Risk of pollution and the cost of misinformation

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Abstract

This paper estimates the change in averting behavior following the openings of residual waste plants in Mexico in the period 2000 to 2011. Following an environmental change, it first shows theoretically that the difference in willingness to pay between two different perception of a risk can be attributed to preventive behavior. Empirical results from the difference in difference model show households undertake bottled water expenses even if the environmental health risk is close to zero. Household level of revenue plays an important role in the demand for bottle water consumption.

1 Introduction

The analysis of expected economic benefits of reductions in pollution is of great importance both in Europe and America. Benefit-cost analyses of environmental regulations are increasingly mandated. Monetary values are assigned to benefits and costs using the willingness for society to pay (WTP) for a good or service. Different methods can be used to attach estimates of willingness to pay to changes in the level of environmental quality. Cost of Illness (COI) and Averting Behavior Methods (ABM) are examples of approaches to estimate the economic benefits of reduced morbidity effects associated with pollution releases.

The health literature often measures the cost of illness (COI) which considers both medical expenses and the cost of employment compensation due to illnesses, accidents or premature deaths. Cost of illness sums out-of-pocket health care expenses and lost wages (Alberini and Krupnick, 2000). However, COI method ignores the capacity of individuals to mitigate the effects of poor environmental quality and can lead to erroneous conclusions. As a consequence, previous studies also rely on how individuals respond to avoid exposure to an environmental hazard in order to obtain an appropriate measure of WTP for valuation. This is known as averting or defensive behavior method. If there is a change in the environmental quality, households must increase their expenditure on other inputs to maintain constant the quality of the environment. Willingness to pay is linked to the actions taken to mitigate adverse health outcomes resulting from pollution (Dickie and Gerking, 1991). Averting expenditure, utility constant measure, is defined as the costs of measures undertaken in efforts to counteract the consequences of pollution (Harrington and Portney, 1987). It requires detailed information on the market and the nonmarket measure that individuals take to defend themselves against pollution or other environmental threats (Harrington and Portney, 1987). Courant & Porter (1981) developed theoretical frameworks of averting behavior in response to pollution. They consider the relationship between the willingness to pay for environmental quality and averting expenditures. Main results are that defensive expenditures normally underestimate benefits. In fact defensive expenditure does not capture the disutility induced by illness, and the cost of illness. Theoretical literature tells us the only way that the defensive expenditure can exceed WTP is if the increase in defensive expenditure, in response to an increase in pollution, improve health (Harrington and Portney, 1987). Besides, Harrington & Portney (1987) highlight that WTP can be estimated from the changes in medical expenditures. In the same vein, Dickie and Gerking (1991) stated that a possible approach to implement the averting-behavior model is to estimate the demand for medical care. If medical care is a necessary input in the production of health, changes in the area under this demand curve when pollution changes can be used to estimate WTP for pollution reductions (Dickie and Gerking, 1991). As an example, Age and Crocker (Agee and Crocker, 1994) estimate parents' WTP for health risk reductions posed by their child's body lead burden and for information about possible chelation therapy.

ABM in response to pollution has been used a lot in the previous empirical literature about water contamination (Abdalla et al., 1992), (Abrahams et al., 2000),(Um et al., 2002), urban air pollution (Bresnahan et al., 1997) or more specifically ozone exposure (Mansfield et al., 2006). Many empirical studies find evidence that household's education, households' knowledge of contamination, perception of risk (Nauges and Van Den Berg, 2009) (Abdalla et al., 1992), (Abrahams et al., 2000),(Um et al., 2002),(Jalan and Somanathan, 2008), (Sattar and Ahmad, 2007) increases the probability that households undertake averting expenditure.

Our approach in this paper is to estimate WTP as a genuine representation of the change in household's utility. We focus on a lower bound of WTP by estimating averting behavior through health and water expenses, components of WTP, following a negative environmental shock: the opening of incineration plants. In response to a pollution shock, we wonder in this paper, to what extent households' perception of risk determine their demand for averting goods.

We first derive a theoretical expression of WTP for improving water quality with respect to risk perception. We make the hypothesis utility function is the same for all agents and we look at the implications in terms of elasticity of WTP with respect to risk perception. This theoretical model sheds light on different aspects: Several authors developed theoretical model of WTP including health in the utility function (Harrington and Portney, 1987), (Bresnahan et al., 1997), (Dickie and Gerking, 1991),(Mansfield et al., 2006) but they did not take the importance of risk awareness in seeking medical care in the expression of WTP. Besides, the demand for medical care represents both cost of illness and defensive expenditure. However, our model will show that the COI method, widely criticized in the literature, can be a good estimate of WTP under the assumption of an absence of risk perception. We give a possible explanation to recent empirical literature which restore COI method saying it may approximate more comprehensive measures of economic benefits for some disease (Guh, 2008).

