Is the income elasticity of the willingness to pay for pollution control constant?

Edward B. Barbier, University of Wyoming, USA
Mikołaj Czajkowski, University of Warsaw, Poland
Nicholas Hanley, University of St. Andrews, Scotland

2015 European Association of Environmental and Resource Economists Conference, Helsinki, Finland, 24-27 June 2015

Overview

- Since the seminal study by Kriström and Riera (1996), economists have continued to debate whether or not the willingness to pay (WTP) for environmental improvement varies with respect to income, and what the likely magnitude of that income elasticity might be.
  - Czajkowski and Ščasný (2010); Ebert (2003); Flores and Carson (1997); Ghalwash (2008); Hökby et al. (2003); Jacobsen and Hanley (2009); Kriström and Riera (1996); Ready et al. (2002)
- The issue as to whether the elasticity of the WTP for environmental improvement with respect to income is constant has also yet to be resolved.
- This paper explores both theoretically and empirically whether or not the willingness to pay (WTP) for pollution control varies with income.
- Empirical application: the benefits of meeting nutrient reduction targets for the Baltic Sea (Ahtiainen et al. 2014).

Key findings

- Our model indicates that the income elasticity of the marginal WTP for pollution reduction is only constant under very restrictive conditions, which are not necessary for an environmental Kuznets curve relationship between pollution and income.
- Our empirical analysis tests the null hypothesis that the elasticity of the WTP for pollution control with respect to income is constant, employing a multi-country contingent valuation study of eutrophication reduction in the Baltic Sea.
- Our findings reject this hypothesis, and estimate an income elasticity of the WTP for eutrophication control of 0.1 - 0.2 for low-income respondents and 0.6 - 0.7 for high-income respondents.
- Thus, our empirical results suggest that the elasticity is not constant and always less than one.

Theoretical model: assumptions

- Assume that there are *N* individuals in an economy, who may be willing to pay for a specific improvement in environmental quality, such as reducing the water pollution associated with eutrophication of a nearby coastal sea.
- Eutrophication is disliked because it accelerates growth of algae in water bodies, diminishes enjoyment of seaside recreation and disrupts aquatic ecosystems.
- In addition, the water pollution causing eutrophication consists of nutrient, phosphorous and nitrogen emissions, which are directly linked to the total levels of production and consumption in the economy.
- However, assuming a feasible technology for abating these emissions, individuals may be willing to forego some of their income that would otherwise be spent on consumption in order to contribute to overall pollution abatement.

Marginal WTP for pollution control

- A representative agent ($N = 1$) receives utility from per capita consumption c and disutility from the overall water pollution level P associated with eutrophication.
- Let y denote the individual's given level of per capita income.
- The choice is to allocate a share ω of this income to pollution control, with the remainder 1-ω spent on consumption.
- For a given income level, pollution abatement is an increasing function of expenditure allocated to pollution control, $\alpha(\omega y)$ and $\alpha' > 0$.
- MWTP for pollution control:

$$w_p = -\frac{U_P}{U_c} \leq \frac{1}{1+\alpha'}, \qquad \omega \geq 0$$

Corner solution (ω = 0)

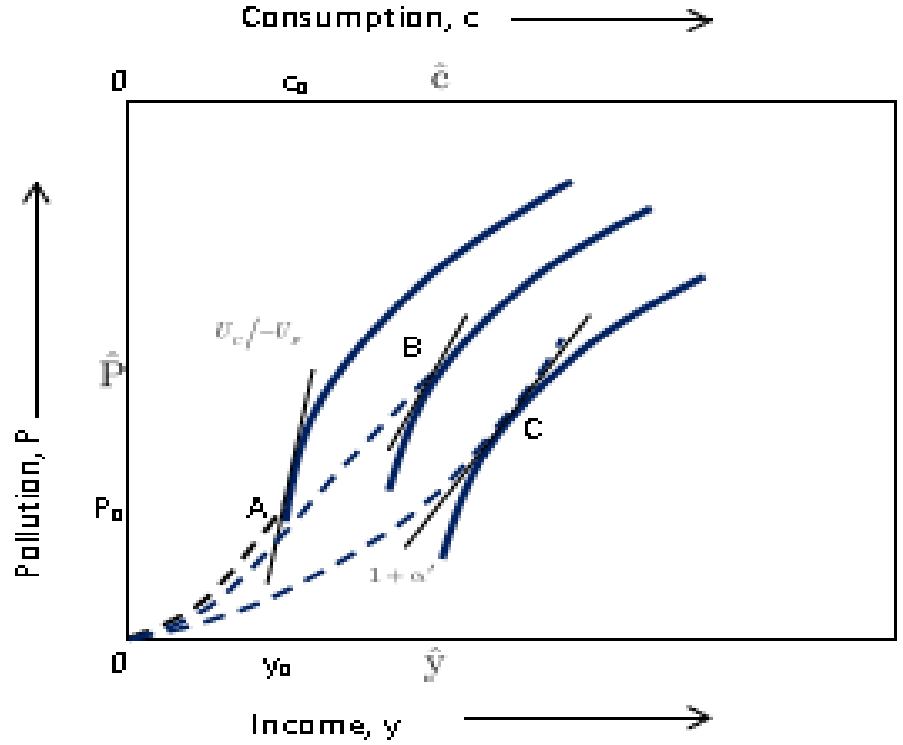
$$\frac{\partial w_P}{\partial y} = \frac{-U_{PP} - U_{cc} - 2U_{cP}}{\left[U_c\right]^2} > 0, \qquad \varepsilon_P \equiv \frac{\partial w_P}{\partial y} \cdot \frac{y}{w_P} = \frac{-U_{PP} - U_{cc} - 2U_{cP}}{-U_c U_P} y > 0$$

