HEALTH AND ECONOMIC VALUES FOR MORTALITY AND MORBIDITY CASES ASSOCIATED WITH AIR POLLUTION IN BRAZIL

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1. Introduction

If divergences on economic values used for valuation exercises are to be accounted among countries, the same concern should be applied for valuation among regions within a country where degree of development varies significantly in regional terms, as it is the case in most developing economies.

Ancillary benefits from mitigation options are key issues to promote actions to combat climate change. Since they are usually locally captured, particularly those related to health benefits associated with air pollution, their valuation require site-specific parameters which may demand a great deal of research and data collection, not always feasible for developing countries.

This study is an attempt to present back-of-the-envelope estimates of morbidity and mortality health benefits associated with air pollution in the Metropolitan Area of São Paulo in Brazil[1]. Atmospheric contamination, mainly caused by mobile sources, is a serious environmental problem in the region and radical changes in transport systems may drastically reduce emissions, including CO_2 ones.

The aim of this study was then to undertake a valuation exercise to offer health cost benefit indicators for air pollution problems in this region applied for evaluation procedures of the new region's transport programme. The study should be an attempt to measure these indicators without relying on direct survey approaches which were not possible within the budget scope of the programme.

[1] This paper is based on some results of a health benefit valuation indicators for transport sector in São Paulo (Programa Integrado de Transporte Urbano de São Paulo - PITU) conducted by the São Paulo environmental agency (CETESB) and co-financed by the World Bank. Authors thank all the participants of this research team for comments and suggestions.

Literature on pollution's health costs are prone to suggest several methodological procedures to value health benefits, particularly with emphasis on willingness to pay estimates methods. However, since these methods are costly, several studies in developing countries have applied back-of-the-envelope procedures to account for health costs associated to pollution[2]. More recently, transfer functions have been seen as a promising methodological shortcut to apply WTP based estimates and thus avoiding costly willingness to pay direct surveys[3].

Therefore, this study applies benefit transfer functions on values estimated for Europeans countries. In addition to that, we also apply short-cut procedures for hedonic and human capital approaches, carried out specifically for the MASP, and discuss the differences of the results. As expected, methodological and data source differences led to great divergence in the results.

The next section briefly presents our estimation procedures and results of each adopted methodology. In our concluding section, we discuss the divergences of the results and their implications for ancillary benefit valuation.

2. Methodological procedures

Willingness to pay measures are the basis of environmental monetary valuation. As pointed out in Markandya *et.al* (1999), "the conceptual foundation of all cost estimation is the value of the scarce resources to **individuals.** Thus values are based on individual preferences, and the total value of any resource is the sum of the values of the different individuals involved in the use of the resource. This distinguishes this system of values from one based on 'expert' preferences, or on the preferences of political leaders. The values which are the foundation of the estimation of costs are measured in terms of the **willingness to pay (WTP) by individuals to receive the resource or by the willingness of individuals to accept payment (WTA) to part with the resource**".

Measures of WTP and WTA can be calculated directly through several survey methodological approaches, including contingent valuation, which is the most recommended method. Since these survey oriented approaches are very costly, other methodological options based on indirect valuation are usually employed, such as, marginal productivity losses and surrogated markets[4].

The most controversial indirect approach is that based on human capital valuation which measures labour output foregone caused by death and morbidity medical care costs. Apart from theoretical problems, its results on output losses cannot be seen as "true" WTP measures.

For the estimation of health cost benefits, hedonic price functions of urban property markets has been largely applied to capture changes in property prices against environmental quality variations across areas. Based on these functions, WTP values are estimated for marginal variations of environmental quality. Data and econometric related problems have, however, made this approach less accepted to calculate full welfare changes.

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2 See Seroa da Motta, Huber and Ruitenbeek (1999) for a survey of Latin American studies.

3 See, for example, Markandya (1998) and Pearce (1998).

4 We are not going to discuss here the several issues related to environmental valuation which are covered by an extensive literature. For those not familiar with the subject, see, for example, text-books, such as, Pearce and Markandya (1989) and Freeman (1995).

In order to avoid mounting survey costs, it has been recently postulated the application of benefit transfer functions. This estimation procedure relies on the conversion of other sites' WTP measures to a specific area. This conversion is based on differences of social and economic factors which affects the determination of WTP values. As will be seen, for local health benefits such approach may also face serious data availability constraints.

In the following section we present our estimation exercise for the valuation of health effects associated with air pollution concentration in the Metropolitan Area of São Paulo (MASP). This region is by far the most developed area in the country and faces an acute air pollution problem[5]. Our exercise will use short-cut procedures based on the three distinct approaches, as follows:

- Estimating measures of output foregone caused by premature death and health related expenditures.

