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Air pollution in Cotonou: An evaluation of the statistical value of life

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ABSTRACT

In air pollution context, the database of at least 40 years old of Cotonou citizens was used to make an evaluation of the statistical value of life (SVL) from the maximum willingness to pay (WTP). With a two-step Heckman model, the average of maximum WTP was estimated. The average of maximum WTP represents the psychological cost of mortality and is worth FCFA5, 924 per month. Hence, for a reduction in the probability of death of 5/10,000 per year over a period of ten years, the annual SVL related to air pollution mortality in Cotonou was calculated and is FCFA 142,760,000. For the first time in Benin, the SVL is one of the few indicators needed for environmental policy that has never been calculated before. Thus, the SVL allows the authorities to reinforce the decision-making while paying more attention to the effects of air pollution on the populations' health.

INTRODUCTION

Air pollution has non-negligible effects on human health. The mortality risk associated with this pollution externality is one of the world-wide major concerns. Apart from the short-term effects observed through benign diseases, the long-term effects in terms of mortality are also noticed. According to Pigou (1920), these effects constitute indeed the pollution externalities costs. For Ngô and Regent (2012), the increasing rate and quantity of waste and pollution compromise the great natural equilibrium. It becomes necessary to find the mechanisms to reduce the quantity of pollution and waste to make it harmless.

The long-term effects of air pollution are often perceived through mortality. This mortality reflects the consequence of a negative externality of air pollution. In such a context, through the mortality costs generated by air pollution, an evaluation on the value of life is often assessed statistically. Thus, the statistical value of life (SVL) corresponds to the cost of living of an individual who may die due to his long-term exposure to AP. The concept of SVL is not based on the definite value of a death but on the value of a very small variation in the risk of death (Viscusi, 2005). In other words, the SVL reflects what society is willing to pay for the safeguarding of a human life following a variation in risk (Dionne and Lebeau, 2010). In this condition where individuals are exposed to air pollution for a long period of time, there is the risk of death. For Hunt (2011), the air pollution causes deaths from cardiopulmonary diseases. Thus, when populations perceive the risk of death related to this externality, they can decide on their willingness to pay (WTP) in front of a decrease in the risk of death related to air pollution. Based on this, an evaluation of SVL is possible and constitutes an indicator of the cost of mortality due to air pollution, useful for decision-making. More precisely, in any situation where individuals are exposed to a risk to their lives, SVL is very important for better decision-making.

In the case of air pollution, several studies have focused on the effects in terms of mortality and some inspired by others. Thus, Chanel et al. (2008) with their theoretical model gotten by simplifying the Johansson's (2001); proposed a definition for SVL. This definition is a serious interpretation of the present monetary value of expected utility if consumption is independent of age.

Chanel et al. (2004) perform a contingent assessment specific to air pollution in a contextual approach within the inhabitants of Bouches-du-Rhône. The hypothetical scenario used placed the individual in a compulsory moving situation with his family. Using the econometric model derived from McFadden and Leonard (1993), Chanel and Luchini (2008) estimated the averages of WTP for the overall effects of air pollution. With a transformation of the Box-Cox type, this estimation was made with and without providing information on risk. Based on this scenario, these averages of WTP for a 50% reduction in air pollution was €69.7 and €65 per month and per household, respectively. Therefore, the contribution of information expresses into an increase of €4.7 on average. In addition, the death avoidance value (DAV) was estimated with a random-lifetime utility optimization model.

The contingent valuation method used by Alberini et al. (2004) was in three countries: France, Italy and the United Kingdom. Using a standardized protocol, they interviewed the individuals aged 40 and over about their WTP for a specific risk reduction. The results of the WTP estimated for this risk reduction and SVL suggest that the SVL is between €1,052 and €2,258 million. The questionnaire used was similar to that used by Krupnick et al. (2002) with some differences.

In a context of air pollution, the risk of death was assessed for taking economic policy measures. These types of valuations are estimates of the value of active living (Viscusi and Aldy, 2003). These authors have critically examined various studies relating to a dozen countries, while at the same time addressing the questions of the effects of age on the value of a statistical life. Their meta-analysis showed an income elasticity of the value of a statistical life between 0.5 and 0.6.