Second, we estimate the demand for water bottle and preventive medical care to emprirically test the role of risk perception in the expression of WTP, following a change in environmental quality. To do so, the date of opening of twenty three residual waste plants in Mexico from 2000 to 2011 serves as a exogeneous shock. Despite an absence of health risk, mexican households frm middle class have a positive response to this environmental change.

2 THE MODEL

2.1 Utility function

The starting point for utility theoretic analysis is the household's utility maximization problem over one period. The utility $U^i(X^i;H^i)$ is the household's, continuous, differentiable and quasi concave utility function. i represents an household, X is a private good, and H, perceived health depends on different variables: Health is produced by combining medical care received with medical treatment due to illness M^i, genetic capital endowments K^i, exposure to pollution g, risk perception household have about environmental quality s^i [1], and averting behavior AB^i. The variable g represents an environmental quality variable and is assumed to be a public good not chosen by households. It enters the preference structure such that $\partial u/\partial g > 0$. In this paper, g will be affected by the opening of an incineration plant which has a negative effect on environmental quality. s^* is the critical stock of risk awareness related to preventive expenditure required to maintain good health.

$$H(M^i, g, s^i, AB^i, K^i) \tag{1}$$

$$\text{If } \; s^i > s^* \; \text{ then } \; AB^i > 0$$

$$\text{Otherwise} \qquad AB^i = 0$$

Risk perception s^i and averting behavior AB^i are important inputs in the production of good health. Both variables represents preventive expenditure in this model.
The full income budget constraint, conditional on the level of information, is:

$$wT + S^i = X^iQ_X + s^iQ_s + AB^iQ_{AB} + M^iQ_M + G_H$$

where w is the wage rate, T denotes total time available and S are subsidies and R^i, the revenue such that $R^i = wT + S^i$. G_H is the monetary value of time lost from market and non market activities as a function of H with $G_H < 0$. Q_k takes the form $Q_k = p_k + wT_k$ such that Q_X, Q_M and Q_{AB} are the monetary value of time lost and price of each input.

[1]Let's i, j, k be different types of households. The perception of risk can be different according to the households taken into consideration (ie: $s_i^* = 0; s_j^* > 0; s_k^* \to \infty$). We can perceive a risk leading us to undertake preventive expenditure but it is a choice not to do it, due to revenue constraint for example.

Substituting consumption good and health demand into the utility function yields indirect utility functions with respect to s : $V^i = V(Q_X, Q_M, Q_{AB}, Q_s, I^i, w^i, g)$

The inverse of the indirect utility function with respect to income argument is the minimum expenditure function with respect to information:

$$e(Q_X, Q_M, Q_{AB}, Q_s, S^i, w^i, g) =$$
$$\min\{Q_X X^h + M^h Q_M + AB^h Q_{AB} + s^i Q_s + G_H - wT - I(U(X^i; H^i) = U^i)\}$$

Given the assumption that g is a good, $e(Q_x, Q_M, Q_{AB}, Q_s, I^i, w^i, g)$ is decreasing in g (i.e.$\partial e / \partial g < 0$)

2.1.1 The role of risk perception

The opening of incineration plants, negative environmental quality change (Δg) will have both a direct and an indirect effect on medical care. First, it will increase medical expenditure due to illness which represents the cost of illness. Second, we assume households will take into account a negative change of environmental quality by increasing their demand for preventive medicine. They will do so if they perceive a risk about the negative consequences it implies on their health $\frac{ds}{dg} \neq 0$. A change in environmental quality (Δg) will also have an impact on the consumption good, X in the sense that (Δg) will lead to a change in the level of substitution between the consumption good and health. It implies an indirect effect of environmental quality on health through s^i, risk perception household have about environmental quality, such that $M(s^i)$. The indirect effect suggests that a negative environmental quality shock may not have any impact on household's health if they sufficiently compensate the negative effect by a positive one, spending more to protect their health. We integrate this structure in a model where perceiving a negative environmental quality shock, increases averting behavior ($\frac{dAB^h}{dg} \neq 0$). As an example, if we perceive the consequences of drinking contaminated water, not only, we will start buying mineral water or begin some form of home purification (Jalan and Somanathan, 2008) but also, we will take preventive health measure such as buying medicine, immunizations or going to the doctor.
The level of risk perception is a key point in this paper.

