METHODS

When green isn’t mean: economic theory and the heuristics of the impact of environmental regulations on competitiveness and opportunity cost

Morris Altman *

Department of Economics, University of Saskatchewan, 9 Campus Drive, Saskatoon, Sask., Canada S7N 5A5

Received 24 August 1999; received in revised form 15 June 2000; accepted 16 June 2000

Abstract

The conventional neoclassical economic wisdom argues that the opportunity costs of environmental regulations are high, with negative implications for costs and profits and, by implication, for growth and per capita gross domestic product (GDP). The minority view that environmental controls induce cost offsets that minimise such opportunity costs is marginalised by the conventional wisdom, which assumes that economic agents are x-efficient in production. A behavioural model of the firm is presented in this paper, whereby x-inefficiency in production prevails even in a world of perfect product market competition that is dominated by rational economic agents. In this model, environmental regulations affect both the level of x-efficiency and the extent of technological change and greener firms can be cost competitive and profitable. However, private economic agents cannot be expected to adopt 'Green' economic policy independent of regulations since, in this model, there need not be any economic advantage accruing to the affected firms in becoming greener. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Pollution abatement; X-inefficiency; Induced technical change; Green

1. Introduction

To what extent need environmental regulations increase production costs, lower returns to investment, and reduce the level of per capita gross domestic product (GDP)? Related to this question: can 'Green' be competitive? The conventional economic wisdom, built upon neoclassical microeconomic theory, maintains that the opportunity costs of environmental regulations are positive and reasonably high, increasing costs and reducing profits and, thereby, negatively affecting growth and the level of per capita GDP. The conventional wisdom does not deny that social benefits might be generated by such regulations, where pollution represents an externality in production, and that the marginal social benefits
might even outweigh the marginal private costs. It
only denies that these benefits can be obtained at
economically insignificant private costs (Cropper
and Oates, 1992; Stewart, 1993; Jaffe et al., 1995;
Palmer et al., 1995). This is in contrast to a
minority view, found largely outside of the eco-
nomics domain, that environmental controls in-
duce cost offsets such that the opportunity costs
predicted by the conventional wisdom are mini-
mal. The minority view, clearly articulated by
and referred to as the Porter hypothesis, is mar-
ginalized by the conventional wisdom using the
analytical framework of neoclassical theory
whereby it is assumed that economic agents are
x-efficient (Leibenstein, 1966) in production at all
points in time. Economic agents are assumed to
be operating along the production possibility
frontier. From the neoclassical perspective, the
opportunities for economic efficiency are ex-
hausted independent of environmental regulation
and would be exhausted prior to the introduction
of such regulation (Stewart, 1993; Jaffe et al.,
1995; Palmer et al., 1995).

Following the Axiom of Modest Greed, ratio-
nal profit seeking economic agents would not
allow any significant or economically meaningful
economic opportunities to go unexploited. As
McCloskey (1990, p. 112), articulates the axiom:
‘The Axiom of Modest Greed involves no close
calculation of advantage or large willingness to
take risks. The average person sees a quarter and
slides over it. He sees a $500 bill and jumps for it.
The Axiom is not controversial. All economists
subscribe to it, whether or not they believe in the
market... and so should you.’ It follows from this
Axiom that $500 cannot be expected to be lying
around. To wit, economic inefficiencies, of any
substantial order of magnitude, should not be
assumed to be lingering in the economy waiting to
be exploited through the action of regulators and
prescient economic agents. Therefore, forcing
firms to become greener, although generating so-
cial benefits, necessarily elicits private economic
costs. Moreover, any evidence that greener
economies appear to be economically vibrant and,
therefore, viable and competitive, should not be
taken as evidence that environmental regulations
have induced appropriate cost countervails as
such a deduction runs contrary to the analytical
predictions of the conventional economic wisdom
(Stewart, 1993; Jaffe et al., 1995; Palmer et al.,
1995). It is, indeed, a long standing scientific
tradition, as pointed out by Thomas Kuhn
(Coase, 1994, p. 27) that: ‘Anomalous observa-
tions... cannot tempt [a scientist] to abandon his
theory until another one is suggested to replace it... In scientific practice the real confirmation
questions always involve the comparison of two
theories with each other and with the world, not
the comparison of a single theory with the
world.'