As noted by Bowland and Beghin (2001), the use of VSL assessment is done by most environmental economists to estimate the value of changes in mortality resulting from an improvement in the environment. These authors, based on a meta-analysis of VSL work in developed countries, establish a predictive function of VSL for developing countries taking into account the characteristics of different countries. Their VSL was used to assess the WTP for the reduction of air pollution mortality in Santiago and Chili. Following these authors, Alberini et al. (2007) showed that WTP for such a reduction depends on the age and state of health of the individual. Indeed, the latter, after two contingent valuation surveys conducted in Hamilton and Ontario on people aged 40 and over, have a mixed result on the fact that WTP decreases with age; except for individuals aged 70 or over. They also got people who were critically ill to consent more.

Other authors (Desaigues et al., 2011) focused on assessing changes in life expectancy due to air pollution. Thus, starting from a contingent valuation, they estimated the monetary value of a life year (VOLY). Based on the 1,463 respondents from nine European countries, the authors recommended a VOLY estimate of €40,000 for cost-benefit analysis in the context of air pollution control policies in the European Union. And just a few years ago, Hammitt (2007) pointed out that the value of monetary changes in mortality risk that are subject to environmental policy can be measured in terms of VSL or VSLY. For the author, the link between VSLY and VSL can be explained by the fact that any variation in mortality risk can depend on the number of lives saved or the expected number of years of life saved. In fact, as economic theory has suggested, the author states that VSL and VSLY are a function of the characteristics of the change in the survival curve, the initial state of the survival curve of the individual, and the individual characteristics such as income and health.

Indeed, the valuation of the SVL is a consequence of derivation of an environmental policy indicator resulting from the evaluation of the effects on mortality of a phenomenon. Thus, in a context of air pollution where mortality costs are assessed for a given population, depending on the rate of change in the mortality risk, an estimate of the VSL can easily be made for political decision-making. In this order, Hammitt and Robinson (2011) show that income elasticity of VSL is an important indicator for policy analysis. In the case of the VSL, VSL once again provides tools for environmental policy.

In Canada, for example, a pilot study of consultants was conducted to obtain quantitative probabilistic estimates of uncertainties in estimates of the value per useable statistical life in the context of air pollution (Roman et al., 2012). Thus, the results of each expert have made it possible to develop quantitative probability distributions for VSL that are used in the air quality models. But how can the SVL be assessed for the Cotonou city in the situation of air pollution?

In terms of the risk of death related to air pollution, a real evaluation of SVL has not yet been made for most of the West Africa countries and particularly for the Cotonou city in Benin.

The objective of this study was to evaluate the SVL in a context of air pollution for the Cotonou city in Benin.

METHODOLOGY

Evaluation methodology for SVL

For the evaluation of SVL, the approach adopted in this study is similar to those of Desaigues et al. (2007) or Krupnick et al. (2002). First, the WTP is estimated; then the SVL is calculated taking into account changes in risk of death. Then, Chanel et al. (2004) use the contingent valuation of Desaigues et al. (2007) in a context of life expectancy gain linked to a reduction in air pollution in

France (Strasbourg). The authors adjusted the questionnaire developed by Krupnick et al. (2002) and administered to 300 individuals aged 40 to 75 years. They found that the value of a life year (VLY) is between €0.020 and €0.220 million. With the same questionnaire as that adopted by Alberini et al. (2004) and under the assumption that the zero responses for WTP are valid, an appropriate econometric approach was used (Heckman's two-step method). The understanding of the probabilities of death was sought using grids of 1,000 tiles. The respondents gave their annual WTP for the next 10 years for medical treatment, which would reduce their risk of dying by 1/1,000, and 5/1,000. In addition, they were asked for their current WTP to reduce their risk of dying for a period of 10 years from 70 to 80 years by 5/1,000. In order to find out how the respondents understood and interpreted the questionnaire, a written comment was required from them at the end.

In their method, where the questionnaire was administered by computer, the authors arrived at the SVL and that of a VYL using the following expressions:

$$\mathrm{SVL} = \mathrm{WTP} \times \frac{10}{\Delta R} \qquad (1)$$

$$\mathrm{VYL} = \mathrm{WTP} \times \frac{10}{\Delta EV} \qquad (2)$$

In Equations 1 and 2, ΔR and ΔEV represent the risk reduction and the life expectancy gain, respectively.

As for the Krupnick et al. (2002), the contingent valuation was carried out in the context of the risk of death due to air pollution. To this end, the individuals' WTP are revealed for specific reductions in risk of death. The study examined a sample of 930 individuals aged 40 to 75 years in the Hamilton Ontario area.

