CAN EQIP ENHANCE ENVIRONMENTAL QUALITY?: A TIME SERIES AND CROSS-SECTIONAL ANALYSIS

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ABSTRACT

This paper explores how abatement of environmental stress pursued through a market-based prices and quantities policy could promote environmental quality. Environmental quality incentive programs (EQIP) provides incentives to individual and group economic actors to pursue greater environmental quality. The paper offers a stress abatement model, and applies a combination of time-series and cross-sectional data to analyze and verify how incentive parameters can be used to enhance environmental quality.

INTRODUCTION

Since Thomas Schelling's (1992) Presidential Address to the *American Economic Association* calling for "a way to mobilize (the country's) population in support of national greenhouse policies" (p. 13), the problem of atmospheric warming has continued to pose a serious threat. Atmospheric warming and erratic climatic upheavals are only part of the overall environmental stress problem that now constitutes one of the most hazardous challenges facing the progress of human development and civilization on planet earth. And that "way to mobilize the population" for tackling this problem has hardly been found. The present study is a contribution towards this mobilization.

This paper develops a model to explore how abatement of environmental stress pursued through a market-based (prices and quantities) approach could promote environmental quality. Established in the *1996 Farm Bill* of the US government, the Environmental Quality Incentive Program (EQIP) initiative was designed as a new program aimed at reducing the environmental impacts of the agricultural sector. It provided federal cost-share payments for farming operations that are aimed toward reduction of their environmental impacts. These are operator-based initiatives generated through active incentive provisions by the authorities.[1]

The EQIP initiative was reauthorized under the 2002 *Farm Bill* for federal funds on conservation programs able to provide technical and/or financial assistance to crop growers willing to adopt eligible water, soil, and habitat conservation practices (Eckas, 2005). The improved EQIP provides cost-share funding that is available through the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture, which has been developed for obtaining the Comprehensive Nutrient Management Plan (CNMP) -- NRCS gives $1,000 incentive payments to producers who enter into EQIP contracts for a CNMP developed in 2005.

The present study is an economy-wide generalization of the EQIP initiative aimed at tackling the overall environmental degradation problem.

Individual and group decisions driven by economic prices and quantities are the forces that determine the magnitude of the demand that is made of the environment. Because of this, it is important to approach the problem of environmental degradation with policies that apply these prices and quantities from the standpoint of the economic decisions of these economic agents. EQIP-type instruments such as emission fees, permits, or excise taxes can be effective in abating the environmental stress problem. This paper applies a model based on the idea of such an incentive designed to prompt the individual or group economic agent toward economic (consumption/production) choices that are consistent with enhancement rather than deterioration of environmental quality.

ENVIRONMENTAL STRESS AND DEGRADATION: THE BASIC MODEL

Economic production and consumption activities impose stress on the environment in terms of *depletion* and *pollution* by-products. Previous research on this problem abound in some recent works on the *Environmental Kuznets Curve* such as Kahn (1998), Kaufman *et al*. (1998), Suri and Chapman (1998), Pearson (1994), or Selden and Song (1994). Earlier studies such as Ehrlich and Holdren (1970) also expressed environmental degradation solely in terms of pollution.

A functional relationship between environmental degradation index, *N,* and stress, *s*, can be given as:

$$\varphi = f(s),\ f'(s) > 0 \tag{1}$$

where

$s = u(Y)+v(Y)$,
u = pollution effect, $u'(Y) > 0$,
v = depletion effect, $v'(Y) > 0$,
Y = Gross Domestic Product (GDP).

Recent works such as Agras and Chapman (1999), or Robert and Grimes (1997), have applied this relationship in the analysis of the environmental degradation problem, to posit a *Ruttan-Kuznets model* of the relationship between environmental degradation and per capita income. The *Environmental Kuznets Curve* depicting a positive relationship between environmental degradation and income at low income levels, and a negative relationship between these at high income levels, has been applied by many researchers.[2] The Ruttan theory is based on Ruttan's (1971) proposal that the demand for environmental quality increases with the level of income as well as the rate of increase in income. Although the Kuznets and Ruttan models propose separate and opposite relationships between environmental degradation and per capita income, it is assumed that pollution is closely linked to depletion intensity, as increasing depletion of resources per unit of output creates more pollution per unit of output. That is:

$$u = \lambda v$$

so that $$v = (1/\lambda)u \tag{2}$$

where

λ = stress abatement factor (and is constant over time, which is the Ruttan case), or λ = f(Y), which is the Kuznets case).

