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Does Trade Liberalization Make the Porter Hypothesis Less Relevant?

Neil Campbell*
Department of Applied and International Economics, *Massey University*, *New Zealand*

Abstract

The Porter Hypothesis refers to the idea that environmental regulations push firms into developing and adopting new technologies. Controversially, it asserts that the investments in new technology that the firms are pushed into making would be profitable irrespective of whether the regulations had have been put in place. In this paper a simple model is used to illustrate a Porter Hypothesis situation. This framework allows us to establish what conditions are required for a tariff reduction to be an alternative to environmental regulations. That is, we look at a case where, under tariff protection, the firm will only invest in new technology when the environmental regulation is put in place, but in the absence of tariffs, the firm will invest in new technology irrespective of whether the environmental regulation is in place.

Key words: CFCs; environmental regulation; innovation offsets; managerial incentives; Porter Hypothesis; trade liberalization

JEL classification: F13; L51; L21

1. Introduction

The Porter Hypothesis makes the controversial and interesting claim that environmental regulations push firms into developing new and profitable technologies. More specifically, it asserts that the innovations the firms are pushed into making would be profitable irrespective of whether the regulations had have been put in place. Not surprisingly, this claim by Porter has been regarded with considerable scepticism by mainstream environmental economists. Porter's story involves some kind of abandonment of conventional profit maximisation. He also takes a critical stance on the standard cost-benefit paradigm; see Palmer et al. (1995). For a very useful compact survey of the literature criticizing the Porter Hypothesis, see Heyes

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*Correspondence to: Department of Applied and International Economics, Massey University, Private Bag 11222, Palmerston North, New Zealand. E-mail: N.A.Campbell@massey.ac.nz. The author wishes to thank Graeme Wells, Jeffrey Kline, Gerald Garvey, Simon Grant, Stephen King, Rohan Pitchford, Martin Richardson, and two anonymous referees for helpful comments and discussions.

and Liston-Heyes (1999).

Here we present a simple model where the manager of a firm behaves in a manner consistent with the Porter Hypothesis. We consider a firm that initially uses a production technology which emits chlorofluorocarbons (CFCs), and then a CFC ban is put in place. The manager has the option of investing in a research and development (R&D) program that if successful will reduce the firm's operating costs and allow it to operate without emitting CFCs. With appropriate parameter values, the manager will reject the investment prior to the CFC ban and then accept the investment once the CFC ban has been put in place. The manager is assumed to maximize his expected income. The reason for the manager's behaviour is that the owner of the firm, because of information limitations, adopts the following rule of thumb. The owner pays the manager a proportion of profit; fires the manager if the manager makes an investment which ex post reduces profit. A rationale for this rule of thumb, with its asymmetry between the reward for success and punishment for failure, is provided later in this introductory section.

This model allows us to explore the question alluded to by the title of the paper as to whether it is more likely that Porter Hypothesis situations occur when a regime of trade protectionism is in place. The idea behind the contention of this question is that fat and lazy protected firms are more likely to need a push to innovate. This notation of the fat and lazy protected firm has substantial populist support. It also has a reasonable degree of empirical and theoretical support; see Campbell (1998).

An important assumption used in this analysis is that the firm cannot simply buy new technology from foreign firms. It is central to the analysis that the manager is not 100% sure that investment in new technology will be successful. Some form of R&D will have to take place to gain the new technology. The need for R&D can be justified by conducting fundamental research or purchasing existing technologies and attempting to adapt these technologies. Making the assumption that you cannot simply pay to receive a new technology with 100% certainty would be in many cases quite realistic. This, of course, is not to deny that in some cases this assumption is unrealistic.

In the remainder of this introduction a characterisation is presented on how Porter, and other authors who support the Porter Hypothesis, consider that various forms of "organizational failure" will allow the Porter Hypothesis to occur. It is then argued that the owner's rule of thumb used in this paper captures much of the essence of these ideas and is consistent with various scholarly works on the incentives that mangers face. Finally, a guide to the remaining sections of this paper is given.