Although the theoretical model can be apply to different kind of environmental threat, we estimate, in this paper, WTP for improved water quality. To do so, we use the averting behavior method (ABM). First, we consider the purchase of bottle water as being one part of preventive expenditure (Abrahams et al., 2000). Medical expenses and more specifically preventive health expenses are the second part of defensive behavior we estimate.

2.2 The expression of WTP

We first consider the complete expression of health when perceiving a risk involves averting behavior and preventive care expenditure. From the indirect utility function, we know the derivative of health with respect to environmental quality :

$$\frac{dH}{dg} = \frac{\partial H}{\partial AB}\frac{dAB}{dg} + \frac{\partial H}{\partial g} + \frac{\partial H}{\partial s}\frac{ds}{dg} + \frac{\partial H}{\partial M}\frac{dM}{dg} + \frac{\partial H}{\partial s}\frac{ds}{dg} + \frac{\partial H}{\partial K}\frac{dK}{dg}$$

Genetical endowment and risk perception do not change with the level of environment quality such that $\frac{dK}{dg} = 0$ and $\frac{ds}{dg} = 0$.

We obtain the partial derivative:

$$\frac{\partial H}{\partial g} = \frac{dH}{dg} - \frac{\partial H}{\partial AB}\frac{dAB}{dg} - \frac{\partial H}{\partial M}\frac{dM}{dg}$$

We can also obtain the expression of WTP from the derivative of the expenditure function developped previously. Considering the minimum expenditure function, and applying the envelope theorem, we obtain:

$$\frac{\partial e}{\partial g} = \frac{\partial G_H}{\partial H}\frac{\partial H}{\partial g} - \frac{\partial U}{\lambda \partial H}\frac{\partial H}{\partial g} = \frac{\partial H}{\partial g}(\frac{\partial G_H}{\partial H} - \frac{\partial U}{\lambda \partial H})$$

$$\frac{\partial e}{\partial H} = \frac{\partial G_H}{\partial H} - \frac{\partial U}{\lambda \partial H}$$

Differentiating the expenditure function with respect to g yields households' marginal willingness to pay for an improvement in environmental quality.

$$MWTP^i = \frac{\partial e}{\partial g} = -\frac{\partial e}{\partial H}\frac{\partial H}{\partial g} \tag{2}$$

where $\frac{\partial H}{\partial e}$ is the marginal utility of income. This formula states that the marginal willingness to pay for an environmental quality change is given by the marginal utility of environmental quality, converted in monetray units via the marginal utility of income.

$$WTP^i = \frac{\partial H}{\partial g}(\frac{\partial G_H}{\partial H} - \frac{\partial U}{\lambda \partial H})$$

We substitute $\frac{\partial H}{\partial g}$ into the expression of WTP, and we obtain:

$$WTP^i = \frac{dH}{dg} - \frac{\partial H}{\partial AB}\frac{dAB}{dg} - \frac{\partial H}{\partial M}\frac{dM}{dg}(\frac{\partial G}{\partial H} - \frac{\partial U}{\lambda \partial H}) \tag{3}$$

From FOC, we know that :

$$Q_M + \frac{\partial G_H}{\partial H}\frac{\partial H}{\partial M} = \frac{\partial U}{\lambda \partial H}\frac{\partial H}{\partial M} \Leftrightarrow -Q_M = (\frac{\partial G_H}{\partial H} - \frac{\partial U}{\lambda \partial H})\frac{\partial H}{\partial M}$$

$$Q_{AB} + \frac{\partial G_H}{\partial H}\frac{\partial H}{\partial AB} = \frac{\partial U}{\lambda \partial H}\frac{\partial H}{\partial AB} \Leftrightarrow -Q_{AB} = (\frac{\partial G_H}{\partial H} - \frac{\partial U}{\lambda \partial H})\frac{\partial H}{\partial AB}$$

We replace FOC into the expression of WTP. The welfare effect of a marginal improvement of environmental quality is then given by:

$$WTP^i = \frac{\partial G_H}{\partial H}\frac{dH}{dg} + Q^i_M\frac{dM}{dg} + Q^i_{AB}\frac{dAB}{dg} - \frac{\partial U}{\lambda \partial H}\frac{dH}{dg} \tag{4}$$

$$\text{If } s^i > s^* \text{ then } Q^i_{AB}\frac{dAB}{dg} > 0$$

$$\text{Otherwise} \qquad Q^i_{AB}\frac{dAB}{dg} = 0$$

The first two terms represent the cost of illness (COI) which is a sum of the monetary value of lost time, $(\frac{\partial G}{\partial H}\frac{dH}{dg})$, and the change in medical expenditure due to illness $(Q^i_M\frac{dM}{dg})$. If $s^i > s^*$, WTP is an expression of the COI, the change in the disutility of illness, plus the observed change in defensive expenditure. We consider that defensive behavior is the sum of a change in averting expenditure $Q^i_{AB}\frac{\partial AB^h}{\partial g}$.

