Optimal Regulatory Instruments for a self – polluting firm in the presence of water pollution

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Abstract

The paper emphasizes of profit maximizing firms that produce output (with water being an important input in the production process), and generates a negative externality like pollution in water resources. Such quality degradation in the water input affects, inevitably, the production of firm in the forthcoming period. In order to capture this, the paper envisages the existence of two types of firms, namely, *myopic* and *visionary*. The myopic firm is one that maximises its profit function without considering the impacts for the future period. One the other hand, the visionary firm maximises its profits by considering the entire planning horizon of its existence. The paper argues that *better* decision in terms of resource use and profit is taken by the visionary firm, as compared to the myopic firm. The paper has been attempted in the context of industries like textile, paper and pulp, which creates an adequate amount of water pollution using water as an essential input in the production process. Thus, the paper presents a theoretical framework for regulating the polluting behaviour of the firms in water polluting industries.

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1. Introduction

Water pollution through emissions by firms is a matter of prime concern in today's world. The increasing awareness and concerns over water pollution have led to the development of new approaches towards achieving better management of water pollution, water quantity globally. However, economic instruments, as modes of regulation, have rarely been put forward in developing countries, and if at all implemented, they have been applied primarily on an ad-hoc basis, without proper economic rationale. Command and control measures still remain the basis of pollution control in developing countries {Ghosh. N – Forthcoming (in press)}.

This paper relates to a framework, which shows how a representative firm, being visionary, can actually take a better decision on water use, as compared to the condition of being myopic. In this structure of environmental regulation, a firm faces a supply constraint on environmental services in the form of prescribed standards for the effluent quality. The effluent standards are normally fixed such that the demand for the services of environmental resources like water does not exceed the natural sustainable level of supply. The firm has to spend some of its resources to reduce the pollution loads to meet the effluent quality standards. The firm with a resource constraint will have lesser resources left for the production of its main product after meeting the standards. Therefore, the opportunity cost of meeting these effluent quality standards is in the form of a reduced output of the firm. If all the firms in the industry meet the standards, the value of the reduced output of firms is the cost of sustainable industrial development. The entry point of research is from the point that in a given situation a firm using water as an input in its production process (with the objective of profit maximization process) faces a situation where the demand for the services of environmental resources like water does not exceed the natural sustainable level of supply which is available to the firm at each point of time. The first section of the paper highlights about the literature review which has been done for deriving the modeling approach. The second section of the paper deals with the *entry point of the research*, *selection of the variables for the model*, *definition of* *the myopic, visionary firms, theoretical model* followed by the final section of the paper which illustrates some of the interesting corollary of non – mandatory approaches to regulation which could be linked to the theoretical modeling.

2. Literature Survey

Literature, however, has been replete of frameworks dealing with economic instruments, like valuation of water pollution. While initial attempts date way back in the 60s, it was in the early eighties that the impact of environmental regulation on the economic performance of firms started being conducted. The ultimate aim of these studies has been to measure the effect of pollution regulation on total factor productivity growth (TFP). The absolute shadow prices of the undesirable outputs reflect the opportunity cost, in terms of foregone revenue, for an incremental increase in the use of water and water pollution.

The United Nations Manual (2003) of System of Environmental and Economic Accounting (SEEA) provides descriptions of maintenance cost or cost of sustainable use of environmental resources. According to SEEA, there are two major valuation techniques namely cost based valuation method and damage based valuation method. Costs based valuation techniques are based on the costs of mitigating and abating environmental damages from production processes. According to SEEA there are three ways in which emissions polluting water by water- using firms can be controlled. Steps can be taken to avoid the emissions in the first place, either by abstaining from the activity or by substituting less damaging inputs. The second solution is to procure, treat the emissions and to make them less harmful. The third option is to restore the environment by means of clean-up activities.

A number of recent studies have tried to value environmental damage especially based on pollution from firms. Fare et al. (1993) have used output distance function approach to derive shadow prices for air pollutants for USA. They showed how to adjust efficiency measures in the presence of undesirable outputs and also how to estimate output distance functions as frontiers in order to generate shadow values of the undesirable outputs that are required to make both types of adjustment. Coggins & Swinton (1996) estimate the shadow price of SO_2 abatement for Wisconsin coal burning utility plants, USA. There has been attempt to estimate the costs of abating nitrogen pollutants by linking costs for construction of wetlands to the de-nitrification capacity of wetlands for Sweden. Results demonstrate that the wetlands have the capacity to provide low cost abatement of nitrogen compounds in runoff.

