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On Environmental Quality: "Normal" versus "Luxury" Good*

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ABSTRACT

This note considers a simple model in which we reconcile two seemingly contradictory findings on environmental quality: Kristrom and Riera's (1996) "normal" good versus Pearce and Palmer's (2001) "luxury" good.

Key Words: environmental quality, normal good, luxury good

I. Introduction

There have been a series of discussions on whether the income elasticity of environmental quality is greater than unity or not, i.e., whether environmental quality can be classified as a luxury or not. This discussion is related to the possible existence of an "environmental Kuznets curve" (EKC): an inverted-U shaped empirical relationship between pollution and per capita income.[1] Grossman and Krueger (1995) emphasized that the eventual decline in pollution as income rose via an induced policy response (1995: 372), i.e.,

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1 Starting with the seminal work of Grossman and Krueger (1993), the EKC hypothesis has been recently reviewed by Stern (2004) and Yandle et al. (2004).

the government was required to devote more proportional resources to improving environmental quality because consumers increasingly demanded a cleaner environment quality as the people got richer, cf. Lopez (1994), Magnani (2000) and Eriksson and Persson (2003).

Moreover, there are distributional reasons to be concerned about benefit incidence for environmental policy. The distribution of the benefit will be classified as pro-rich if the benefit received from environmental services increases with income. Baumol and Oates (1988) and Ebert (2003) concluded that the benefit incidence for environmental policy depended on the income elasticity of demand for environmental quality.

Identifying whether the environmental quality can be classified as a luxury from empirical findings has been an important issue in the environmental literature. In a review of contingent valuation method (CVM) studies, Kristrom and Riera (1996) evaluated the evidence on the income elasticity of people's willingness-to-pay (WTP) for environmental improvement. They concluded that the value of this parameter was positive, but was consistently found to be *less than one*. Later studies, including Aldy et al. (1999), Ready et al. (2002) and Hokby and Soderqvist (2003), also confirmed this conclusion. However, Pearce and Palmer (2001) documented the OECD public expenditures on pollution abatement and control, and found that the income elasticity of these expenditures was *greater than one* and close to 1.2. One may wonder if there is an inconsistency between Pearce and Palmer's "luxury" good finding and Kristrom and Riera's "normal" good finding.

Kristrom and Riera (1996: 45) remarked: "most economists would argue intuitively that environmental quality is a luxury good, [but] our results do not support this intuition." Pearce and Palmer (2001: 426) commented on Kristrom and Riera's finding: "If they are right, then the 'environment' is a normal good but not a luxury good, contradicting the usual intuition about the demand for environmental quality."[2] Actually, the inquiry of Kristrom and Riera (1996) or Pearce and Palmer (2001) arose from adopting different methodologies to explore the demand for environmental quality and then wondering why the other's findings were inconsistent with them.

2 McFadden and Leonard (1993) and McFadden (1994) argued that income elasticities less than one found in contingent valuation studies do not accord well with economic intuition.

Flores and Carson (1997) to some extent clarified the relationship between the income elasticity of demand and WTP for environmental improvement, showing that knowledge of one is insufficient to determine the magnitude or even the sign of the other. This clarification is helpful, but it falls short of resolving the controversy arising from the empirical findings: while the income elasticity of WTP for environmental improvement is found to be positive but less than one, the income elasticity of demand for environmental improvement is found to be greater than one. In this note we don't justify which kind of income elasticities of environmental quality is more proper to identify whether environment is a luxury good or not, but consider a simple model to reconcile the seemingly contradictory findings between Kristrom and Riera (1996) and Pearce and Palmer (2001), and our model will show that a positive income elasticity of WTP for environmental improvement is *sufficient* for an income elasticity of expenditures that is greater than one (a luxury).

II. The demand for environmental quality

The private goods would be classified as luxuries if the income elasticity of demand (or the income elasticity of the expenditures on the goods) are greater than unity. In comparison with private goods, however, there are at least two basic problems about how to estimate the income elasticity of demand for environmental quality. First, there is no market for trading environmental quality directly. The other is that the environmental quality is typically rationed. Therefore, there is no market price for reflecting the consumers' WTP for the environmental improvement, and the real environmental quality is not the outcome of consumers' utility-maximizing process.