Porter (1991) advocates that the US does not delay implementation of strict environmental regulations. Within Porter's discussion, he makes the following claim:

> *Properly constructed regulatory standards, which aim at outcomes and not methods, will encourage companies to re-engineer their technology. The result in many cases is a process that not only pollutes less but lowers costs or improves quality.*

Porter and van der Linde (1995) make a stronger version of this claim:

> *... properly designed environmental standards can trigger innovation that may partially or more than fully offset the costs of complying with them.*

They coin the term "innovation offsets" for such innovations. The obvious question is why profitable innovations are not carried out irrespective of the introduction of regulations. They answer this with the following catch-all statement:

> *... the actual process of dynamic competition is characterized by changing technological opportunities coupled with highly incomplete information, organisational inertia and control problems reflecting the difficulty of aligning individual, group and corporate incentives.*

They give various examples which they characterize as innovation offsets. It is useful to consider the first of these examples, which involves the Raytheon corporation. Raytheon used a CFC technology to clean circuit boards after soldering. In 1990 the Montreal Protocol and US Clean Air Act required Raytheon to no longer use this technology. In response Raytheon successfully developed a new CFC-free technology. Raytheon's initial assessment of the probability that a successful investment can be made in the development of the new technology is described as "impossible." However, this seems best interpreted as a belief that the probability of success was low. That is, if Raytheon really believed that the probability of success was zero, then it would not invest in an attempt to develop the new technology. It seems clear that ex post Raytheon regards this innovation as profitable. Operating costs became lower and average product quality improved.

What is unclear about the above example is whether, prior to the CFC ban, the investment was rejected because of inertia (suboptimal behaviour by the firm) or because the expected return on the investment was negative. If we are to take seriously the inertia idea as an explanation for a general tendency by firms to reject profitable investments in environment-friendly technology, then we need a plausible story about what is driving the suboptimal behaviour by the firm. That is, we need an explanation which involves individuals within the firm acting in a manner which they perceive is in their own interests. DeCanio (1994), a strong advocate of the Porter Hypothesis, provides a useful discussion of possible sources of firm inertia. He states that

> *... asymmetrical consequences for failure and success can induce lower-level managers to play safe by avoiding initiatives having any risk, however small.*

DeCanio also mentions the idea that top management may reject a project proposed by lower management because of the suspicion that lower management is engaging in "empire building." That is, an individual in lower management may advocate a project, in which he or she has special expertise, by exaggerating its benefits and underestimating its costs. Under these circumstances, DeCanio argues, top management will only accept such a project if the estimated return is very high. A more modest estimated return could be masking a true return which is negative.

Gabel and Sinclair-Desgagné (1998) also favour the Porter Hypothesis. Their discussion is very much in the tradition of "the behavioural theory of the firm" as expounded by Cyret and March (1963). That is, they explain inertia by emphasising the importance of systems, procedures, and routines in the decision-making process within the firm. The idea being that in a world of bounded rationality, decision makers, with limited knowledge and computational ability, use a variety of rules of thumb, albeit some very sophisticated rules of thumb. Gabel and Sinclair-Desgagné make the point that a firm may have a system in place that once was optimal, or close to optimal, but now, in changed circumstances, fails to recognize ex ante profitable investments in environment-friendly technology. They go on to argue that the firm can restructure, but there is a substantial cost associated with doing this. "Organisational failure" can be said to result if top management fails to restructure because it does not realize that the cost of doing so is less than the cost of not restructuring (the performance gap). Under these circumstances environmental regulations may push management into making such a restructuring.