Households may not perceive the negative consequences of pollution on their health or that they are constrainted so we do not further consider defensive expenditure in the expression of WTP. Consequently, they will not seek preventive medical care or start averting behavior. COI approach have been widely critized as a measure of willingness to pay (Dickie and Gerking, 1991). However, we assume that the cost of illness plus the change in the disutility of illness can be a theoretically correct measure of benefits if households do not perceive any risk. We restore COI method saying it may approximate more comprehensive measures of economic benefits for some disease (Guh, 2008). Guh et al. compare COI with stated preference estimates of WTP associated with shigellosis in a rural area of China. They find a similarity between COI and WTP with the explanation that preventive expenditures and disutility due to pain and suffering are low for shigellosis. In line with the literature, averting expenditure only provides partial protection from unsafe water (Dickie and Gerking, 1991).

We can also express the expression (2) in term of α for further estimation.

$$MWTP^i = \frac{\partial e}{\partial g} = \frac{-1}{\alpha}(\frac{\partial H}{\partial g}) \tag{5}$$

We obtain:

$$MWTP^i = \frac{-1}{\alpha}[\frac{dH}{dg} - \frac{\partial M}{\partial g}\frac{dM}{dg} + \frac{\partial AB}{\partial g}\frac{dAB}{dg}] \tag{6}$$

This formula states that the marginal willingness to pay for an environmental quality change is given by the marginal utility of environmental quality depending on medical care (M) and averting behavior (AB), converted in monetary units via the marginal utility of income. This expression also assumes that deciding to seek preventive actions will also change the effect of environmental quality on illness. It yields to a change in medical care M. The marginal willingness to pay takes into account the reduction of medical curative expenses if we undertake preventive health expenses. This distinction has several interests. As we will consider the averting behavior method, utility constant measure, we will only focus on the expression of AB. The quality of water g will be given by the presence of an incineration plant. While water quality may be affected in the long term, after the opening of an incineration plant, we may convincingly argue there is an absence of environmental health risk in the short term. We assume disutility from pollution and curative care being the same for all households. After an environmental change, theoretically we have shown the difference in willingness to pay between an household that perceived a risk and an household that does not perceive the risk can be attributed to defensive behavior. In the rest of the paper, defensive behavior then refers to both bottle water and protective health expenses. In fact, in an absence of an environmental health risk, the overall change in health expenses can be attributed to protective health expenses.

3 Descriptive statistics

90% of Mexican people have drinking water coverage. Water coverage is defined as having tap water in its household, outside of its household but within the grounds from a public tap (INEGI, Mexico). Water quality in Mexico is managed by municipalities. Municipal treatment plants condition the quality of water in surface and or groundwater sources for public urban use. While water leaves the plant in drinkable form, Mexican argue water travels through old underground pipes and dirty rooftop water tanks to the consumer. In a 2002 report on the state of water quality in the world by the United Nations Development Programme, Mexico ranked 106th out of 122 countries. Drinking contamined water is the most direct route of exposure to pollutants in water. Acute exposure to contaminants in drinking water can cause irritation or inflammation of the eyes and nose, skin, and gastrointestinal system. Gastrointestinal diseases were estimated to cost Mexico US $3,6$ billion in health care expenditures in 1990 and continue to be one of the most serious health problems today especially for children in their fist year of life. The most significant health effect is due to chronic exposure to copper, arsenic, or chromium in drinking water. In this context and despite reassurances from the authorities that municipal plants pump clean water into the supply network, skepticism is widespread. As a consequence, Mexicans used about 127 gallons of bottled water per person a year, more than four times the bottled-water consumption in the United States (Inter-American Development Bank). As an incentive to consume tap water, a law from 2014 by Mexico City's legislators require all restaurants to install filters so they can offer patrons free, drinkable water.

In this context, we use incinerator openings in Mexico as a natural experiment to analyze people perception about water pollution. Incineration plants is part of water pollution. Incinerator plants are the source of serious toxic pollutants: dioxins; furans; acid gases; particulates; heavy metals; The pollutants are transported in the air and deposited in water and soil. These pollutants can leach out posing a more immediate threat to ground water and rivers. Numerous studies confirm that a typical incinerator releases a cocktail of toxic chemicals, including dioxins, lead, cadmium, mercury and fine particles, into the atmosphere. There has been little follow up investigation into the effects of these poisons on people near incinerators. However there is no reason to believe tap water is affected due to the presence of municipal treatment plant that condition water quality.