Freeman (1993) showed that indirect and direct methods were developed to resolve the preceding problems. The indirect method means that the observable market behavior on the goods whose consumption is related to environmental quality is adopted as a proxy to reveal the demand for environmental quality. Pearce and Palmer (2001: 417) documented that public expenditures on pollution abatement and control in OECD countries exceeded the private expenditures concurrently, and the growing rate of the public abatement expenditures was greater than that of the private sector. In a log-linear function form, Pearce and Palmer (2001) estimated a model that was a function of $\ln(PE)=\beta_1+\beta_2 \ln(income)+\beta_3 X+\varepsilon$, where PE was the public expenditure on pollution abatement and control, X was the other covariates, and ε was a random component. The estimator of β_2 was 1.19495 with $p<0.05$, which meant the income elasticity of the public expenditures on pollution abatement was significantly *greater than one*. Recognizing the public expenditures as a proxy of the demand for environmental quality, Pearce and Palmer's finding endorsed the status of environmental goods as luxuries.

CVM is a widely used direct method. In a CVM setting, welfare change is estimated as WTP for environmental improvement,[3] and the respondents are invited to answer what's their WTP for environmental improvement if there were a market for trading environmental quality. CVM studies often include an estimation of a value function, $WTP=W(r)$, where r is a vector of explanatory variables, such as income and other socio-economic characteristics of the respondents in the CVM survey. Kristrom and Riera (1996) found income was a very significant determinant for WTP, and also concluded the value of the income elasticity of WTP for environmental improvement is positive, but was consistently found to be *less than one*. The income elasticity of WTP is, in some sense, analogous to the income elasticity of the expenditures for the private good case. Thus, environmental quality is not a luxury good if the income elasticity of WTP for environmental improvement is *less than one*.

Pearce and Palmer (2001) defined environmental quality as a luxury based on the elasticity of the public expenditures on pollution abatement and control, and questioned why Kristrom and Riera (1996) concluded that environmental quality was not a luxury good; see Pearce and Palmer (2001: 426).[4] Pearce and Palmer (2001: 426) implied it would be reasonable that the income elasticity of WTP for environmental improvement should be consistently greater than one since they found that the elasticity of the public

3 Hokby and Soderqvist (2003) defined the WTP for an discrete increase in environmental quality from Z^0 to Z^1 as $V(q, M, z^0)=V(q, M-WTP, z^1)$, where V was the indirect utility function, q was an n-vector of market prices of private goods, and M was income, i.e., WTP, in this case, is measured by compensating variation.

4 Kristrom and Riera (1996) reviewed the CVM literature of major European countries, Australia and the USA. Pearce and Palmer (2001) documented their finding by estimating the public expenditure in OECD countries. Besides most European countries, the OECD also includes Australia, Japan, Korea, Mexico and the USA. In other words, the countries which Kristrom and Riera (1996) surveyed were covered by Pearce and Palmer's research even though there were contradictory findings between them.

abating expenditures was greater than one.

However, the methodology used by Kristrom and Riera (1996) was completely different from the one of Pearce and Palmer (2001) for measuring the demand for environmental quality. In fact, the public expenditures on pollution abatement and control which Pearce and Palmer (2001) estimated should not be classified as the direct expenditures on consuming an environmental improvement, but should be classified as the derived expenditures related to environmental improvement because there is no market for trading environmental quality directly. In other words, the derived expenditures are not identical to the WTP for environmental improvement with which Kristrom and Riera (1996) were concerned. That is why the empirical evidence appears contradictory.

To reconcile these two seemingly contradictory findings, in this note we consider a simple model for policy decision making. In the model, the public expenditures for environmental improvement are decided endogenously by the voters, who make their own utility-maximizing decisions based on their preferences for environmental quality. In the model, we link the possible relationship between consumer's WTP for environmental improvement and the public expenditures on pollution abatement and control, and explain that positive income elasticity of WTP for environmental improvement is *sufficient* for income elasticity of expenditures that is greater than one (a luxury).