- Applying benefit transfer functions to European countries' values (ExternE, 1998).

- Adjusting an existing estimate of WTP (Oliveira, 1997) based on hedonic property price function derived for the region.

It must be noted that we are here engaged in an exercise concerning monetary valuations of health risks and not estimates of risk functions for air pollution concentration variations[6].

3. Estimation procedures

3.1 Output foregone pricing

This approach admits that one life lost represents an opportunity cost to society equivalent to present value of its capacity to generate output. Therefore, in the case of a premature death this present value would represent a foregone output which could be taken as a proxy value for the statistical value of life (SVOL).

This approach faces serious criticisms because, as can be seen below, apart from discounting sensitivity, it can be only applied with demographic data, and, consequently, it will use averaging values which precludes people's preferences and risk perceptions. Its results tend, therefore, to offer lower bound WTP estimates.

5 See Seroa da Motta and Mendes (1995) for an overview of air pollution problems in Brazil.

6 For the MASP region, studies on dose-response risk functions associated with air pollution can be found in El Khoury Miraglia (1997).

The present value of future output (PVFO) of a person in the age i is given by[7]:

$$\text{SVOL} \Leftrightarrow PVFO_i = \sum_{j=i+1}^{85} \left[(P_i^j)_1 \right] \cdot \left[(P_i^j)_2 \right] \cdot \left[(P_i^j)_3 \right] \cdot \left[Y_i \cdot \left(\frac{1+g}{1+r} \right)^{j-i} \right]$$

$\left[(P_i^j)_1 \right]$ is the probability of a person at the age i will be alive at the age j.

$\left[(P_i^j)_2 \right]$ is the probability of a person at the age i will be economically active at the age j.

$\left[(P_i^j)_3 \right]$ is the probability of a person at the age i will be working at the age j.

g is the growth rate of per capita income

Y_j is the expected income of a person at the age i

r is the discount rate.

All the above parameters were taken from demographic surveys conducted by the Brazilian statistical office (IBGE) and income levels from IPEA (1998), relative to the MASP. Since discounting is a crucial parameter in this approach, a sensitivity analysis was taken assuming values of r of 3 and 10%. Results are presented in Table 1. The resulting average value of PVFO was determined excluding the age brackets over 65 years old which presented the lowest value, as shown in Table 5.

Table 1. Present value of future output (PVFO) of premature death in MASP (1997 US$)

age bracket in years	mortality rate (%)	economically active share	unemployment rate (%)	monthly avg income	PVFO r = 3%	PVFO r = 10%
15-17	0,72	28,70	10,88	217,68	254.777,08	45.195,16
18-24	1,11	65,21	9,23	420,98	255.353,99	60.637,59
25-29	1,11	74,77	5,44	673,39	248.352,34	79.208,47
30-39	2,73	75,33	3,60	870,27	213.299,45	87.066,73
40-49	5,21	72,41	2,13	1.045,46	151.187,34	81.661,27
50-59	7,38	52,21	1,64	971,14	74.100,64	51.871,67
60-64	9,64	29,69	1,25	867,30	24.656,93	19.857,08
65-	12,91	11,25	0,91	860,27	10.959,40	9.325,26

Source: Demographic data from IBGE and income data from IPEA (1998).

[7] See, for example, Seroa da Motta and Mendes (1995), for a previous application of this approach in Brazil as proposed by Ridker (1967).

For morbidity cases, output foregone estimates are based on observed health expenditures, public and private, which are related to air pollution related disease, namely:

- Medical care costs.
- The respective work days lost.
- Prevention expenditures.

For the purpose of our case, we have considered respiratory disease and heart failure related cases provided by the public health system database (DATASUS) relevant to the MASP.

Although we have faced serious data availability constraints, the following valuation exercise was carried out to estimate these health expenditures. For medical care costs, we have been only able to obtain data on public expenditure related to hospital admissions. Health experts assume that in the MASP, however, private hospitals are covering equal number of cases registered in public attendance for these diseases. Therefore, to account for private hospital cases, we will multiply our public cost estimates by two.

Work days lost were also counted as those related to hospital admissions and measured as the days spent by patients in hospital during the treatment of their respective diseases, as also registered in the DATASUS, multiplied by the average income as reported in IPEA (1998).