The objective of this paper is to develop a
behavioral model of the firm where pollution is a
joint output of production (both 'goods' and
'bads' are produced). In this model, x-inefficiency
in production prevails even in a world of perfect
product market competition that is dominated by
rational utility maximising economic agents. In
this scenario, environmental regulations affect
both the level of x-efficiency and the extent of
 technological change. Therefore, the conditions
are established whereby regulations induce cost
offsets. Greener firms can be more productive
than polluting firms and greener economies might
generate higher levels of per capita output than
polluting economies. In other words, both green
and polluting firms can be cost competitive and
profitable. However, private economic agents can-
not be expected to adopt ‘Green’ economic policy
independent of regulations since, in this model,
there need not be any economic advantage accru-
ing to the affected firms in becoming greener.
There is no free ride to becoming Green. The
induced changes inside of the firm serve largely as
a countervail to the higher costs incurred in re-
ducing the level of pollution. Therefore, the in-
duced productivity increases that account for the
cost offsets need not generate further benefits to
firm owners. For this reason, one might have the
simultaneous existence, even in a competitive
economy, of Green and polluting firms, which is
one of the stylized facts of economic life. Con-

1 This logic fits well into the methodological world view of
the Chicago school (Reder, 1982). See also Altman (1999).
trary to what is argued by the conventional wisdom, economic theory, per se, does not preclude environmental regulations or environmentally friendly firm owners motivating increases in firm productivity as cost offsets to the development of environmentally friendly firms. It is therefore possible for Green economies to remain cost competitive and profitable relative to pollution-intensive economies. Whether or not Green and cost competitiveness and profitability are not mutually consistent hinges upon whether or not an economy is typically x-inefficient in production and whether or not technological change is independent of environmental regulation.

2. The Porter hypothesis and its critics

The Porter hypothesis is a multi-part hypothesis that was first put forth in Michael Porter’s oft-cited *Scientific American* (1991) essay. The least emphasized component of the Porter hypothesis is that environmental regulation will induce companies to produce new environmental-friendly products that prove internationally competitive, adding to an economy’s overall competitiveness. Few critics of the Porter hypothesis deny this possibility. What is denied is that these new products do not add to an economy’s overall costs of production using the pre-regulation period as a baseline of comparison. Also not in dispute is the other component of the Porter hypothesis that stipulates that the manner in which regulations are implemented will affect the costliness of these regulations. Porter (1991, p. 168), argues: ‘Turning environmental concern into competitive advantage demands that we establish the right kind of regulations. They must stress pollution prevention rather than merely abatement or cleanup. They must not constrain the technology used to achieve them, or else innovation will be stifled. And standards must be sensitive to costs involved and use market incentives to contain them.’ What is in dispute is whether or not private costs would be lower, net, in the absence of pollution regulations.

It is the following and key component of the Porter hypothesis that has engendered the most controversy and criticism. Porter stipulates that, contrary to conventional economic theory, the introduction or strengthening of environmental legislation (Porter, 1991, p. 168, ‘[does] not inevitably hinder competitive advantage against foreign rivals; indeed they often enhance it. Tough standards trigger innovation and upgrading.’ Moreover (Porter, 1991, p. 168): ‘Exacting standards seem at first blush to raise costs and make firms less competitive, particularly if competitors are from nations with fewer regulations. This may be true if everything stays the same...But everything will not stay the same. 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 and improves quality.’ Thus, environmental regulation is expected to induce productivity increases in the pollution-producing firms that will, it appears, offset or even more than offset the unit costs to the firm of such legislation. Nevertheless (Porter, 1991, p. 168): ‘This is not to say that all companies will be happy about tough regulations: increased short-term costs and the need to redesign products and processes are unsettling at the least.’ Therefore, Porter expects companies to successfully resist, even over the long haul, for short-run reasons, what is to their long-run economic advantage.

This argument is elaborated in some detail elsewhere (Porter and Van der Linde, 1995a,b; Van der Linde, 1993).\(^2\) Porter and Van der Linde conclude that contrary to the mainstream economic view the economy must be regarded as a dynamic system wherein companies are not always making optimal choices in terms of input combinations and technical change, and where, therefore, there are profitable opportunities waiting to be picked-up — $500 bills lying visibly all over the place — if only there is a regulatory push (Porter and Van der Linde, 1995a, p. 99; Porter and Van der Linde, 1995b, p. 127). At one point they argue (Porter and Van der Linde, 1995a, p. 99; Porter and Van der Linde, 1995b, p. 127): ‘This is not to say that all companies will be happy about tough regulations: increased short-term costs and the need to redesign products and processes are unsettling at the least.’ Therefore, Porter expects companies to successfully resist, even over the long haul, for short-run reasons, what is to their long-run economic advantage.