III. Model

Our model is built on Andreoni and Levinson (2001, hereafter A&L) with a minor modification. Instead of being a constant, we allow a person's WTP for environmental improvement to positively depend on her own income. This dependence is necessary for the study of the income elasticity of WTP.

Consider an economy in which there is a unit mass of identical individuals, whose preferences are represented by the utility function:

$$U = C - \lambda P \tag{1}$$

where C is consumption (a private good), P is pollution (a public bad), and $\lambda > 0$ is the marginal disutility of pollution with $\lambda = \lambda(M)$, where $\lambda(.)$ is a function of M (an individual's income).[5] The WTP for environmental improvement means the maximum quantity of money which could be taken away from an individual in exchange for a decrease in pollution, subject to keeping the utility constant. For simplicity, normalize the price of C to be 1 in our model. The WTP for environmental improvement can be measured by $(dC/dP)_{U=\bar{U}}$ for the case of a marginal change of pollution. From (1), we obtain $(dC/dP)_{U=\bar{U}}=\lambda$. Therefore, it is a worthy noting that λ represents the individual's WTP for environmental improvement, which is represented by the reduction in P.[6]

Assumption I. $0<\varepsilon<1$, where $\varepsilon\equiv(d\lambda/dM)(M/\lambda)$.

ε denotes the income elasticity of WTP. Kristrom and Riera (1996) reviewed and evaluated the evidence on the income elasticity of people's WTP for environmental improvement. They concluded that the value of this parameter was positive, but was consistently found to be less than one. This conclusion was continually supported by Aldy et al. (1999), Ready et al. (2002) and Hokby and Soderqvist (2003).

As in A&L, pollution is a byproduct of consumption, but it can be abated through environmental effort. Following A&L's assumption, C is the gross pollution before abatement and is directly proportional to consumption, for simplicity. The pollution-abatement technology is represented by:

$$P=C-C^{\alpha}G^{\beta} \tag{2}$$

where P is the net pollution to which consumers are exposed after abatement, and $G=sM$ (s is the share of income devoted to pollution abatement

5 The utility function, $U=C-\lambda P$, is not originated by Andreoni and Levinson (2001). Actually, in order to examine the possible influence of income inequality for environmental policy, Magnani (2000) adopted a quasi-linear utitlity function. The utility function in Magnani (2000) was represented by $U=C+\gamma Q$, where $\gamma(.)$ expressed the preference for environmental quality Q and was positively correlated to relative income R (the ratio of an individual's income to average income). With the setting of the preference for environmental quality, $\gamma(R)$, Magnani's model predicted that pro-environmental public expenditure was a decreasing function of income inequality and confirmed this prediction by the empirical model.

6 Environmental improvement means that environmental quality gets better compared to the status quo. Actually, in equation (1) of our model, $-P$ represents environmental quality. In other words, environmental improvement is identical to the reduction of pollution level.

and control). Pearce and Palmer (2001) documented the OECD data on pollution abatement and control expenditures, showing that a large part of environmental effort is channeled through collective action (as public expenditures directly or private expenditures indirectly via regulation). The variable G can be regarded as total expenditures devoted directly or indirectly to pollution abatement and control in the economy. A main difference between our model and A&L's is that while s is privately chosen in A&L, it is collectively determined (say, by taxation or regulation) in our setting. The variable s represents the environmental policy of our economy.

According to (2), $P=C$ if $G=0$. This means that the net pollution to which consumers are exposed is identical to the gross pollution without devoting any resource to pollution abatement. In our model, $G=0$ if $s=0$ since $G=sM$.

Assumption 2. $0<\alpha,\beta<1$ and $\alpha+\beta\geq 1$.

The case where $\beta=0$ is obviously uninteresting, while the case where $\alpha=0$ leaves out a plausible possibility that the abatement productivity of G has to do with the existing level of pollution. The assumption $\alpha,\beta<1$ is made to rule out the "corner" solution $s=0$ or 1 (see below). Following A&L's (2001: 278) definition, the abatement technology exhibits increasing returns to abatement if reduplicating both gross pollution and clean-up effect get more than double pollution abated. Following this definition, increasing returns to abatement means $\alpha+\beta>1$ under the Cobb-Douglas abatement function, $A=C^{\alpha}G^{\beta}$. A&L argued for increasing returns to abatement and provided some supporting evidence in the case of air pollutants. Hence we allow for the possibility that $\alpha+\beta>1$.