The owner's rule of thumb for rewarding and punishing the manager in this paper is designed to capture much of the essence of the inertia ideas from DeCanio and Gabel and Sinclair-Desgagné. Instead of having a hierarchy of managers, there is just an owner and a manager. The reason why the manager is modelled as being paid a proportion of profit rather than a flat wage is to incorporate the stylised fact of a positive relationship between managerial compensation and shareholder wealth; see Grant et al. (1996). The rule that the manager is fired for initiating an investment which ex post reduces profit may seem a somewhat extreme system or procedure. However, it reflects the idea that being associated with unsuccessful projects can be detrimental to a person's career. Empirical evidence supports the idea that dismissal is used to punish poor share performance. Grant et al. (1996) cite a number of studies that find a statistically significant negative relationship between managerial turnover and stock returns. Rappaport (1978) states that

> *... managers generally operate under an "asymmetrical reward function"—that is, the penalties of failing to meet some minimum performance standard appear to be much greater than the uncertain rewards for exceeding that standard.*

Roedel (1970) was manager of exploratory research in the development department of E. I. du Pont de Nemours & Company. Roedel makes the following comments with respect to the problem of "selling" an innovation to the general manager:

> *Each month, he has to produce a sheet showing profits and losses on each individual business, return on investment, and performance against forecast. He is constantly under the microscope on all phases of his business, plus or minus* 10%.… *If the venture succeeds, the pat on the back that he gets is not equivalent to the jab in the fanny with a spear if he fails. The spear is there every month and the pat only at the end of the line, possibly not at all since success is always obvious, and who should get credit for doing the obvious*?

The reason why we assume that the manager is always fired if the investment fails is that it injects into the model asymmetrical consequences for failure and success.

An obvious question to ask is why cannot the owner do better than use this rule of thumb? More specifically, why doesn't the owner pay the manager the same proportion of profit whether the investment is successful or unsuccessful? The reason is based around an implicit assumption that the owner is at a substantial informational disadvantage. Think of the following perfectly plausible information imperfection. Suppose there are 1000 potential investment projects, all of which would be judged as having a slightly negative expected return by some kind of "ideal" or "best-practice" manager. The owner does not know how many of these 1000 projects that the presumably less-than-ideal manager that he employs will mistakenly regard as having a positive expected return. Here a reward scheme that has asymmetrical consequences for failure and success would plausibly be perceived by the owner as being superior to a scheme with symmetrical consequences. With the particular investment that is the focus of this paper, it is assumed that the manager does have the correct information to calculate the expected return, but the owner has no way of knowing that this is the case.

The rest of the paper is organized as follows. Section 2 sets out the simple Cournot model on which this analysis is based. Section 3 specifies the condition for when an investment in a cost-reducing CFC-free technology is rejected by the manager. Section 4 specifies the condition for when a CFC ban will cause the manager to accept the previously rejected investment rather than switching to the production of some other good. Section 5 discusses the issue of whether the likelihood of a Porter Hypothesis situation occurring is affected by whether the domestic firm is protected by a tariff. Section 6 provides some numerical illustrations. Finally, Section 7 presents some concluding comments.

2. The Model

We use a Cournot model with one domestic and one foreign firm. The domestic firm, at least initially, produces good A. The production of good A, with current technology, results in CFC emissions. To attempt to develop a new technology for producing good A, the domestic firm can invest in an R&D program at a cost of *I*. There is a probability of *g* that the R&D will be successful. The new technology will allow good A to be produced at a lower cost per unit, a decrease from c_0^A to c_S^A. The new technology also produces no CFCs. If the R&D is unsuccessful, then no new technology is found for producing good A. If, in the domestic country, technologies that produce CFCs are banned and the new technology has not been tried or has not been successfully developed, then the domestic firm has the option of switching to the production of some other good or goods which yields the next-best-alternative profits to producing good A, denoted π^{NBA}. The foreign firm produces good B, at a cost per unit of c^B, using a technology which does not result in any CFC emissions. Consumers regard good B as an imperfect substitute for good A.

The market which is analyzed is the domestic market for goods A and B. There is a tariff of t on the imports of good B. The goods' respective inverse demand functions are

$$p^A = a^A - b^A x^A - \theta\, x^B$$
$$p^B = a^B - \theta\, x^A - b^B x^B ,$$

where p^A, p^B, x^A, and x^B are the respective prices and quantities of goods A and B.