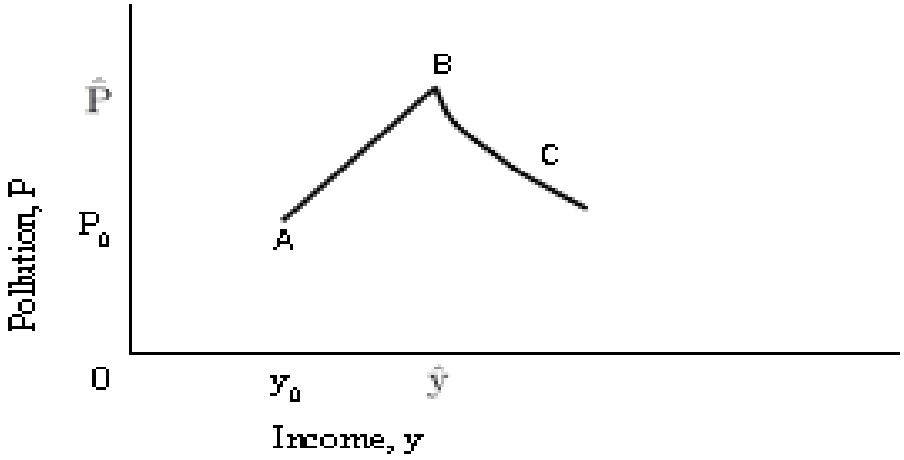
- When no income is allocated to pollution reduction, the marginal WTP for pollution control increases with income, and the elasticity of w_P with respect to income is also positive.
- Because the terms in the denominator of ε_P are a function of per capita income, this elasticity is not constant.
- If income arises above some threshold level (*y* hat) , the interior solution is reached.
- Pollution reaches a maximum at *y* hat , because for income beyond this threshold, emissions declines with increases in *y*.

Interior solution ($\omega > 0$)

$$\frac{\partial w_P}{\partial y} = \frac{-\alpha''\omega}{\left[1+\alpha'\right]^2}, \qquad \varepsilon_P \equiv \frac{\partial w_P}{\partial y} \cdot \frac{y}{w_P} = \frac{-\alpha''}{1+\alpha'}\omega y$$

- For the interior optimum, changes in w_P correspond to changes in the opportunity cost of reduced pollution.
- How the marginal WTP for reduced pollution changes with income depends on the abatement technology, i.e. the sign of α".
  - If abatement technology is increasing and convex (α" > 0), then as income increases w_P falls.
  - if abatement technology is increasing and concave (α" < 0), then w_P increases as income increases.
  - Only if abatement technology is linear (α" = 0) does w_P remain constant as income rises.
- Unless abatement technology is linear, the income elasticity of WTP is not constant.


