractive to consumers because of being considered "green"). I discuss implications for market efficiency.

Keywords: carbon tax, imperfect competition, oligopoly, strategic delegation
JEL codes: L13, L22, Q52, Q54

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1 Introduction

Carbon pricing can be an effective tool to combat climate change, forcing economic agents to internalize the environmental damage of their actions (Andersson, 2019). As a result, economists have called on countries and their governments to implement market-based policies such as a carbon tax (Arrow et al., 1997). Some companies, however, have chosen to self-impose a carbon tax where governments have not done so. Examples include Disney, Microsoft, and Shell.[1] Why would a firm self-impose a carbon tax?

Self-imposing a carbon tax is, in principle, costly because the firm is choosing to constrain itself (e.g., forcing itself to abate emissions when it would not otherwise abate them). In this paper, I show that a self-imposed carbon tax can be a tool for relaxing price competition with rival firms, potentially making it a profitable strategy. A self-imposed carbon tax increases equilibrium prices, and it can increase efficiency (by forcing the firm to internalize the environmental damage caused by production) despite a loss in consumer surplus. The mechanism I highlight does not depend on the self-imposed carbon tax shifting demand or yielding marketing benefits (e.g., making the firm's products more attractive to consumers because of being considered "green").

In line with the examples cited above, I propose a model that considers a decentralized firm consisting of the firm's headquarters and a downstream division, with the latter producing and selling a good to consumers. The downstream division chooses the price for its good to maximize its own profit (hence, the decentralized firm), and it faces competition from a rival firm selling a differentiated product. The firm's headquarters may impose a carbon tax on the downstream division (either per unit of the good sold or per unit of emissions). If a carbon tax is in place, the downstream division pays the carbon taxes to the firm's headquarters. Because the carbon tax money is paid to the firm's headquarters, the money stays within the organization. This makes a self-imposed carbon tax different from participation in a voluntary carbon market in which a firm buys offsets from other organizations, with money leaving the firm to pay for offsets.

What are the impacts of the self-imposed carbon tax? Consider a carbon tax per unit of the good sold. For the downstream division, this carbon tax is equivalent to an increase in its marginal cost of production. Consequently, the firm's equilibrium price increases with the carbon tax, which results in a loss of market share to the rival firm. From the perspective of the firm as a whole (headquarters plus the downstream division), the carbon tax results in a higher equilibrium price without a change in the marginal cost of production, since the

[1] See, for example, "Disney, Microsoft and Shell opt for self-imposed carbon emissions taxes", *The Guardian*, March 26, 2013 (`https://amp.theguardian.com/sustainable-business/carbon-emissions-tax-microsoft-disney-shell`).

carbon tax paid by the downstream division is collected by the firm's headquarters, dropping out of the consolidated profit function.[2] Thus, the carbon tax increases the firm's price-cost margin. This relaxing of the intensity of price competition comes at the cost of a lower market share, creating a tradeoff. I show that the benefits of relaxing the intensity of price competition can outweigh the costs, making a self-imposed carbon tax a profitable strategy.

I show that this result also holds when the carbon tax is on emissions (as opposed to a tax per unit sold) and the downstream division has the possibility of abating emissions to reduce its carbon tax liabilities. Depending on the nature of the demand function and the carbon footprint of the rival firm, a self-imposed carbon tax may increase market efficiency despite causing a loss in consumer surplus. The efficiency gains come when the carbon tax reallocates output to producers with a lower carbon intensity via the change in equilibrium prices.