The resulting profit function for the domestic firm if it produces good A is

$$\pi^A = b^A \left[\frac{2b^B (a^A - c^A) - \theta(a^B - (c^B + t))}{4b^A b^B - \theta^2} \right]^2 ,$$

where c^A can either represent c_0^A or c_S^A and t represents a possible tariff levied on each unit of good B imported.

Profits made by the domestic firm in various situations are denoted as follows:

π_0^A	No R&D, CFCs not banned.
$\pi_S^A - I$	Successful R&D, CFCs not banned.
$\pi_0^A - I$	Unsuccessful R&D, CFCs not banned.
π^{NBA}	No R&D, CFCs banned.
$\pi_S^A - I$	Successful R&D, CFCs banned.
$\pi^{NBA} - I$	Unsuccessful R&D, CFCs banned.

The manager of the domestic firm is a risk-neutral expected-income maximizer. The manager's remuneration is a proportion γ of profit. If the manager makes an investment which results in a reduction in profit, then the manager is fired. The low income associated with being fired is T.

3. Prior to a CFC Ban

Here we consider the condition needed to have an expected-profit-maximising investment rejected by the manager. First note the condition that ensures that an investment project leads to a net increase in profit:

$$g\pi_S^A + (1-g)\pi_0^A - I > \pi_0^A \tag{1}$$

or

$$g(\pi_S^A - \pi_0^A) > I . \tag{1a}$$

The condition for the manager rejecting the investment is:

$$g\gamma(\pi_S^A - I) + (1-g)T < \gamma\pi_0^A . \tag{2}$$

Comparing (2) with (1) we can see that if T was to equal γ times the net profit associated with the investment being unsuccessful, any profitable investment will be accepted by the manager. This is the case because if the investment fails, the manager receives a payoff that is exactly proportionate to the payoff received by the firm. However, provided $T < \gamma(\pi_0^A - I)$ there will be a "range" of profitable investments that the manager will reject. This is because the cost of the unsuccessful investment incurred by the manager is proportionately greater than the cost incurred by the firm.

4. With a CFC Ban

The condition for the previously rejected investment being accepted once the CFC ban has been put in place is

$$g\gamma(\pi_S^A - I) + (1-g)T > \gamma\pi^{NBA} . \tag{3}$$

Clearly, comparing (2) and (3), the payoff from not investing is lower now (that is, $\gamma\pi^{NBA}$ must be smaller than $\gamma\pi_0^A$ or the analysis would not start with the domestic firm producing good A with the old technology). Hence a previously rejected investment might now be accepted. It is simple to show that, if the investment was profitable prior to the banning of CFCs, then the investment will definitely be profitable following the banning of CFCs. Consider the criterion for the investment being profitable following the banning of CFCs:

$$g\pi_S^A + (1-g)\pi^{NBA} - I > \pi^{NBA} , \tag{4}$$

or

$$g(\pi_S^A - \pi^{NBA}) > I . \tag{4a}$$

Comparing (4a) with (1a), we can see that the expected gain in profit has now increased.

By way of summary, consider the following proposition.

Proposition 1: With a CFC ban, the manager may switch from rejecting the investment to accepting the investment because the payoff from not investing has decreased from $\gamma\pi_0^A$ to $\gamma\pi^{NBA}$.

Both of the numerical illustrations in Section 6 prove Proposition 1 by example.

5. The Porter Hypothesis and Protection

Intuitively, we might think that the manager of a highly protected domestic firm is more likely to reject the investment, provided that good A is allowed to be produced with the old technology, because, with more protection, there is more to lose from making an unsuccessful investment. In this section it is shown that it is only under certain conditions that reducing the tariff can induce investment. This ambiguity arises because not only the payoff from not investing decreases with a tariff reduction but the expected payoff from investing also decreases with a tariff reduction. To see this it is convenient to consider the special case where the manager is indifferent between accepting and rejecting the investment:

$$g\gamma(\pi_S^A - I) + (1-g)T - \gamma\pi_0^A = 0 .$$

For a reduction in t to cause the investment to be accepted, the following expression needs to be negative:

$$\gamma(g\frac{\partial \pi_S^A}{\partial t} - \frac{\partial \pi_0^A}{\partial t}) .$$

