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Social Benefits of Education: Feedback Effects and Environmental Resources

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Abstract

This paper considers the ways that education might influence the environmental quality that people experience. Education could accomplish these effects by promoting private behavior that enhances environmental quality for everyone, or by increasing people's effectiveness in protecting themselves from environmental externalities. An important reason for addressing these questions is to consider complementarities between different public sector activities that create public or mixed public-private goods. After reviewing the conceptual issues associated with modeling these types of relationships, the paper reviews the available empirical literature to determine if there is support for this type of linkage and reports some new findings of a link between risk information programs and education. The paper closes with a discussion of the policy implications of these types of relationships.

Key Words: environmental quality, education, risk communication

JEL Classification No(s).: I21, H41, D62

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V. Kerry Smith*

I. Introduction

Richer countries are safer, healthier places to live.[1] They pollute less and enjoy a higher standard of material well-being.[2] Several recent statistical studies have used aggregate cross-country data to suggest a causal link between the level of economic activity, safety (Lutter and Morrall [1994]), and the environment (Grossman and Krueger [1991]). Is education the real source of these positive results? The answer to this question will not be found in aggregate statistical models. Evaluating the indirect, non-market effects of education requires detailed, micro economic analyses of education's causal role in people's behavior. While there is extensive evidence that education and training enhance people's productivity and earnings, what we know about education's effects outside markets is much more limited.

The purpose of this paper is to consider how education might influence the environmental quality people experience. Education could promote private behavior that enhances environmental quality for everyone, or increase people's effectiveness in protecting

themselves from negative environmental effects. These negative influences result from conventional externalities or from unrecognized impacts of the environment on people (e.g. radon and lung cancer, etc.).

In order to attribute an indirect social benefit to one of these behavioral responses, we must establish that it resulted from a causal rather than a taste related association with education. There is no direct evidence of these types of connections in the environmental economics literature. Economists who evaluate people's behavior in avoiding environmental externalities or enhancing its quality have not tested these hypotheses.

Because there was no literature on education's role in improving environmental quality, this paper considers three questions: (1) how should we define the social or non-market benefits of education? (2) do existing studies of people's mitigating behavior, avoiding environmental hazards, offer any indirect evidence of a causal link between education and increased activities to improve the environment people experience? and (3) assuming there might be a causal relationship between education and people's non-market behavior, would that connection have implications for the design and evaluation of environmental policy?

II. Defining Terms and Examining Trends

A. What is Education?

Education is both a process and a set of outcomes. For the issues discussed in what follows, I am interested in what the educational process conveys to the individual. Today's students at all levels are involved in activities that enhance environmental quality in many cases as part of their science courses. While these programs may be important as vehicles to teach environmental stewardship, there is insufficient information about them to permit any evaluation. As a result, specific environmental education is not a focus of my analysis. Rather, the primary concern is whether the outcomes resulting from education as a whole alter people's behavior toward the environment when they leave school.

Because the outcomes resulting from education are diverse and often difficult to measure in quantitative terms, most studies of the effects of education have focused on duration and degree based measures - years of schooling and completion of specific stages of the process (i.e., high school diploma, college degree, graduate degree, etc.). Refined outcomes such as cognitive reasoning skills, mathematical ability, or understanding of science are more difficult to measure and are usually not available. This is potentially important. If we hypothesize that education affects people's ability to protect themselves from environmental hazards or increases their understanding of the environmental system and, as a result, their concern for protecting it, then we should expect to see specific causal links to what takes place in school. That is, it seems reasonable to expect these changes could be

related to specific aspects of the educational process, such as a set of environmental science modules in the primary, secondary, and college curriculum. Indeed, it is a belief that these activities promote such responses that has increased their presence in instructional programs.[3]

Unfortunately, the measures available do not offer this level of resolution. This limitation has at least two implications. Finding a correlation between a general measure of education such as years of schooling and an individual's actions to improve environmental quality is more difficult to accept as a causal relationship. Equally important, the prospect of detecting these correlations is small. Years of schooling can involve many different mixes of activities and patterns of learning. There is no reason to believe all aspects of an educational program will be equally relevant to behavior that either enhances environmental quality or promotes people's understanding of how to protect themselves from environmental hazards.

B. Social Versus Public Benefits

Conventional economic discussions of the motives for public intervention arise from some type of "market failure." Externalities and public goods are the most prominent examples of these failures. To the extent a private activity has an impact on the production process or well-being of others that is outside any market determined transaction, we consider it to be an externality. When an individual acquires the skills and understanding provided through education, these may enhance the others' well-being in some way (e.g., each citizen makes "better" decisions in a democratic society). This is an external effect.

To the extent residents of a community demand and experience welfare gains when

their school systems (whether primary and secondary, or their state universities) are enhanced, then these gains may reflect some public good aspects of these educational programs. This effect is, in principle, different from what happens to each individual through education. Of course, it may well be that the reasons for these "public" values arises as an ex ante expectation that the citizens emerging from enhanced educational programs will create externalities for the community in the future at the time they finish.

Nonetheless, these explanations are "stories" an analyst offers to explain a set of choices. As I argue below, they do not necessarily mean people have these values unless their choices were, in fact, motivated by them.

Why do we make a distinction between private and public benefits from education, and how does the issue of social benefits enter an economic evaluation? The answers to these questions relate to two concerns. Do the conventional private returns from education measured using education's effects on productivity and earnings reflect the total value of education to each individual? Here the answers relate to the role of the social effects. To the extent education enhances a person's abilities in non-market activities, the private earnings related measures would be only a partial gauge of the economic value of education to that individual. Omitting these effects could lead the analyst to incorrectly interpret comparisons of education's costs with its benefits measured solely from earnings effects as indicating irrational behavior. This follows because the benefit side of the comparison omits the non-market or social influences. Nonetheless, this type of comparison does not in itself motivate public intervention because the gains are "captured" by the individual. The only

issue is one of measurement and, perhaps, testing the hypotheses implied by revealed preference.

Externalities and public goods do motivate intervention because private action alone would not necessarily assure an efficient level of the activity that contributes to these effects. Both the non-market private and the public good effects of education must rely on methods of non-market valuation to evaluate their impact. Thus, a substantial component of the discussion in this paper will consider whether existing analyses of the demand for and value of education have adequately accounted for these potential impacts.

C. Trends in Support for the Environment

Over the past decade, environmental quality in the U.S. has generally improved. This is especially true for air quality. Figure 1 includes Box-plots for three of the criteria air pollutants: ozone, particulate matter, and sulfur dioxide, over different time intervals beginning in some cases in 1983 and ending in 1992.[4] The message for each graph is consistent; there has been a decline in the whole distribution of ambient concentrations over the past decade. As in the case of cross-country comparisons of environmental quality, economic activity, and education, this pattern results from a complex process related to the regulations imposing national ambient standards and the state specific plans to meet these standards. While the record is not as well documented for other aspects of overall environmental quality, it would be difficult to establish whether these types of changes were in any way linked to changes in education.

A focus on the available information of individual behavior over this time does not improve our ability to gauge the potential for causal links based on long-term trends. There are no systematic records of household activities related to promoting environmental quality or sustaining private averting behavior over time. The only consistent long-term information about attitudes toward the environment can be found in the NORC General Social Surveys. From 1972 to 1993, 19 national samples were asked the same questions about support for environmental and other programs. Table 1 summarizes the years and sample size used in each of these independently constructed samples of English speaking persons, 18 years of age or over, living in non-institutional arrangements in the U.S.

Figure 2a plots the results for four of a total of six questions derived in each of these 19 surveys. The first curve includes the average years of schooling (relative to thirteen to represent high school equivalent), RAVED. The remaining curves plot the fractions indicating that we are spending too little money on improving and protecting the environment (mean env. high); too little money on improving the nation's education system (mean educ. high); as well as the fraction indicating that they had "a great deal "of confidence in those people running the Executive branch of the federal government (mean fed. high). As the graph indicates, there is a slight upward trend in the years of schooling completed over the 21 years covered by these samples. Support for education is also consistent with a somewhat more pronounced upward trend. The most surprising outcome of the comparison is the decline, beginning about 1991, in those indicating we are spending "too little" on the environment. This change is not sufficient to change a positive and significant trend in the

fraction agreeing that too little is being spent over the full time period, but it is a departure in a trend that appears to have begun about 1977. This result does not seem to be related to any change in the educational levels of those surveyed, and does not in itself indicate people would be less willing to take private actions to enhance the environment.

It may be the result of a decline in confidence in the Executive branch of government as well as other public functions, as illustrated by the lowest line in Figure 2a, displaying those respondents expressing "a great deal" of confidence in those running the Executive Branch of government. Indeed, a similar pattern arises when this type of question was asked about those running education in this country (mean ed. high) and about scientists (mean sci. high), plotted in Figure 26 in comparison to education and the confidence in those running the Executive Branch (plotted again for comparison).

Thus, the overall conclusion to be drawn from these trends parallels the judgment from cross country studies. Aggregate trends in country are the result of complex processes. Even at the level of suggestive evidence, there is little in the trends in support for environmental programs and in the average levels of schooling over time that would imply a close link. Evaluating the prospects for these connections will require more detailed micro analyses that incorporate the reasons for connections between education and individual behavior that improves environmental quality. These conceptual and empirical issues will be the primary focus of this paper.

III. WTP for Education:

The Role of Preference and Household Production Functions

A. Background

Measures of economic value are commonly understood to be constructed from people's choices. A choice defines a lower bound for an individual's willingness to pay (WTP) for any commodity-- marketed or not. For example, when a person gives up one or more years of work to pursue an advanced degree, the economic value must be at least as great as what was foregone. Under ideal conditions, we expect people to adjust until the value of the last unit selected exactly equals its incremental cost. By reconstructing the implicit net "price" in this tradeoff and expressing it as a rate of return to an investment, Becker [1964] and Mincer [1974] developed a model that has been one of the key organizing frameworks for evaluating education over the past thirty years.

Education was an investment providing each individual that decided to pursue more schooling a private rate-of-return. This return could be estimated directly from the time profile of costs, together with foregone and final earnings (Becker), or from earnings functions (Mincer). Each approach was derived by assuming that the market experience of people "revealed" their economic values. While this model had most of its early applications in evaluating the returns to college and on-the-job training, it has also been extended to consider a number of policy issues, including more recently, the effects of the educational quality on the rates of return for primary and secondary education (see Behrman and Birdsall

[1983], and Card and Krueger [1992] and Betts [1993]).

Models based on an alternative framework, consistent with revealing individual WTP for primary and secondary education, have also been developed from a completely different perspective - that of local public finance. Two approaches for estimating the demand for local education can be distinguished. The first of these, sometimes described as the "standard model," postulates a functional form for the median voter's demand for a local public good (in this case education) based on what is assumed to be the individual's (or the household's) tax rate and a measure of income.[5] With a variety of assumptions (see Oates [1994]), it is possible to recover estimates of the price and income elasticities of demand by relating the per capita expenditures for the local "public good" to constructed measures for the median voter's tax rate and income. A variation on the framework relies on household surveys. This approach is sometimes referred to as the "micro" method. It can use either households' actual choices (Gertler and Glewwe [1990]) or stated choices (Bergstrom, Rubinfeld, and Shapiro [1982]) to estimate a representative household's preferences for different types of educational alternatives.

In comparing these three sources of information about people's willingness to pay for education, it seems natural to ask whether each approach is capturing the same type of economic tradeoff and, therefore, would imply comparable estimates for the typical individual's WTP for education. I believe the answer is no. These models actually measure the demands for different commodities.