The Ruttan model suggests that high levels of environmental degradation are consistent with low per capita income; but as per capita income increases, the level of environmental degradation falls steadily. The nature of causality implied by this proposal is not clearly stated until we examine the Kuznets case. In the Kuznets model, environmental degradation is positively correlated with low levels of per capita income, y, up to a maximum level, and then becomes negatively correlated with per capita income thereafter. The level of per capita income corresponding to the maximum level of environmental degradation can be said to represent an individual's environmental quality income threshold, y*.[3] Thus, for all per capita income levels below y*, a positive causal relationship can be said to exist between per capita income and environmental degradation.

hese hypotheses are based on the idea that the demand for environmental quality depends on people's income levels. If, as supposed, "pollution levels and forest degradation increase as incomes grow", during the phase of economic development when per capita income lies around US$4,000 to US$5,000, then it means that at lower income levels, environmental stress (pollution and depletion) are greater relative to higher income levels. Beyond y* (the environmental quality income threshold), greater demand for environmental quality tends to bring about decreases in the intensities of stress. Thus, the essence of the Ruttan-Kuznets model is that income levels and living standards are the key factors that determine the desire (demand) for greater environmental quality (Panayotou, 1997; Robert and Grimes, 1997; Cropper and Griffith, 1994).

A Ruttan-Kuznets relationship can be formally stated as:

$$\varphi = f(u(Y) + (1/\lambda)u(Y)$$
$$= f[(1+(1/\lambda)).u(Y)] \qquad (3)$$

where: $f'(u) > 0;\ f'(y)_{y>y^*} < 0;\ f'(y)_{y<y^*} > 0;$
$f'(\lambda)_{y>y^*} < 0;\ \ f'(\lambda)_{y<y^*} > 0.$

This provides a formal expression of environmental degradation in terms of the traditional Kuznets variables (*u* and *Y*) as well as a policy parameter (*8*). We now apply this expression to develop the model of society’s long-term environmental planning and projection targets, which forms the basis for specifying the equations of the empirical analysis that follows in the next section.

The Environmental Quality Trajectory

Following Chapman (1999), and Cropper and Griffith (1994), a relationship linking the size of a society's population, per capita income, and pollution per unit of consumption imposed by that income, may be specified.[4] The relationship depicts environmental degradation as the product of the population size (N), the level of per capita income (y), and the level of stress intensity (s) per unit of goods/services produced and consumed in the economy:

$$\varphi = N.y.s.$$

Since $y = Y/N,$ and substituting (3), we have

$$\varphi = N.y.f[(1+(1/\lambda)).u(Y)]$$
$$= f[(1+(1/\lambda)).u(Y)]Y$$

from which

$$u(Y) = \varphi/(1+(1/\lambda))Y \qquad (4)$$

Equation (4) is the *Ruttan equation* depicting an inverse relationship between u and Y -- expressing pollution intensity in terms of environmental degradation, GDP, and the parameter of *stress abatement* activity (λ).[5]

To implement an EQIP-type environmental quality, stress abatement becomes:

$$\lambda = \lambda(Y) = -\beta Y^{\xi}$$

where $\beta, \xi < 1$.
Substituting into the Ruttan equation, we have

$$u(Y) = u(Y) = \varphi / (Y - \beta Y^{(1+\xi)}) \qquad (5)$$

This gives the *Ruttan-Kuznets curve* -- depicting a quadratic relationship between u and Y, of which solution yields the income threshold Y^* (that corresponds with the environmental quality income threshold suggested by the original Kuznets model). This income threshold represents the level of GDP beyond which pollution decreases as GDP increases.

Environmental quality is depicted as the inverse of environmental pollution. Therefore, the level of environmental quality intensity, σ, may be written as:

$$\sigma = -u = -\varphi/[Y-\beta Y^{(1+\xi)}] \qquad (6)$$

This indicates a positive function of the abatement parameter (ξ), an increasing and decreasing function of GDP level (Ruttan-Kuznets model), and a negative function of environmental degradation intensity.