Table 2. Total health expenditure (HE) associated with air pollution in MASP (1997 US$)

		RESPIRATORY MORBIDITY		
age brackets in years	hospital expenditures	work days lost	monthly avg income	HE
0-14	8.100.408,22	0	0,00	16.200.816,43
15-59	5.989.939,15	141.708	772,10	19.274.036,56
60-	3.736.039,68	79.739	864,23	12.066.302,64

		HEART FAILURE MORBIDITY		
age brackets in years	hospital expenditures	work days lost	monthly avg income	HE
0-14	-	0	0,00	-
15-59	10.275.887,10	54.069	772,10	23.334.858,49
60-	12.298.218,09	58.592	864,23	27.972.250,45

Source: Hospital expenditures and work days lost from DATAASUS and income data from (1998).

In order to convert these estimates into equivalent full WTP measures, which should consider the resulting disutility associated with these diseases, we have applied a rule of thumb proposed by Rowe *et al* (1996). This study, based on USA direct estimates, suggests that the ratio of WTP to avoid health risks to medical care costs should be around two. That will result in multiplying again our health expenditures by two. Final results are presented in Table 2 also for age brackets.

Summing up all these expenditures and dividing by the number of hospital admissions for each disease, we calculated our crude estimates on personal health expenditure, proxies to WTP morbidity values[8], for each disease case, as presented in Table 5.

3.2 Benefit transfer pricing

Transfer functions are dependent on adjustment variables which affect people's preferences and therefore are based on variables which affect income values among localities.

We have used two transfer functions. A simple one proposed by Markandya (1998), Function 1, based solely on per capita income differential adjusted by purchase parity power index and weighted by the demand income elasticity. We also applied another function, Function 2, proposed by Heintz and Tol (1996) which also includes adjustments for life expectancy and health expenditure variables[9].

The value of the demand income elasticity (e) represents the marginal reduction of a person's WTP value for a certain benefit in relation to a marginal reduction in the person's income and, consequently, it will vary spatially accordingly to changes of people's preferences.

Our exercise will be on transferring European values on health benefits presented in ExternE (1998) to the MASP context.

Again we faced serious data problem. The value of e for MASP was not possible to measure specifically within the scope of this study and also the other variables are not available to the MASP for the reference year adopted in the European valuation. Therefore, we could only apply national figures for income, expectancy and health expenditures and *ad hoc* values for e.

Estimation biases are difficult to determine. While one could expect that in MASP purchase power, per capita income, health expenditures and life expectancy would be higher than the assumed values, consequently increasing transferred values, we do not know the bias direction of our assumptions on the parameter e.

8 Here we included the age bracket over 65 years.

9 Heintz and Tol (1996) do not adjust to purchase power parity as we do in this exercise.

Both functions and data sources are presented below:

Function 1: $(PPC_{br} / PPC_{eu})^{e}$

Function 2: $(PPC_{br}/PPC_{eu})^{e}.(E_{br}/E_{eu}).(G_{br}/G_{eu})$

Where:

PPC_{br} = Brazil's per capita income adjusted by purchase power parity (*sources*: IBGE and World Resources, 1998).

PPC_{eu} = European per capita income adjusted by purchase power parity (*source*: Markandya, 1998).

E = national life expectancy (*source*: World Resources, 1998).

G = national health expenditures (*source*: World Resources, 1998).

If variations in personal income and health benefits are valued at par, the value of e is one. However, Ardila, Quiroga and Vaugham (1998) made specific estimate of e for Latin American and Caribbean countries based on contingent valuation studies of sanitation programmes which generated a value equal to 0.54. Therefore, due to the sensitivity of this parameter, we have decided to use values of e equal to 1.00 and 0.54. Results of benefit transfer pricing are shown in Tables 3 and 4.

As can be seen in Table 4, the transfer function factors are very sensitive to the parameters adopted. For example, the introduction of life expectancy and health expenditures results in a value decrease of approximately 25% whereas its combined effect with changes in e's value results in reductions of 60%.

Table 3. Adjustment parameters for benefit transfer functions to Brazil (1995 US$)

Parameters	Brazil	Europe
Per capita GDP at Purchase Power Parity (PPC)	5.500,00	17.900,00
Life expectancy (E)	67,1	77,3
Health expenditures (G)	7,4	8,6
Functions	e = 0,54	e = 1
Function 1 (*)	0,528756	0,307263
Function 2 (**)	0,395069	0,229577

Source: Authors' estimates with data from WR (1998) and Markandya (1998).