The questionnaire was subdivided into five parts: the first part recorded the personal information of the respondent, including his / her state of health and that of his / her immediate family; the second part introduced the concepts of probability to assess their understanding of the risk of death; the third part presented each respondent with the main causes of death for someone of the same age and sex as the respondent; the fourth part included the WTP for the risk reductions of a given magnitude occurring in a specified time, using dichotomous choice methods; while the latter part highlighted reporting issues followed by socio-demographic questions.

Whether the SVL, the VYL or the AVD (Avoidance Value of a Death), the assessments were made on the basis of the WTP of the individuals surveyed. For most of the studies mentioned above, the respondents concerned were of a given age range (over 40 years). Contingent valuation surveys were those often conducted as part of this work.

In the analysis of the impact of air pollution on mortality leading to an assessment of SVL, the contingent valuation method seems to be the most appropriate given the lack of an effective market.

Sources of data

The data used for this search came from a database. This database was developed by the Center for Studies for Training and Research in Development (CEFRED). The data in this database came from a contingent evaluation survey carried out under the support of CEFRED.

This survey was conducted as part of the assessment of the health effects of air pollution in the city of Cotonou in Benin. Air pollution is recognized as strong in Cotonou by Fourn and Fayomi (2006). For these authors the pollution is characterized by a concentration of CO which varies from 26 to 38.6 ppm in the morning and increases in the afternoon ranging from 58 to 78.6 ppm; benzene meanwhile was around 7.2 $\mu g/m^3$ on average. They actually showed that symptoms such as conjunctival hyperemia and respiratory disorders are caused by air pollution in Cotonou. In these atmospheric pollution conditions, victims incur health expenses, either for disease prevention or for treatment. This situation generates significant costs for the population of Cotonou from the point of view of health.

The contingent valuation survey relating to air pollution in the city of Cotonou is based on a questionnaire. The contingent valuation questionnaire used took into account the recommendations of N. O. A. A. Panel (Arrow et al., 1993) and included two parts, apart from questions relating to the characteristics of the respondents. The first part focused on morbidity issues and the second part focused on mortality.

The logic of Krupnick et al. (2002) and Desaigues et al. (2007) were used to elaborate the second part of the questionnaire. These logic were used to investigate individuals having at least 40 years of age because they become more aware of life and seem to think more about death. In the second part, there were two sub-parts. The first sub-section sought to understand respondents' perceptions of the probability of death or risk of death. To do this, probability grids were constructed for this purpose. The second sub-section presented the contingent scenario favoring the knowledge of the monthly WTPs with a goal to reduce the probability of death. The scenario used is as follows.

Mortality contingent scenario

The current urban mortality rate in Benin is about 10/1,000 (1/100). Given the situation of air pollution in the Cotonou city, in the next ten years the mortality rate will pass according to you to: 1) 5/1,000; 2) 10/1,000; 3) 15/1,000; 4) 20/1,000.

We assume two individuals A and B whose probabilities

of death in the next ten years are respectively 15/1,000 and 20/1,000.
Which of the individuals faces the highest risk of death?
: 1-Individual A; 2-Individual B.
It has been shown that there is a relationship between air pollution, age and mortality. So in a situation of continuous air pollution, the risk of death is high.
Two situations are proposed:

***Situation 1**: Air quality in Cotonou is deteriorating. In this case the risk of death due to air pollution increases and then you are unresponsive by not bearing any financial cost; but the quality of the air does not improve.*

***Situation 2**: You agree to contribute to the funding of a program of medical treatment and improvement of the quality of the air. Here you bear a financial cost and your risk of death is reduced.*

Which of the two situations do you prefer?

If choice = Situation 2
Would you be willing to pay for a medical treatment against air pollution for the next 10 years, which would reduce your risk of death by 5/1,000 per year over the 10-year period?
IF YES
What maximum amount would you be willing to pay per month for such a program?
The declared amounts of WTP are between zero and sixty thousand FCFA francs ([0, 60000])
IF NOT
What are your reasons?

This scenario proposed at least 40 years of age respondents to pay for medical treatment over the next 10 years that could reduce their risk of death due to air pollution. As soon as an individual agreed to the project, he/she was asked to specify his/her maximum WTP to receive this medical treatment. The medical treatment was not specified in the questionnaire.

Description of variables

In several studies (N'Guessan, 2008; Desaigues et al., 2007), highlighting the Contingent Valuation Method and for the given assessments, the usual variables considered were related to socio-economic or demographic characteristics on the one hand, and those linked to the specific characteristics of the good being assessed on the other hand.