This paper contributes to several strands of the literature. First, it contributes to our understanding of the equilibrium effects of carbon taxes in markets with imperfect competition (Fowlie, 2009, 2010; Fowlie et al., 2016).[3] Second, the mechanism highlighted here relates to the literature on strategic delegation (see, e.g., Spencer and Brander, 1983; Vickers, 1985; Fershtman and Judd, 1987; Sklivas, 1987), where the firm may choose to delegate its decision making to secure a strategic advantage. The result that a self-imposed carbon tax is profitable relies on the assumption of a decentralized firm, where pricing is decided by a separate division from the one that chooses the carbon tax. Third, within decentralized organizations, the finding that a self-imposed carbon tax may be profitable relates to some results in strategic transfer pricing. Transfer prices are used to distribute resources within an organization, and the literature has shown that these can be used to achieve profits that are only attainable under collusion (Alles and Datar, 1998; Göx, 2000).

The rest of the paper is organized as follows. Section 2 presents the model and the key results that show that a self-imposed carbon tax can be profitable. Section 3 extends the model to cases where the carbon tax is on emissions, and the downstream division can choose to abate emissions to reduce its carbon tax liabilities. Section 4 discusses the impact of the carbon tax on efficiency, and Section 5 concludes.

[2]For the purpose of the discussion in this paragraph, I assume that the marginal cost of production of the downstream division (excluding the carbon tax) is constant.

[3]See Timilsina (2022) for a survey of the literature on carbon taxes

2 A Model of Self-Imposed Carbon Taxes

Consider a decentralized firm consisting of the headquarters of the firm and a downstream division that produces and sells a good to consumers. The downstream division is a profit center, seeking to maximize its own profit. In the model, this firm will be called "firm A." Firm A competes with firm B in the downstream product market selling differentiated products to final consumers.

2.1 Demand

Consumers have a valuation of v for the products of firms A and B, and they have a preference parameter x, which is uniformly distributed on the unit interval. A consumer with a preference parameter x will choose firm A's product if and only if:

$$v - tx - p_A \geq v - (1 - x)t - p_B,$$

where t is a preference parameter capturing the relative weight of product differentiation for consumers' decisions.[4]

The demand for products A and B are given by $q_A(p_A, p_B) = x(p_A, p_B)$ and $q_B(p_A, p_B) = 1 - x(p_A, p_B)$, respectively, where

$$x(p_A, p_B) = \frac{1}{2} + \frac{p_B - p_A}{2t} \tag{1}$$

captures the "position" of the consumer who is indifferent between purchasing from firm A or B.

2.2 Downstream Pricing

Since firm A is decentralized, its pricing and production decisions are delegated within the organization to the downstream division.

Assume that the pricing decision maker in firm j faces a marginal cost of production that is constant and given by c_j. In the case of firm A, c_A may combine the actual marginal cost of production and a carbon tax that headquarters charges the downstream division for every unit of the good sold.

Given the demand function, firm i (in the case of firm A, its downstream division) chooses

[4]For simplicity, I assume v is sufficiently large that all consumers are served.

its price by maximizing its product-market profit, which is given by

$$\pi_i^{\text{prod mkt}} = (p_i - c_i)q_i(p_A, p_B) = (p_i - c_i)\left(\frac{1}{2} + \frac{p_j - p_i}{2t}\right).$$

The first-order necessary condition holds when

$$2p_i = t + p_j + c_i.$$

Solving the system of first-order conditions, we obtain the equilibrium prices and quantity,

$$p_i = t + \frac{2}{3}c_i + \frac{1}{3}c_j \tag{2}$$

and

$$x^* = \frac{1}{2} - \frac{c_A - c_B}{6t}. \tag{3}$$

The equilibrium product-market profit of firm i is given by

$$\pi_i^{\text{prod mkt}} = \left(t - \frac{c_i - c_j}{3}\right)\left(\frac{1}{2} - \frac{c_i - c_j}{6t}\right). \tag{4}$$

In the case of firm A, $\pi_A^{\text{prod mkt}}$ corresponds to the profit of the downstream division.

2.3 Carbon Tax

Let us now consider the equilibrium impact of a carbon tax. Assume $c_A = c + \tau$, where c is a constant marginal cost of production and τ is a carbon tax that headquarters imposes on its own downstream division for selling a unit of their good. Assume also that $c_B = c$.