To understand why, we need to consider the assumptions implicit in each framework,

including the economic agent hypothesized to make educational decisions and the specification of education as the object of choice. With that background, it is possible to relate what can be learned from the models about the economic value of education.

B. Interpreting Past Modeling Strategies

Two features distinguish the economic decision underlying the Becker-Mincer framework from the models used in local public finance. First, the human capital model assumes each individual decides about education, evaluating his (or her) market alternatives with added schooling in comparison to what they would be without it. In the terminology used in the non-market valuation literature, the model assumes education is a weak complement in production to labor market time.[6] That is, if we use a Becker-Mincer estimate of the rate of return to education as the basis for computing education's social value, then from society's perspective, the enhanced value of labor time (due to education) is being assumed to capture all of the relevant economic value of education.[7] Second, the basic unit of measurement for the amount of education selected is usually expressed in years of schooling or variables that identify a set of discrete intervals corresponding to the degrees received with different levels of schooling (i.e. high school, college, etc).

In contrast to this approach, models of the demand for local education based on household surveys (and the median voter framework) shift the decision context from the individual deciding about her education to an adult deciding about the education provided to children. Usually this choice involves public education (certainly this is the case for median

voter models). Both the object of choice and the individual making the choice are different. It is an educational system for most local public finance applications. Demands are acknowledged to be different for people with children in comparison with those who do not have children (Wyckoff [1984]) and sometimes between property owners versus renters (Oates [1994]).

These differences are most often explained as the result of price effects, rather than from the nature of the object of choice and what motivates each type of agent's decision. For example, in comparing the responses of households with and without children, differences in the demands for public schools are assumed to arise because the former consumes the educational services, pays the tax price, and experiences any Tiebout [1956]-related property appreciation arising form the tax rate/ educational services provided. By contrast, the household without children (or with children beyond school age) faces the tax price and experiences only the property value appreciation effects of education.

To consider how economic model conceptualizes the economic value of education to the individual hypothesized to be making educational choices, we need to consider what each model implies about the object-of-choice and how it is assumed to affect each individual. This shifts the focus of the analysis away from imputed net prices, the issue emphasized in the comparisons between these approaches, to all aspects of these decisions.

Consider first the Becker-Mincer labor market model. Education is represented by the years of schooling selected by each individual. This formulation implies that all sources of education are perfect substitutes (from the perspective of any market evaluation of the

added value of labor time due to education) and ignores any role of education in contributing to other aspects of an individual's activities. Incorporation of quality into the Mincer earnings model (as in Behrman and Birdsall), relaxes the first of these assumptions, and the use of the household production framework (HPF) broadens the second, allowing for a wider set of potential motives for the private demands for education. Within it, education can be interpreted as a "public input" to several household production activities. Indeed, this is exactly the argument of Haveman and Wolfe [1984] in their proposed method for calculating the WTP values for non-market impacts.

Nonetheless this formulation does not necessarily alter any efficiency judgment about the private decisions for education implied by the Mincer model.[8] Instead, it suggests the labor market tradeoff may not accurately capture the complete marginal value an individual places on education. Indeed, based on their arguments, one might suggest labor market estimates provide a poor lower bound for an individual's full marginal WTP. Because these values accrue to private individuals, this expansion in the sources of value for education would help to explain why individuals would select educational investments when they yield lower rates of return relative to comparable investment alternatives. However, it would not provide a basis for measuring whether education had additional social effects that might be considered "public goods".

This conclusion may be seen more directly by applying the revealed preference logic used in the non-market valuation of environmental resources to this model. The key elements in the economic tradeoff used to reconstruct values are given in the model's

specification of the marginal rate of substitution (MRS) between education, as an argument in individual preferences, and a numeraire. The simple "individual preferences" model has education as a private good entering in preferences with all gain from an additional "unit" captured by the individual. The HPF generalization has education exerting effects on the production of multiple final services, but they are all captured by the individual (or her household) who has invested in education. This makes the resulting expression for the MRS more complex (because it now combines the contributions of final service flows linked together through the effects of education on each) but does not necessarily imply effects outside the household (see Haveman and Wolfe's [1984] equation (3) as an example). To gauge the tradeoff between added education and a numeraire, the analyst must consider all of the effects on these within home activities.

With aggregate versions of the median voter model, the object of choice, or specification for the commodity used to represent education is never developed. Indeed, in most cases the price of a unit of education is also left undefined. The empirical models are based on demand specifications that allow estimates of the price and income elasticities to be recovered from per capita expenditure models.[9] The object of choice in the survey-based models is also described by responses to questions about increasing "expenditures on local public schools" together with an analyst's construction of what prices people perceive they are paying for these increases. Private benefits from enhanced education in this model are derived by families with children in the schools and by homeowners through any positive net capitalization of the local public education in their property values.

Wyckoff [1984] has argued that, after taking account of property value effects, households with no children (or with children beyond school age) have demands for local public education that motivated exclusively because of its public good characteristics.[10] Those with children in school have demands due to both the private and public components. Thus, in his framework, by sorting the sample into these two groups, and assuming common underlying preferences, these different sources of demand for local public education (as a mixed good) can be distinguished. His estimates imply that the total demand (considering both the private and public components) is more inelastic than the public component. With further assumptions, they would imply that the share of WTP for local education due to the public component is about ninety percent.[11]

The strategy used to develop Wyckoff's estimates is comparable to the distinction drawn in the valuation of environmental resources between use and nonuse values for these resources. The former correspond to economic values attributed to in situ uses, while the latter do not require any form of observable consumption. Nonuse values correspond to the values for any pure public good services a resource provides (see Plourde [1975] and McConnell [1983]). One early approach for measuring these components of total value distinguished users from nonusers.[12] The latter's economic values for improvements in a resource were assumed (by definition) to reflect nonuse values.

The only relevant definition of economic value derives from a choice. It is the object of choice that provides the basis for how we interpret that value. When analysts adopt a revealed preference approach to estimate people's economic values, they must focus on

situations where there is some reason to observe people's decisions. The linkage between the observed decision and the underlying object of choice is then used to construct the necessary tradeoff information for estimating economic values.

To illustrate how this works, consider two of the Haveman-Wolfe estimates of the incremental WTP for education, arising from its effects on non-market activities. The first of these is their calculation of the value of education through its impact on the attainment of "desired family size and child spacing." Their calculations estimate the marginal effect of schooling on family size and child spacing. The net changes in household time related to their activities are then interpreted in terms of the non-market time effects of these decisions and valued at the husband's market wage rate to estimate the marginal value. The second considers the effects of education on criminal activity. Here, these authors evaluate the years of schooling that would be equivalent to an additional unit of police time in a local jurisdiction in terms of its contribution to the probability of criminal apprehension and punishment. Using the dollar cost of police time, an individual's incremental WTP is imputed from these two sources. The community effect (or public good) value of the increment is derived by multiplying the estimated individual value by the number of people in the community. This approach relies on an analogy to the traditional public good logic (i.e., $n \bullet MRS$, with n = number of people).[13]

Neither of these estimates is an economic value for the public good effects of education. Each is a clever economic reconstruction of the values of time (household and police) in specific activities that are attributed to education. This attribution arises because

there were models "describing" how the levels of schooling influence these outcome variables. Even if the models correctly reflect an effect due to education, people did not make the choice to undertake the education in order to accomplish these goals. They are constructed values; akin to what would be expected if all these activities took place in ideal markets so that any discrepancies in implied values would create incentives for arbitrage.

Decompositions of value into use (or private good) related measures of WTP reflect only the fact that a private decision can be recorded; and it is assumed that a reason for the decision is found in the object being valued. In Becker-Mincer human capital model this amounts to requiring that the exclusive basis for an individual valuing education is due to the enhanced labor market returns. By contrast, for the local public finance, any recovery of components of the total value relies on observable characteristics of a household (i.e., school age children). These are used to identify those households with both private and public demands, along with their associated "contributions" to each one's total value. Experience with these types of approaches in estimating values for non-marketed environmental resources suggests that a more fruitful strategy may be found in specifying more completely the economic commodity of interest and how it affects people.

C. Describing Education's Role in Individual Behavior

One lesson that emerges from these past efforts is the central role of the linkages between education and other types of decisions that are used to re-construct people's values. In this section we consider three preference specifications and describe how each might be

used to evaluate connections between education and other public goods. While the primary focus of the discussion will be on how they could be used to consider the relationship between education and environmental quality (as a public good), the arguments are general. My objective is to evaluate two aspects of modeling decisions that attempt to explain the sources of "public good" values for education. First, I consider whether indirect links between education and other public good are capable of providing one explanation for what are sometimes postulated as the "public good" services or social components of education (e.g. Wyckoff [1984]). Second, to the extent there is empirical evidence to support such links, I discuss whether observed behavior (or the responses captured in traditional models) could be used to estimate these public benefits.

The first model is the simplest with a private good, X, a public good, Q, and education, E. It is given in equation (1). The additional term, θ, is a parameter included to reflect the heterogeneity in individual preferences.

Model I

$$U = U(X, Q, E; \theta) \qquad (1)$$

As noted earlier, restrictions on preferences (or physical connections due to location) link X to Q and generally provide the basis for revealed preference measures of the implicit tradeoff perceived to be involved in increasing Q. For example, weak complementarity (see Mäler

[1974], Bradford and Hilderbrandt [1977]) restricts the marginal rate of substitution between Q and X to be zero when the demand for X is zero (i.e.) $\frac{U_Q}{U_X}|_{X=0} = 0$) . A connection between Q and E would be difficult to interpret from empirical model based on this framework. Is E serving as an indicator of differences in individual preferences (i.e., as a proxy for the unobserved sources of heterogeneity assumed to be present in θ or a component of a composite good with Q that is linked to X? Pursuing the second part of this question is easier with a more structured model, building on the household production framework (HPF) and will be discussed as part of the development of Model II below.

We could also simply postulate a public good element to education (though the measure used to represent E would likely be different from what has been used in most empirical studies) and argue it was linked with Q in any relationship hypothesized to govern X. For example, Bockstael and Kling [1988] have discussed situations where sets of public goods can be treated as weak complements with specific private goods. This would imply that the values for Q could not be recovered from individual decisions about X, without also considering E. Here too, the distinction between a public good rationale for E and a difference in the taste for Q due to varying levels of education is largely an assumption. We can reinforce the assumption in empirical modeling through the ways our models measure E. The public good effects would be most likely to be based on community level measures for E, while the private good is more likely to be captured with individual measures of education such as years of schooling.

The logic underlying such a restriction is that people's enjoyment of the set of Q's

can only be realized if they undertake some private activity. For example, the preservation of unique art, scientific or historical material, can only be appreciated as "enhancing culture" if the citizens involved in such activities simultaneously attain the levels of education necessary to understand their significance. Then we take the next step (required to use a revealed preference method) and assume that for these composite gains to be realized, the people must be able to devote time to visiting museums, unique scientific, historical or cultural sites, etc.

These analytical arguments raise more general questions about how we describe commodities that have public good attributes. Are they part of more general composites that involve an array of services? And do these broader relationships condition how the group of public goods influences preferences? This point was raised, implicitly, in the discussion of the embedding question as part of a set of issues recently raised about the use of survey methods to value environmental resources.[14] Because all of these types of assumptions must be maintained hypotheses, they cannot be tested. Informal, qualitative evaluations, relying on cognitive interviews and focus groups, may provide insights into how people evaluate groups of public goods and whether they evaluate them as composites. Nonetheless, for the short-term, specifying groups of public goods, including education in that group, as weak complements to a private commodity, is unlikely to offer practical empirical insights.