\(^2\)The Porter hypothesis was articulated in a weaker form in an Organisation for Economic Co-operation and Development (1985) study on technical change.
the belief that companies will pick up on profitable opportunities without a regulatory push makes a false assumption about competitive reality — namely, that all profitable opportunities for innovation have already been discovered, that all managers have perfect information about them, and that organizational incentives have aligned with innovating. In fact, in the real world, managers often have highly incomplete information and limited time and attention. The conventional wisdom, therefore, exaggerates the true private costs of pollution control by assuming optimal behavior on the part of firm managers and owners in the absence of strict regulatory standards, and so overlooking the possibility that there are profitable opportunities that are taken up as a direct consequence of pollution regulations. This line of argument, often making direct reference to the Porter hypothesis, is adopted by leading advocates of pollution regulation (Ehrlich and Ehrlich, 1996; Von Weizsäcker et al., 1997; Elkington, 1998). From the perspective of the conventional wisdom the fundamental dilemma of the Porter hypothesis is the assumption that corporate leaders will systematically chose not to reduce pollutants in spite of the fact that it is to their economic advantage to do so.

The focus of criticism of the Porter hypothesis is not an empirical one. Rather, it is based on the belief, rooted in the conventional economic wisdom, that rational economic agents, managers and owners alike, will not persistently forsake profit opportunity in the absence of environmental regulations. There is a consensus, on all sides of the debate, that environmental regulations impose substantial costs to firms and to economies at large. (Organisation for Economic Co-operation and Development, 1985; Jorgenson and Wilcoxen, 1990; Cropper and Oates, 1992; Marsh, 1993; Arrow et al., 1995; Jaffe et al., 1995; Palmer et al., 1995; Porter and Van der Linde, 1995a; Von Weizsäcker et al., 1997). These costs include the direct expenditures by the firm to comply with pollution regulations as well as the indirect costs incurred through the payment of higher input prices from regulated suppliers (assuming that input prices must increase as a result of environmental regulations). The increased direct and indirect costs to the firm include the cost of plant and equipment, operating expenditures, investment in research and development, and the administrative and legal fees associated with environmental regulations. Moreover, there are opportunity costs of investing in environmentally friendly technologies as opposed to the (assumed) more productive alternative technologies. There are also the costs to government of drawing up, monitoring, and enforcing these regulations, costs that must ultimately be paid by consumers and firms (Jaffe et al., 1995, pp. 138–139; Stewart, 1993, pp. 2061–2065).

Nevertheless, it is agreed that in spite of these induced economic costs (Jaffe et al., 1995, p. 157): ‘Overall, there is little evidence to support the hypothesis that environmental regulations have had a large adverse effect on competitiveness, however that elusive term is defined. Although the long-run social costs of environmental regulations may be significant, including adverse effects on productivity, studies attempting to measure the effects of environmental regulation on net exports, overall trade flows, and plant-location decisions have produced estimates that are either small, statistically insignificant, or not robust to tests of model specification.’ (See also Tobey, 1990; Cropper and Oates, 1992; Stewart, 1993.)

In the literature critical of the Porter hypothesis, the key reason for environmental regulations not having a negative impact on the economy (including the relatively heavily regulated American economy) is given by the fact that the costs of environmental regulation are small relative to either gross national product (GNP) or to total production costs. These costs amount to no more than 2–3% of GNP or total costs, albeit there is considerable variation about the mean (Cropper and Oates, 1992; Jaffe et al., 1995). For this reason Palmer et al. (1995, p. 130), argue these costs are: ‘…sufficiently small (in most instances) to be swamped by international differentials in labor and material costs, capital costs, swings in exchange rates and so on.’ In addition, it is argued that competing economies and competing firms in different economies have in place like
sets of environmental regulations — this is true even amongst many developing economies — thereby limiting the competitive advantage that might otherwise accrue to a particular economy or firm. Moreover, multinational companies have been inclined to build environmentally friendly plants even in locations with poor or non-existent environmental regulations. Therefore, argue the Porter hypothesis’ detractors, the fact that more stringent environmental regulations have not, for example, damaged America’s competitive position, is not evidence for such regulations inducing cost-offsets as the Porter hypothesis would have it. Of course, it quite possible that cost-offsets were produced and that these have protected those firms that have invested in pollution abatement. However, this possibility is ruled out largely for theoretical reasons.