Empirically testing of pollution abatement efforts of Chinese industries in response to pollution regulations, especially the pollution charge instrument practiced in China for about 20 years. The results show that the plant-level expenditure on end-of-pipe wastewater treatment is strongly responsive to the pollution charges. The estimated elasticities of operation cost and new investment with respect to the pollution price are 65 and 27% respectively. In India Murty & Kumar (2002) have estimated the cost of water pollution abatement of the Indian water polluting industries.

A number of recent studies have also explored the relationship between economic development and environmental quality. Transition paths for pollution, abatement effort and development under alternative assumptions about social welfare functions, pollution damage, the cost of abatement, and the productivity of capital have been developed in the recent years. Empirical studies have searched for systematic relationships by regressing cross-country measures of ambient air and water quality on various polynomial specifications of income per capita. Overlapping generations' economy has been used in water pollution studies in which young individuals choose between investing in physical capital or in environmental maintenance. Each period, firms buy non-tradable permits of emissions from the government. The proceeds are redistributed to young households. The study shows that environmental maintenance may be positive or zero at equilibrium. In the business-as-usual economy, the higher capital accumulation, the lower environmental quality. In equilibria with permits sales and no maintenance, the dynamics of capital and those of environment is independent. If maintenance is also operative, capital and environmental quality move together, i.e. the economy may become wealthier and cleaner. The analysis has been carried out with both instruments – permits and maintenance – when the economy lies initially at business-as-usual steady state. It has been seen in this case that there always appears an immediate gain in environmental quality. However the magnitude of this gain is not always maintained in the long run.

3. Entry Point of this Research

The basic premise with which this modeling analysis begins is that the endowment of water is available and given at any point of time. The modeling makes a simplistic assumption that with an acute water scarcity the water availability is always given for the firms which are using water as their input and the water demand by the firms never exceeds the water availability. The water availability is thus not dependent on time in our modeling framework. The condition is just like as if the firms are being imposed and forced into a situation where water is being given to them and they have to utilize the given amount of water, which is available to them.

3.1 The Model

Selection of the variables:

The independent variable used in the model as an input is the water quantity used in the production process. The only variable which is an independent variable in the modeling functional framework is the water used in the production process. Although the model deals with water polluting and water using firms, no variable capturing water quality has been incorporated into the model. The reason behind it is the fact that the model works on the premise of the assumption that larger the firms are more is the water used for generating outputs which means greater impact on the water quality by these water using firms. There is hence a correlation between the water quantity used and the impact on the water quality by the water polluting firms as they produce the outputs which generate the revenue for them. In order to avoid any multicollinearity problem between the input variables in the model only one variable which is water quantity has been taken into the model. Water quality has been not taken in the model as it is implicit in the assumptions of the model that larger the water used by a firm for generating its output greater is its polluting impact on the quality of the water which the literature mentioned above on water polluting behavior of firms using water also justifies.

3.2 *Definition of myopic and visionary firm*

Given this set up of the model the next task is to define what is a myopic and a visionary firm in the context of the model. A myopic firm is a firm which maximizes its profit by producing the output using water with the given endowment of water but fails to discount the impact of its input usage on the water degradation and hence on water quality which thereby impacts its productivity and hence its profits too in the long run. In this model there are only two periods for simplicity. So a myopic firm doesn't discount the pollution and the negative impact on water degradation, quality (through water pollution) created by the firm in the first period which affects its output, productivity, profit in the second period. But the visionary firm could visualize this possible impact of water degradation and on water quality (through pollution) in the first period and hence discounts the second period profits while taking its profit maximization decision in first period. So a visionary firm manages its inputs more efficiently although both the myopic and visionary firm produces with the objective of profit maximization. Thus the visionary firm manages the inputs more efficiently and realizes more profits in two periods by producing in an environmentally sustainable way (i.e. creating less impact of water degradation and water pollution).

4. The Theoretical Framework

4.1 There are two firms in the model viz. myopic and visionary. The assumptions for the models are as follows:

1. The firms specialize on a single product.
2. The firms use labour (L), capital (K) and water (W) as inputs for production.
3. Production is carried out in two distinct time periods viz. period1 and period2.
4. The objective of the firm is to maximize profits in both the periods.