The second type of modeling structure, with the most direct empirical relevance to environmental resources is the "household production story" and it follows the Haveman-Wolfe [1984] framework. As in the examples they identified, education is assumed to

enhance production of those activities involving environmental resources. However, this effect is unlikely to be comparable to a pure public good. For this second model, we would re-write equation (1) with more specific implicit structure on how the goods, services, environmental resources, and education combine to enhance well-being as in equation (2):

Model II

$$U = U(f_1(X_1, Q_1, E), f_2(X_2, Q_2), f_3(X_3, Q_1, E), f_4(X_4, E), \ldots; \theta) \quad (2)$$

Each $f_i(.)$ corresponds to a household production activity with private goods (X_i), environmental public goods (Q_i) and education (E). The form given in (2) illustrates the variety of specifications that would be possible. For example, in the first HPF a vector of private goods (X_1), a unique environmental resource (Q_1) and education contribute to production, E. That same Q_1 is seen to enhance $f_3(.)$ as does education. Education could enter production relationships without Q_1, as was the case in several of the Haveman-Wolfe studies and illustrated in my expression for the first activity. The situation described by $f_1(.)$ is also analogous to their example of education's contribution to reducing crime.

Lest we get carried away with the possibilities for "story-telling," it is important to acknowledge the limitations in what can be learned from observations of people's behavior. Twenty years ago Mäler demonstrated that the marginal willingness to pay for any non-marketed good could be expressed in terms of the price of any private good and the marginal

rate of substitution between that private good and the non-marketed good as in equation (3).

$$MWTP_Q = -\frac{\partial e(\cdot)}{\partial Q} = P_{X_i} \cdot MRS_{Q,\,X_i} \qquad (3)$$

where:

MWTP = marginal willingness to pay for Q

e(.) = Hicksian expenditure function

P_{X_i} = price of X_i

Unfortunately, when Q is not a choice argument, there is no real basis for observing the MRS. This is where the maintained hypotheses restricting preferences and the HPF "stories" enter. They describe cases where the decisions observed provide the analyst sufficient information to reconstruct measures of economic value. One of the most widely used such assumptions is perfect substitution. That is, we can estimate an individual's MWTP for Q if there is a perfect substitute using the change in expenditures for the private good that accompanies any change in Q (see Smith [1991a] for the details). As a rule, this restriction has been used for empirical models of averting behavior. Consider, for example, the case of a deterioration in air quality. If a household cleaning activity is a perfect substitute for air quality in completely mitigating the full effects of that pollution on people

(e.g., air pollution causes increased soiling of houses, automobiles, clothing, etc.), then the MWTP would be measured by the increased cleaning expenditures required by increased pollution.[15] To the extent that education contributes to the effectiveness of such a production process, then we could argue that incremental cost savings (reduced expenditures required for cleaning) because of the learning accompanying education offer a measure of this component of education's economic value.

This connection does not imply education is a public good. Any public action such as an information or risk communication program that is described within the averting behavior framework relies on:

(1) consumers' incomplete knowledge about an environmental problem or method to reduce its effects;

(2) consumers' "inappropriate" risk perceptions in comparison with experts' judgments about environmental risk:

(3) cost advantages to the collective provision of information; or

(4) cost advantages to decentralized responses for mitigating the effects of an environmental externality.

In each case, education can be argued to have a complementary effect by enhancing the effectiveness of a household's private responses. To understand how the logic works, consider an example. Suppose the action to be evaluated concerns contamination of groundwater that is used as a drinking water source through private wells (see Poe and Bishop [1993]). Private household action may be the most cost effective response with

testing and filters, but this would require household recognition of the problem and a corresponding set of actions. The externality motivates the public intervention and education enhances the effectiveness of that public intervention. The opportunity for a household to mitigate individually creates a private commodity--"clean" water from that household's perspective. If this is the least cost response and education enhances its success, then education reduces the cost of responding to a local public bad--the contaminated groundwater.

A second line of reasoning, popular among environmental policymakers, is that people's risk perceptions for environmental sources of risk are incompatible with the experts' judgments.[16] In this case, too much private (and public) action is taken for some environmental problems and too little for others (because of these misperceptions). This can also be described as a type of HPF model (see Ehrlich and Becker [1972]). Treating self protection as an influence on subjective probabilities, with education as a factor in "improving" perceptions, allows a comparable explanation to be presented. It can either be in reducing the "incorrect perceptions" or enhancing the effectiveness of risk communication.

In all of these cases, education is not a public good. It has social consequences because it affects the performance of other private or public actions. These examples avoid the criticism that might be made of many of the Haveman-Wolfe non-market effects. In several of their cases, the consequences were also specific to the household, education enhanced effectiveness. Why then wouldn't this be acknowledged by the household and reflected in their educational choices? The policy implications of the existence of these types

of effects would not be to call for increased public intervention, but rather a realization that more detailed models are needed to explain behavior. That is, when analysts reconstruct what those choices mean, account must be taken of these effects.

Here the externality mitigating or cost reducing properties of an information program create the "publicness." Education of the targeted population simply reduces the "costs" of any actions to respond to these problems.

The last category of model for individual (or household) behavior does provide a link between education and a public good that could be interpreted to expand its public dimension. It is given in equation (4) and requires some explanation.

Model III

$$U_1 = U_1 \left(X_1, q_1, h(q_1, q_2, \ldots, q_N), E_1; \theta \right) \qquad (4)$$

This preference specification is intended to describe an individual identified by the subscript "1" for convenience. It includes a vector of private goods, education (treated here as a private good), and the middle terms with q_1 and the function h(.). The intention is to reflect a set of models describing how people's actions contribute to the availability of public goods.

The most common application in these models has been for describing charitable contributions (see for example Andreoni [1989]), but the implications of the models are much more general. Each person can engage in activities (or contribute) to their production. This

type of action is represented here for individual 1 as q_1. The collection of all individuals' actions leads to a public good, represented here with the function h(.). The other arguments in h(.) are the activities of others. In the simplest models:

$$h(\cdot) = \sum_{i} q_i$$

This specification has been used for the charitable contributions literature where the total "output" of the charity is the sum of all contributors. It is also one that is frequently adopted for describing public goods that result from individual action (see Cornes and Sandler [1986][1994] and Sandler [1992]).

It is written generally in equation (4), with the function h(.), used to acknowledge that people's responses to the anticipated actions of others depends on how each person perceives the public good is linked to individual behavior. Vivid examples of this relationship were provided in Hirshleifer's [1983] description of the role of the function, labeled by him as a social composition function. More recently, both experimental (Harrison and Hirshleifer [1989]) and conceptual analysis (Cornes [1993]) have confirmed and extended his arguments.

How do these analytical details relate to the treatment of education as having an "indirect" public good effect through its impact on environmental quality? The answer lies in the chain of effects of education on each q_i, such as the one identified for individual 1, and then each q_i on the resulting public good represented through h(.). In the environmental context, does education promote environmentally "responsible" behavior? This could be the

specific context for interpreting a measure of $P_X \cdot MRS_{Eq_i} \left(\frac{\partial h}{\partial q_i}\right) MRS_{QX}$ as an estimate of

the incremental WTP of education because of its public good effects. They arise from education's induced effects on private behavior that in turn contributes to providing a larger amount of public good.

Of course, this type of logic is not limited to private behavior that might be described environmentally responsible. Often in describing the potential for education's public good effects, analysts have suggested that an informed population is likely to act more responsibly in other ways that have been associated with externalities, including actions that might take place in a public choice context (see Jimenez [1994]). Nonetheless, to move from concept to practice, three connections must be measured:

- a relationship describing the effect of education on the specific type of private behavior that contributes to a public good (i.e. MRS_{Eqi})
- a relationship specifying how an increment in private behavior changes the level of the public good (Hirshleifer's arguments clearly document that this relationship is important and it need not be a one-for-one relationship, $\partial h/\partial q_i$).
- a function describing how monetary measure the measure of the economic value varies with the amount of the public good (i.e. $P_x \bullet MRS_{QX}$).

As the next section discusses, we usually do not have the ability to completely construct this sequence for a typical household. Instead, empirical studies will reflect one or more parts of the sequence (often from different studies). Usually these types of studies

report the results as suggestive of education's public good (or social values) or develop illustrative calculations by supplementing what is available with maintained assumptions in order to estimate the desired economic value (this was the strategy adopted in Haveman and Wolfe).

D. Implications of the Models for Measurement

Table 2 summarizes the issues identified in this overview of three alternative conceptual structures for describing the role of education for people's behavior. My discussion has considered the types of assumptions required to evaluate whether private decisions about education, interpreted as a private good, can have non-market and especially public good, consequences. The primary focus of the applications considered (in a few simple examples) has been with respect to environmental resources because they are the source of the empirical results discussed in the next section.

Two of the elements in the table have not been explicitly discussed. Both of the new items relate to informal judgments about the prospects for success in addressing specific empirical questions. Thus, there seems little basis for an extensive discussion. The first of these involves whether the models used to describe behavior are likely to permit distinguishing education's role as a proxy for taste (i.e. an unobserved source of heterogeneity) versus as a causal factor. My evaluation is that only in the case of household production models, does this type of distinction seem likely to have reasonable chance of success.

The second measurement issue concerns questions that would need to be addressed in order to implement the models. Here my judgments are more diverse, depending on the particular framework and application to be considered. Nonetheless, there are a few common themes. The measure intended to represent education as an object of choice--whether it is specific to the individual, such as years of schooling, (as in models II and III) or more general, as a measure of the educational output in a community will be important to the ability to distinguish heterogeneity from causal relationships. It is also important to consider the specific measures used to describe the outcomes influenced by education and how these will be used in non-market benefit measurement. Without restrictive assumptions such as perfect substitution in HPF relations, estimates like those proposed by Haveman and Wolfe will not accurately reflect Hicksian WTP.

Finally, when models acknowledge a jointness, we face a problem in isolating the value attributed to education. The source of that jointness, whether with other public goods, across HPF descriptions of private activities, or due to the effect education has on people and their joint actions for a common good (i.e., Hirshleifer's social composition function) does not necessarily affect the relevance of the issue. All sources lead to questions comparable to those found in cost allocation problems. That is, how do we allocate what might be argued as the joint benefits due to either a composite of public goods or arising from people's actions, in attempting to distinguish the social benefits of education?

The last column identifies some conceptual issues that may be opportunities for further research where greater interaction between economists who attempt to use people's

behavior to value environmental resources with those interested in comparable issues for public education. The first of these is an analogy to the Baumol, Panzar, and Willig [1982] concept of a distinction in the properties of costs when they are involved in producing individual outputs separately versus producing them together. Economies of scope refer to the reduced total cost argued (in some cases) to be associated with producing outputs together. The Bockstael-Kling suggestion of weak complementarity between groups of public goods and a private commodity may well reflect a preference equivalent. of this type of relationship. That is, when combined, the public goods are more valuable. Exceptional visibility and a view from the South Rim of the Grand Canyon would be a pair that might be cited in discussions of environmental resources. However, one could also identify education together with cultural, historic, or scientific resources. Would biodiversity be a different public good to a community with a higher overall level of education that appreciates the interconnections linking ecological resources?

Finally, there is an important omission in the analyses reviewed here that have provided the primary basis for describing people's behavior and its implications for the value of education. They have all focused on interior solutions, considering the effects of education on MRSs. By conducting the analysis at the intensive margin of choice, these models overlook a view of education that describes economic behavior as a composite of decisions made at the extensive and intensive margins of choice. That is, there will be people who do not participate or who change their decisions to participate based on the action under study (see Bergstrom, Blume, and Varian [1986] for a discussion of this issue in the

context of charitable contributions). The conditions defining decisions at the extensive margin are often referred to as individual rationality or participation constraints, and require evaluation of total gains and losses arising from choices. For marketed commodities, these conditions define the extent of the market.