(*) $(PPC_{br}/PPC_{eu})^e$

(**) $(PPC_{br}/PPC_{eu})^e (E_{br}/E_{eu}) (G_{br}/G_{eu})$

Table 4. Estimates of transferred values of health benefits to Brazil (1997 US$)

			statistical value of life	willingness to pay for hospital admission respiratory morbidity	heart failure morbidity
Europe			4.141.652,32	3.677,52	6.017,76
Brazil	function 1	e = 0,54	2.189.923,05	1.944,51	3.181,93
		e = 1	1.272.574,74	1.129,96	1.849,03
	function 2	e = 0,54	1.636.239,48	1.452,88	2.377,43
		e = 1	950.826,57	844,27	1.381,54

Source: Authors' estimates with European values from ExternE (1998) and Markandya (1998).

3.3 Hedonic pricing

Oliveira (1997) using hedonic property price functions estimated WTP values against reductions of particulate matter (PM) concentration in the MASP. Due to data constraints, the author was only able to estimate WTP estimates related to a 10% reductions in particulate matter concentration levels, using only sale prices of new properties. Estimates are calculated in a value range according to distinct econometric functions.

The estimated WTP value represent people's willingness to pay for better air quality in terms of marginal changes of PM. In that case, estimated WTP would cover mortality as well as morbidity risks. Assuming, however, that mortality risk aversion is dominant, we have used this estimate for this purpose as an overestimate value. To make our comparison analysis, we converted the WTP values into equivalent SVOL, using the expression SVOL = WTP/ ΔR where ΔR is the risk factor[10], indicating maximum and minimum figures. The value of ΔR was taken as 0.006 from Ponka *et al* (1998) for both diseases.

4. Conclusions

As said before, if divergence on WTP values are to be accounted among countries, the same concern should be applied for valuation among regions within a country with significant variations on factors and parameters affecting WTP, as it is the case in most developing economies.

Our exercise applying short-cut valuation approaches has, however, shown that data constraints are dominant in each of them when one is willing to estimate site-specific values for ancillary benefits, as in our case for the Metropolitan Area of São Paulo (MASP),

In Table 5 we summarize our estimates and, as can be seen, they vary significantly according to each methodological approach. As expected, mortality results are the highest from benefit transfer valuation whereas output foregone estimates are the lowest ones. Although the hedonic pricing estimate of SVOL is just in the middle of these two other estimates, one must bear in mind that it also includes morbidity risks.

As already mentioned, due to the introduction of adjustment parameters, divergences within transfer benefit estimates are almost in the order of 3. When comparison is made with other approaches, for example, in the case of SVOL, variation may reach the factor of 30 between output foregone and benefit transfer pricing. Although for the case of morbidity WTP, results for these two approaches tend to be closer for respiratory diseases, they are again quite divergent in values for heart failure.

The results above have emphasized that, apart from the methodological divergences, there are also serious data source constraints if one is trying to make site-specific calculations.

Difficulties associated with the need for comprehensive data on property and air pollution concentrations were faced in the reported survey on hedonic pricing. For benefit transfer functions, the adjustment parameters were not available for the MASP.

In the case of output foregone pricing, although all required demographic data was available for output losses, its estimates are very controversial and highly dependent on discounting.

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10 See, for example, Markandya (1998) and Pearce (1998).

Table 5. Summary of the estimates of health benefit values associated with air pollution in MASP (1997 US$)

Valuation of Statistical Life

Transfer Pricing	
function 1 - e=0,54	2.189.923,05
function 1 - e=1,00	1.272.574,74
function 2 - e=0,54	1.636.239,48
function 2 - e=1,00	950.826,57
Hedonic Pricing	
minimum	166.000,00
maximum	487.406,67
Output Foregone Pricing	
r=3%	197.664,07
r=10%	73.079,05

Willingness to Pay for Morbidity Risk Reduction

	RESPIRATORY	HEART FAILURE
Transfer Pricing		
function 1 - e=0,54	1.944,51	3.181,93
function 1 - e=1,00	1.129,96	1.849,03
function 2 - e=0,54	1.452,88	2.377,43
function 2 - e=1,00	844,27	1.381,54
Hospital Expenditures	1.985,79	7.336,85

However, as already emphasized, our aim with this exercise was not to verify convergence in results derived from distinct valuation approaches which have been fully explored in the relevant literature[11]. The main message here is to discuss the possibility of applying these short-cut approaches to offer reliable economic indicators for ancillary health benefits.

Our intention was to show that, if health benefit measures are important ancillary benefits to justify and promote actions to combat climate change, more research efforts should be devoted to their measurement, since the choice of any one of these specific short-cut approaches will significantly affect the economic assessment of these actions. Consequently, it seems that WTP surveys must be promoted and improved in developing countries to offer reliable health benefit valuations. This is another opportunity for north-south research cooperation in the field of climate change issues.

[11] For example, ExternE (1998) offers a comprehensive on this matter.

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