The main variables used to estimate the mean of maximum WTP representing the cost of mortality are the socio-economic variables of the respondents. The following variables of the database are considered:

- The maximum monthly WTP [Mcapmax] which is a discrete quantitative variable taking values between zero and sixty thousand. This is the explained variable.
- Age [age] is a continuous variable. It refers to the age of the respondent who is at least 40 years of age. Its values depend on the respondent past age expressed in years. As the individual's age increases, he or she is tempted to contribute more to have good health up to a level. According to Phelps (1995), the health status of the individual deteriorates with age and therefore he attaches greater importance to his health in old age; therefore it tends to contribute more than a young.
- The age square [agecare] is a variable that takes into account the non-linear effect of age. Beyond some age threshold the income of the individual decreases and the effect of age on the WTP per month become negative. So an individual who grows up has a low labor productivity compared to the younger one hence his income may be low; therefore its WTP may decrease.
- The time of residence [tempshabit] which is a continuous variable relate to the number of years spent by the respondent in the Cotonou city. An individual who has spent a long time in the city can make comparisons between pollution area and his contribution to improving air quality would be high.
- The level of study [nivetude] which is a qualitative variabletakes four modalities [primary, secondary, higher, none]. More the individual is educated, more he will contribute to the improvement of air quality. Before introducing this variable into the econometric model, each modality is dichotomized.
- The respondent's monthly income [tranchrev] being a continuous quantitative variable is classed in tranches. We have nine income tranches: (i) Under 30,000 FCFA, (ii) 30,000-40,000 FCFA, (iii) 40,000-50,000 FCFA, (iv) 50,000-60,000 FCFA, (v) 60,000-70,000 FCFA, (vi) 70,000-80,000 FCFA, (vii) 80,000-90,000 FCFA, (viii) 90,000-100,000 FCFA, (ix) More than 100,000 FCFA. More the individual's income increases, more willing he will be.
- The respondent's move [projdemenagpoll] is a dichotomous variable that takes the value 1 when the individual has a project to leave the Cotonou city because of air pollution and 0 otherwise. When an individual has such a project, he will have a small contribution to the improvement of the air quality due to his departure from the heavily polluted area.
- [Airpollue] variable reflects the fact that the individual recognizes the polluting state of the air in the Cotonou city. It is dichotomous taking the value 1 when the individual recognizes that the air is polluted in Cotonou and 0 otherwise. It has a positive effect on WTP.
- The dichotomous variable [visitmedic] represents the visit to a doctor. It takes the value 1 if the respondent visits a doctor and 0 if not. Its effect must be positive.
- The [genpoll] variable reflects the fact that the individual recognizes that the pollution is either embarrassing or not. It takes the value 1 if the

Table 1. The explanatory variables and expected effects.

Variables	Expected effects
Age	+
Agecare	-
Tempshabit	+
Nivetude	+
Tranchrev	+
projdemenagpoll	-
Airpollue	+
Visitmedic	+
Genpoll	+

- individual is embarrassed and 0 otherwise. A positive effect is expected from this variable.

The Table 1 presents the expected effects of the explanatory variables on the explained variable (maximum monthly WTP: Mcapmax). The indeterminate effects assume that it is not easy to make a prediction about the effects of the different variables concerned on the variable "Mcapmax".

WTP estimation model

In the scenario, the maximum WTP choice of the heads of household according to the database is made in two stages. First, he may choose the situation 1 or situation 2, which shows that he is willing to participate or not in the program of medical treatment and improvement of the air quality. Next he gives the maximum amount he can pay when he decides to participate. In this process the decision-making is sequential. Then the formalization of this situation can be presented as follows:
In the first stage, the individual is faced with a situation of choice that can be presented by a dichotomous model based on a latent variable z_i^*

$$\begin{cases} if \quad z_i^* > 0 \quad \text{the individual i decides to participate in the program (situaion 2)} \\ if \quad z_i^* \leq 0 \quad \text{the individual i doesn't decide to participate in the program (situaion 1)} \end{cases}$$

In the second stage, if the individual chooses the situation 2, he gives his maximum WTP. Here is the censured data model defined as:

$$\forall\ i = 1, \dots, n\ ; Mcapmax_i = \begin{cases} Mcapmax_i^* & if \quad z_i^* > 0 \\ 0 & if \quad z_i^* \leq 0 \end{cases} \quad [M\ 1]$$