Together with the MRS, these two types of conditions combine to lead to measures of the benefits of a public good. As the next section discusses in several cases, empirical evaluations of information or risk communication policies have encountered both types of responses without having a unified conceptual framework. The point to be made here is that education can in principle also influence both--the choice over amounts of an environmental resource and whether or not to participate or be concerned about it.

IV. Education and Environmental Resources

A. Background

To my knowledge, there have been no attempts, comparable in objectives to Haveman and Wolfe (and the recent update by Wolfe), to estimate education's effects on improving environmental resources. Because education is frequently argued to be a "control" variable reflecting the influence of taste and knowledge related effects, the empirical studies do not claim a causal relationship.[17] Instead, they acknowledge that people with amounts of education can be different in their propensities: to undertake averting behavior, to respond to

information programs, and to form risk perceptions for the different types of environmental hazards.

To evaluate whether a causal argument could be made requires another look at these empirical findings. In the first subsection, I provide that overview. However, it is not a comprehensive review. Instead, I focus on four sets of research: (1) my own work on averting behavior with hazardous waste risks and the implications of information programs for averting behavior intended to reduce risks of exposure to an indoor pollutant, radon; (2) Viscusi's findings concerning the impacts of labels on people's precautionary intentions along with some of my own work on a radon risk communication program, (3) a recent contingent valuation study describing the effects of the framing of risk information about the risks of groundwater contamination; and (4) the work of Ippolito and Mathios and Kenkel concerning health information, nutrition, and behavior because the issues involved are closely aligned with some new research reported later in the section.

B. Averting Behavior and Information Policies

The logic underlying these types of models can be described within an HPF framework. Indeed, the conceptual arguments suggesting that these actions offer opportunities to observe people's values for environmental resources are widespread in the literature. Unfortunately, empirical tests using people's decisions and linking them to environmental resources have been limited. Two types of studies have been used--reports of actual averting or mitigating behaviors and stated choices in response to a predefined

situations. Each has advantages and disadvantages for estimating people's marginal valuations or testing the role of education in enhancing the effectiveness of public information or risk communication programs.

Studies relying on actual reports necessarily use indirect measures of the policy and/or behavior of interest. Nonetheless, the responses studied are reports of actual choices. By contrast, the stated choice studies often have greater control over the way the policy is presented and the object of choice framed to people, but this comes at the cost of the use of statements about choices that would be made.

The first study (Smith and Desvousges [1986a]) involved both types of responses. It was based on a survey of households in suburban Boston. Conducted during the spring and summer of 1984 using a stratified sample selected from two strata, the town of Acton and the rest of suburban Boston, the survey was designed to estimate people's willingness to pay for reductions in the risk of being exposed to hazardous waste (see Smith and Desvousges [1987]). A number of different types of actual and stated response measures were collected from respondents during in-person interviews lasting nearly an hour each. Acton was oversampled because its residents had experienced several incidents where hazardous wastes contaminated their drinking water supplies.

One aspect of the information collected in the survey involved household's decisions to undertake one of three "averting" activities during the five years preceding the survey for the sole purpose of reducing the risk of exposure to hazardous waste. These activities were: installation of water filters, purchase of bottled water, and attendance at public meetings

concerning hazardous waste. Nearly 30 percent of the sample indicated that they purchased bottled water regularly to avoid hazardous waste, seven (7) percent installed water filters and eight (8) percent attended public meetings.

Probit estimates for each activity individually and for a composite (designed to measure whether a person had undertaken any one of the three types of averting behavior) indicated that attitudes concerning the degree to which hazardous waste was harmful, experience, and recent knowledge of the problem in the respondent's town as well as proxy variables for overall attitudes toward risk and the effectiveness of public mitigation were significant, and consistent with a priori sign expectations, as determinants of several of these reported actions, whether measured individually or as a composite variable. Education (measured as years of schooling) was not.

By contrast, when the homeowners in the sample (approximately 44 percent of the sample) were asked about their willingness to move to avoid proximity to a landfill with hazardous waste, the respondent's years of school was a significant, positive determinant of their demand for distance. These demand intention models included income, age, family size, years at the address, as well as experience and attitude measures. The question providing the basis for the demand model was framed, following the logic of a hedonic model (see Freeman [1993]) where homeowners were told houses like their current home would vary in price depending on their distance from landfills with hazardous waste (see Smith and Desvousges [1986b]).[18] This difference in findings illustrates the complexity in linking specific reported behaviors to goals that might then be associated with environmental

resources and then distinguishing an additional contributing factor, such as education's role, in these decisions.

There are any number of explanations for the limited nature of the factors identified in the actual behavior models. The actions are likely to be multiple purpose and we do not know how people interpreted the original question's request that they report only activities whose "sole purpose" was related to reducing exposure of hazardous waste. Recall of behavior, especially actions that are not important or regular, can have substantial error; and finally, the categorical nature of our outcome measure limits the ability of statistical models to capture the effects by potentially important, but subtle effects.[19] With these caveats, it is not clear that the interpretation of education as enhancing people's understanding of the issues would have implied a clearcut sign for its implied effects--either positive or negative.

To evaluate the benefits from education's role in inducing people to take action, we must first judge whether the action would be warranted by some "objective" standard. If the exclusive pathway of exposure to hazardous waste is through drinking water and the household is served from a community source, proximity between one's house and a landfill will not influence the pathway. Similarly, if experts judge a particular risk to be small and education has a positive, significant effect on subjective risk perceptions for that source, we must ask whether the educational effect is meaningful.[20] It may be that education heightens awareness of the source (a "good" outcome), does not influence perceived risk greatly across individuals (a "neutral" outcome), but is found to be a significant positive influence in empirical models (a seemingly "bad" outcome) because of the type of measures of risk

perceptions available.

Where does this leave my discussion of the conflicting results from the role of education in the first area? I believe it implies that if we are seeking a clear interpretation that education has a social benefit due to its effects in enhancing the performance of environmental policies directed at private responses to externalities or inducing people to undertake behavior that makes "more" environmental quality available, then the cases must involve actions with unambiguous interpretation and substantial control on how the policy or activity influences the "claimed" environmental benefits.

Use of behavioral intentions for products labeled as having specific hazards defines both the context and the judgment about what is a "correct" outcome for each person. To do so requires that the analysis be based on respondents' statements about their intentions for using this hypothetical commodity. While this research may seem far afield from applications to environmental resources, Viscusi's research (see Viscusi and Magat [1987]) and Magat and Viscusi [1992]) was designed as part of a larger effort to evaluate information programs in implementing environmental policies (i.e., regulating the use of pesticides, etc.).

A variety of products and outcome measures were considered using both computer assisted, mall intercept, and telephone surveys. Two outcome measures are potentially important to evaluating the role of education: (a) recognizing the warning message and (b) being able to use the information to undertake (or intend to undertake) the recommended mitigating behavior.

Under a variety of controlled conditions, Magat and Viscusi [1992] report that

education enhances recognition and ability to recall warning messages (see Appendix H for their specific multivariate results). Open ended questions seeking information about the warnings yielded responses that identified the precautionary words and the prospects respondents would remember those warnings as positively related to education. While these results are related to specific types of consumer products with hypothetical labels, my risk communication experiments evaluating brochures explaining radon's risk confirms their findings (see Smith et al., [1988]).

That is, by exploiting the panel design of a study intended to evaluate the effectiveness of a risk communication program, this analysis was able to consider whether different types of information materials influenced people's knowledge about radon, its risk, and how to mitigate its effects. Years of schooling was a positive and highly significant determinant of participants' scores on a quiz given after they received the risk information treatments; it positively contributed to their learning (as measured by correctly answering questions previously answered incorrectly) and to their "correct" interpretations of the risks associated with radon and the mitigation recommendations they would make. While this study used a specific set of questions (and not the often preferred open ended approach used in Magat and Viscusi), it involves real risks and controls over the circumstances in which learning is measured.

Thus, both of these studies would support the type of link hypothesized in the conceptual discussion between education and household production functions. However, this evidence alone does not indicate whether years of schooling increases the rate of mitigation

or reduces its costs (by improving household production activities). It simply suggests that people recognize the message.

If we consider that next step, mitigation, the record is mixed with some encouraging evidence on an indirect effect. To some degree, the conclusions here overlap with the activities in the health area noted below with the Ippolito-Mathios and Kenkel research. For these applications, there are fewer assumptions required to connect behavior (stated or actual) to education.

Viscusi's research with product warnings does not find a significant role for education in enhancing the effects of a warning on promoting the recommended behavior (as a stated intention). The variable, years of schooling, is a positive contributor to the behavioral intention, but not significant. (Viscusi, Magat, and Huber [1986]). In a continuing evaluation of the panel of households' decisions, some years after the learning questions were posed, we (Smith, Desvousges, and Payne) investigated their reported mitigation and found no direct effect. That is, with a sample of 853 households who had participated in the original analysis cited earlier, received radon readings and differing information materials, we found there was no significant separate effect of education on mitigation. However, there was a significant positive effect of respondents' knowledge (measured by the score of the same individual on the quiz taken two years prior to the mitigation survey). Because education was a key determinant of the effectiveness of information programs in conveying the correct messages, these results would suggest the types of impacts outlined in the HPF model.

Nonetheless, it is important to acknowledge that these effects need not be uniform for all people. That is, if people already know about radon, its risks, and the mitigation options, then the information programs do not change their knowledge base. They may well choose not to do anything about it. Hence for these people, education, by enhancing their effectiveness in test scores, but not their choices (stated or actual), would not yield indirect benefits. This conclusion reinforces the distinction between the effects of education on the participation and the marginal conditions in describing its indirect benefits. Unfortunately, the data available do not permit measuring the cost of the activities to the people involved. Thus, an incremental tradeoff, similar to that suggested by Haveman and Wolfe, is not possible. The next two sets of research would allow some version of this type of tradeoff, but neither is ideal.

The first is a contingent valuation study focused on how risk information was presented to respondents. The design relies on the Smith-Desvousges [1987] study of people's willingness to pay for reducing the risk of exposures to hazardous wastes. Using a split-sample design, Loomis and duVair [1993] evaluate whether the method used to explain a proposed risk reduction (i.e., a risk ladder versus pie charts) influences respondents' willingness to purchase plans (identified with different costs) to reduce risk. The most interesting aspect of the findings for judging the effects of education is the differential impact of education on a stated behavior (i.e., purchasing a program to reduce exposure risk) using the two different information approaches. Education is a highly significant, positive influence on the likelihood of supporting the plan when a more complex, compound lottery

format (involving pie charts) was used. It was a positive, but insignificant influence when a single risk measure, with, a risk ladder, was used. If we interpret education's role as permitting increased understanding of the object of choice in the complex case and not necessarily important to the questions posed in the other sub-sample, then the behavioral link suggested by the mitigation results described above would appear to be present for decisions where both prices and information matter.