IV. Analysis

Utilizing the constraint $C=(1-s)M$ and (1)−(2), the preferred s of the economy is implicitly determined by the following equation:

$$\frac{\partial U}{\partial s}=\frac{\partial C}{\partial s}-\lambda\frac{\partial P}{\partial s}=0 \tag{3}$$

with

$$\frac{\partial C}{\partial s}=-M \tag{3-1}$$

$$\frac{\partial P}{\partial s} = -M - M^{\alpha+\beta}(1-s)^{\alpha-1}s^{\beta-1}[\beta-(\alpha+\beta)s] \tag{3-2}$$

Because $0<\alpha,\beta<1$, $[\beta-(\alpha+\beta)s]$ is positive and $\lim_{s\to 0} s^{\beta-1}=\infty$ if $s=0$. Then, as a result, $\lim_{s\to 0}(\partial P/\partial s)=-\infty$. Similarly, $\lim_{s\to 1}(\partial P/\partial s)=\infty$ because $0<\alpha,\beta<1$. Then, according to (3), $\partial U/\partial s>0$ at $s=0$ because $\lim_{s\to 0}(\partial P/\partial s)=-\infty$, and $\partial U/\partial s<0$ at $s=1$ because $\lim_{s\to 1}(\partial P/\partial s)=\infty$. Thus the preferred s of the economy that is determined by $\partial U/\partial s=0$, denoted by s^*, must satisfy $0<s^*<1$.

Using (3-2) yields:

$$\frac{\partial^2 P}{\partial s^2} = -M^{\alpha+\beta}(1-s)^{\alpha-2}s^{\beta-2}[\alpha(\alpha-1)s^2+\beta(\beta-1)(1-s)^2-2\alpha\beta s(1-s)] \tag{4}$$

As we know that $(1-s)^{\alpha-2}$ and $s^{\beta-2}$ in (4) are always positive because $s\in(0,1)$, so is $s(1-s)$, the last term of [.] in (4). Therefore, the sign of (4) is positive because Assumption 2 ($0<\alpha,\beta<1$) makes the sign of [.] in (4) negative for $s\in(0,1)$. $\partial^2 P/\partial s^2>0$ implies that $P(.)$ is strictly convex with respect to s and reaches its minimum at $\partial P/\partial s=0$. Putting this result together with $\partial C/\partial s$ being a negative constant (see Eq. (3-1)), we see from (3) that s^* will be located in the regime where $\partial P/\partial s<0$ and that this s^* is unique. Finally, $\partial^2 P/\partial s^2>0$ implies that $\partial^2 U/\partial s^2<0$ and, therefore, the unique s^* that satisfies (3) is the preferred s of the economy.

Let $f(s)\equiv(1-s)^{\alpha-1}s^{\beta-1}[\beta-(\alpha+\beta)s]$ (see Eq. (3-2)). The function $f(s)$ has the following properties: (i) $df/ds<0$ because $\partial^2 P/\partial s^2>0$, and (ii) $\lim_{s\to 0} f(s)=\infty$ and $\lim_{s\to 1} f(s)=-\infty$ under Assumption 2.

From (3), we obtain:

$$s^* = f^{-1}\left[\left(\frac{1}{\lambda}-1\right)M^{1-(\alpha+\beta)}\right] \tag{5}$$

where $f^{-1}(.)$ is the inverse function of $f(.)$. According to (5), two factors drive the share of income devoted to pollution abatement and control as income M grows: individual preferences (λ) and pollution abatement technology ($\alpha+\beta$). An increase in income will raise individual preferences (λ) and hence results in a higher s^* (remember that $df/ds<0$). However, the public expenditures on pollution abatement in the equilibrium, $G^*=s^*M$, are not solely dependent on the WTP for environmental quality, but are also contributed by abatement technology.