The traditional models used to critique the Porter Hypothesis assume that it is not possible for cost-offsets to occur that would render the net costs of pollution abatement negligible. In one lucid critique of the Porter hypothesis, Palmer et al. (1995, p. 121–125), argue that what distinguishes the conventional neoclassical wisdom from the mindset articulated in the Porter Hypothesis is the assumption in the latter that economic agents systematically overlook profitable opportunities that would result in both less pollution and lower costs and, moreover, that government can correct for this ‘market failure’ by designing, implementing, monitoring, and enforcing the appropriate environmental regulations at a low cost, one that is well below the private benefits induced by these regulations. This implies that regulations provide the possibility of reducing pollution at no cost, as a result of the cost offsets induced by environmental regulations. Pollution abatement would then be a free lunch (see also Jaffe et al., 1995, pp. 154–157; Stewart, 1993, pp. 2079–2082).

They develop a simple model that assumes perfect product market competition, profit maximizing on the part of all polluting firms, and that competitors’ outputs and research and development expenditures are given. More importantly, this model is designed such that environmental regulations — increases in the set of constraints on the firm’s choices — necessarily increases the net marginal costs to the firm. They conclude (Palmer et al., 1995, p. 125): ‘…in this model of innovation in abatement technology, an increase in the stringency of environmental regulations unambiguously makes the polluting firm worse off. Even if the firm can invest and adopt a new, more efficient abatement technology, if that technology wasn’t worth investing in before, its benefits won’t be enough to raise the company’s profits after the environmental standards are raised, either.’ In this model, since no incentives exist for firms to adopt environmentally friendly technology prior to the introduction or the toughening up of environmental standards, it is assumed that the private production costs must increase as a consequence of environmental regulations. This argument sits well with the logic put forth in another critique of the Porter hypothesis by Jaffe et al. (1995, p. 156): ‘…one must be careful when claiming that firms are not operating on their production possibility frontiers [this claim is implicit in the Porter hypothesis]: if there are managerial costs to investing in new production technologies, then firms may be efficient even if they do not realize that new, more efficient processes exist until regulations necessitate their adoption. In other words, there may be many efficiency-enhancing ideas that firms could implement if they invested the resources required to search for them. If firms do successfully search in a particular area for beneficial ideas, it will appear ex post that they were acting suboptimally by not having investigated this area sooner. But with limited resources, the real question is not whether searching produces new ideas, but whether particular searches that are generated by regulation systematically lead to more or better ideas than searches in which firms would otherwise engage.’ In this world view there are invariably costs of one type or another that make the current production set-up achieved by private economic agents optimal, at least from the point of view of the private economic agents. In this case, any forced deviation from the optimal production set-up, such as environmental
regulation, will incur additional costs to the firm.3

3. X-inefficiency and environmental regulation

In the behavioral model of the firm, first elaborated upon elsewhere (Altman, 1996), that is built upon x-efficiency and efficiency wage theory, it is quite possible for firms to systematically avoid developing and implementing environmentally friendly production processes even if this is not expected to generate higher unit production costs or lower rates of profit. This would be true even if product markets are perfectly competitive and even if one assumes rational utility maximizing behavior on the part of all economic agents. In this scenario there need not be any benefits to firms, as is assumed in the Porter hypothesis, from engaging in environmentally friendly behavior. Rather, it is only assumed that environmental regulation creates the incentives for cost offsets to be developed. In this case, to firm managers and owners — the decision makers in the typical firm — the pollution-intensive production set-up and the relatively environmentally friendly method of production yield the same average costs and the same rates of return.

The essence of the behavioral model of the firm adopted for this paper is that firms are typically x-inefficient. Firms are considered to be x-inefficient if output per unit of input is less than the ideal maximum, which is given when firm members (Leibenstein, 1966, 1978, p. 206): ‘…interpret their jobs in such a way that they made effort choices which involved cooperation with peers, superiors, and subordinates, in such a way as to maximize their contribution to output.’ X-efficiency is therefore defined by the outermost production possibility frontier. This is determined by the state of technology and the ideal, relatively cooperative, system of industrial relations.4 X-inefficient firms operate somewhere in the interior. Fundamentally, x-inefficiency in production implies that firms are producing a lesser quantity and quality of output than is technically and economically feasible. There is now considerable evidence in favour of the existence of x-inefficiency (Frantz, 1998).