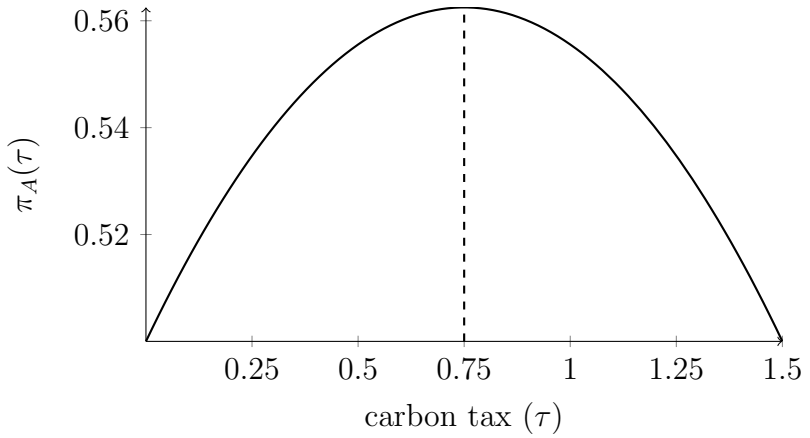
Since the carbon tax is self-imposed, the profit of firm A, combining the profits of the downstream division and headquarters, is given by

$$\pi_A = \pi_A^{\text{prod mkt}} + \tau q_A(p_A, p_B) = (p_A - c - \tau + \tau)q_A(p_A, p_B) = \left(t + \frac{2}{3}\tau\right)\left(\frac{1}{2} - \frac{\tau}{6t}\right), \tag{5}$$

where $\tau q_A(p_A, p_B)$ is the carbon tax revenue collected from the downstream division by headquarters (i.e., headquarters' profit). Note that the carbon tax impacts equilibrium prices and quantities, but it otherwise drops out of the profit function since the carbon tax money paid by the downstream division stays within the organization (headquarters collects it).

What is the optimal self-imposed carbon tax? We optimize π_A with respect to τ. The

Figure 1: Optimal self-imposed carbon tax (when $t = 1$)



first-order necessary condition is given by

$$\frac{d\pi_A}{d\tau} = \frac{1}{6} - \frac{2\tau}{9t} = 0,$$

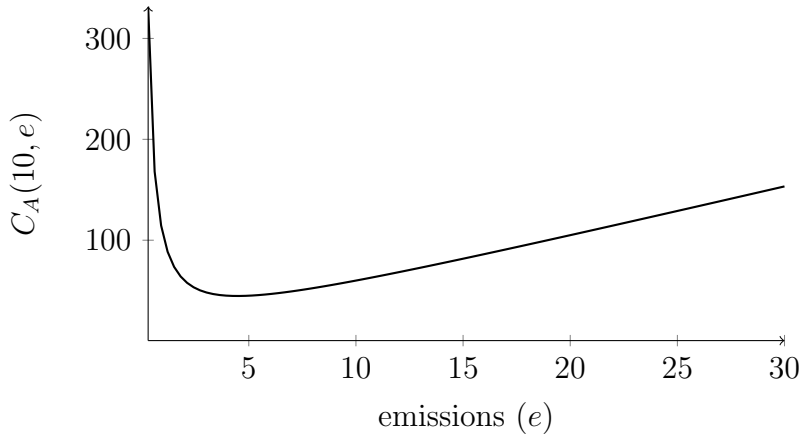
which holds when $\tau^* = 0.75t$. Since the profit function is concave in τ, this value is the optimal carbon tax. As an illustration, Figure 1 plots the profit function π_A as a function of τ and the optimal tax when $t = 1$.

What are the economics of this result? From the perspective of firm A's downstream division, the carbon tax is equivalent to an increase in its marginal cost of production. From a strategic point of view, equilibrium prices are increasing in marginal costs, implying that the carbon tax causes a decrease in firm A's market share. This distortion causes the profits of firm A's downstream division to decrease.