Obviously this will only be negative if $g\frac{\partial \pi_S^A}{\partial t} < \frac{\partial \pi_0^A}{\partial t}$. Now we can note that $\frac{\partial \pi^A}{\partial t} = \frac{2b^A\theta[2b^B(a^A - c^A) - \theta(a^B - (c^B + t))]}{(4b^A b^B - \theta^2)^2}$. Thus $\frac{\partial \pi_S^A}{\partial t} > \frac{\partial \pi_0^A}{\partial t}$, and the size of this difference depends upon the gap between c_0^A and c_S^A.

The above analysis is summarized by the following proposition.

Proposition 2: Suppose that g and the gap between c_0^A and c_S^A are relatively small, so that $g(\partial \pi_S^A / \partial t) < \partial \pi_0^A / \partial t$. Then we can have a case where reducing the tariff can cause a previously rejected investment project to be accepted.

Proposition 2 is proved by example using the first numerical illustration in Section 6.

If the conditions for Proposition 2 hold, we can have a situation where in the protected state of the world a CFC ban is necessary to facilitate investment but in the trade liberalized state of the world the CFC ban is not necessary to facilitate investment. In this case trade liberalization does make the Porter Hypothesis less relevant (literally, it makes it irrelevant). However, clearly if the conditions for Proposition 2 do not hold, then an increase in the tariff can facilitate investment. For an example of this see the second numerical illustration in Section 6. It should be clear from the above discussion that the answer to this paper's title "Does Trade Liberalization make the Porter Hypothesis less Relevant?" is "not necessarily."

6. Numerical Illustrations

Two numerical illustrations are provided. The first one has its parameters set so that g and the gap between c_0^A and c_S^A are relatively small. The parameter values selected are:

$$a^A = a^B = 1000,\ b^A = b^B = 1,\ \theta = 0.9,\ c_0^A = 40,\ c_S^A = 35\ ,$$
$$c^B = 30,\ g = 0.5,\ \gamma = 0.01,\ T = 1100,$$
$$I = 1000, t = 30, \pi^{NBA} = 100000.$$

Using these we can calculate the following:

$$\pi_0^A \approx 113351.4804,\ \pi_S^A \approx 115472.1357.$$

Even prior to the CFC ban this is a profitable investment:

$$g\pi_S^A + (1-g)\pi_0^A - I \approx 113411.81 > \pi_0^A.$$

However, prior to the CFC ban, the manager will not make this investment:

$$g\gamma(\pi_S^A - I) + (1-g)T \approx 1122.36 < \gamma\pi_0^A \approx 1133.51.$$

Once the ban on CFCs is put in place the manager will make the investment:

$$g\gamma(\pi_S^A - I) + (1-g)T \approx 1122.36 > \gamma\pi^{NBA} = 1000.$$

Now recalculating profits following the removal of the tariff:

$$\pi_0^A \approx 107723.8824,\ \pi_S^A \approx 109791.4722,$$
$$g\pi_S^A + (1-g)\pi_0^A - I \approx 107757.68 > \pi_0^A.$$

This time the manager will make the investment even if there is no CFC ban:

$$g\gamma(\pi_S^A - I) + (1-g)T \approx 1093.96 > \gamma\pi_0^A \approx 1077.24.$$

What is driving this result is that, with the removal of the tariff, the payoff from not making the investment, $\gamma\pi_0^A$, is reduced.