A necessary condition for the existence of x-inefficiency is the existence of effort discretion that, in turn, is facilitated by the existence of incomplete contracts (based on their transaction costs) and different behavioral functions, especially between employees and members of the firm hierarchy. In other words, economic agents are assumed to be maximizing different behavioral functions. In contrast, what the conventional theoretical wisdom implies is that economic agents are not endowed with effort discretion and that they ultimately make effort choices that yield x-efficient solutions to the productivity and quality of output question. In this sense, it is implicitly assumed that economic agents are all working as hard and as well as they can or are maximizing the quantity and quality of effort inputs into the process of production (Akerlof and Yellen, 1986; Miller, 1992; Stiglitz, 1987; Altman, 1996). However, for x-efficiency to be achieved, the firm must invest, at least in the short run, in the organizational capital (Tomer, 1987) of the firm. Members of the firm hierarchy would also have to work harder and smarter. They would, at least, have to reinvent their approach to human resource management. Moreover, not all layers of the firm hierarchy benefit from the superior, more cooperative work culture required to construct a relatively x-efficient firm. For example, the ratio of management to employees tends to be much lower

3 Stigler (1976) makes a similar point in his critique of Leibenstein’s (1966) x-efficiency theory. At one point he writes (Stigler, 1976, pp. 214–215): ‘The near-universal tradition in modern economic theory is to postulate a maximum possible output from given quantities of productive inputs — that is the production function — and to assert that each firm operates on this production frontier as a simple corollary of profit or utility maximization… In neoclassical economics, the producer is always at a production frontier, but his frontier may be above or below that of other producers. The procedure allocates the foregone product to some factor, so in turn the owner of that factor will be incited to allocate it correctly.’

4 There is now an extensive empirical literature relating various forms of cooperative work cultures to higher level of productivity (Appelbaum and Batt, 1994; Barney, 1995; Neal and Tromley, 1995; Pfeffer, 1995; Gordon, 1996; Ichniewski et al., 1996; Alcaly, 1997; Becker and Huselid, 1998; Logue and Yates, 1999).
in the relatively cooperative more x-efficient work environment, thereby threatening the position of many middle managers. In addition, principals may witness a loss of power and prestige to which they attach utility and a heavy weight in their objective function. In this sense, achieving x-efficiency is not a free ride. It clearly involves opportunity costs (both material and non-material) that differ across the spectrum of the firm’s economic agents (Appelbaum and Batt, 1994; Gordon, 1996; Ichniowski et al., 1996). Be this as it may, if effort discretion exists the quantity and quality of effort inputted into the process of production per unit of time is not fixed at some maximum and is affected by the work culture of the firm. X-efficiency then becomes a benchmark for maximum output per unit of input that occurs under ideal circumstances.

The Porter hypothesis can be investigated in light of a behavioral model of the firm where x-efficiency in production is a possibility (Altman, 1996, 1997). Assume that all economic agents attempt to maximize their utility in calculating forward-looking (rational) manner. Moreover, and more specifically, polluting firms are assumed to be profit maximizing. As per the conventional model, it is assumed that given its constraints, firms attempt to equate marginal costs and benefits. However, the objective function of agents and principals can differ and they may face different objective constraints. In a world of effort discretion, utility maximization does not imply effort maximization where the marginal costs of so doing does not equal the marginal benefits. Also assume that in a competitive product market, principals are subject to the binding constraint that unit costs must be competitive. Output is a product of inputs such as capital, labor, land, and technology as well as of work culture. Ceteris paribus, a more effective work culture generates a higher level of output and quality of output. Assume also that the product market is subject to severe competitive pressures and that firms are not protected from the competitive process in any way, such as through subsidies and tariffs, so that inefficient firms must be subject to the full force of competitive pressures. Assume further that firms take regulations and competitors’ output and investment in research and development as exogenously given. Based on the stylized facts of the firm, also assume that for the quantity and/or quality of effort to be increased, the firm must also invest in the organizational infrastructure of the firm. These assumptions differ from the standard model adopted by Palmer et al. (1995) in their critique of the Porter hypothesis, only with respect to the assumptions allowing for effort discretion and x-inefficiency.

A fundamental question related to the Porter hypothesis is, must the environmentally friendly firm be a higher cost firm than a polluting firm, where both firms produce the same output and use the same technology? To address this question we assume that the polluting firm is x-inefficient. This firm produces two goods: the marketed good and pollution, which has no market value. However, pollution abatement incurs a positive production cost. The average cost of producing marketed output to the firm (the private economic costs) is given by:

\[
AC = \frac{EC}{Q} + \frac{OC}{Q}
\]  

(1)

where \(AC\) is average costs, \(EC\) are the abatement costs of reducing pollution, \(OC\) are the other production costs, and \(Q\) is output. \(EC\) and \(OC\) are inclusive of labor and capital costs. Assume that for a polluting firm \(EC\) is zero. Ceteris paribus, average costs increase as pollution abatement increases. Eq. (1) can be transformed into:

\[
AC = \frac{P_{EC} \cdot EI}{Q} + \frac{P_{OC} \cdot OI}{Q}
\]  