When taking the perspective of firm A as a whole (the profits of headquarters and the downstream division combined), the carbon tax creates a tradeoff. On the one hand, the carbon tax relaxes the intensity of price competition as equilibrium prices increase. This causes an increase in the price-cost margin of firm A as a whole, since $p_A - c - \tau + \tau$ is increasing in τ (via the impact of τ on p_A). On the other hand, the greater equilibrium price caused by the carbon tax decreases firm A's market share. The analysis above shows that for small enough values of the carbon tax, the increase in the price-cost margin more than compensates for the decrease in market share, making a self-imposed carbon tax optimal.

What is crucial here is that the carbon tax revenue stays inside the organization, implying that the carbon tax increases the organization's price-cost margin. Thus, the carbon tax drops out of the profit function except for how it affects the endogenous objects (price and quantity). In contrast, the price-cost margin of firm A's downstream division, $p_A -$

Figure 2: Cost function for a given level of output ($q = 10$, $\beta = 1$, $\delta = 5$, $\tau = 0$)



$c - \tau$, decreases in τ because the carbon taxes exit the downstream division when paid to headquarters. This makes a carbon tax unambiguously costly for the downstream division of firm A, as it decreases its price-cost margin and market share.

In summary, a self-imposed carbon tax can be profitable for the firm because of how it relaxes the intensity of price competition.

3 Analysis with Emissions Abatement

In the previous section, we considered the case of a tax that is imposed on each unit sold. An alternative scheme is one that imposes a carbon tax per unit of emissions of the downstream division. In response, the downstream division may choose to abate emissions (e.g., switch to an alternative fuel) to decrease their carbon tax liabilities.

To explore the merits of such a carbon tax scheme, consider a cost (of production) function given by

$$C_A(q, e) = \beta \frac{q^2}{e} + \delta e + \tau e,$$

where q is units produced and e is emissions. Here, the level of emissions is a choice variable that affects cost and marginal cost. While the marginal cost is decreasing in the level of emissions, the average cost is non-monotonic in the level of emissions, implying that the optimal level of emissions for a given level of output is finite. Figure 2 provides an example.[5]

Given this cost function, for a given level of output q, the firm will choose its emissions

[5]See Phaneuf and Requate (2016) for a detailed discussion of cost functions in which the level of emissions is a choice variable.

to minimize cost. The first-order condition with respect to emissions is given by

$$\frac{\partial C_A}{\partial e} = -\frac{\beta q^2}{e^2} + \delta + \tau = 0, \tag{6}$$

which holds when

$$\frac{q}{e} = \sqrt{\frac{\tau + \delta}{\beta}}.$$

In this case, the carbon intensity (emissions per unit produced) is constant in the level of output. Replacing equation (6) in $C_A(q, e)$, we obtain

$$C_A^*(q) = 2\sqrt{\beta(\tau + \delta)}q,$$

which implies a constant marginal cost of production of $2\sqrt{\beta(\tau + \delta)}$, once the optimal emissions level is factored in. Note that this constant marginal cost includes the carbon tax (if any).

3.1 Equilibrium

Given the cost functions of firm A and B given by $C_A^*(q) = 2\sqrt{\beta(\tau + \delta)}q$ and $C_B(q) = cq$, respectively, the equilibrium prices and quantity are given by

$$p_A = t + \frac{4}{3}\sqrt{\beta(\tau + \delta)} + \frac{c}{3}, \quad p_B = t + \frac{2}{3}\sqrt{\beta(\tau + \delta)} + \frac{2c}{3},$$

and

$$x^* = \frac{1}{2} + \frac{c}{6t} - \frac{1}{3t}\sqrt{\beta(\tau + \delta)},$$

where we make use of equations (2) and (3).