Consumption, c
0
c_0
$\hat{c}$
Pollution, P
$\hat{P}$
P_0
A
B
C
$v_c/-v_e$
$1+\alpha'$
0
y_0
$\hat{y}$
Income, y


Pollution, P
$\hat{P}$
P_0
A
B
C
0
y_0
$\hat{y}$
Income, y

Summary

- The demand for environmental quality with respect to income does not indicate the actual income elasticity for the WTP for pollution reduction (Flores and Carson 1997; Ebert 2008).
  - A pollution-income EKC relationship can be derived from the latter, but is not necessarily related to the former.
- The elasticity of the marginal WTP of individuals for pollution reduction is only constant under very restrictive conditions.
- Nor is a constant elasticity necessary to derive an environmental Kuznets relationship between pollution and income (McConnell 1997; Israel and Levinson 2004).
- Determining whether and how this elasticity varies with income, and its magnitude at different income levels, is therefore an empirical issue that requires further investigation.

Case study and empirical strategy

- We explore the relationship between WTP for pollution control and income using a large dataset from a contingent valuation study of the benefits of meeting nutrient reduction targets for the Baltic Sea.
- The survey was aimed at estimating respondents' WTP for reducing eutrophication and its environmental effects on water clarity, blue-green algal blooms, underwater meadows, fish species composition and deep sea bottoms (Ahtiainen et al., 2014).
- The study was conducted in 9 littoral countries of the Baltic Sea: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden (N = 10,396 representing 230 million people).
- The purpose of our empirical analysis is to employ a multivariate Box-Cox model to test the null hypothesis that the elasticity of the marginal WTP for pollution control with respect to income is constant.

Results: tests of the null hypothesis

- The Box-Cox transformation parameters associated with the variables *WTP* and *income* are both significantly different from zero.
- Indicates that lognormal transformation of WTP and income is not superior to other functional forms, and hence the elasticity of WTP for pollution control with respect to income is not constant.
- Thus, it appears that our null hypothesis can be rejected.
- To formally test this hypothesis, we estimate models in which both Box-Cox transformation parameters were constrained to zero, resulting in the log-log relationship between WTP for eutrophication reduction and income.
- Likelihood ratio tests comparing these restricted to unrestricted models are highly significant, and thus the restrictions are easily rejected.

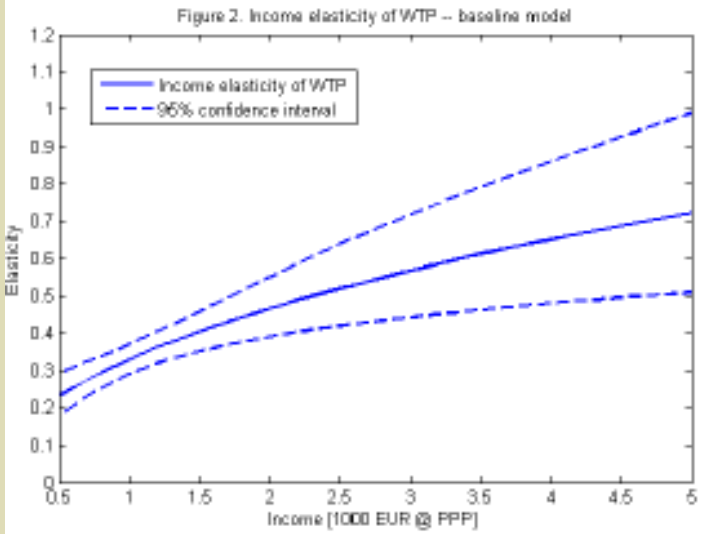


Figure 2. Income elasticity of WTP -- baseline model
Income elasticity of WTP
95% confidence interval
Elasticity
Income [1000 EUR @ PPP]

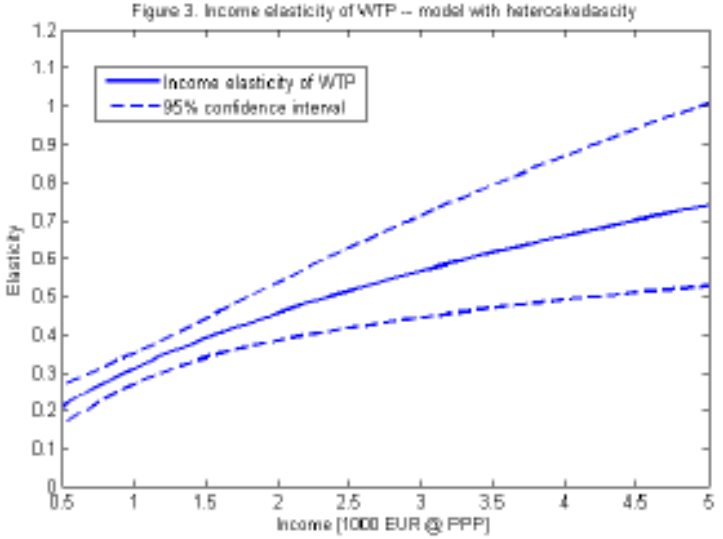


Figure 3. Income elasticity of WTP -- model with heteroskedascity
Income elasticity of WTP
95% confidence interval
Elasticity
Income [1000 EUR @ PPP]