Under *ceteris paribus* assumption (β, ξ = 0), the ratio φ/Y in equation 5 -- the ratio of environmental degradation intensity to GDP -- gives the measure of *environmental degradation index* (EDI) for society. It indicates an index for determining the "environmental health" of a society. Its values, both cross-sectional and time series, can be determined and used to assess the state of environmental performance across countries or trend performance within a given country.[6]

The *trajectory* of the relationship between environmental quality and GDP, that is equation 6, represents the society's *environmental quality trajectory* (EQT). The trajectory can be used to illustrate the ability of a country to attain or fail to attain some desirable level(s) of environmental quality over time, at any given GDP level (Y_t*) and time period (t). The EQT is a long-run model that can be applied toward long-term planning and projection of a country's environmental targets. That is, a country may project its environmental quality target at some future date and corresponding level of GDP. For example, under the *Kyoto Protocol*, various countries undertook to achieve some set levels of reduced emissions (pollution) over a certain time period.[7] In this case a given country would be setting choices for its process of shifting its EQT toward the (desired) optimal path (optimal trajectory), while operating along the EQT curve at the given combinations of levels of environmental quality intensity, GDP, and EDI. The country could then determine how fast it wishes to attain these set levels by reducing the levels of environmental degradation.

THE EMPIRICAL ANALYSIS

A number of previous studies have carried out estimation techniques based on cross-country data to verify the relationship between per capita income and a selection of environmental indicators (Jha and Murthy, 2003; Grossman and Krueger, 1995; Selden and Song, 1994; and Shafik, 1994). A most recent work by Khanna and Plassmann (2004) argues that the threshold income level at which the Environmental Kuznets Curve turns downwards (or the equilibrium income elasticity of demand for environmental quality changes sign from positive to negative) depends on the ability to spatially separate production and consumption. The authors tested this household demand for “better *environmental* quality” by estimating the equilibrium income elasticities of five pollutants based on 1990 U.S. data. They found that the change in sign occurs at lower income levels for pollutants for which spatial separation is relatively easy as compared to pollutants for which spatial separation is difficult. The results led them to conclude that high-income households in the U.S. have not yet reached the income level at which their demand for “better environmental *q*uality” is high enough to cause the income–pollution relationship to turn downwards.

The present study looks within a country’s own environmental policy approaches to determine the links between stress abatement activities and their impacts on environmental outcomes. We apply a combination of time series and cross-sectional data -- time series data for a cross-sectional representation of 40 locations in the U.S.-- to assess the impact of stress abatement programs and the public’s attitude to them on environmental quality. The linear specification of equation (6) may be represented as:

$$ENVQ = INT + \alpha_1 EDI + \alpha_2 SABTA + \alpha_3 RESP + \alpha_4 GDP + \varepsilon \qquad (7)$$

where

ENVQ = σ = level of environmental quality intensity,
INT = intercept term,
EDI = φ/Y = environmental degradation index,
SABTA = β = level of environmental stress abatement activity,
RESP = ξ = degree of responsiveness to abatement activity,
GDP = Y = Gross Domestic Product of location,
α_i's = parameter estimates, (i=1,2,..4),
ε = error term.

The sign expectations of the various explanatory variables of the environmental quality equation helps provide a preliminary indication of the paper’s central intuition regarding the impact of the variables EDI, SABTA, and RESP (EQIP). It is expected that the parameter estimate for:

- EDI be negative (as more degradation leads to reduced environmental quality).
- SABTA be positive (abatement measures result in higher environmental quality).
- RESP be positive (positive response to SABTA programs yield higher environmental quality).
- GDP be positive (to verify the EQT relationship).

The Data Set and Estimation

The data was collected from a cross-section survey of samples from 40 States across the U.S., taken at a series of five different time periods, namely, 1985, 1990, 1995, 2000, 2004. As a result of the vastness of the data set, the sample size covered were quite large. We anticipate a possible source of weakness in the data, in that they were collected for once in each of the target years. Also, we recognize the possibility of biases in the responses obtained from the individual respondents according to their respective leanings on environmental issues. This may raise some question of how reliable the data would be, and the results need to be taken with caution.