For Sartori (2003) and N'Guessan (2008), the good quality of the estimators resulting from the generalized Tobit depends on how the explanatory variables are introduced in the explanation of z_i and of the maximum WTP. The same explanatory variables must not retain exactly in the two equations. Thus we have:

$$Mcap\max_i = \begin{cases} Mcap\max_i^* & si \quad z_i^* > 0 \\ 0 & si \quad z_i^* \leq 0 \end{cases}$$

$$z_i^* = Y_1\beta_1 + \varepsilon_{1i}$$
$$Mcap\max_i^* = Y_2\beta_2 + \varepsilon_{2i} \qquad [M_2]$$

Y_1 and Y_2 are the explanatory variables [socio-economic or demographic characteristics]; β_1 and β_2 the parameters to be estimated and εj (j=1, 2) the error terms that follow a bivariate normal distribution with ρ a correlation coefficient. After the normalization [σ_1=1]. We have:

$$\begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} \sim \mathcal{N}\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \Omega\right) \quad with\ \Omega = \begin{pmatrix} 1 & \rho\sigma_2 \\ \rho\sigma_2 & \sigma_2^2 \end{pmatrix}$$

For simplicity reasons, a dichotomous variable IND_i is introduced such that:

$$IND_i = \begin{cases} 1 & if \quad z_i^* > 0 \\ 0 & if \quad z_i^* \leq 0 \end{cases} \quad [M\ 3]$$

The estimation of the model can therefore be done using Heckman's (1979) two-step method or the full-length maximum likelihood method. This method was further developed with Amemiya (1985) and taken up by Wooldridge (2002).

RESULTS AND DISCUSSION

Descriptive statistics

According to the database, there are 197 respondents who were at least 40 years old and who answered the mortality questionnaire. The descriptive statistics of the variables presented by Table 2 shows that individuals live in Cotonou for 30 years on average. The maximum residence time is 68 years and the minimum of this time is six months. On average these respondents are approximately 49 years and the maximum age was 82 years. About 44% have a predominantly secondary level; 23% with primary education then about 16% have the upper level.

Approximately 97% of the individuals acknowledged that the air in the town of Cotonou is polluted. It should be noted that about 95% of the heads of household who were interviewed know that air pollution is troublesome. As for the income variable, 24% of the individuals earn more than FCFA100,000 and about 16% have less than FCFA30,000.

Table 2. Statistics of variables.

Variables	Mean value	Minimum value	Maximum value
Tempshabit	29.962	0.5	68
Age	49.122	40	82
Nivetude	2.254	1	4
Airpollue	0.975	0	1
Genpoll	0.949	0	1
Tranchrev	5.168	1	9
Projdemenagpoll	0.421	0	1
Visitmedic	0.508	0	1
Mcapmax	5878.426	0	60000

Table 3. Determining variables of the participation model.

Variables	Coefficients	P >|z|
Tranchrev	0.0418	0.402
niv2	0.606*	0.071
niv3	-0.592	0.132
niv4	-0.066	0.845
visitmedic	0.418*	0.088
genpoll	0.550	0.220
projdemenagpoll	0.326	0.196

Number of observations = 197; LR chi2(5) = 20.60; Prob > chi2 = 0.0044
*Significant at the 10% threshold.

From individuals of the base concerned, about 41.44% have plans to leave completely the city of Cotonou against 58.56% who do not. In addition, those who admit visiting a doctor are about 51%. It should be noted that we used the database of a contingent valuation survey conducted in the context of air pollution and its health effects on households in the city of Cotonou. Then, respondents at least 40 years of age at the base who reported having visited a doctor because of illnesses due to air pollution are about 51%.

The "Mcapmax" variable describes the amount that respondents are willing to pay for participation in the medical treatment program that can reduce their risk of death. From the analysis of these results, we note that the maximum WTP varies between zero and sixty thousand FCFA francs, and that the average ofmaximum WTP is about FCFA5,880 with a standard deviation of FCFA 9,212. In addition, there is 14.21% of the individuals (28 of the 197 respondents) who have a zero WTP compared with 85.79% with a non-zero WTP.

It is necessary to estimate the average ofmaximum WTP per month to get an idea of the cost beared by individuals in the Cotonou city in terms of mortality in the context of air pollution.

