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Do profit maximizers take cold showers?

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Abstract

A firm takes a "cold shower" if removal of a protective subsidy induces investment in a cost-reducing technology. We show that if the investment lowers marginal cost everywhere, then profit maximizers never take cold showers. However, if the investment does not lower marginal cost everywhere, a profit maximizer may take a cold shower.

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1. Introduction

There is now a reasonably extensive literature on the idea that taking protection away from a firm can somehow improve its performance (a cold shower)[1]. In this paper we will say that a firm is subjected to a cold shower whenever its incentive to invest in a cost-reducing technology is heightened by a reduction in protection. Theoretical contributions to this literature typically either deviate from profit-maximizing firms, use strategic effects, or use limited liability in order to obtain the cold shower effect.

Corden (1974) and Martin (1978) use a Scitovsky-type[2] framework with a utility-maximizing, but not profit-maximizing, entrepreneur. Vousden and Campbell (1994) and Horn, Lang and Lundgren (1995) use a principal-agent framework. Campbell (1998) uses limited liability to generate a cold shower. Rodrick (1992) and Lambson (2000) use strategic (game-theoretic) effects from multiple investors where the incentive for each to invest is affected by how much the others invest.

In this note we consider a single profit-maximizing firm protected by a per unit subsidy with the option of investing in a cost-reducing technology. We provide a sufficient condition on the cost-reducing technology to guarantee that cold showers never occur when the subsidy is removed. The condition is that the technology lowers marginal cost everywhere. This emphasizes that cold showers are difficult to obtain in a profit-maximizing setting without strategic effects. We then use this result to construct an example of a cost-reducing investment that generates a cold shower.

[1] For a discussion of this literature see Campbell (1998).

[2] Modeling the entrepreneur or manager as a utility maximizer rather than a profit maximizer is a tradition which goes back to Scitovsky (1943).

2. Analysis

Consider a single domestic firm producing a good that is sold at the world price *p*. In addition to the price, the firm receives a subsidy of *s* on each unit sold. The firm has the option of paying *I* to invest in a new technology. The investment will be successful with probability $g \in (0,1]$. If the new technology is successful then the firm's cost function changes from $C_O(x)$ to $C_G(x)$ where $C_i'(x) > 0$, $C_i''(x) > 0$ for *i*=*O*,*G*. If the new technology is not successful, then the cost function continues to be $C_O(x)$. It is assumed that a successful investment lowers total cost, i.e., $C_G(x_G^s) < C_O(x_O^s)$ where x_O^s and x_G^s are the respective profit-maximizing choices of output under subsidy $s \geq 0$. Under subsidy *s* the profit level is $\pi_i{}^s = (p+s)x_i^s - C(x_i^s)$ for $i = O,G$. Given a subsidy level *s*, we define the firm's incentive to invest A^s as the difference between expected profit from investing and expected profit from not investing:

$$A^s \equiv [g\pi_G^s + (1-g)\pi_O^s - I] - \pi_O^s$$

The following question arises: "Will a profit-maximizing firm having rejected an investment at a subsidy level *s* > 0, ever choose to invest if the subsidy is reduced?"

In answer to this we can say the following:

Proposition 1. *If the investment lowers expected marginal cost everywhere,* $C_G'(x) < C_O'(x)$ *for all x, then the incentive to invest rises with the subsidy,* $\frac{\partial A^s}{\partial s} = g(x_G^s - x_O^s) > 0$.

Proof

Since $\pi_G^s = (p+s)x_G^s - C_G(x_G^s)$,

$\partial\pi_G^s / \partial s = x_G^s$ by the envelope theorem.

Similarly, $\partial\pi_O^s / \partial s = x_O^s$.

Therefore, $\partial A^s / \partial s = g(x_G^s - x_O^s)$.

Now with the respective output quantities chosen to maximize profit, we have the following marginal revenue equals marginal cost relationships:

$(p+s) = C_G'(x_G^s)$ and $(p+s) = C_O'(x_O^s)$.

Therefore, $C_G'(x_G^s) = C_O'(x_O^s)$.

Now if $C_G'(x) < C_O'(x)$ for all *x*, then we must have $x_O^s < x_G^s$ since $C'' > 0$. This implies

$\partial A / \partial s = g(x_G^s - x_O^s) > 0$

Q.E.D.

The intuition is straightforward. If the subsidy is increased by \$1, then a profit-maximizing firm will benefit by one dollar for each unit it is currently producing. Profit maximization implies that a small change in the subsidy will have a negligible effect on profit via output responses. If the firm chooses to invest, the increased subsidy nets it \$$x_G^s$ with probability *g* and \$$x_O^s$ with probability (1-*g*). If the firm doesn't invest it gets an addition \$$x_O^s$ for sure. Since the cost of investment *I* does not change with the subsidy, the incentive to invest will rise with the subsidy if and only if

$gx_G^s + (1-g)x_O^s > x_O^s$, or equivalently, $g(x_G^s - x_O^s) > 0$. But clearly $x_G^s > x_O^s$ whenever the new technology has lower marginal cost.

This result shows that obtaining a cold shower in a profit-maximizing setting will require the cost-reducing technology to raise marginal cost somewhere. We now give one such example. We assume, for simplicity, that the investment is always successful (*g*=1). This not only slightly simplifies the analysis, but also emphasizes that we do not require uncertainty to achieve a cold shower result. The world price *p* = 20 and the cost of the investment *I* = 20. The old and the new technologies are: $C_O(x) = \frac{x^2}{2} + 150$, and $C_G(x) = x^2 + 20$.

One might imagine a case where an investment leads to a technology with a lower overhead and thus lower total cost, but a higher marginal cost.

When *s* = 1 the investment is rejected since:

$x_O^1 = 21, x_G^1 = 10.5, \pi_O^1 = 70.5, \pi_G^1 = 90.25, A = -0.25.$

However, when *s*=0 the investment is accepted since:

$x_O^0 = 20, x_G^0 = 10, \pi_O^0 = 50, \pi_G^0 = 80, A = 10.$

Let's see why the reduction in the per unit subsidy leads to the cold shower. Since the marginal cost of the old technology is lower, the firm produces more with that technology than with the new technology. Since the subsidy is paid per unit of output, the subsidy benefits users of the old technology more. When the subsidy is removed, the firm weighs the true benefits and costs and opts for the new technology.

Finally, we remark that the choice of competition does not seem to be relevant to the results of this paper. They hold for a subsidy used in non-competitive markets as well.

First consider an oligopoly of firms in the home country selling in a competitive world market. The marginal benefit to one of these firms of a dollar rise in the subsidy will still be equal to the output level produced by the firm and Proposition 1 holds. Next, consider a subsidized domestic firm in an oligopoly world market with quantity competition. Here again the marginal benefit to the domestic firm of a dollar rise in the subsidy equals the output level produced by the firm. The key reason for this irrelevance is that we are only considering investment by one firm, or if you like, non-strategic investment. Rodrik (1990) and Lambson (2000) showed cold showers can come from strategic investment, so Proposition 1 might fail in that setting.

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