Information about incineration plants comes from the mexican ministry of environment and natural resources (SEMARNAT). I look at every waste treatment process plant in Mexico and their date of opening. 23 companies in Mexico have opened between 2000 and 2011. 15 corresponds to incineration of biological/infectious hazardous waste and 8 corresponds to incineration of hazardous industrial waste. Every plants are still open. In addition, we use Data from the Mexico National Institute of Statistics and Geography - Instituto Nacional de Estadística y Geografía (INEGI). The Household Income and Expenditure Survey (ENIGH) is a long-running nationally-representative series on household income and expenditures. Topics included detailed food, alcohol, tobacco, transportation, education, housing and health expenditures. It also included questions on income, sources of income, employment, housing materials, water, sanitation, assets, and drainage.

I use the dataset from ENIGH for seven years 2000, 2002, 2005, 2006, 2008, 2010, 2012. 2004 is missing because there is no information about bottle water expenses in this sample so that I decided not to include it. Descriptive variables are presented in table 1. The type of household varies from 1 to 5. 1, 2 3 4 5 corresponds to single, married, married with children, extended family or shared house respectively. Expenses corresponds to the household total expenses in health, bottled water, smoking, transport, housing or education. Concerning bottled water consumption, households fill in their spending only if they spend something for bottled water. We do not recall information about non monetary expenses that corresponds to gifts to households. Health sums together expenses in hospital, medicine and out-patient care. Transfer corresponds to the amount of transfer and household can reveive. Young corresponds to the number of people within the household with maximum 11 years old whereas old correponds to the number of people with 65 years old or more.

As shown in the previous section, WTP for an improvement of environmental quality should depend on averting behavior AB, preventive health behavior, the cost of illness and the disutility of pollution. We will then only focus on both averting behavior through health and water expenses to estimate WTP.

4 Econometric Analysis

4.1 Identification

In this section, we derive, from (2) and (5), an observable expression for MWTP for actions taken by households to avoid chronic health risk after the opening of an incineration plant next to their place of residence. To do so, I view households' decision to seek preventive actions as discrete choices (Agee and Crocker, 1996). I use estimate of the demand for medical care and the demand for purification to compute willingness to pay for improved water quality. Let $\widetilde{V_1^i}$ denotes households' maximum attainable expected utility if preventive actions are chosen and $\widetilde{V_0^i}$ denotes households's maximum attainable expected utility if preventive actions are not chosen. The conditional indirect utility function of household i on preventive goods 1, $\widetilde{V_1^i}$, is additively separable as follows:

$$\widetilde{V_1^i} = V(Q_X, Q_M, Q_{AB}, Q_s, I^i, w^i, g) + u_i \tag{7}$$

Household i perceived a certain level of risk (s) will choose preventive actions (AB) , if $\widetilde{V_1^i} > \widetilde{V_0^i}$. The probability that household i will choose preventive actions conditional on income, price and observable household characteristics, is:

$$\pi_1 = Prob[u_1^i - u_0^i < V_1^i - V_0^i] \tag{8}$$

$V_1^i - V_0^i$ measure the remaining elements, water bottle AB and the part of medical expenses M that corresponds to preventive health. The probability π_1 can be interpreted as the probability of households seeking preventive actions if they perceive a risk.

First, households will start averting behavior, AB, if the utility differential between purification and non purification D(p) is higher than the cost of purifying C(w) depending on wealth. Averting behavior measures the propensity of an household to use bottle water rather than not using any purification system. This dichotomous variable is a function of households characteristics (health status, education, number of people within households, connexion to water, water disponibility, number of domestic and profesional workers , information, marital status, number of children) , place of residence (rural, municipalities), pourcentage of potable water within localities, and on determinants of the budget constraint. The model predicts that purification would rise for households informed about the importance of water treatment and would have no effect on households who does not purify their water.

In turn, households will start preventive health expenditure, M, if the utility differential between seeking medical care and non seeking medical care D(p) is higher than the cost of medical care C(w) depending on wealth.