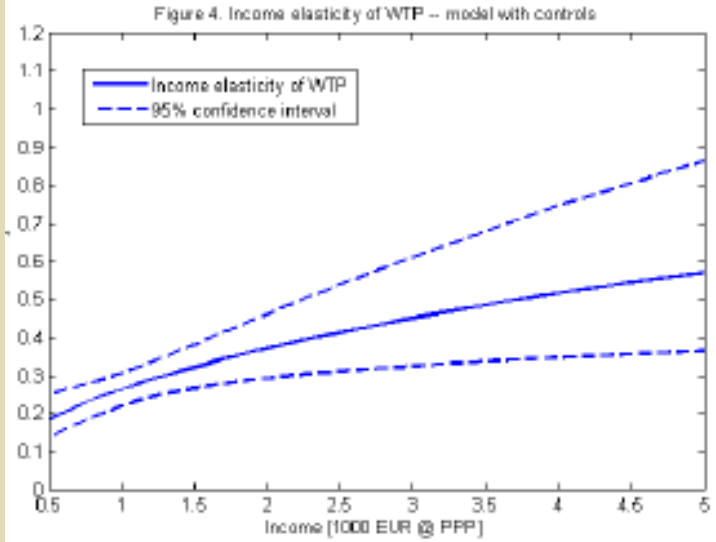


Figure 4. Income elasticity of WTP -- model with controls
Income elasticity of WTP
95% confidence interval
Income [1000 EUR @ PPP]

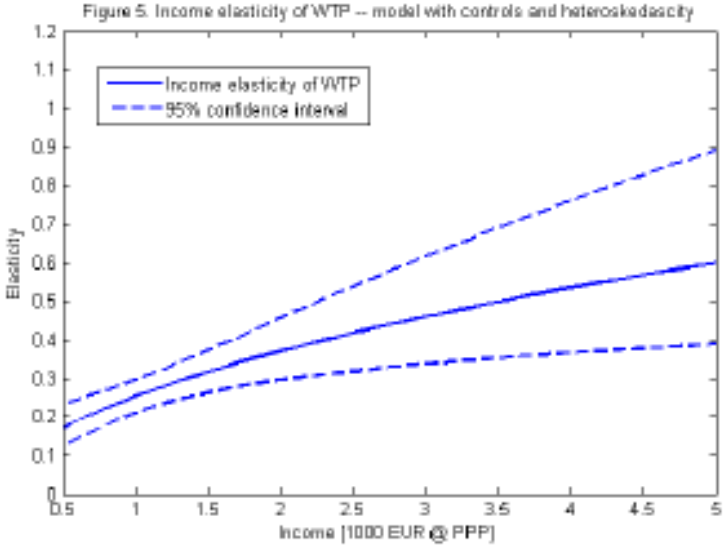


Figure 5. Income elasticity of WTP -- model with controls and heteroskedascity
Income elasticity of WTP
95% confidence interval
Elasticity
Income [1000 EUR @ PPP]

Elasticity estimates

- We find that the income elasticity for the marginal WTP for pollution control is increasing and concave, and that it behaves similarly irrespectively of the model specification.
- The income elasticity takes values of 0.1 - 0.2 for low-income respondents and reaches 0.6 - 0.7 for the highest income levels observed in our dataset.
- This result is consistent with previous findings that the elasticity:
  - is less than one (Hökby et al. 2003; Jacobsen and Hanley 2009; Kriström and Riera 1996; Lindhjem and Tuan 2012), and
  - varies with income (Ready et al. 2002; Czajkowski and Ščasný 2010).

Conclusion

- Our analysis demonstrates both theoretically and empirically that the income elasticity of the marginal WTP for environmental improvement is unlikely to be constant – and only under very restrictive conditions.
- Our estimated income elasticity for the marginal WTP for pollution control is increasing, concave and less than one.
- Counters the "folklore myth" that an environmental Kuznets curve for pollution control implies that the environment is a luxury good, or that one can determine the magnitude of the income elasticity of the WTP for environmental improvement from estimating an "EKC" relationship.
- Casts in doubt recommended guidance principles for transferring estimated WTP values for environmental improvement to other sites based on the assumption that the income elasticity of these WTP values is constant.