Determinants of the likelihood of participation in the reduction pollution program

The Table 3 presents the results of the program participation model for reducing the scale of air pollution. These results first show that the set of variables used explain the whole model (LR chi2 (5) = 20.60; Prob > chi2 = 0.0044). Then the probability of participating in such a program is basically determined by the secondary level of education and the visit of a doctor. More precisely the modality niv2 of the variable "nivetude" and the variable "visitmedic"are significantat the threshold of 10%. So it is more likely for an individual having a secondary level of education to participate in the air quality improvement program to reduce the risk of death than the one with a primary level. Moreover the visiting a doctor increases the likelihood of participation. This means that the individual knows that to participate in such a pollution reduction program would help less to visit a doctor.

Determinants of maximum willingness to pay and mortality cost

The Table 4 presents the results of the maximum WTP

Table 4. Determining variables of the willingness to pay.

Variables	Coefficients	P >|z|
tranchrev	805.060**	0.012
tempshabit	-57.887	0.270
visitmedic	-3248.907	0.107
agecare	-1.606	0.822
age	227.444	0.771
genpoll	-8502.535*	0.064
niv2	-5136.645*	0.055
niv3	7156.607**	0.033
niv4	-1919.642	0.425
airpollue	-4242.091	0.373
lambdaN	-23432.23**	0.033

Number of obs = 168; F(11, 156) = 3.67; Prob > F = 0.0001.
**Significant at the 5% threshold; *significant at the 10% threshold.

model. These results highlight the determinants of the monthly maximum WTP. From the analysis of Table 4, the model is globally significant (F=3.67; P > F = 0.0001). The main determinants of the monthly maximum WTP for reducing the air pollution mortality rate are: income, being embarrassed by pollution, secondary education, level of higher education.

The significance of income (significant at 5%) shows that an increase in an individual's income increases his maximum WTP. This finding confirms the economic theory that an agent's willingness to pay depends positively on his or her income. That means that an individual of at least 40 years old would be more likely to contribute to reducing air pollution with a view to reducing their risk of death when their income increases. Moreover, the embarrassing of the pollution contributes negatively (significance to 10%) to the maximum WTP; this assumes that an individual hampered by air pollution contributes less to the program to fight this calamity.

Regarding the level of study of individuals, it should be noted that the effect on the maximum WTP depends on two modalities; namely the secondary and higher levels. Indeed, the individual secondary level acts negatively on the maximum WTP compared to the primary one. The positive effect of the higher level shows that an individual of higher level contributes more to the reduction of pollution to better preserve his life than a primary level individual. This implies that among those aged at least forty years, those with a higher level are more aware of the issues of air pollution in terms of effect on mortality.

The average of maximum WTP predicted by the model is about FCFA 6,837 and FCFA 5,924 when the predicted average probability of participating in the pollution reduction project to limit the risk of death is taken into account.

In this subsection, the issue is the average of maximum WTP derivative. Thus, we calculate this average of maximum WTP for all individuals aged 40 or older by predicting the maximum WTP from the linear regression and the probit model of participation. Finally, the average of maximum WTP obtained per individual is FCFA 5,924 per month. It represents the average of maximum contribution that an individual over 40 years of age is willing to pay monthly for medical treatment and improved air quality.

We recall that the medical treatment is to reduce the probability of death by 5/1,000 per year over a period of ten years. In other words, to reduce the air pollution mortality rate over the next 10 years, every head of household in Cotonou aged 40 or older is ready to bear a cost of FCFA 5,924 per month. This cost is slightly lower than that obtained by Chanel et al. (2004), which is worth €69.7 per month (about FCFA 45,720) per household for all the effects of air pollution. The result of these authors corresponds to about 8 times the one we obtained. This difference is because these authors have made an assessment considering all the effects of air pollution on the one hand and the environment of the study is not the same on the other hand (for example the living standards and income levels are not the same). Krupnick et al. (2002) obtained an annual cost of US $480.8 for a risk reduction of 5/1,000 over ten years (which is about FCFA 18,030 per month). Their monthly cost is slightly more than three times that obtained in this paper.

Ami and Desaigues (2003), meanwhile, find an average WTP between 404 euros and 663 euros with a risk reduction of 1/1,000 respectively 5/1,000 for the next 10 years. For the same level of reduction in mortality risk, the authors find 663 euros (about 36,242 FCFA/month) against US $ 480.8 obtained from Krupnick et al. (2002). We note that the average WTP obtained in France is almost twice that obtained in the Hamilton Ontario region in the United States. This could be justified on the one hand by the importance attached to the effects of PA on mortality in each country; and secondly in the differentiation of study areas in which individuals do not necessarily have the same understandings or perceptions of the assessed risk.