The last set of research returns to actual behavior in a health related context and considers the effects of information on continuous measures of activity. The reason for considering it here is to evaluate whether education would influence both the decision to undertake activities and the amount of those activities.[21] The results from Ippolito and Mathios [1990, 1989] suggest that education may be enhancing the effect of fiber information available through cereal ads on the amount of fiber consumed as a result of a person's cereal choice. Their analysis uses the difference in these fiber consumption patterns before and during a period when cereal manufacturers were permitted to use fiber related health claims in their advertisements. Education is a significant determinant of the selected fiber content in cereal in each of the two periods studied. Its estimated effect increased on fiber consumption for the period with the fiber-health claims, but these differences would not be judged as significantly greater than those for the period before the advertisements. Moreover, the results relate to two <u>different</u> samples of women, with somewhat different educational levels (12.72 years of schooling for the sample before the advertising and 12.84 after). Supporting evidence is also available in their summary of the fiber consumption of women based on the

USDA Continuing Survey of Food Intakes by Individuals in the same years when it is decomposed by education (Ippolito and Mathios [1989]). This comparison indicates significant differences in the fiber consumption between 1985 and 1986 for those with some college (i.e., 13-15 years of reported schooling), but no significant differences at other educational levels.

Perhaps the strongest evidence of an interaction effect is in Kenkel's [1991] study of the interaction effects of knowledge of the "harms" posed by smoking and drinking and the benefits of exercise with the level of education as a differential factor influencing reported behavior. As in the work associated radon, Kenkel used respondents' answers to questions about each source of health effect to measure knowledge and then investigates, using interaction terms, education's additional influence for each type of behavior (i.e., cigarettes per day, drinks with alcoholic beverages in the past two weeks, and minutes of exercise in past two weeks). He interprets a significant interaction effect between a knowledge measure and education as supporting a differential effect of education. For example, education enhances the impact of knowledge about the ill effects of smoking and that increase in impact is unlikely to be taste related.

There are two problems with these results. The first arises with the interpretation of a knowledge variable as a measure for what an information program would accomplish. The second is recognized by Kenkel, but not fully developed in his results. That is, it concerns the separate effect of education on knowledge. Education influences both knowledge and behavior so the interaction effect may simply reflect simultaneity in Kenkel's knowledge and

behavior variables. Because both variables are based on reports after the learning and the activity studied have taken place, they may well be jointly determined.

Equally important, Kenkel's argument that an interaction effect of knowledge can distinguish causality from taste assumes a fairly simple relationship. As the earlier work suggests, there is clear evidence of a link between knowledge and policies in more controlled settings, but it is difficult to establish the "knowledge equivalent" of a policy. Simple interaction effects do not in themselves distinguish taste from the role of education in enhancing the effectiveness of an information program. They could reflect the need for a more detailed specification. Indeed, these interaction effects were significant and incorrectly signed (if the argument is intended to suggest that they provide evidence of the complementary effects) with two of the three other activities using his male sub-sample. Simultaneity between knowledge levels and the activities studied also poses a potential problem in interpreting these interaction effects. Unfortunately, Kenkel does not report enough information to resolve matters. Models based on estimates adjusting for simultaneity are reported, but they do not include the interaction terms.

The lessons from my selective review of links between education and people's behavior in learning about sources of environmental externalities and what the people can do to protect themselves from these hazards, confirms education's role as enhancing learning. Both specific information (Smith, et al., [1988]) and general reports (Viscusi, et al., [1986]) suggest that years of schooling improves the transmission of information from brochures and labels.

Education also seems to increase the likelihood of undertaking behavior because of this enhancement in knowledge. Thus, the effect is unlikely to be taste related, but it may also be possible to accomplish this increase in the effectiveness of information programs in other ways (i.e., different information messages, as in Loomis and duVair). Moreover, education's impact on the amount of effort devoted to mitigation has not been unambiguously established with models based on actual behavior. At this point, the empirical findings are suggestive "hints" about an association. To extend the link beyond this point would seem to require more control than is usually available. To illustrate whether such a strategy can be successful, the next section summarizes the findings from an earlier evaluation of a public information program about radon (Desvousges, Smith, and Rink [1992]) and a re-analysis of those results to determine whether the complementary effects of education could be detected using actual behavior and the experimental controls that were present as part of an evaluation of that program.

C. Some New Evidence on Education and Averting Behavior

This section describes the results of an extension to Desvousges, et al., [1992] investigating education's interactive role with information programs and controlling for knowledge as well as other economic and demographic effects. The context of this evaluation is a panel study designed to evaluate two different risk communication programs intended to increase the likelihood that homeowners would test their residences for radon. Three communities in Maryland were selected for that evaluation. All had high reported

levels of radon and similar socio-economic characteristics. Table 3 identifies the treatment and control communities and describes the characteristics of the two programs--an extensive program in Frederick and a more modest campaign in Hagerstown. Unfortunately, the control that can be exercised in "real world" experiments is limited. Moreover, confounding effects can arise independent of experimental controls. Independent of our study, a Washington, D.C. television station (WJLA) launched an information campaign over the same time period consisting of public service announcements about radon and a prime time special. Because this activity had its primary effects on Hagerstown and Frederick, not our study's control community, this independent effort confounded our ability to unambiguously evaluate the impact of our controlled program, but does not affect the objective of gauging education's causal role with information programs. As Table 3 indicates, the WJLA program appears to have greatest effects on the community that also received the most extensive risk communication campaign.

Baseline surveys were conducted in each city prior to each program (December 1987), to obtain information about attitudes, knowledge, prior radon testing, and demographic information for each sub-sample. A random digit dialed survey screened the initial sampled telephone numbers to be sure they were associated with owner occupied dwellings, and obtained a listing of adult decision makers. We randomly selected one of these identified decisions makers and conducted a baseline and followup (after the program) interview with that person. This followup interview took place in April 1988.[22] Table 3

includes the response rates for the two surveys and the sample sizes for each community and interview.

The panel design of the study, together with the experimental variation in the risk communication programs, allows the separate effects of education on learning and then mitigation to be evaluated. The outcome variables used in this analysis are learning measures and mitigation in the form of conducting a home radon test. The later was a key objective of the communication program--to promote testing and self protection where it was needed.

The original analysis of this experiment focused on attitude change, learning, and testing as measures of the results for each program. There was no attempt made to evaluate whether education enhanced either program's effectiveness. Our earlier conclusions on the mitigation decisions were that the concentrated media campaign (in Frederick) did significantly increase testing, but that the modest media campaign was not any different than the control community in its radon testing. Moreover, the sensitization associated with the survey activity itself did not alter these general conclusions.

My re-analysis of these data focused on distinguishing the effects of education through learning versus its direct impact on program effectiveness using the new testing decision as the outcome measure. Tables 4 and 5 report these results based on probit and ordinary least squares models with the panel sample pooled across the three communities. There is clear evidence of education's complementary effect with risk communication programs on people's home testing decisions. Indeed, the initial analysis overlooked an important component of

this effect by failing to allow for this complementarity.

Table 4 considers the effects of selected attitude and demographic variables on each respondent's decision to test his (or her) home for radon after the risk communication program is completed.[23] The first column reports a somewhat different specification than originally reported in Desvousges, Smith, and Rink [1992], changing the treatment of information available through television (the WJLA effect) and introducing a specific learning variable, measured by the percentage improvement on a seven question quiz given during the baseline interview and then again in followup interview. Concerns about health, initial knowledge, learning, and the qualitative variable indentifying the more extensive program were all significant positive influences on these people's decisions to test. While the learning effect was not recognized before, measures for the remaining variables were reported in that earlier analysis. Education has no apparent separate effect with this model. However, we never considered the possibility of a complementary effect with the program.

The next two columns divide the sample into those respondents with more than high school and those with high school education or below. Here we begin to see the potential for interaction effects. The intensive information program has a differential impact for only those respondents with more than a high school level of schooling. This would suggest that the complementary effects are selective, depending on the level of education and potentially the type of activity involved.

However, this is not the end of the story. Based on the earlier conceptual argument, as well as the Viscusi, et al., [1986] and Smith, et al., [1988] results, we would also expect

to see an impact of the risk communication programs on learning. Under this hypothesis, some of the effect captured in the learning measure would be due to any indirect effect of the communication programs. Table 5 tests this hypothesis using a regression analysis of the learning measure, "improve," as a function of demographic and program-related variables. The first column reports the full sample. The second and third columns provide the same two subsamples (i.e., greater than high school education and high school and below) as considered in describing radon testing decisions.

These findings are important to the earlier conclusions (i.e., Desvousges, Smith, and Rink [1992]). By failing to take explicit account of learning, our evaluation of each program overlooked the potential for differences in the direct and indirect impacts with education. These new findings indicate a small effect of the media-only program (Hagerstown) on testing through enhancements in people's learning.

More specifically, it appears that the more extensive program has its greatest effect on learning for those respondents with high school and below. The WJLA television based program also enhanced learning for this group. Within this group, there is also a separate effect of years of schooling. By contrast, with those households with greater than high school education, there appears to have been a learning effect due to the media-only format. The primary effect of the extensive program (Frederick) takes place directly in inducing them to undertake home testing, once they already know about radon.

D. Implications

Three cases were distinguished in developing a model that would permit estimating education's social value: (1) education as a complementary public good with other public goods (i.e., the preference equivalent of economies of scope); (2) education as a private good that improves the effectiveness or reduces the cost of programs intended to promote private actions mitigating public bads; and (3) education as a private good that induces people to pursue activities that contribute to public goods.

This section concerned the empirical evidence on these types of relationships linking education to environmental resources. To my knowledge, there has been no research on the first type of relationship.[24] The last requires an external, generally agreed set of private activities that actually contribute to an environmental public good. Private efforts at recycling or in the definition of eco-labels illustrate the difficulties in making judgments about what is in fact "environmentally good," private behavior (see Menell [1993]). To pursue this line of research further would also require that there be general recognition and acceptance that these activities were consistent with producing improved environmental quality. There did not appear to be examples that would meet these criteria.

As a result of these constraints, the bulk of this section was devoted to a selective review of the literature on averting and mitigating behavior models to gauge whether a complementary role for education (separate from taste effects) could be established. The available results seem to suggest a complementary role in learning tasks. The level of education enhances the effectiveness of information and risk communication programs in

increasing people's ability to learn. No separate complementary effect of education has been detected for precautionary activities with either the environmental or health issues. Part of the reason for this conclusion (in the environmental research) was that few of the studies were looking for these types of effects. Education was largely a control variable. Distinguishing the effects of education as a proxy for taste versus as a causal factor was not important to the objectives of that research. Moreover, the level of control necessary to do so seems beyond most of this past research.

The last part of this section then asked--would it be possible to evaluate the potential for a complementary role when there was sufficient control available in the research design. Here, the discussion offers one example--a re-examination of an early risk communication program for homeowners' decisions to test for radon. The results were surprising. In contrast with earlier conclusions, not only were the effects of the risk communication programs more detailed and complex than originally concluded, but the complementary role of education seems to help in explaining them. For this one example, then, there appears to be an effect of education in enhancing learning and one in promoting action (separate from the learning effect).

V. Environmental Policy Design and Evaluation

A. Speculations on Education's Impact on the Environmental Policy

To the extent education plays a role in influencing people's performance in market and non-market tasks, then recognition of these impacts should alter policy. This implication is simply an extension of the Blinder and Rosen's [1985] recognition of the importance of heterogeneity for the design of tax policies (i.e., creating "notches" or budget discontinuities to target the distortionary effect of these policies).

Targeting policies, based on other criteria, are not new. Differential policies for large and small firms, minority groups, by gender, age, etc. have been developed to achieve policy objectives related to these groups. Targeting based on educational levels has generally been regarded as more difficult because of the transactions costs of identifying and separating the groups.

A better understanding of how education serves as a complementary resource, enhancing the effectiveness of environmental and other policies, may change this preconception. Moreover, to the extent that differentiated programs already exist (or would need to be developed to meet declining educational levels among large segments of the population), then direct efforts to promote enhanced education offer a substitute for these program adjustments.