Now consider the second illustration. With this illustration, g is larger and the gap between c_0^A and c_S^A is much larger. The parameter values selected are:

$$a^A = a^B = 1000,\ b^A = b^B = 1,\ \theta = 0.9,\ c_0^A = 160,\ c_S^A = 35,$$
$$c^B = 30,\ g = 0.9,\ \gamma = 0.01,\ T = 10,$$
$$I = 40000, t = 0, \pi^{NBA} = 50000.$$

Using these we can calculate the following:

$$\pi_0^A \approx 63997.8970,\ \pi_S^A \approx 109791.4722,$$
$$g\pi_S^A + (1-g)\pi_0^A - I \approx 65212.11 > \pi_0^A.$$

Prior to the CFC ban the manager will not make this investment:

$$g\gamma(\pi_S^A - I) + (1-g)T \approx 629.12 < \gamma\pi_0^A \approx 639.98.$$

Once the ban on CFCs is put in place the manager will make the investment:

$$g\gamma(\pi_S^A - I) + (1-g)T \approx 629.12 > \gamma\pi^{NBA} = 500.$$

With this second illustration it is actually the case that adding a tariff will eliminate the Porter Hypothesis failure to invest. Now recalculating profits with $t = 50$:

$$\pi_0^A \approx 71334.2047,\ \pi_S^A \approx 119338.8430,$$
$$g\pi_S^A + (1-g)\pi_0^A - I \approx 74538.38 > \pi_0^A.$$

Now the manager will make the investment even if there is no CFC ban:

$$g\gamma(\pi_S^A - I) + (1-g)T \approx 715.05 > \gamma\pi_0^A \approx 713.34.$$

Clearly in this example the tariff's effect upon the expected payoff from making the investment overwhelms its effect upon the payoff from not investing.

7. Concluding Comments

One way of thinking about the Porter Hypothesis is to divide sceptical reactions to it into the "Strongly Sceptical Position" and the "Weakly Sceptical Position." The Strongly Sceptical Position is that the Porter Hypothesis never happens and cases like the Raytheon case can be explained in terms of a positive ex post draw from a negative ex ante distribution. That is, while it turns out that making the investment prior to the CFC ban would have increased profit, making this invest would have been like taking a long-shot bet with a negative expected return. The Weakly Sceptical Position is that, while there probably are firms in a Porter Hypothesis situation, this does not justify Porter's argument that the traditional cost-benefit approach to environmental regulation is inappropriate because it is based upon a "static mindset" (i.e., ignores the improvements in technology induced by the environmental regulation). Conventional environmental and resource economists regard the main benefits of environmental regulation as social benefits, for example health benefits, and the main costs being the expenditures which firms need to make so as to comply with the regulation. The Weakly Sceptical Position is that, while some of the cost of complying may be mitigated by induced technological change, these costs are still substantial and need to be justified by substantial social benefits; see Palmer et al. (1995).

The thrust of this paper is consistent with the Weakly Sceptical Position. That is, under certain conditions, which are by no means naive or extreme, a firm is shown to reject an expected-profit-maximising investment because of inertia but then make the investment when a CFC ban prevents the firm from simply carrying on with the status quo. Using a simple formal model to analyze the Porter Hypothesis provides us with a number of insights. We can clearly see that, with a model where the returns to investment are stochastic, there is no need to model the manager as being averse to effort in order to show a problem of inertia. Also we can see that if the punishment for a failed investment is disproportionately severe compared with the reward for success then there will be some investments which will be rejected even though their expected returns are positive. When the CFC ban is put in place, the manager still suffers the same punishment for failure in the sense of being fired. However, the opportunity cost of making the investment and perhaps being fired is reduced with the banning of the old CFC technology.

This simple model allows us to see under what conditions the removal of a tariff can act like a CFC ban in that it can cause a previously rejected investment to be accepted. That is, we find that it is only under certain conditions that protectionism makes it more likely for a Porter Hypothesis situation to occur. Thus we can think of this paper as being in the tradition of those analyses that consider whether trade policy instruments can be seen as second best alternatives to environmental regulations. It should be emphasized that this paper certainly does not advocate that trade liberalization should be used as an alternative to environmental regulations. Rather it makes the point that the effects of environmental regulation can differ depending upon whether it is a situation of protectionism or free trade. An excellent survey of work on trade and environment issues can be found in Jayadevappa and Chhatre (2000).

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