The output of the firms is denoted by Y. As the production takes place water is used in the process which results in degradation of water quality. Given initial water endowment, in the absence of the pollution treatment plant, less usable water will be available in later stages of production. The degradation of water is assumed to be a function of output which is defined as ϕ (Y), such that, $\phi^{'}(Y) > 0$, $\phi^{''}(Y) > 0$. This means that with increase in production there will be degradation of water and the rate of degradation will be will be faster with increase in production. Let Y_i denotes the total output produced at the end of i^{th} period. Therefore total degraded water at the end of i^{th} period is given by $\phi(Y_i)$. Assuming 'i' to be one, the total degradation at the end of first period is $\phi(Y_1)$. So usable water available at the beginning of the second period is given by -

- $\hat{W} - \phi(Y_1)$, (where $\hat{W}$ is the water purchased in the first period)

Let us define a treatment technology such that if a unit of effluent water goes for treatment then 'η' unit of treated water is obtained from the process. It is assumed that $0<\eta<1$. If $\phi(Y_1)$ amount of waste water is generated in period 1 then total water available at the beginning of period2 is given by –

$$\hat{W} - \phi(Y_1) + \eta\{\phi(Y_1)\} \text{ (where } 0<\eta<1 \text{)}$$

Here η is defined as the degree of efficiency of the treatment process.

The cost of setting up the treatment plant is defined as

$$C = \alpha + \beta\, \phi(Y) \text{ ------------------------------ (1)}$$

(Where α denotes the fixed capital cost and $\beta\, \phi(Y)$ the varying cost component of the total cost function. Here β denotes the unit cost of treatment of water.)

The analysis starts with the production of myopic firm. The production function of the myopic firm in period1 defined as

$$Y_1^m = f_1^m (W, L, K) \text{ -------------------------------------- (2)}$$

The cost function that the myopic firm faces is

$$C = gL + rK + p_w \hat{W} \text{ --------------------------------------- (3)}$$

Here $g>0$ is the wage rate, $r>0$ the rate of return to capital and $p_w>0$ the unit cost of procuring water for production. Now given the production function and cost function the profit function is defined as

$$\pi_1^m = f_1^m (W, L, K) - (gL + rK + p_w \hat{W})$$

The constraint that the firm faces is that the degraded water cannot exceed the total water available during the first period. Therefore

$$\phi(Y_1) - \hat{W} \leq 0 \text{ ----------- } (4)$$

$$\text{i.e. } \phi(Y_1) \leq \hat{W}$$

$$\text{i.e. } \phi(f_1^m (W, L, K)) \leq \hat{W}$$

The Lagrange function for the myopic firm is given by

$$L = f_1^m (W, L, K) - (gL + rK + p_w \hat{W}) + \nu_1^m (\hat{W} - \phi(f_1^m (W, L, K)) \text{ ----- } (5)$$

Here ν_1^m is Lagrange multiplier and is defined as the shadow value of water in period 1.

In (5) we replace $\phi(f_1^m (W, L, K))$ with $F_1^m (W, L, K)$.

Following the definition of $\phi(Y)$,

$F'^m_1 (W, L, K) > 0$ and $F''^m_1 (W, L, K) > 0$.

Now differentiating relation (5) with respect to W and equating it to zero (from first order condition of maximisation) we have

$$\partial f_1^m / \partial W = \nu_1^m \, \partial F_1^m / \partial W$$

$$\text{i.e. } f'^m_1 (W, L, K) = \nu_1^m F'^m_1 (W, L, K)$$

$$\text{i.e. } \nu_1^m = f'^m_1 (W, L, K) / F'^m_1 (W, L, K) \text{ ------------------ } (6)$$

For period 2 the profit function of myopic firm is given by

$$\pi_2^m = f_2^m (W, L, K) - (gL + rK) \text{ ------------------------ } (7)$$

Again in period 2 the degradation of water cannot exceed the total water available. Therefore

$$\hat{W} - \phi(f_1^m (W, L, K)) \geq \phi(f_2^m (W, L, K))$$

Now replacing $\phi(f_1^m (W, L, K))$ by $F_1^m (W, L, K)$ and $\phi(f_2^m (W, L, K))$ by $F_2^m (W, L, K)$ we have

$$\hat{W} - F_1^m (W, L, K) \geq F_2^m (W, L, K) \text{ ----------------------- } (8)$$

The Lagrange function is given by

$L = f_2^m (W, L, K) – (gL + rK) + \nu_2^m [\hat{W} – F_1^m (W, L, K) - F_2^m (W, L, K)]$ –

(9)

ν_2^m is the shadow price of water in period 2.