There is another way in which policy design is affected by education. In a democratic society, to the extent the public has unwarranted fears of any phenomenon, such

as the risks arising from exposures to hazardous wastes, and policymakers direct resources to mitigate these problems, (and away from more serious hazards according to "the experts"). In these cases, one might argue that education could improve the allocation of public resources by changing the perceived fears driving the policy agenda.

This suggestion is not a random speculation. The disparities between expert and public evaluations of environmental risks has been argued to provide the reason why EPA's policy initiatives appear inconsistent with technical risk estimates. Indeed, EPA's Science Advisory Board identified this disparities in beliefs between experts and the layperson as a central problem facing the agency in its policymaking.[25] Education is related to subjective risk perceptions and there is now wide appreciation in economics of the importance of the cognitive problems that can arise when people consider environmental risks. However, to evaluate the full consequences of this misperception requires the definition of a standard. Someone must specify the "right risk perception" for each person.

Subjective risk perceptions are the result of both an understanding of the process giving rise to risk and individuals' preferences (e.g., judgments of the importance to that individual of what is at risk). Thus, we cannot be sure that stated risk perceptions are "mistakes" due to cognitive errors in interpreting risk information or simply reflections of preferences. To alter the latter as a correction would abandon consumer sovereignty. Nonetheless, because there are very large discrepancies between public and expert perceptions for important sources of risk, there is certainly scope for improved efficiency without necessarily defining a "best" subjective risk perception for each person. Education's

role in reducing simple cognitive errors and information limitations would no doubt lead to substantial gains before entering into discussions that could be argued as questioning consumer sovereignty. Unfortunately, beyond identifying the issues and empirical research on risk perception processes (e.g., Viscusi [1993], Smith, et al., [1990]), there has been no research on how enhanced education might influence the policy agenda.

B. Education and Policy Evaluation

Information is essential for evaluating any policy activity. There has been increasing recognition of how education is impacting the collection of information from surveys. At the simplest level, reading skill among the U.S. population (currently at about the seventh grade level) limits the methods used to both convey information and to collect it.[26] Thus, to the extent that mailed surveys are used to collect information for policy evaluation, education has a long term effect on the types of information that can be collected using this format.

To my knowledge, there is little direct evidence on the effects of education on response rates and survey administration. There is a developing set of literature indicating that the cognitive effort devoted to answering attitude and related questions is influenced by educational attainment. Krosnick [1991], for example, suggests that the likelihood respondents will adopt "satisfying" approaches to answering questions (i.e., offering answers that appear acceptable, but do not result from a thoughtful evaluation of the issues posed) will be inversely related to the respondents' cognitive sophistication. This sophistication is described in his and other's work as an ensemble of abilities associated with retrieving

information from memory and integrating it into verbally expressed summary judgments. These skills are related to both innate factors and learning experiences.

Thus, education can, in principle, affect who participates in surveys designed to collect information used in policy evaluation as well as the quality of the responses they provide. In short, it contributes to the measurement error in the economic models we use to evaluate programs and policy outcomes. In the long term, these errors are influenced by the educational level (and associated cognitive skills) of the population providing that information. Thus, we have short term effects on the design of mechanisms to collect information comparable in its role to the design of policies as responses to existing educational levels.

There is also a longer term return to education for both policy and evaluation. These influences may be especially relevant to environmental policies where the issues involved are complex and require detailed understanding of the interactions within ecosystems and between people and their environment. Educational constraints may well limit the ability to convey information about such complex policy issues. A few examples illustrate the dilemma. Decisions about biodiversity and species loss, climate change, and the long term hazards posed by alternative management policies for high level nuclear waste require extensive technical information to appreciate their short and long term implications. Informed choices cannot be made without understanding of the technical issues involved. In these areas, one might ask whether education imposes a constraint on the ability to rely on consumer sovereignty in such large scale choices (see Ecosystem Valuation Forum [1992]

and Weitzman [1992, 1993] for more technical arguments).

VI. The Environment's Role in Education's Social Benefits: Next Steps

Over thirty years of empirical research on the impact of education has focused the greatest attention on its private returns. While social returns to education have been informally acknowledged for most of this time, systematic efforts to estimate these benefits have been more limited. This overview of the relationship between education and efforts to enhance environmental quality has identified a more general set of questions associated with developing measures of education's social benefits. Past efforts to explain the demand for education have used two quite different specifications for the education as an object of choice or economic commodity. One focuses on years of school and each individual's choice to pursue increased education. Within this framework, social benefits have been defined as a composite of the effects of education on that individual's non-market activities and any private decisions that relate to social objectives. These linkages are best described in a household production framework where education must be considered an input that has a causal role in improving the effectiveness of these activities. The classification of activities based on their relationship to private services or public goals determines whether this causal link would imply a public benefit.

The second approach measured the object of choice attributed to education as some

type of average level of activity for students within an educational system. Usually these evaluations focused on primary and secondary education, but the same logic could have been applied to public higher education. The only attempt to distinguish social from private benefits in this context was based on the attributes of households (e.g. presence of children and capitalization effects) in comparison with those without the possibility of these sources of private gains.

Using either approach to construct separate measures for the social benefits of education requires the analyst to compose what is taken to be the object of choice motivating people's decisions. This strategy is the accepted paradigm for revealed preference approaches to economic analysis. Results are evaluated, in part, by how much can be inferred from extremely limited information.[27] An alternative strategy would suggest that the analyst should begin by determining how people conceive of education as an object of choice. While there are limits to what can learned from this approach, the literature seems to be in little danger of reaching the point of diminishing returns. No economic research has considered this option.

Why might it be important, given the prospect of success with the alternatives? The reasons arise in the role attributed to education and measures of economic value. The conventional strategy relying on cost savings due to education's role in improving households' abilities to accomplish tasks that are related to private or public goals imputes values to each of these savings by considering a substitute for what was accomplished with education. Education is a means to some other objective. It enhances private activities or

improves public mechanisms (i.e., public information or risk communication policies), but no independent role can ever be detected. This follows because maintained assumptions are required to link education to the activities in the first place. Even if people appreciate these connections, they may have other objectives (unrelated to private returns) for supporting public education.

These more general efforts should be regarded as requiring longer term research programs. In the short term, there does appear to be a significant role for education as a complementary factor in improving the performance of public information and risk communication related to environmental resources. With the increasing complexity of environmental resource problems, programs to communicate information about environmental resources seem likely to play a growing role in future environmental policy design and evaluation. Because of these trends, it would be desirable to consider opportunities for short term research insights from investigating links between education and these past policy initiatives.

Over the past decade, the Environmental Protection Agency sponsored a substantial program of research on public information and risk communication. These efforts involved job-related risk, product labeling, indoor radon, food safety (i.e., pesticide residues), siting decisions involving undesirable land uses, recycling, and others. In some cases, the studies had a specific component designed to evaluate the effectiveness of the policy interventions being considered. To my knowledge, none of these efforts attempted to evaluate how education might have enhanced programmatic objectives or if the policies could be designed

to reflect the effects of education on people's responses. My re-analysis of one of these earlier research efforts indicates evidence of a complementary role for education "waiting in the responses" that was never observed because the researchers did not look. Equally important, there are new initiatives, such as the EPA's Toxic Release Inventory, that make emission information generally available to the public. These programs could be leading to changes in community response activities that differ by education levels. Such differences in education may offer a natural experiment to further investigate these complementarities, provided causal and taste related effects can be separated.

In all of these efforts, it is important to distinguish social from public values, where the latter are assumed to arise from public goods. There is also a need to distinguish value from monetary benefit. Reconstructions of imputed cost savings due to measures of education's effects on household or policy performance do not mean that people would, in fact, pay these amounts for the education. They are an analyst's imputation. Measuring willingness to pay from these implicit decisions requires that people recognize the objects of choice in ways that are consistent with what analysts assume.

Table 1: Summary of General Social Surveys: 1972-1993[a]

Year	Sample Size
1972	1,613
1973	1,504
1974	1,484
1975	1,490
1976	1,499
1977	1,530
1978	1,532
1980	1,468
1982	1,506[b]
1983	1,599
1984	1,473
1985	1,534
1986	1,470
1987	1,466[b]
1988	1,481
1989	1,537
1990	1,372
1991	1,517
1993	1,606

[a] National Opinion Research Center, *General Social Surveys* 1972-1993: *Cumulation Codebook*, August 1993

[b] In 1982 and 1987 there were black oversamples with 354 observations in 1982 and 353 in 1987.

Table 2. Overview of Modeling Implications

Framework	Potential Theoretical Restrictions	Education Causal or Source of Unobserved Heterogeneity	Measurement Issues	Types of Environmental Application
Model I (Simple)	Weak Complementarity; Potential for cascading chain of linkages; Group linkage across public goods	Difficult to establish causality with theoretical restrictions in this format and only Revealed Preference Data (RPD)	Measuring amount of education-Years of schoolings versus average level of overall education; Allocation of "Joint" benefits	Unique rare environmental resources in groups with Education;examples include Bidiversity, historic and cultural resources
Model II Household Production Functions (HPF)	Group private commodities based on *a priori* restrictions due to defined activities; assumes knowledge of a process; Links education to activities based on assumed *a Priori* knowledge	Likely to define rationale for causality with prior HPF restrictions and RPD	Estimating HPF functions; Time allocation measures of pollution; Jointness in education's role across HPF as a type of public input; and may be Jointness in other inputs confounding role of education	Mitigating exposure to pollution; recreation; self protection and risk perception
Model III Public Good Production by Individuals	Structure of Hirshleifer's Social Composition Function (SCF)	Comparable to simple model	Substantial data issues; Measuring behavioral Activities; Estimating SCF	Green labeling; Environmental altruism

Table 3. Design Features of Maryland Public Information Program

Community	Role in EPA Test	Elements of Treatment[a]			Impact of Independent WJLA Program[b]	Sample Size	
		Media	Mailings	Outreach		B	F[d]
Randallstown	Control	None[c]	None[c]	None[c]	10 kits	495 (48)	307 (78)
Hagerstown	Modest Media Campaign	5 different PSA to 3 radio stations every two weeks; project-designed posters ran in newspaper one week in February; four additional articles in paper	Pamphlet inserted in utility bills during February/March billing cycle	None	93 kits	529 (64)	432 (82)
Frederick	Extensive Media Campaign	5 different PSA to 2 radio stations every two weeks; five of eight articles in local newspaper project-related	Pamphlet inserted in utility bills during February/March billing cycle	Posters (4) in locations around town; nine presentation to community groups between January and March 1988; organized Radon Awareness Week; arranged for Mayor and Alderman to monitor their homes	669 kits	523 (56)	432 (83)

Table 3 (continued)

[a] The primary messages emphasized in the public service announcements (PSA), posters, public meetings, etc. were:

- Radon is a serious health risk. You may be at risk. The only way to find out is to test.
- Testing is easy and inexpensive.
- Radon problems can be fixed.

[b] Independent of the EPA Project, a Washington, D.C. television station, WJLA, conducted a month-long campaign to encourage people to test their homes for radon during January/February of our study period. The campaign had multiple components, with coordination by television and newspapers, and availability of radon test kits at a reduced price at Safeway Supermarkets. The campaign began on January 12, 1988, included a three-part news series during the week of January 18, and ended with another three-part series during the week of February 15-19. Advertisements for the effort appeared in the Washington Post and on television. 100,000 radon tests kits were purchased, with 70,000 returned for analysis. Television ratings indicated an audience of 76,000 viewers. The television programs targeted the Washington, D.C. viewing area. Residents of Frederick were most likely to watch the station airing the programs. Hagerstown residents could view WJLA, but reception is poor without cable. Randallstown is outside the viewing area, but reception is good. Numbers refer to the radon test kits returned from each community.