Effect of air pollution on the value of life

In a same logic of some authors (Desaigues et al., 2007; Krupnick et al., 2002), the derivative of the SVL can be found for Cotonou. The Equation 1 represents the ratio of the average of maximum WTP annual rate and the reduction rate and then multiplied by ten (Desaigues et al., 2007; Krupnick, 2002). Assuming that the reduction in the probability of death is 5/1,000 over the 10-year period (corresponding to a reduction of 5/10,000 per year), the SVL is determined by this equation for a period of ten years or a year. So we have:

$$SVL = 10 \times \frac{Average\ of\ maximum\ WTP \times 12}{\Delta R}$$

$$= 10 \times \frac{5{,}924 \times 12}{0.0005} = 1{,}421{,}760{,}000$$

Therefore the annual SVL relative to the mortality due to the air pollution, in the Cotonou city for a reduction of the probability of death (ΔR) of 5/10,000 per year over a period of ten years, is FCFA 142,760,000. Krupnick et al. (2002) found an annual SVL of US $ 0.96 million for the same risk reduction of 5/10,000 per year over ten years, which is about FCFA 432,000,000 at least three times the result of this work. This difference in cost is because of the different economic environment and the level of the dollar exchange rates with the FCFA which is not fixed.

The ambiguities in risk aversion can be observed in the analysis of mortality risks. Treich (2010) shows that these ambiguities can come from several sources and increase SVL. They can also cause the problems of communication, credibility, lack of information about the heterogeneity of individuals and so on.

After the case study of France, Italy and the United Kingdom, Alberini et al. (2004) suggest that SVL is between 1.052 euros and 2.258 million euros. The results of Chanel et al. (2004) made it possible to estimate the value of a life year (VLY) which is between 0.020 and 0.220 million euros; between FCFA 13,119,095 and FCFA 144,310,040. This limit value obtained by these authors exceeds that obtained in this work. The difference can be justified by the fact that the levels of understanding and awareness of the two types of populations (European countries and West African countries) are not the same. Basically it should be noted that income levels in countries are not the same; income being the key economic determinant of maximum WTP.

Still, VSVs are indicators of decision-making in environmental policy. Thus, Desaigues et al. (2011) estimated the monetary value of one year of life (that is, VOLY) and recommended a VOLY of 40,000 euros for cost-benefit analysis in the context of pollution control policies in the European Union.

Conclusion

Air pollution is a negative externality that has proven effects on mortality. In this study, the effect on mortality due to air pollution in Cotonou was assessed by the cost of mortality and the SVL. The survey relating to air pollution and healthcost in Cotonou was carried out on a sample of 197 individuals aged 40 years and above. The psychological cost of mortality was estimated on the basis of the maximum WTP for each individual. The determinants of maximum WTP are: (i) income, (ii) being embarrassed by pollution, (iii) secondary education, and (iv) higher education. The average of maximum WTP is estimated taking into account the likelihood of individuals participating in the medical treatment and air quality improvement program. This average of maximum WTP represents the psychological cost of mortality and it equals to FCFA 5,924 per month.

Finally, the annual SVL related to air pollution mortality in the Cotonou city for a reduction in the probability of death of 5/10,000 per year over a period of ten years is calculated and is worth FCFA 142,760,000. This result is one of the few indicators that has never been calculated before in Benin for environmental policy. This SVL thus reinforces the decision-making at the level of the authorities while paying more attention to the effects of air pollution on the health of populations and the reduction on air pollution.

REFERENCES

Alberini A., Cropper M., Krupnick A. & Simond B. N. (2007). Does the value of a statistical life vary with age and health status? Evidence from the US and Canada. J. Environ. Econ. Manage. 48:769-792.

Alberini A., Hunt A. & Markandya A. (2004). Willingness to pay to reduce mortality risks: Evidence from a Three-country contingent valuation study. NOTA DILAVORO 111.2004.

Amemiya T. (1985). Advanced Econometrics. Cambridge, MA: Harvard University Press.

Ami D. & Desaigues B. (2003). Valuing health risk: does context matter? GREQAM, Document de Travail N° 03B07.

Arrow K., Solow R., Leamer E., Portney P., Radner R. & Scuman H. (1993). Report of the NOAA Panel on contingent valuation. Janvier.

Bowland B. J. & Beghin J. C. (2001). Robust estimates of value of a statistical life for developing economies. J. Policy Model. 23(4):385-396.