The profit of firm A is given by

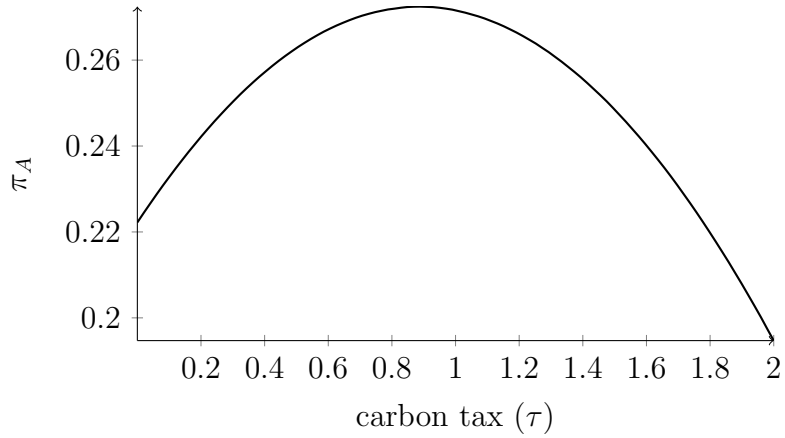
$$\pi_A = (p_A - 2\sqrt{\beta(\tau + \delta)})x^* + \tau x^*,$$

where the first term is the profit of the downstream division (taking into account the carbon tax it must pay to headquarters) and the second term is the profit of headquarters (the carbon tax revenue).

The first-order condition with respect to τ lacks analytic tractability, but when $t \to \infty$ (demand is arbitrarily price inelastic) it simplifies to

$$\lim_{t\to\infty} \frac{\partial \pi_A}{\partial \tau} = \frac{1}{2} - \frac{1}{3}\sqrt{\frac{\beta}{\tau + \delta}} = 0,$$

Figure 3: Optimal self-imposed carbon tax (when $t = 1$, $c = 1$, $\delta = 1$, $\beta = 1$)



which has a solution at $\tau^* = 4\beta/9 - \delta$ (the second-order condition holds at this point, making it the optimal tax). Beyond this limit case, Figure 3 plots the profit function π_A as a function of τ for a given set of parameters ($t = 1$, $c = 1$, $\delta = 1$, $\beta = 1$). This analysis shows that even when an internal carbon tax induces the firm to abate emissions, a positive internal carbon tax can be profitable for the firm. The economics of the result remains unchanged.

4 Efficiency

The nature of the demand model is that consumers will always purchase one of the two products (the aggregate demand elasticity is zero). For this reason, firm A's self-imposed carbon tax does not create deadweight loss; the higher equilibrium prices under a carbon tax simply result in a redistribution of wealth from the consumers to the producers.

Aside from the impact of the carbon tax on prices, the carbon tax may increase efficiency if two conditions are met. First, if firm B's product is less carbon intensive than firm A's product. Second, firm A's carbon tax is set at or below the social cost of carbon. Under these conditions, firm A will abate emissions to a point where the social value of abating the last unit of emissions (social cost of carbon) is greater or equal than the cost of abating that marginal unit of emissions ($\partial C_A/\partial e$), and output will be reallocated to firm B, which sells a product that is less carbon intensive.

A richer model may have an aggregate demand elasticity that is non-zero, implying that the carbon tax would reduce aggregate demand, creating a loss in surplus due to the higher equilibrium prices. As before, this decrease in demand may be socially efficient if the firms are not fully internalizing the social cost of their emissions. This version of the model would

not need for firm B to be less carbon-intensive for the carbon tax to increase efficiency.

5 Concluding Remarks

Some companies have chosen to self-impose a carbon tax where governments have failed to act. This paper provides an explanation for this phenomenon, showing that this strategy can be profitable because of its impact on the intensity of price competition. Importantly, the result does not rely on the firm using the carbon tax to signal to consumers that the firm is "green" or to achieve any marketing benefit that may shift demand. Despite a loss in consumer surplus due to higher equilibrium prices, the self-imposed carbon tax may enhance market efficiency.

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