Following Small and Rosen (Small and Rosen, 1981)and the empirical application for environmental quality (Dickie and Gerking, 1991), households' MWTP is approximated by :

$$MWTP_1^i = \frac{\pi_1}{\alpha}(\frac{\partial \widetilde{V_1^i}}{\partial g}) \tag{9}$$

where $\frac{\partial \widetilde{V}}{\partial g}$ and α are the marginal utility of environmental quality and income. We can use this expression as an approximation of the MWTP expression derived in the previous section if the compensated and marshallian demands for preventive actions are approximately equal (Small and Rosen, 1981). To implement this expression empirically, we consider the probability is given by:

$$\pi_i = \phi(V_1^i - V_0^i) \tag{10}$$

where ϕ is the cumulative standard normal distribution function. Thus, the change in consumers' surplus area behind the preventive demand curve asssociated with reduction in pollution is approximated by (Small and Rosen, 1981):

$$MWTP_i = \frac{-1}{\alpha}\frac{\partial \widetilde{V}}{\partial g}\phi(V_1^i - V_0^i) \tag{11}$$

$V_1^i - V_0^i$ being the remaining elements following a change in g, we also can write it:

$$MWTP_i = \frac{-1}{\alpha}[\frac{\partial \widetilde{AB}}{\partial g}\phi(\widetilde{AB}) + \frac{\partial \widetilde{M}}{\partial g}\phi(\widetilde{M})] \tag{12}$$

The marginal willingness to pay following a change in environmental quality is composed of the change in averting behavior, such as buying mineral water, AB, and the change in health care, M. As emphasized previously, in the absence of a real environmental health risk, we assume the change in curative care being the same for all households following a change in environmental amenities. In this context, the difference in health care expenses that would be measured between an household that will anyway perceive a potential risk and an household that would not perceive any risk, can be attributed to preventive health care.

We will use this expression in the next section to compute the $MWTP_i$ for a decline in environmental quality.

4.2 Results

4.2.1 The role of averting behavior in the MWTP for an environmental change

The change in health care and water bottle determine to what extent households are willing to pay more to protect their health. We distinguish the model of purification from the model of health care, both averting behavior components of the WTP approach model. First of all, we present a double difference model using the opening of an incineration plant as an exogenous shock of pollution. We exploit this definitive event to identify the marginal willingness to pay for a change in environmental quality, comparing preventive behaviors in areas close to the incineration plant after the opening of a plant vs. before the opening, using areas far from the incineration plant as a control group. It has the advantage to remove the problem of endogeneity widely commented in the literature.

This paper first tests the effect of incinerator openings on bottled water expenditure in table 2. The first column presents results for a fixed effect model. Controls variables are added in the second column and the third column takes advantages of monetary controls. Monetary controls reduces the significativity of the coefficient. Control variables show the expected sign. The first three columns of Table 2 shows demand for bottle water increase nearby 10% after the opening of an incineration plant in the same geographical area where the plant has been installed. Results are robust to different kind of models. Thus, there is a positive effect of the opening of an incinerator on water expenditure.

Secondly we test in this article the effect of incinerator openings on health care expenses. The three columns of Table 3 shows demand for health care does not have any marginal effect on health expenses after the opening of an incineration plant in the same geographical area where the plant has been installed. Health corresponds to both curative care and preventive care. Preventive care and curative care are not presented separately in table 3 due to data constraints. If we had observe an increase in health expenses after the opening of an incineration plant, it could have been attributed either to an increase of illness or to an increase in preventive behavior. Nevertheless, in the absence of health risk, in the ABM with utility constant measure, curative care stays constant and all changes in health expenses can be attributed to preventive health.

While a perceived health risk tends to increase the demand for purification in average, risk perception does not increase the demand for health. Let's note, the estimation model is not able to consider other kind of averting behavior an household can undertake (i.e:

spending less time outside).

The positive change in water bottled indicates households are willing to pay more to protect their health against an environmental change. As we underline before, however there is no reason to believe water quality has suffered from the incinerator openings. Results highlights protection may be costly. Results also show misinformation drive people to undertake expenses that may have been avoided. Results reinforce the necessity for public authorities to well communicate to reduce social costs.

4.2.2 The role of revenue in the decision to seek averting behavior

As stated theoretically in the previous section, the level of household's revenue can help us to understand to what extent households decide to undertake preventive actions. Literature tells us poorly informed consumers tend to underestimate the productivity of medical care in treating illness (Kenkel, 1990).

The sample is split into four categories with respect to total revenue. I repeat previous estimation for these four categories of revenue. I first consider the demand for purification in table 4. We observe a positive effect of incinerators openings on bottled water consumption in the second category of revenue. Results show middle class are responsive to environmental changes. In this paper, they seem to overestimate the risk by undertaking averting behavior. Despite a positive coefficient sign, the three other categories of revenue are not significant.

Second, I focus on the demand for health in table 5. In line with previous results, health care expenses do not change after the openings of incineration plants.