TABLE 1
DESCRIPTIVE STATISTICS -- SAMPLE MEANS AND STANDARD DEVIATIONS

Variable	**1985**	**1990**	**1995**	**2000**	**2004**
ENVQ	0.6380	0.5289	0.5191	0.5924	0.5878
Std. Dev.	0.752	0.789	0.788	0.802	0.774
EDI	52.9%	55.2%	57.7%	58.3%	58.0%
Std. Dev.	18.54	11.56	14.23	16.82	18.92
SABTA	-	-	-	-	-
Std. Dev.	1.3302	1.612	0.935	0.869	1.560
RESP	-	-	-	-	-
Std. Dev.	0.9213	0.8862	1.2208	1.0223	1.4432
GDP(Y)*	18.4	22.5	23.8	32.9	38.6
Std. Dev.	7.88	6.56	6.98	7.29	9.22

Notes: * Billion dollars

The data set comprises the daily measure of environmental quality index (as the measure of ENVQ), and the concentration of particulate matter (sulphur dioxide or smog) in the atmosphere (as proxy measure of environmental pollution intensity), as measured by the U.S. Environmental Protection Agency (EPA) for the central area of each State (Capital City area). The level of GDP for each location is used as the proxy measure of economic activity, and the ratio of the level of smog to the level of economic activity, times 100, gives the proxy for EDI of each location. Environmental stress abatement activity is measured by a dummy variable: 1 for the presence of a composite of market-based variables, namely, taxes on resource use, emission fees, container deposits, litter fines, and the like; and 0 for a weak presence or absence of the composite. The abatement receptivity variable is also measured by a dummy variable: 1 if 50 percent or more of the respondents favor the abatement policy, 0 if not. Table 1 provides the descriptive statistics of the variables for each target year used in the estimation.

The equation is estimated for each year using the 2-stage least squares method. Table 2 gives a tabulation of the regression results. Use of t-tests indicate that the coefficients are all significant. The values of the *F*-ratios also confirm an overall significance. The low values of R^2 seem to be due to the use of the cross-sectional data involved; however, despite the high *F-ratio*, a pairwise correlations test of the presence of multicollinearity is performed among the independent variables (EDI and Y) to ascertain the reliability of their estimated coefficients. A strong *correlation coefficient* (0.706) is found among them.

That the coefficients for EDI are all negative and significant (except for 1990 and 1995) is not surprising. However, since the EDI is comprised of the ratio of environmental degradation intensity to GDP, it seems that the degradation intensity across the locations must be much higher than the GDP (despite the relatively high growth rate of GDP over the period).

The most important results are the positive coefficients for the stress abatement activity (SABTA) and the public responsiveness (RESP) variables, and consistently so over the time span covered by the data samples. This suggests that an EQIP-type policy can succeed in abatement of environmental stress if such a program is maintained as a long term policy initiative.

TABLE 2
REGRESSION ESTIMATES OF EQIP EFFECTS

Variable	**1985**	**1990**	**1995**	**2000**	**2004**
INT	3.4882 (1.0532)	2.9651 (0.9123)	4.3323 (1.7640)	3.6899 (1.9807)	3.5996 (1.8822)
EDI	-2.9224*** (2.821)	-1.9962 (1.789)	-2.1181 (0.4568)	-4.1424** (2.673)	-3.5878** (2.706)
SABTA	2.2041*** (3.821)	4.2245** (2.659)	3.0812** (2.466)	2.4115*** (3.1267)	2.8541** (2.6697)
RESP	4.162*** (3.4113)	2.8661** (2.5428)	2.5116** (2.0996)	3.7009*** (3.2201)	2.8022** (2.5569)
GDP	2.1998** (3.5440)	2.6632** (2.9881)	1.9226** (2.4422)	2.1862*** (4.3121)	2.8225*** (3.1423)
R^2	0.5782	0.5525	0.5992	0.4797	0.5632
F	28.3	22.5	25.9	23.6	34.4
DW	1.8892	1.6983	1.8210	1.8532	1.8276

Notes: t-statistics in parenthesis.
**Significant at 5% level
***Significant at 10% level

POLICY ANALYSIS AND CONCLUSION

Environmental policy perspectives toward long-term abatement of environmental stress are needed to combat the problem of environmental degradation. To this end, results from this study help us formulate EQIP-type initiatives aimed at providing individual incentives to enable people plan their demand and supply needs with due regard for environmental quality. Because the level of environmental stress is dependent on the demand-side and supply-side economic factors such as the price and output levels, size of market, income levels, and population, efforts to abate environmental stress must center on adjustments in these variables. EQIP-type approaches amount to incentives designed through adjustment of economic variables in order to make people to adjust their life-style choices which contribute to (if not determine) environmental stress. For example, on the demand side, the choice of the number and type of automobiles operated reflects the choice of desired level of environmental quality. A similar point goes for the choice of level of consumption of fossil fuels (or, say, the demand for electricity). On the supply side, we have the choice of level of agricultural output or choice of production method in agriculture.