(2)

where \(P_{EC}\) and \(P_{OC}\) is the price of inputs related to the \(EC\) and to the \(OC\), respectively. \(EI\) and \(OI\) are the inputs related to \(EC\) and \(OC\), respectively. For simplicity, assume that \(EI\) and \(OI\) are composed of labor and capital. Average costs are positively affected by increases to the price of inputs. However, even holding input prices constant, ceteris paribus, average costs are positively related to increases in the quantity of inputs used in the production process. Therefore, increasing environmental inputs serves to increase average costs, unless offset by some positive impact on
output. What is typically assumed, however, is that only increasing $O_I$ will increase output, whereas increases in $E_I$ serve only to reduce pollution. The latter is a public good with no corresponding private material benefits to the firm. The relationship between average cost and input prices, inputs, and output is illustrated by Eq. (3), which is in turn derived from Eq. (2):

$$AC = \frac{P_{EC}}{Q} + \frac{P_{OC}}{Q} = \frac{Q}{EI} + \frac{Q}{OI}$$

(3)

Average cost is positively affected by the price and quantity of inputs and is negatively affected by the productivity of these inputs. Assume that for pollution abatement to take place either one of or both $E_I$ and $P_{OC}$ increase. This need not yield a higher average cost if input productivity increases sufficiently. In this case, not only would increasing environmental inputs reduce the level of pollution associated with a particular level of output, this would also serve to increase the firm’s average productivity.

If the polluting firm is x-inefficient, the increased costs required to reorganize the process of production so as to reduce pollutants can create the incentives — the need to keep average costs from rising — necessary to reduce the extent of x-inefficiency. The firm that is becoming environmentally friendly, either voluntarily or through the force of regulations, would, in effect, become relatively x-efficient so as to keep average costs competitive. In other words, the requirement or desire on the part of firm decision makers to become greener force them to reconfigure their firms into more x-efficient units of production so as to survive in a competitive market. Indeed, the higher productivity and environmentally friendly x-efficient firm might be characterized by the same average costs as the lower productivity x-inefficient and polluting firm if productivity and the costs associated with pollution abatement rise in an offsetting fashion. It would, therefore, be possible for the x-efficient firm to compete on a basis of more effective and cooperative work cultures that generate the higher levels of productivity required for the environmentally friendly firms to survive and even prosper in a competitive environment. Under these conditions, it is possible for there to exist, simultaneously in a competitive environment, an array of firms producing the same product, each firm characterized by an array of pollution abatement rates and related costs, and each firm characterized by an array of offsetting input productivities. In this scenario, the relatively heavily polluting firms will not have a cost advantage over the relatively environmentally friendly firms. Of course, it is possible that in a world of little x-inefficiency, the costs of reducing pollution will not be offset by reductions in the level of x-inefficiency, this being the world of the conventional neoclassical wisdom. Under these circumstances, efforts to reduce the level of pollution will increase the average costs of the greener firms and the analytical predictions of the conventional wisdom become operational. This point is illustrated in Fig. 1, where along the horizontal axis there is an array of firms characterized by different levels of pollution abatement, beginning with zero. In this figure, firms in the 0B range are producing their output at the same average cost, 0A as a result of the costs of increasing the level of pollution abatement being compensated by higher levels of x-efficiency. At a certain level of abatement, given by point B, average costs rise since input productivity can no long increase sufficiently to offset the rising cost of abatement, given technology.

There is no competitive advantage accruing to the polluting firm from engaging in a pollution abatement or green strategy if productivity increases just offset the firm’s pollution abatement costs, inclusive of those costs related to increasing the relative level of a firm’s x-efficiency. Adopting a green strategy then becomes a matter of prefer-
ence or taste amongst the managers and owners of the relatively x-inefficient polluting firms in the absence of environmental regulation. Clearly, becoming greener is not a free ride even when the increased costs of pollution reduction do not increase average production costs. Unlike in the Porter hypothesis, it is not stipulated here that adopting an environmentally friendly system of production is profitable in the sense of yielding increased profits or lower unit production costs. Failing to become greener, therefore, does not imply that owners and managers are somehow systematically ignoring economic opportunities for gain in a market economy. The latter is the fundamental dilemma posed by the Porter hypothesis to the conventional neoclassical worldview. In a world of x-inefficiency this dilemma would not exist and environmental regulations are afforded the opportunity to push the decision-makers of firms into adopting greener production processes that in the long run need not generate higher costs or lower profits.