Differentiating (9) with respect to W and equating with respect to zero we have $\partial f_2^m / \partial W = \nu_2^m \partial F_2^m / \partial W$

$f'_2{}^m (W, L, K) = \nu_2^m [F'_1{}^m (W, L, K) + F'_2{}^m (W, L, K)]$

i.e. $\nu_2^m = f'_2{}^m (W, L, K) / [F'_1{}^m (W, L, K) + F'_2{}^m (W, L, K)]$ ----- (10)

Assuming marginal product of water and the rate of degradation of water to be same (i.e $F'_1{}^m (W, L, K) = F'_2{}^m (W, L, K)$) in both the periods, equations (10) takes the following form as

$\nu_2^m = f'_1{}^m (W, L, K) / [2F'_1{}^m (W, L, K)]$ -------------- (11)

Comparing equations (6) and (11) it is evident that shadow price of water in period 2 is less than period 1. Now what is the definition of shadow price in our case. It is the rate at which the profit will increase when there is a unit relaxation in the constraint i.e. more availability of water for production. This rate is less in the period two compared to period 1. Because of the non-availability of proper treatment facility, less water is available in period two thus reducing the scope of increased production and profit. Next we consider the visionary firms production process. We have defined a visionary firm as a firm who discounts the future period's profit in the current period. We define the production functions for the visionary firm in period 1 and 2 as

$Y_1^v = f_1^v (W, L, K)$ and $Y_2^v = f_2^v (W, L, K)$.

The profit functions for the firm be defined as

$\pi_1^v = f_1^v (W, L, K) – (gL + rK + p_w \hat{W})$

$\pi_2^v = f_2^v (W, L, K) – (gL + rK)$

Given that the firm is visionary in nature, it discounts the second period's profit in the period 1 and hence the total profit function in period 1 is given by $= \pi_1 + \pi_2 / (1+\rho)$, ($\rho$ being the discount factor). The constraint that the firm faces is that the degraded water cannot exceed the total water available during the first period. Therefore

$\phi(Y_1) - \hat{W} \leq 0$

i.e. $\phi(Y_1) \leq \hat{W}$

i.e. $\phi(f_1^v (W, L, K)) \leq \hat{W}$

In period – 1 the visionary firm's Lagrange function is given by

$$L = \pi_1 + \pi_2/ (1+\rho) + \nu_1^v (\hat{W} - F_1^v (W, L, K)) \text{ ---------- } (12)$$

$\partial L/\partial W = 0$ (maximising condition)

Therefore, $\partial\pi_1/\partial W + \partial\pi_2/\partial W^* (1/1+\rho) = \nu_1^v F'_1{}^v (W, L, K)$

i.e. $[\partial\pi_1/\partial W + \partial\pi_2/\partial W^* (1/1+\rho)] / F'_1{}^v (W, L, K) = \nu_1^v$

i.e. $\nu_1^v = [(2+\rho)/(1+\rho)](f'_1/ F'_1)$ ------- (13)

Comparing the shadow value in (13) with that of (6) and (11) and assuming same functional forms for production and water degradation functions, we see that shadow value for the visionary firm is greater than the myopic firm. In other words a unit relaxation in the constraint i.e. more availability of water, will result in an increase in the profit rate of the visionary firm compared to that of the myopic firm.

Till now we haven't discussed the treatment process and costs for the visionary firm. Let us assume that the visionary firm invests for setting up a treatment plant at the beginning of period1. We have defined the production functions for the visionary firm in period 1 and 2 as

$$Y_1^v = f_1^v (W, L, K) \text{ and } Y_2^v = f_2^v (W, L, K).$$

The different costs that the firm faces in the production process are labour cost, capital costs and the water treatment costs. The initial capital investment for water treatment at the beginning of period 1 is defined as 'α'. Hence the total treatment cost in period 1 is given by $\alpha + \beta^*F_1^v (W, L, K)$ and in period 2 as $\beta^*F_2^v (W, L, K)$, where F_1^v and F_2^v are the total degraded water in period 1 and 2 respectively. The total profit functions in different periods are as follows

$$\pi_1^v = f_1^v (W, L, K) – (gL +rK + p_w \hat{W}) - \alpha - \beta^*F_1^v (W, L, K) \text{ ----- } (14)$$

$$\pi_2^v = f_2^v (W, L, K) – (gL +rK) - \beta^*F_2^v (W, L, K) \text{ ------------ } (15)$$