To sum up, results vary substantially with respect to the level of income. People living near the residual waste plant may actually be concerned differently by its opening. The budget constraint plays a crucial role. The second category of income has a significant and larger response to pollution. It is often assumed in the literature that concern about environmental pollution is middle-class (Cutter, 1981). The perception of the increase in health risks may be higher than the real increase in health risks. The public engage in behavioral responses even if the costs of the exposure do not exceed its benefits. Overprotection is costly; Policy makers have an important role in the design of communication. Not only is information costly, but also misinformation.

5 Conclusion

This paper aims to understand to what extent perception differs from the objective health risk in the estimation of the marginal WTP for an improvement in environmental quality. The hypothesis of this paper is that individuals take substantial action to reduce exposure to risk. We rely on both averting behavior, buying mineral bottle and medical care to measure preventive expenditure. While the risk is close to zero, households seem to undertake action to reduce a perceived contaminated water risk. More specifically, we find that the level of revenue plays a crucial role in estimating the marginal WTP for an environmental change. Thus, there may be a cost of misinformation. Overprotection may be costly for society.

6 Annex

Table 1: Summary statistics

Variable	Overall Sample (931 municipalities)	Treatment group	Control group
Quaterly Expenses			
Health	833.6591 [3496.576]	839.3283 [3319.718]	833.1953 [3510.7]
Bottled water	244.8996 [192.4255]	258.707 [206.7644]	243.7697 [191.1675]
Smoking	56.40062 [281.9781]	63.76051 [290.1554]	55.79854 [281.2949]
Transport	4812.176 [8079.707]	5702.14 [8045.741]	4739.372 [8078.27]
Housing	2333.274 [4580.158]	2718.187 [3681.4]	2301.786 [4644.632]
Education	3574.563 [8257.814]	4366.233 [9878.525]	3509.8 [8107.683]
Others			
Transfer	3825.796 [11389.91]	4064.618 [12361.69]	3806.259 [11306.71]
Wage	18432.16 [25005.03]	23185.13 [29653.6	18043.34] [24545.76]
Total income	40477.42 [54642.31]	45436.89 [51973.97]	40071.7 [54835.8]
Total expenditure	38525.98 [47056.07]	42230.72 [42153.39]	38222.91 [47422.53]
Household controls			
household type	2.206975 [.5940529]	2.210423 [.6153666]	2.206693 [.5922847]
Old	.2306803 [.5342218]	.2155172 [.520631]	.2319208 [.5353074]
Young	.9220991 [1.096794]	.8863636 [1.111404]	.9250224 [1.095557]
Water coverage	.8396646 [.3669223]	.906348 [.2914011]	.8342095 [.3718984]

Table 2: Bottled water consumption

	(1)	(2)	(3)
VARIABLES	bottled water	bottled water	bottled water
post_treatment	0.128**	0.127**	0.101*
	(0.0647)	(0.0642)	(0.0564)
water_coverage			0.0332
			(0.0251)
smoking			-4.03e-05
			(3.62e-05)
transport			3.75e-06***
			(1.40e-06)
trasnfer			3.12e-06***
			(9.86e-07)
wage			3.37e-06***
			(4.51e-07)
education			4.90e-06***
			(1.41e-06)
household_type		0.0532***	0.0259*
		(0.0135)	(0.0135)
housing			6.82e-06*
			(3.58e-06)
health			3.79e-06*
			(2.14e-06)
Old		0.0169	0.0363**
		(0.0182)	(0.0179)
Young		-0.0176**	-0.00841
		(0.00885)	(0.00811)
Year FE	x	x	x
HH FE	x	x	x
Municipality Cluster	x	x	x
HH Controls		x	x
Monetary controls			x
Observations	33,748	33,748	33,748
R-squared	0.721	0.722	0.740

Standard errors in parentheses

* p<0.01, ** p<0.05, *** p<0.1

Table 3: health consumption

	(1)	(2)	(3)
VARIABLES	health	health	health
post_treatment	257.1	257.0	122.1
	(360.2)	(356.9)	(335.7)
water_coverage			62.34
			(129.1)
smoking			0.0859
			(0.159)
transport			0.0289**
			(0.0127)
transfer			0.0264***
			(0.00943)
wage			0.0163***
			(0.00609)
education			0.0204
			(0.0124)
household_type		98.97	-64.24
		(78.15)	(86.82)
housing			0.0665**
			(0.0322)
Old		449.7***	527.5***
		(166.4)	(164.5)
Young		10.13	72.89
		(46.19)	(45.57)
Year FE	x	x	x
HH FE	x	x	x
Municipality Cluster	x	x	x
HH Controls		x	x
Monetary controls			x
Observations	33,748	33,748	33,748
R-squared	0.669	0.671	0.687