4. Induced technical change and environmental regulation

The Porter Hypothesis maintains that firms can go well beyond adjusting the production process within the constraints of the prevailing technology so as to become greener without generating higher costs or lower profits. Applying a simple behavioral model of induced technical change, it can be shown that the Porter hypothesis may hold true without posing the dilemma to the conventional economic wisdom of producing profit opportunities that are systematically bypassed by the decision makers of the firm. Following in the tradition established by Hicks (1932) (see also Habbakkuk, 1962; Hayami and Ruttan, 1971; Binswanger,
In Fig. 2, capital and labor are the two factor inputs that comprise both $OI$ and $EI$. The latter are required to reduce pollutants. Capital and labor are mapped out along the vertical and horizontal axes, respectively. The initial equilibrium for marketed output is given by point A along isoquant $Q_1$. For pollution abatement to take place more $EI$ are required, and therefore, more capital and labor are required to produce a given level of marketed output. This is illustrated by a shift outward of the budget or isocost line from $BC$ to $BC'$ and of the isoquant from $Q_1$ to $Q_0$, where the level of output at $Q_1$ and $Q_0$ is equal. The new equilibrium is given by point E along $Q_0$. In other words, pollution abatement increases the average cost of marketed output, given by $Q_0$, as expected.

6 This discussion follows the argument developed in Altman (1996), Chs. 2 and 4.
more expenditure is required to produce a given level of marketed output. For average cost to remain unchanged with pollution abatement requires technical change or a reduction in the level of x-inefficiency such that the isoquant shifts from $Q_0$ to $Q_1$, where the level of output produced at $Q_1$ and $Q_0$ is equal. In this case, unit costs need not increase if pollution abatement induces a sufficient amount of technical change or increases in the level of x-efficiency to neutralize the cost of pollution abatement. However, such improvements in productivity also typically require and go hand and hand with improving the conditions of labor, resulting in increasing the relative price of labor, which is illustrated by increasing the slope of the isocost line from $B'C'$ to $B'C''$. Without further technological change and or further reductions in the level of x-inefficiency, the profit maximizing firm will adjust its input combination along ray 2, at $A^*$ of isoquant $Q_2$, so as to minimize unit cost. To produce the initial level of output given by isoquant $Q_1$ translates into producing marketed output, now with less pollution, at a higher unit cost — the isocost curve shifts outward along ray 2 to isoquant $Q_1$. However, this expected or realized increased cost of pollution abatement might induce further technological change, shifting the isoquant from $Q_1$ to $Q_2$, where the level of output at $Q_1$ to $Q_2$ is equal. The firm could then produce the original level of output at the original unit cost since isocost curves $B'C'$ and $B'C''$ represent the identical level of expenditure. The technological changes and reductions in the level of x-inefficiency are discussed here sequentially for illustrative purposes only and can be expected to take place simultaneously in response to the cost increases flowing from pollution abatement.\(^7\)

In this scenario, the relatively pollution intensive firm produces its marketed output at the same unit costs as the relatively green firm once technological change is introduced into the equation. From this perspective, the pollution intensive firm has no incentive to adopt the new technology if the new technology yields no unit cost advantage to the firm. Moreover, the old and new technologies are linked to specific and differential costs reflected in isocost curves $BC$ and $B'C'$. In other words, pollution abatement technology requires an investment in time, effort, and capital. In addition, if firms are required to become more x-efficient for the new technology to become cost competitive, it becomes even more costly for firms to adopt the greener technologies. For this reason, there would be no economic imperative, in the absence of regulation, for polluting firms to become greener, unless the preferences of the firms’ decision makers drove them in this direction. In effect, environmental regulations serve to induce environmentally related technological change. Only if the relatively green firms developed even more advanced technology, given by a shift in the isoquant from $Q_2$ to $Q_3$, where the quantity of output at $Q_2$ equals that at $Q_3$ and where the isocost curve shifts inward from $B'C''$ to $B'C''''$, would the unit cost of the greener firm drop below that of the more pollution intensive firm. In this case, market forces induce the pollution intensive firms to become greener.

At a more general level, Rosenberg (1982, p. 27), argues with respect to the process of technological change that, ‘...there is a threshold level at which the costs of the new technology become competitive with those of the old.’ For this reason, there need not be a widespread adoption of the new technology unless the production costs generated when using the new technology fall below those associated with the old. If the threshold level is not passed, only environmental regulation will result in the widespread adoption of the greener technologies. Moreover, if the threshold is not passed, the relatively pollution intensive firms would not be foresaking economic gain by avoiding greener technologies. Induced technological change adds another degree of freedom to the capacity of firms to become greener without causing unit production costs to rise or profit rates to fall. However, it bears repeating that even if greener technologies are cost competitive and do not cause average costs to increase, this in no way implies that the free market will force their adoption by polluting firms as long as

\(^7\)The notion that environmental regulations might induce technological change has been explored by Faucheux and Nicholaï (1998).
these firms, themselves, remain cost competitive and profitable. If the new technology is known to all firms and is not adopted by the pollution intensive firms, this represents a type of x-inefficiency in so far that the new technology yields a higher level of output than is possible with the old.