As already mentioned, the firm is visionary in the sense that it discounts the second period's profit in the period 1. So the total profit function in period 1 is given by = π_1+

$\pi_2/(1+\rho)$, (where ρ is the discount factor). The constraint that the visionary firm faces in period 1 is that the total treated water cannot exceed the initial water available. There fore

$$\eta\phi(Y_1) - \hat{W} \leq 0$$

$$\text{i.e. } \eta\phi(Y_1) \leq \hat{W}$$

$$\text{i.e. } \eta\, F_1^{v}(W, L, K) \leq \hat{W} \text{ ------------------------------------ (16)}$$

In period – 1 the visionary firm's Lagrange function is given by

$$L = \pi_1 + \pi_2/(1+\rho) + \nu_1^{v}(\hat{W} - \eta\, F_1^{v}(W, L, K))$$

$$\partial L/\partial W = 0$$

$$\partial\pi_1/\partial W + \partial\pi_2/\partial W^* (1/1+\rho) = \nu_1^{v}\, \eta\, F'{}_1^{v}(W, L, K)$$

$$\nu_1^{v} = [\partial\pi_1/\partial W + \partial\pi_2/\partial W^* (1/1+\rho)] / \eta\, F'{}_1^{v}(W, L, K) \text{ --------- (17)}$$

Taking derivates of equations (14) and (15) and putting in (17) gives us

$$\nu_1^{v} = [\{f'_1 + (f'_2/(1+\rho))\} - \beta\{ F'_1 + (F'_2/(1+\rho))\}] / \eta\, F'_1 \text{ ------- (18)}$$

Assuming $f_1 = f_2$, $F'_1 = F'_2$ we have

$$\nu_1^{v} = [\{(2+\rho)/(1+\rho)\}^* f'_1 {}^*(1/ F'_1) {}^*(1/\eta) - (\beta/\eta)\{(2+\rho)/(1+\rho)\}]$$

$$\Rightarrow \quad \nu_1^{v} = (2+\rho)/(1+\rho)^* (1/\eta)\{(f'_1 / F'_1) - \beta\}$$

So from the model we have the following shadow values, which are –

For the myopic firm we have –

$$\nu_1^{m} = f'{}_1^{m}(W, L, K) / F'{}_1^{m}(W, L, K)\text{………… (period – 1)}$$

$$\nu_2^{m} = f'{}_1^{m}(W, L, K) / [2F'{}_1^{m}(W, L, K)]\text{…………..(period – 2)}$$

For the visionary firm we have two set of shadow values which are –

$$\nu_1^{v} = [(2+\rho)/(1+\rho)](f'_1/ F'_1) \text{ (With no water treatment costs)}$$

$$\nu_1^{v} = (2+\rho)/(1+\rho)^* (1/\eta)\{(f'_1 / F'_1) - \beta\}\text{(With water treatment costs)}$$

As $\eta < 1$ and $\{(2+\rho)/(1+\rho) * (f'_1/F'_1)\}$ is greater than (f'_1/F'_1)

$\nu_1^m > \nu_2^m$, $\nu_1^v > \nu_1^m$ and $\nu_1^v > \nu_2^m$ …………………(A)

However in case of the visionary firm we have two cases where –
$(2+\rho)/(1+\rho) * (1/\eta) \{ (f'_1/F'_1) - \beta \} > [(2+\rho)/(1+\rho)](f'_1/F'_1)$
or $(2+\rho)/(1+\rho) * (1/\eta) \{ (f'_1/F'_1) - \beta \} < [(2+\rho)/(1+\rho)](f'_1/F'_1)$

⇨ $\eta < (1 - \beta * \{F'_1/f'_1\})$ or $\eta > (1 - \beta * \{F'_1/f'_1\})$…… (B)

The equilibrium value of η would be-
$\eta = 1 - \beta * \{F'_1/f'_1\}$

So the model shows that we could have differences amongst the shadow values of the visionary firms depending on the firm specific factors of treatment costs, marginal cost of treating water, nature of production and marginal productivity (relation – B above).