Standard errors in parentheses

* p<0.01, ** p<0.05, *** p<0.1

Table 4: The role of income in the evolution of bottled water consumption

	(1)	(2)	(3)	(4)
VARIABLES	1st quartile	2nd quartile	3rd quartile	4th quartile
post_treatment	0.141	0.152*	0.0133	0.141
	(0.155)	(0.0901)	(0.0596)	(0.103)
water_coverage	0.0372	-0.00549	0.0372	0.0164
	(0.0544)	(0.0435)	(0.0530)	(0.0674)
smoking	-7.40e-05	1.65e-05	-5.27e-05	-4.26e-05
	(0.000133)	(5.87e-05)	(3.69e-05)	(5.47e-05)
transport	9.95e-06*	3.32e-06	3.98e-06	3.22e-06**
	(6.03e-06)	(3.34e-06)	(2.43e-06)	(1.55e-06)
transfer	9.67e-07	8.07e-06***	4.52e-06***	2.25e-06*
	(4.89e-06)	(2.22e-06)	(1.57e-06)	(1.17e-06)
wage	4.30e-06	3.44e-06***	4.36e-06***	3.05e-06***
	(2.97e-06)	(1.25e-06)	(8.57e-07)	(5.04e-07)
education	6.90e-06	8.98e-06**	7.47e-06***	4.00e-06**
	(7.47e-06)	(4.09e-06)	(2.40e-06)	(1.68e-06)
household_type	0.0377	0.0195	0.0242	0.00421
	(0.0378)	(0.0255)	(0.0238)	(0.0246)
housing	2.62e-05	1.40e-05*	1.29e-05**	4.20e-06
	(1.98e-05)	(8.13e-06)	(5.62e-06)	(3.04e-06)
health	1.19e-05	1.32e-05*	-4.37e-07	5.97e-06*
	(1.13e-05)	(7.81e-06)	(1.61e-06)	(3.27e-06)
old	0.0281	0.0125	0.0698**	0.0367
	(0.0389)	(0.0299)	(0.0288)	(0.0270)
Young	-0.000718	-0.00222	-0.00352	-0.0238
	(0.0183)	(0.0138)	(0.0123)	(0.0152)
Year FE	x	x	x	x
HH FE	x	x	x	x
Municipality Cluster	x	x	x	x
HH Controls	x	x	x	x
Observations	8,437	8,438	8,436	8,437
R-squared	0.824	0.713	0.700	0.710

Standard errors in parentheses

* p<0.01, ** p<0.05, *** p<0.1

Table 5: The role of income in the evolution of health consumption

VARIABLES	(1) 1st quartile	(2) 2nd quartile	(3) 3rd quartile	(4) 4th quartile
post_treatment	78.72	-11.04	69.51	444.1
	(186.0)	(121.6)	(260.6)	(1,058)
water_coverage	276.4	40.52	-110.8	117.9
	(289.1)	(130.3)	(272.5)	(321.2)
smoking	0.378	0.322	-0.0826	0.107
	(0.520)	(0.306)	(0.217)	(0.279)
transport	0.0294	0.0196***	0.0444***	0.0295
	(0.0261)	(0.00714)	(0.0121)	(0.0191)
transfer	0.0706	0.0289**	0.0551*	0.0147*
	(0.0646)	(0.0136)	(0.0315)	(0.00884)
wage	0.00811	0.00387	0.00449	0.0219***
	(0.0116)	(0.00454)	(0.00601)	(0.00740)
education	-0.0275	0.0370**	0.0181	0.0185
	(0.0277)	(0.0175)	(0.0199)	(0.0152)
household_type	17.92	9.044	14.51	-180.4
	(136.7)	(74.40)	(145.2)	(192.3)
housing	0.0637	0.0116	0.0750**	0.0699*
	(0.0734)	(0.0248)	(0.0380)	(0.0375)
Old	-135.3	156.4	671.6*	851.7**
	(172.8)	(106.5)	(377.4)	(349.6)
Young	13.74	28.03	120.6	110.0
	(59.16)	(37.70)	(100.0)	(113.4)
Year FE	x	x	x	x
HH FE	x	x	x	x
Municipality Cluster	x	x	x	x
HH Controls	x	x	x	x
Observations	8,437	8,438	8,436	8,437
R-squared	0.665	0.771	0.516	0.761

Standard errors in parentheses

* p<0.01, ** p<0.05, *** p<0.1

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