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Competitive investment in clean technology and uninformed green consumers

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ABSTRACT

In a market where consumers and the regulatory authorities are not fully informed about the actual production technology or environmental performance of firms that engage in strategic competition, I study the effect of environmental consciousness of consumers on firms' incentive to invest in cleaner technology. Firms compete in prices and may signal their environmental performance to uninformed consumers through prices. I also analyze the effect of an expected liability on firms in this setting. Compared to full information, incomplete information generates higher strategic incentive to invest in cleaner technology particularly when consciousness and/or expected liability are not too high. Requiring mandatory disclosure of technology or environmental performance may discourage such investment. Even though consumers and the regulator are uninformed, competition has a positive effect (relative to monopoly) on the incentive to invest.

Introduction

Environmental consciousness among consumers (i.e., their willingness to pay for the product produced with lower environmental damage) is an important market force that can create incentives for firms to invest in the development and adoption of cleaner technology. Environmental groups often argue that the efficacy of green consumer consciousness as a device to discipline the environmental performance of firms is sharply limited by the availability of information. In particular, the fact that consumers are largely uninformed about the actual production technology or process and therefore, the actual environmental performance of firms, implies that the effect of green consciousness on profit maximizing firms' technology choice may be limited. This is particularly relevant in markets where there are no reliable voluntary disclosure mechanisms (such as eco-labeling or credible third party certification[1]) that enable at least partial disclosure of the actual technology or environmental performance of firms. This would appear to suggest the need for mandatory disclosure of

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[1] Karl and Orwatt (2000), Dosi and Moretto (2001), Sedjo and Swallow (2002), Mason (2006), and Grolleau and Ibanez (2008) show that some information about environmental performance of a technology can be revealed by eco-label or third party certification.

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information[2] about technology or production process used by firms to promote investment in cleaner technology. This paper is an attempt to critically examine the theoretical basis of this claim.

While consumers may not have direct access to information about the nature of actual technology or production process used by firms, as rational agents they may *infer* such information from the observed conduct of firms in the market such as pricing. Indeed, the possibility of such inference creates incentives for firms to signal their private information (in a credible manner) and the incentive to signal, in turn, modifies the market behavior of firms and the market outcome relative to that in a world of full information. When firms evaluate their profit from investment in cleaner technology, they foresee the signaling outcome in the market in the post-investment phase and evaluate the profits generated in that outcome. The efficacy of consumer consciousness on technological change under incomplete information is then based on the signaling outcome. In order to argue for or against mandating direct disclosure of information, we need to compare the investment outcome under full information to that generated in a market where uninformed consumers infer the information from the observable behavior of firms.

The main contribution of this paper is to argue that when firms engage in strategic competition and signaling in the market, the incentive to invest in cleaner technology is generally *higher* when consumers and regulator are ex ante uninformed compared to that under full information. In other words, the lack of information about firms' actual production technology may not inhibit and in fact, may enhance the efficacy of consumer consciousness in inducing greener technological change. From this point of view, the paper suggests that there is not much of a case for mandatory disclosure law.

In this paper, I consider environmental regulation in the form of a liability structure[3] which ensures that a firm has to pay penalty for the environmental damage caused by its own production technology once the damage becomes observable. Even though the regulator and the consumers cannot anticipate whether a firm's production technology will create environmental damage in the future, the firm may be well aware of its own risk of environmental damage. Thus, the expected penalty or liability payment faced by the firm enters its expected marginal cost of production. This, in turn, implies that liability rule creates an additional incentive for firms to invest in cleaner technology. Alternatively, the anticipated liability payment can be also interpreted as a threat of future environmental regulation like emission tax or permit after policy makers become aware of the actual environmental damage caused by the firms. The stringency of this anticipated liability is assumed to be exogenously determined by the regulatory authorities.[4] An important contribution of this paper is that it offers an analysis of the interaction between anticipated liability and consumer consciousness when consumers and regulatory authorities are uninformed, and the circumstances under which they are complementary in inducing the technological change.[5]

I consider an imperfectly competitive industry where two firms compete in prices. A fraction of consumers are environmentally conscious and are willing to pay more for the product produced with a technology that poses lower environmental risk. The production technology of a firm can be of two potential types *dirty* and *clean*. Firms are initially endowed with a dirty technology and may invest in the development of a cleaner production technology where the outcome of investment i.e., whether the realized production process is clean or dirty, is intrinsically uncertain. The latter may reflect uncertainty about the success of the project or the environmental impact of the new technology. Investment is observed publicly but not the realized technology. Thus, a non-investing firm and an unsuccessful investing firm face an anticipated liability payment whereas an investing firm that has successfully adopted the clean technology does not incur any expected cost of regulation. In the next stage, firms with private information about their realized technology set prices competitively. In particular, firms may signal the environmental attribute of their production technology to uninformed consumers through prices.[6]

The signaling and market competition stage of the model in this paper is closely related to models of signaling product quality in the presence of price competition in an oligopoly.[7] The underlying competitive signaling game in this paper draws on the specific model of Janssen and Roy (2010), but introduces a particular type of heterogeneity among consumers. Note that the focus of this paper is on the incentive to invest in technological change generated when firms signal private information about technology rather than the possibility of signaling. Further, unlike the quality signaling literature that often assumes symmetry between firms, analyzing the incentive to invest requires evaluation of market outcomes in asymmetric situations where one firm invests and the other does not.

There is a large theoretical literature on the effect of consumer consciousness on production technology and environmental performance of firms when there is no information problem between consumers and firms.[8] In particular, Moraga-Gonzalez and Padron-Fumero (2002) analyze the effect of different environmental policies on the aggregate emissions and welfare when two

[2] Following are few examples of mandatory disclosure such as Toxic Release Inventory (USA), Environmental Reporting Decree (the Netherlands), Green Accounts (Denmark), and Pollutant Release and Transfer Register (UK).

[3] US's the Comprehensive Environmental Response, Compensation and Liability Act of 1980, Superfund Amendments of 1986, and EU's Environmental Liability Directive are few examples of liability rule.

[4] Sergerson and Miceli (1998) note that the threat of environmental regulation may depend on many external factors such as political support.

[5] Eriksson (2004) illustrates the existence of complementarity between environmental regulation and consciousness when consumers are aware of the environmental performance of firms.

[6] Hwang et al. (2006) find that consumers use price as a signal of the quality of genetically modified food (corn, bread, and egg).

[7] Unlike much of this literature, in this model, the effective marginal cost of production depends on the level of exogenously given expected environmental liability, and for significantly higher level of liability, the clean type has lower effective marginal cost of production compared to the dirty type. Thus, lower price may signal better "quality".

[8] See among others Cremer and Thisse (1999), Arora and Gangopadhyay (2003), Bansal and Gangopadhyay (2003) Anton et al. (2004), Conrad (2005), Deltas et al. (2013), and García-Gallego and Georgantzís (2008).