[c] None refers to the fact that there were no project-initiated information materials presented in public media mailings or meetings. Some independent newspaper articles did appear in a local paper.

[d] The numbers in parentheses below the sample sizes were the response rates. For the details of how they were computed see Desvousges, Smith and Rink [1989]. B designates the baseline survey and F the followup survey with the same individuals. The numbers in parentheses below the sample sizes are the response rates in percentage terms.

Table 4. Testing Education's Role With Maryland Risk Communication Experiment[a]

Independent Variables	Full Sample	Greater than High School	High School or Below
Intercept	-3.072* (-7.50)	-4.113* (-4.99)	-3.422* (-2.80)
Years of Schooling	.007 (0.25)	.066 (1.32)	.063 (0.60)
Family Income (in Thousands)	.050 (1.45)	.065 (1.50)	.028 (0.46)
Health Attitude[b]	.195+ (1.62)	.078 (0.51)	.361+ (1.80)
Identified TV[c]	.156 (1.28)	.127 (0.79)	.167 (0.85)
Know[d]	.239* (6.17)	.229* (4.48)	.244* (3.86)
Improve[e]	.230* (3.61)	.183+ (1.81)	.253* (2.97)
Frederick (=1)	.418* (2.61)	.659* (3.28)	-.025 (-0.09)
Hagerstown (=1)	.082 (0.46)	.163 (0.71)	-.175 (-0.61)
Pseudo R^2	.148	.160	.152
n	1132	633	499

[a] The numbers in parentheses below the estimated coefficients are Z statistics based on the estimated asymptotic standard errors for the null hypothesis of no association.

[b] This is a qualitative variable (0,1) for a health attitude question asked during the baseline overview. It asks each respondent to describe themselves as: "I ask my physician a lot of questions about my health." The question asks to indicate if these things are true about the respondent always, often, sometimes, or never. Those answering always or often were coded as health concerned (1) otherwise as less concerned (0).

[c] This variable attempts to take account of the effects of the WJLA radon information program. Because these efforts were largely related to public service announcements on TV, a qualitative variable coded as one for those individuals identifying TV as the source of their information and zero otherwise.

[d] Know is a count of the correct answers for the seven questions during the baseline interview.

[e] Improve is the proportionate change in the number of correct answers between the baseline and followup interviews. This is interpreted as the effect of the program on learning.

* Significantly different from zero at least at the five percent level.

+ Significantly different from zero at least at the ten percent level.

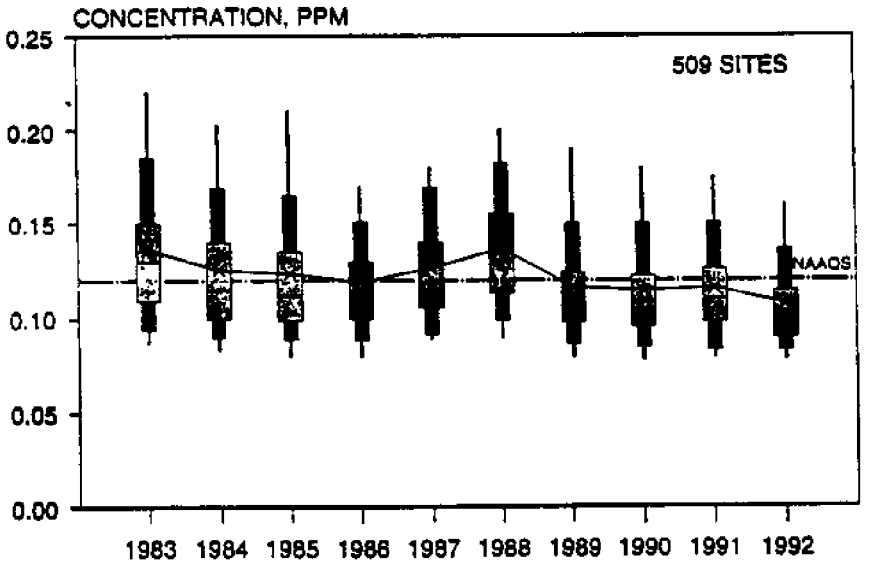
Table 5. Education's Impact on Learning: Maryland Risk Communication Experiment[a]

Independent Variables	Full Sample	Greater than High School	High School or Below
Intercept	.448*	1.192*	-.939+
	(2.09)	(-3.67)	(-1.91)
Years of Schooling	.008	-.034	.107*
	(0.74)	(-1.46)	(3.00)
Health Attitude	.061	.024	.112
	(1.07)	(0.33)	(1.27)
Age (in years)	-.004*	-.004	-.001
	(2.14)	(-1.59)	(-0.44)
Male (=1)	-.153*	-.142+	-.138
	(2.62)	(-1.89)	(-1.51)
Identified TV	.090	.016	.159+
	(1.55)	(0.22)	(1.76)
Frederick	.118+	-.004	.317*
	(1.64)	(-0.05)	(2.59)
Hagerstown	.122+	.163+	.141
	(1.67)	(1.72)	(1.21)
Pseudo R^2	.015	.018	.046
n	1315	721	594

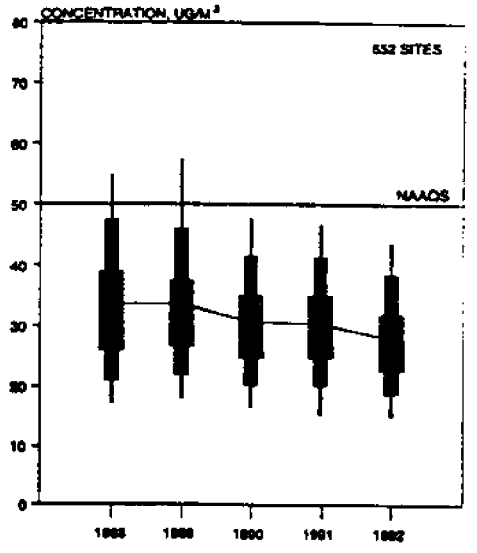
[a] These estimates are based on ordinary least squares with the dependent variable defined as the proportionate increase in the count of correct answers to a seven question multiple choice quiz, asking the same respondent about radon's effects, home testing and mitigation. The numbers in parenthesis below the coefficients are t-ratios for the null hypothesis of no association. The variables are defined in Table 3.

* Significantly different from zero at least at the five percent level.

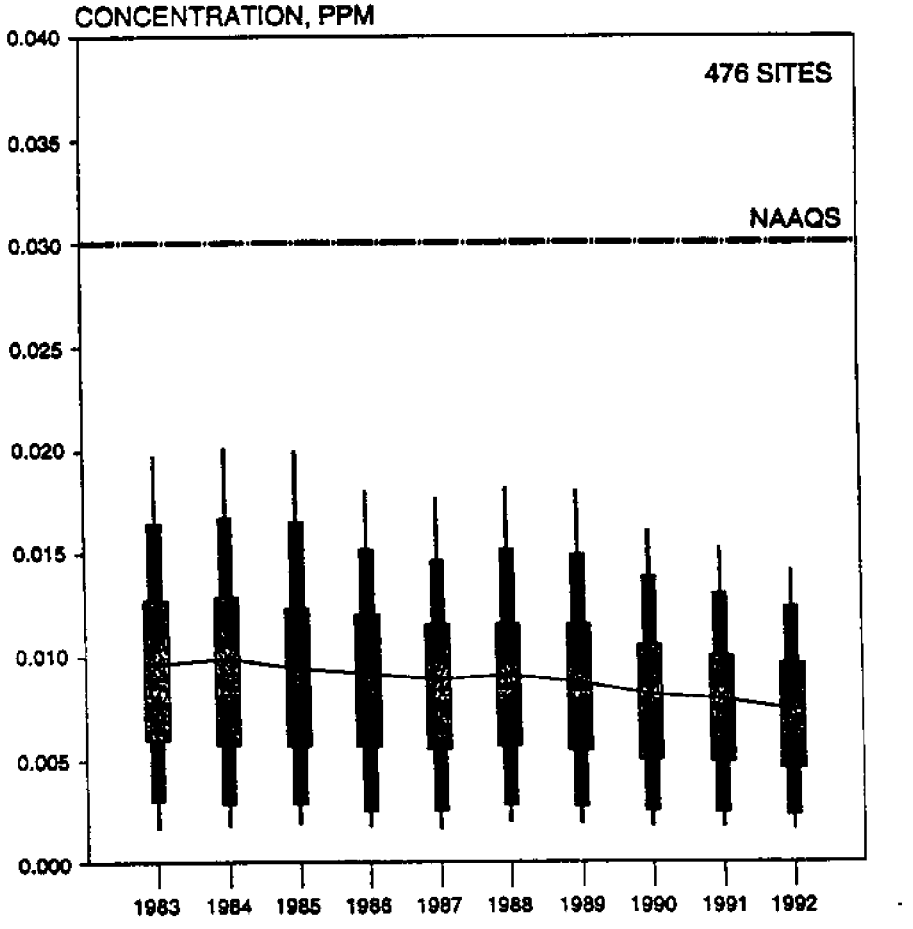
+ Significantly different from zero at least at the one percent level.



Boxplot comparisons of trends in annual second highest daily maximum 1-hour ozone concentration at 509 sites, 1983-1992.



Boxplot comparisons of trends in annual mean PM-10 concentrations at 652 sites, 1988-1992.



Boxplot comparisons of trends in annual mean sulfur dioxide concentrations at 476 sites, 1983-1992.

Figure 1: Trends in Annual Concentrations of Criteria Air Pollutants

Source: US Environmental Protection Agency [1993]. WAAQS refers to national ambient air quality standard. Defined separately for each of the criteria air pollutants.