Chanel O. & Luchini S. (2008). Monetary Values for Air Pollution Risk of Death: A Contingent Valuation Survey. GREQAM, Document de Travail N°2008-05.

Chanel O., Faugère E., Geniaux G., Kast R., Luchini S. & Scapecchi P. (2004). Valorisation des effets de la pollution atmosphérique:

Résultats d'une enquête contextuelle. Revue Economique. 55(1):65-92.

Desaigues B., Ami D., Bartczak A., Braun-Kohlová M., Chilton S., Czajkowski M., Farreras V., Hunt A., Hutchison M., Jeanrenaud C., Kaderjak P., Máca V., Markiewicz O., Markowska A., Metcalf H., Navrud S., Nielsen J. S., Ortiz R., Pellegrini S., Rabl A., Riera P., Scasny M., Stoeckel M. E., Szántó R. & Urban J. (2011). Economic valuation of air pollution mortality: A 9 country contingent valuation survey of value of a life year (VOLY). Ecol. Indicat. 11(3):902-910.

Desaigues B., Rabl A., Ami D., My Kene B., Masson S., Salomon M-A. & Santoni S. (2007). Monetary value of a life expectancy gain due to reduced air pollution: Lessons from a contingent valuation in France. Revue d' Economie Politique. 117(5):675-698.

Dionne G. & M. Lebeau (2010). le calcul de la valeur statistique d'une vie humaine. CIRRELT-2010-48.

Fourn L. & Fayomi E. B. (2006). Pollution atmosphérique en milieu urbain à Cotonou et à Lokossa, Bénin. Bull. Soc. Pathol. Exot. 99(4):264-268.

Hammitt J. K. & Robinson L. A. (2011). The Income elasticity of the value per statistical life: transferring estimates between high and low income populations. J. Benefit-Cost Anal. 2(1):1-29.

Hammitt J. K. (2007). Valuing changes in mortality risk: Lives saved versus life years saved. Rev. Environ. Econ. Policy. 1(2):228-240.

Heckman J. J. (1979). Sample selection bias as a specification error. Econometrica. 47(1):153-161.

Hunt A. (2011). Policy interventions to address health impacts associated with air pollution, unsafe water supply and sanitation, and hazardous chemicals. OECD Environment Working Papers, No.35. OECD Publishing.

Johansson P. O. (2001). Is there a meaningful definition of the value of a statistical life. J. Health Econ. 20:131-138.

Krupnick A., Alberini A., Cropper M., Simon N., O'Brien B., Ron Goeree R. & Heintzelman M. (2002). Age, health, and the willingness to pay for mortality risk reductions: A contingent valuation survey of Ontario residents. J. Risk Uncertain. 24(2):161-186.

McFadden D. & Leonard G. (1993). Issues in the contingent valuation of environmental goods: Methodologies for data collection and analysis. Contingent Valuation: A Critical Assessment. New York, North-Holland, Haussman. Pp. 165-215.

N'Guessan, C. F. J. (2008). Le consentement des ménages ruraux à payer une prime d'assurance maladie en Côte d'Ivoire, Revue d'économie du développement, 22, 101-124.

Ngô C. & Regent A. (2012). Déchets, effluents et pollution : Impact sur l'environnement et la santé. 3è Edition, Dunod. 216p.

Phelps C. (1995), Les fondements de l'économie de la santé, Nouveaux Horizons.

Pigou A. C. (1920). Economics of Welfare, 4th edition, Macmillan, London, 1932. http://www.econlib.org/library/NPDBooks/Pigou/pgEW.html, consultation du 20 Novembre 2013.

Roman A. H., Hammitt J. K., Walsh L. T. & Stieb M. D. (2012). Expert elicitation of the value per statistical life an air pollution context. Risk Anal. 32(12):2133-51. DOI: 10.1111/j.1539-6924.2012.01826.x.

Sartori A. E. (2003). An estimator for some binary-outcome selection models without exclusion restrictions. Polit. Anal. 11:111-138.

Treich N. (2010). The value of statistical life under ambiguity aversion. J. Environ. Econ. Manage. 59:15-26.

Viscusi W. K. & Aldy J. E. (2003). The value of a statistical life: A critical review of market estimates throughout the world. J. Risk Uncertain. 2(1):5-76.

Viscusi W. K. (2005). The value of life. Discussion Paper, n°517, Harvard Law School, Cambridge.

Wooldridge J. M. (2002). Econometric analysis of cross section and panel data. The MIT Press Cambridge, Massachusetts, London, England, 741 p.