Environmental quality incentives programs targeted to individuals and groups can be price-incentive based or quantity-incentive based. Price-incentive based EQIP would involve having each product price tagged with an environmental premium. The size of each premium will be based on the degree of environmental sensitivity of the product (and the product's industry). For example, prices of automobiles and fossil fuels will receive higher proportionate tags, while prices of less-environmentally sensitive products (such as clothing or cookware) will receive lower tags.

In price-incentive based EQIP, a product's market price, p_e, would be given as:

$$p_e = p + \beta p = p(1+\beta),$$

where $1>\beta>0$ is abatement parameter (SABTA, representing an environmental premium), whose level for each product is determined according to the product's (industry) environmental sensitivity.

Thus, as a function of p_e, the level of individual (or group) demand for each product is made environmental-quality sensitive. The incentive is that p_e provides an individual or group with an opportunity to promote environmental quality by either: paying p_e and thereby contributing to the cost of environmental enhancement programs, or not paying p_e and thereby foregoing the consumption of the product and thus contributing to reduction of environmental stress. The product price p_e is an EQIP instrument whose component, β, is a policy instrument that can be controlled in accord with the environmental quality choices of the authorities. This EQIP price-incentive based approach is a demand-side initiative.

Also, quantity-incentive based EQIP (supply-side incentive) would target producers (firms and industries). However, such incentives can be applied to producers only under compelling circumstances because of the conflicting objective of profit maximization and environmental stress abatement. Producers would not ordinarily pursue environmental stress abatement without costless abatement technology.

A quantity-incentive based EQIP would involve the determination of the level of output that takes account of the environmental stress imposed. This implies production activities involving environmentally-sensitive cost functions such as:

$$c_e = cQ + \pi Q = (c+\pi)Q,$$

where c = unit cost of output, Q = total output level. The firm is then able to choose and set its profit-maximizing output level with due regard to the costs involving π. Therefore, such an EQIP-type quantity-incentive based approach enables producers to operate with environmentally-sensitive output levels.

ENDNOTES

1. For some case analysis of the new EQIP, see Chapman (1999, pp. 238-239).
2. Some of the most recent ones include Khanna and Plassmann (2004), and Jha and Murthy (2003). Others are Torras and Boyce (1998), and Suri and Chapman (1998). These were also preceded by others such as Panayotou (1997), Cropper and Griffith (1994), and Selden and Song (1994).
3. Studies indicate that y* range around US$4,000 to US$5,000 (see Chapman (1999, p. 29)).
4. Chapman (1999, p. 182-183) reformulated this Ehrlich-Holdren (1970) relationship in an economic context by redefining and stressing the impact of population growth on total pollution as a one-to-one effect (that is, a unitary population-elasticity of pollution). It is suggested that the relationship can be made a "more realistic economic relationship" by specifying it as: *Pollution per Unit of Consumption = Environmental Policy and Practice times Pollution Intensity per Unit of Consumption.* Without delving into the complex theories of demographic transition, the simple Ehrlich-Holdren relationship seems to adequately capture the level of environmental degradation in terms of the total stress imposed by the population on the environment. This relationship can be applied to model a Ruttan-Kuznets environmental degradation theory.
5. A slight difference here is that this model relates environmental degradation to level of GDP rather than per capita GDP. This difference should not alter the theoretical underpinning that makes this model analogous to the Ruttan-Kuznets theory.
6. Applying known values of GDP (Y), the values of EDI (φ/Y) would depend on the value of the environmental degradation intensity (φ). This can be proxied by monetary costs of stress factors such as cost of treating environment-related illnesses (say, air and water pollution ailments), contingent valuation of eye-sore costs; or, say, cost of suburban-inner city commuting, and the like.
7. Under the *Kyoto Protocol*, various countries committed to a voluntary systematic reduction of their levels of greenhouse-gas emissions.

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