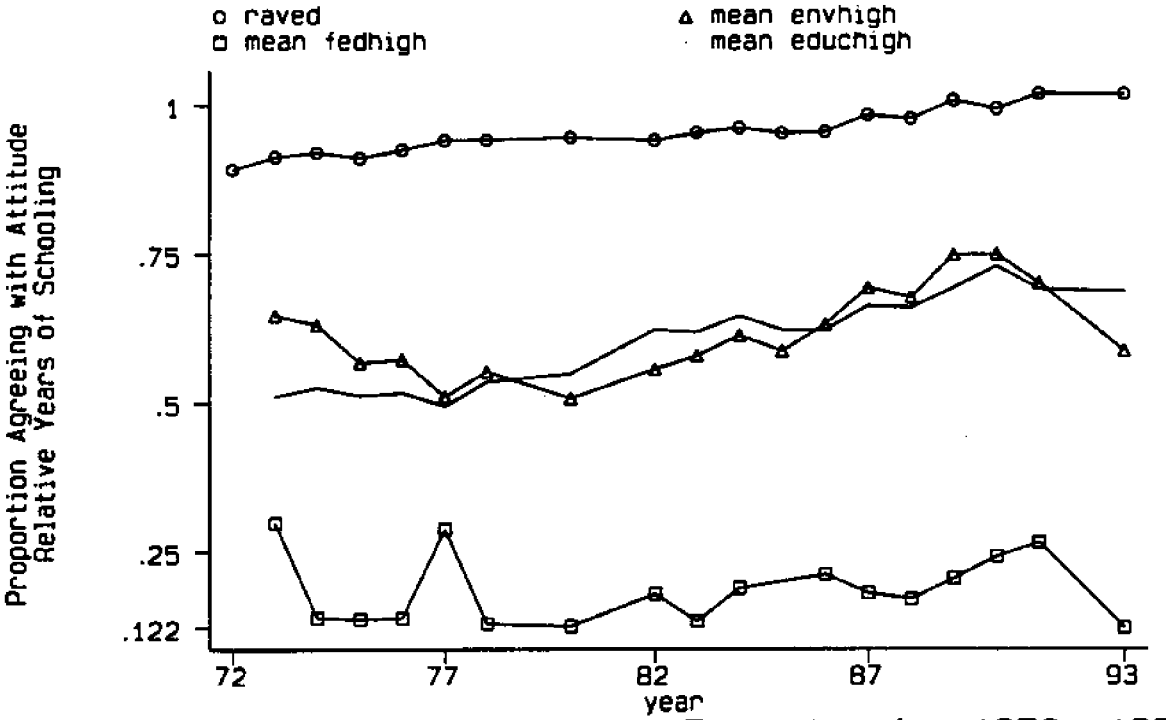


Figure 2a: Trends in Attitudes and Education for 1972 -1993

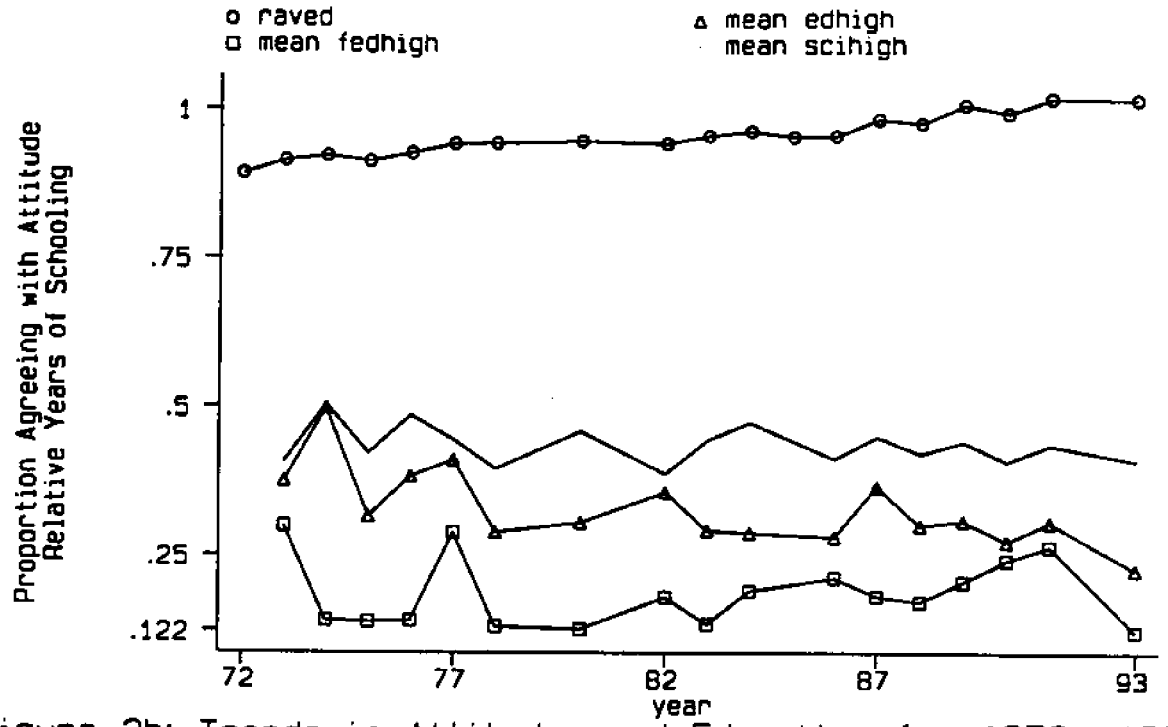


Figure 2b: Trends in Attitudes and Education for 1972 -1993

Footnotes

* Arts and Sciences Professor, Duke University and University Fellow Resources for the Future. Thanks are due Ray Kopp for collaborating in the development of the general conceptual issues associated with valuing nonmarket resources, to Jere Behrman, Winston Harrington, Nevzer Stacey, Albert Tuijnam, and Dennis Yang for constructive comments on earlier drafts, and Paula Rubio, Terrie Rouse, and Tricia Shore for assuring a continuously changing manuscript was completed. Partial support for this research was provided by the U.S. Department of Education and the UNC Sea Grant Program under grant R/MRD25.

1. This observation was first made by Wildavsky [1988] in considering the apparent contradiction between concerns about risk among people in developed economics and the actual risks they experience.

2. Given the concern over environmental quality in the U.S. and most developed economics, this comparison may seem surprising, but it is readily confirmed for air and water quality where there are reasonable monitoring data and may well be an adequate summary for hazardous substances as well. See the World Bank's 1992 report *Development and the Environment* or the United Nation's *Urban Air Pollution in Megacities of the World.*

3. Indeed, the National Environmental Education Act of 1990 sought to develop educational programs and curricula that respond to the complex nature of environmental problems. The legislation notes that:

> ". . . effective response to complex environmental problems requires understanding of the natural and built environment, awareness of environmental problems and their origins, and the skills to solve these problems."

More recently, the National and Community Service Trust Act of 1993 sought to expand community service and student service activities as part of social learning that it argued provided visible benefits to the participants in such programs and to their communities.

4. A Box plot portrays the distribution of readings with the dimensions of the box corresponding to the inter-quartile range, the line in the middle providing median and the lines from the box extend to three-halves the interquartile range extended back to where there is data.

5. These models were proposed by Borcherding and Deacon [1972] and Bergstrom and Goodman [1973] as theoretically consistent alternatives to a earlier literature that used regression models to sought to describe public expenditures per capita in a variety of different categories as a function of state and local area characteristics. The standard models usually maintain a constant elasticity demand function.

6.. See Huang and Smith [1994] for further discussion of the production interpretation of weak complementarity as a basis for measuring the economic value of non-marketed resources that affect production activities.

7. Becker's [1964] discussion of differences between the private and social rates of return to education focuses primarily on the subsidies and indirect costs not reflected in his estimates. No consideration was given in to non-market effects.

8. The HPF framework allows the analyst to introduce structure into the way goods, services, and time combine to yield increases in well-being. See Smith [1991a] for a discussion of other restrictions commonly used to estimate non-market values within this framework.

9. These models sometimes include constructed price measures. See Gramlich and Rubinfeld [1982] an example.

10. Martinez-Vazquez [1981] considered local bond referenda to evaluate whether public goods effects (beyond direct private use benefits) appear to influence the voting behavior. He concluded that the private net benefits was a weak explanatory factor because high income groups voted in favor of proposals that would have benefited lower income groups.

11. This estimate assumes a locally constant elasticity demand function and computes the consumer surplus per unit of education based on the elasticity from the total demand (including private and public components in Wyckoff's framework) and the public component elasticity. See Smith and Desvousges [1986b] for the derivation.

12. See Freeman [1993] for an overview of the issues associated with defining and measuring existence (or nonuse) uses.

13. See Wolfe with Zuvek as (undated) for an update to the Haveman-Wolfe analysis.

14. The embedding issue was first identified by Kahneman and Knetsch [1992] as a fundamental problem with the use of survey techniques in non-market valuation. Support for this view as offered in some of the studies reported in Hausman [1993], notably the Kemp-Maxwell [1993] and Diamond, Hausman, Leonard and Denning [1993] papers. By contrast, an explanation that recognizes embedding as an aggregation issue can be found in Smith [1992] and Carson and Mitchell [forthcoming].

15. See Ridker [1967] for the first example using this basic idea for measuring the value of reducing air pollution.

16. See Slovic et. al. [1985] and the National Research Council [1989] for discussions of these discrepancies and their policy implications. Viscusi's [1993] prospective reference theory offers a different interpretation for this research, suggesting it is a reflection of informal Bayesian formulation of subjective risk perceptions.

17. Behrman's [1994] discussion of this issue in a general context, reflects the longstanding examples. One of these relevant to some of my discussion by Fuchs [1982] argues that unobservables, such as differential rates of time preferences, could have been responsible for more educated individuals making greater health investments, rather than a causal link between education and health.

18. Separate examples for this type of relationship using information from actual housing sales can be found in Michaels and Smith [1990] and Kolhase [1991].

19. There was subsequent evidence of systematic recall errors as the time horizon for the summary judgement of activity is increased see Westat [1989].

20. Machina [1990] has argued that in evaluating the economic efficiency of allocation decisions, analysts should be prepared to intervene and "correct" risk misperceptions people form in valuing policy intervention if they are based on incorrect interpretations of or incorrect use of logical methods (i.e. probability theory) with the available information on the risk. His arguments raise important questions about how consumer sovereignty affects the analyst's interpretation of "mistakes." Education presumably enters this brew by influencing the rate of mistakes. This would seen especially relevant to decisions involving risk, where people seen to have a very difficult time understanding probability concepts. I return to this point as a more general issue in the section IV.

21. Separate analysis of these mitigation decisions of household in the New York panel study, considering their dollar expenditures have a number of problems. Because the activities do not have well defined prices (i.e. the radon mitigation must be adjusted to the characteristics of each house) it was not possible to obtain meaningful price measures. Equally important the actions involved a mix of private homeowners activities and monetary expenditures. The later can include equipment that serves multiple objectives (e.g. a new furnace ventilation system). Finally, the mitigation reports included a limited number of observations reporting expenditure exclusively for radon reduction. Thus, there are reasons to question what can be learned from the monetary expenditures data. A tobit analysis was consistent with these reservations. The overall sign of effects identified with the discrete classification of activities were consistent, but few of the variables would have been judged statistically significant by conventional criteria.

22. There was also an independent sample collected after the public information programs in each town to evaluate the potential for sensitization of respondents in the panel sample due to the baseline survey. These results did not appear to be important (see Desvousges, Smith and Rink [1989]).

23. This outcome measure is a <u>new</u> decision to test for radon. The panel survey was evaluated three ways - without the homeowners' reporting that they had undertaken tests in the baseline survey, adjusting for prior tests as a selection effect, and the current method that treats them as unaffected by the program. All three approaches yield comparable conclusions and the complementary role of education. The current method was selected because it makes the impact "most difficult" to isolate and offers

the largest sample for disaggregated analysis.

24. Three studies, Hoehn [1991], and Hoehn and Loomis [1993] have considered how people's responses to valuation questions are influenced by the sequencing of miles of closely related environmental public goods. This research seeks to evaluate the effects of contemporaneously provided public goods due to substitution and complementarity relationships that may exist between the goods. See Madden [1991] and Carson, Hanemann and Flores [1994] for a discussion of the conceptual rationale for these types of tests. Because education's public good effects are presumably long term impacts, this type of contemporaneous effect seems unlikely.

25. The EPA Science Advisory Board report that started these activities; Unfinished Business: A Comparative Assessment of Environmental Problems [1987] contributed to changing the agency's approach to evaluating its policy goals.

26. A recent study of adult literacy in the U.S. sketches an even more discouraging picture, suggesting that language barriers and insufficient education were important barriers to common tasks like "writing a letter about a billing error or calculating the length of a bus trip from a schedule." see Kirsch et al., [1993].

27. A vivid example of this tendency can be found in Fuchs' Foreward to Mincer's classic study of experience and earnings where he observes

> "In the pages that follow Mincer demonstrates his skill as a wielder of Occam's razor. His objective is to explain a great deal with a little" (P xiii)

What he does not say is whether the explanations are consistent with what people believed they were doing when they made those decisions.

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