4.1 ***Economic Explanation of the inequality (A) –***

The myopic firm (in comparison to the visionary firm) does not use the inputs efficiently and degrades the water level and hence effects the water quality too which is shown by the shadow price of the water quantity. The reduction in the value of the shadow value of the myopic firm shows that the production of the myopic firm is not done efficiently and with the objective of profit maximization the firm uses more water inputs and degrades the water quantity and water quality too there by creating an impact on the sustainability of environment as an outcome of the profit maximizing objective which raises the scope for regulation for these myopic firms.

5. Analysis of the result:

The results above shows that the shadow price of the myopic firm in period – 2 is lesser than the shadow price of the myopic firm in period –1. This implies that the benefit for each unit of resource exhaustion is lesser for the myopic firm in the period – 2 compared to period – 1. For the visionary firm without treatment the shadow value is higher (higher scarcity rent) implying lower use of water and higher benefit in comparison to the water use. However the interesting observation, which arises, is in the case of visionary firm with treatment, which shows a lower shadow value of water. This implies higher use of water as the same water is treated (implying less impact on the resource pollution) and used. This increases the marginal cost at a proportionately higher rate in comparison to the revenue implying an increase in the profit at a decreasing rate. Hence in this case the profit goes up (at a decreasing rate) but the resource exhaustion, pollution is less as well as the scarcity created by the production process on the resource is less. This means there is a higher social welfare in case where the visionary firm incurs a treatment cost through installation of treatment plant. The next section discusses some of the ways of how such resource pollution, exhaustion could be regulated through non – mandatory approaches to regulation by creating peer pressure through information dissemination in the stock market.

6. Corollary to the Model: *Way to Non – Mandatory Approaches to Regulation to control firm behavior regarding pollution*

The above results clearly bring out some interesting results with regard to regulation. The theoretical model shows that in case of the visionary firm with a treatment facility (hence incurring a treatment cost) the profit goes up but the resource exhaustion, pollution is less as well as the scarcity created by the production process on the resource is less thereby generating a higher social welfare. Thus the objective of the regulator could be to attain this state where firms are being incentivized or peer – pressured to attain this state where there is a higher social welfare. One of the ways of doing it is by through dissemination of information of firm regarding their resource use and exhaustion and also the impact of the firm behavior on the resource pollution. The firms could be incentivized to behave like the visionary firm with the treatment facility in our model by indexing their stock market share value to the behavioural patterns of the firm with regard to resource pollution and exhaustion. The previous empirical literature on why firms pollute has focused on the question of whether or not the firms comply with the government regulatory standards. The theory dealing with the linkage between the probability of a firm complying with environmental regulation and the probability of being detected and being penalized for non – compliance has shown that in the context of environmental regulation specifically dealing with pollution control the polluting firms respond to marginal incentives like higher penalties and more monitoring and enforcement. The non – mandatory approach to environmental regulation deals with the voluntary compliance of the polluting firms where peer pressure from the shareholders of the polluting firm, public pressure through information dissemination could create a compliance situation where the firms would voluntarily comply to the environmental standards being set by the pollution control agency. The model developed here could be linked to the voluntary compliance mechanisms of the firms with regard to environmental regulation. The economic instruments (shadow prices) derived through the modeling would act as the basic source of information, a signal of the level of performance of the firm, and could be considered for environmental pollution compliance. Basically the economic instruments (the shadow prices) that came out of the model would be the basic source of information in designing and benchmarking the performance level of the polluting firms. The power of information would thereby create a pressure on the firms to voluntarily comply with the environmental standards. It has been seen that in case of large publicly traded companies it is in the shareholder's interest that the pollution is reduced voluntarily by the firms. Harford (1994)[4] has stated "individual diversification of assets among firms dilutes each person's financial gain from a firm's pollution". However this theory of shareholder's pressure and public pressure on the voluntary compliance of firms with environmental standards and regulation has been tried in U.S.A for long. In 1986 Congress passed the Emergency Planning and Community Right – to – Know Act requiring the manufacturing establishments to publicly disclose the quantity and quality