Although the existence of x-inefficiency and induced technological change provides the possibility of pollution abatement at no increased unit cost, this possibility is contingent upon the elasticity of productivity increases to increases in pollution abatement. The latter is, of course, an empirical question. However, the extent to which productivity must increase to prevent, for example, unit costs from increasing, depends not only on the percentage increase in pollution abatement costs, but also on the relative importance of these costs to the firm's total costs. In reality, abatement costs represent only one component of total costs such that introducing or increasing the stringency of environmental regulation need not increase unit production cost by much, even in the absence of cost offsets. In the absence of these offsets, the increase in average cost is given by the share of abatement or environmental costs to total costs multiplied by the percentage change in abatement costs. This is given by:

\[
\frac{\Delta AC}{AC} = \frac{EC}{EC + OC} \times \frac{\Delta EC}{EC}
\]

where \(AC\) is average cost, \(EC\) are the abatement or environmental costs and \(OC\) are the other costs. At one extreme, if abatement costs represent 100% of total costs, the doubling of such costs would increase average cost by 100% and output would have to increase by the same percentage to keep average cost from rising. If the environmental costs constituted 50% of total costs, the doubling of such costs would increase average cost by only a 50% unless output increased by the same percentage. If environmental costs share in the total falls to 3% — which is much closer to the stylized facts — the doubling of such costs results in a 3% increase in average cost and requires only a 3% increase in productivity as a cost offset. If the environmental costs increased by only 50%, average cost would increase by 1.5%, necessitating only a 1.5% increase in output as a cost offset. In effect, it is easier for firms to manage environmental regulations when these costs represent only a small percentage of total costs. Needless to say, introducing or tightening such regulations does not imply high or higher production costs, as long as labour productivity can be sufficiently increased. The probability of this occurring through reductions in the level of x-inefficiency and through induced technological change increases as the share of environmental costs in the total diminishes. And, the literature has documented that the share of these costs in the total is relatively small (Cropper and Oates, 1992; Jaffe et al., 1995).

5. Conclusion

A fundamental challenge to the Porter hypothesis posed by the conventional neoclassical world view is that it fails the Axiom of Minimum Greed that individuals, and corporate decision makers in particular, should take advantage of reasonable economic opportunities that the Porter hypothesis presumes are ever-present in the realm of pollution abatement. The conventional wisdom also takes issue with the view that environmental regulations can induce firms to behave more efficiently than they would otherwise in the free market. Following from the logic of this argument, it is assumed that environmental regulation must increase the private economic costs to firms and reduce their profits. Moreover, evidence that such regulation has typically not affected the competitive advantage of firms is attributed to factors unrelated to the firm’s capacity to offset the costs of pollution abatement.

Contrary to the conventional wisdom, in a world where effort discretion and, therefore, x-inefficiency exists, the decision makers within firms can be induced into becoming more efficient and productive and greener by environmental regulations. Firms can, therefore, be induced to produce more marketed output (‘goods’) and fewer pollutants (‘bads’). In the model presented in this paper, rational profit maximising firms can be expected to avoid greener systems of production
and greener technologies if they only serve to offset the costs of pollution abatement. On the other hand, if being green yields lower unit costs of production than are generated by the relatively pollution intensive firms, one would expect, as predicted by conventional theory, that the greener firms will drive out of business their environmentally derelict counterparts. In this case, there would be no need for environmental regulations. However, on theoretical grounds there is no reason not to expect that decision makers will avoid becoming greener if such a transformation is a costly process — it is not a free ride — and it only serves to offset such private costs, leaving the decision makers no better off economically than they were from the get go. However, the costs to society from such evasion is not only a higher level of pollution, but a less efficient (more x-inefficient) economy than is necessary. This is apart from the loss of well-recognised social benefits accruing from pollution abatement. Under these circumstances environmental regulations serve to induce both a more efficient and greener economy.

Acknowledgements

I would like to thank three anonymous referees plus David Hanly and Louise Lamontagne for their comments and suggestions, as well as participants of the The Environment Oxford Conference — Third Annual Public Policy and Social Science Conference, Oxford University, June 1999, and of the Third Biennial Conference of the Canadian Society for Ecological Economics, University of Regina, August 1999. The standard caveat applies.

References