[4] Harford, Jon D., "Firm Ownership Patterns and Motives for Voluntary Pollution Control", 18 Journal of Managerial and Decision Economics, pgs. 421- 432, 1997

of toxic chemicals released into the environment. Research on " Toxic Release Inventory (TRI)" by Hamilton (1995) [5] has showed that publicly traded firms reporting TRI releases in the stock market experienced statistically significant negative abnormal stock returns. The implication of the drop in stock return was because of the drop in the stock prices. The reason behind a drop in the stock prices was found to be investors updating their expectation of future pollution -related expenditures or liabilities (e.g. expecting a higher probability of future risk of regulation and exposure to other regulatory measures) which would reduce the firm's future profitability. A study by Konar and Cohen (1997)[6] on effect of stock price reductions on firm behaviour because of disclosure of pollution emission shows that a significant stock price reduction upon disclosing TRI emissions reduced the emissions of the firms disclosing the information compared to their peers. The pertinent question which arises is that why would a firm be concerned and worried about the release of information related to its environmental performance. The literature on this aspect has shown that larger firms having more reputation capital are bound to loose in the event of bad environmental publicity. Moreover larger farms are often biggest polluters of the resources too. The larger and more reputed the firm is it would be subject to greater public scrutiny by community and the public interest groups. The firms would have more at stake considering the effect of the negative publicity. This can be in the form of an expanding firm, which may find that their environmental reputation affects their ability to obtain favorable zoning and tax treatments when they move into new areas of location for operation. Thus it has been seen that ceteris paribus, larger firms are more likely to reduce emissions subsequent to being required to release information to the public about their toxic emissions. This model aims to address that the shadow prices derived from the modeling framework would be used in deriving a disclosure information linked to the stocks of the firms trading in the stock market and the shadow price would be a signal which would create a peer pressure for the water resource degrading and polluting firms to perform in a more efficient manner in terms of balancing its production with the resource degradation and pollution. This information dissemination would hence

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[5] James T. Hamilton, "Pollution as News: Media and Stock Market Reactions to the Toxic Release Inventory Data," 28 Journal of Environmental Economics and Management, pg. 98, 1995

[6] Konar, Shameek and Mark A. Cohen, "Information as Regulation: The Effect of Community Right to know Laws on Toxic Emissions," 32 Journal of Environmental Economics and Management, Pgs. 109 – 124 (1997)

provide a pathway towards sustainable development. The literature on the voluntary compliance and non – mandatory approaches to environmental regulation has shown that firm level pollution varies because of both firm – specific factors (such as age of firm assets, financial liability of firms) and firm – level incentives (such as community pressures or effect on brand name reputation). It has been seen from the literature[7] that the largest firms are most likely to reduce emissions in response to the disclosure of the information regarding environmental performance of the firms in the stock market. The literature on this has shown that financial ability of the firms also plays an important role in the environmental performance of the firms as firms constrained with cash flow positions are often least likely to comply with the environmental regulation which thereby imparts a negative impact on the environmentally sustainable performance of the firms. The paper hence addresses that one of the ways of creating a voluntary compliance for the water polluting and water using firms would be to link the share price value of these water using polluting firms to the shadow prices derived from the model which would be a signal of information to the public about the environmental performance and the efficiency level of the firms with respect to their profit maximization behaviour visa – vis its effect on the environmental resource (water) through quantity and quality degradation which is very important from the perspective of new dimensions of regulation for sustainable development.

7. Conclusion: The paper addresses the important issue of regulating myopic and visionary firms through the use of economic instruments in order to progress in the path of sustainable economic development. The paper illustrates about the differences in the shadow values of the two different types of firm (viz. myopic, visionary) which (shadow values) could be used in designing the regulatory economic instruments. One way of it would be to link the share value (by benchmarking) of the water using and water polluting firms in the stock markets to the respective shadow values. The model clearly illustrates that for visionary firm because of a favourable shadow price the share prices

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[7] Konar, Shameek and Mark A. Cohen, " Why do Firms Pollute (and Reduce) Toxic Emissions" Background Document of Conference on Economic Aspects of Environmental Compliance Assurance", 2nd – 3rd December, 2004, PARIS, France

would be having a greater value in the stock market compared to the myopic firm. But one interesting case which comes out is that within the section of the visionary firms as the shadow values might differ because of firm specific different water treatment costs, fixed costs, marginal productivity it would have a chance to effect the share prices of the respective visionary firms in the stock market also. This means, as a corollary to the model that the share prices of the visionary firm would be getting better valuation (more public demand) compared to the myopic firm. But within the segment of the visionary firms the share prices would have differential valuation (differential demand of visionary firm shares), which would depend on firm specific cost structures and production performance pertaining to use of input usage (like water) and its impact on water degradation and water pollution.

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