To sort out the single impact of individual preferences for environmental quality (λ) on the evolution of expenditures on pollution abatement and control, we let $\alpha+\beta=1$. As a result, (5) is reduced to:

$$s^*=f^{-1}\left(\frac{1}{\lambda}-1\right) \tag{6}$$

On the basis of (6), we then have:

$$\frac{ds^*}{dM}=\frac{-\varepsilon}{\lambda M(df/ds)} \tag{7}$$

It is clear from (7) that $ds^*/dM>0$ as long as $\varepsilon>0$ (remember that $df/ds<0$). That is, *the share of income devoted to pollution abatement and control will rise as income grows (the so-called "luxury" good), as long as the income elasticity of WTP for environmental improvement is positive, and there is no need for the income elasticity of WTP to exceed one as thought by Kristrom and Riera (1996), Pearce and Palmer (2001) and others.*

A&L argued for increasing returns to abatement and provided some supporting evidence in the case of air pollutants. Papers including Fraas and Munley (1984), McConnell and Schwarz (1992), Goldar et al. (2001) and Managi (2006) also find evidence in support of increasing returns to abatement for other pollutants. Allowing for the impact of increasing returns to abatement technology (i.e. $\alpha+\beta>1$), (5) leads to:

$$\frac{ds^*}{dM}=\frac{-1}{\lambda df/ds}[\varepsilon+(1-\lambda)(\alpha+\beta-1)]M^{-(\alpha+\beta)} \tag{8}$$

If $\lambda\leq 1$, the sign of (8) will remain positive as long as $\varepsilon>0$. From (1)−(2), we have: $U=(1-\lambda)C+\lambda C^{\alpha}G^{\beta}$. If $\lambda>1$ were to hold, then consumption-cum-pollution would always yield negative utility, while positive utility could only come from pollution abatement activities. This seems implausible, at least at the present time. Intuitively, $\lambda\leq 1$ implies that the direct utility from consumption $(1\times C)$ is greater than the indirect disutility from the by-product of consumption (say, the disutility of gross pollution λC). In other words, the extent of antipathy to pollution for an individual whose $\lambda<1$ isn't great enough to offset the satisfaction directly from consumption. Riding motorcycles could give a practical example for $\lambda\leq 1$. Riding motorcycles could bring an individual traffic convenience, such as having a shorter time to arrive at the office without being jammed in the crowded metro. At the same time, air pollution emitted by riding a motorcycle makes the rider uncomfortable. However, most riders still evaluates the traffic convenience at a higher value compared to the disutility of air pollution. As a result, most riders just decide to wear respirators while riding to avoid air pollution. In other words, consumption-cum-pollution would still yield positive utility for riding motorcycles.

Actually, $\lambda \leq 1$ has been supported by empirical research. Hokby and Soderqvist (2003: 374) have documented concretely that the median WTP estimated for reducing marine eutrophication effects in Sweden was around 0.3.[7] Thus, on the basis of (8) with $\lambda \leq 1$, we conclude that a positive income elasticity of WTP for environmental improvement is sufficient for an income elasticity of expenditures that is greater than one (a luxury). This result holds even after allowing for the impact of increasing returns to abatement technology.

A&L have successfully proven that the existence of EKC depended on increasing returns to abatement technology. However, A&L couldn't predict clearly whether the society devoted more proportional resources to improving environmental quality while economic growth eventually brings environmental improvement because of increasing returns to abatement technology. In the A&L's special case where $\lambda = 1$, the consumers devoted proportional resources to abating pollution through optimizing behavior. However, in their general case allowing $\lambda \neq 1$, there was no clear specific function form to explain the relationship between abatement expenditure and income. Our model, built on A&L with a minor modification, $\lambda(M)$ and policy decision making for s, successfully displays the variation of the public expenditures as income grows without any restriction on λ. Furthermore, our model concludes that a positive income elasticity of WTP for environmental improvement is sufficient for an income elasticity of expenditures with or without increasing returns in pollution abatement.

7 The environmental quality is not marketable directly. Therefore, Hokby and Soderqvist (2003), a CVM study, assumed the existence of a virtual market for environmental services in the Baltic Sea and asked the respondents the following question: "Would you be willing to pay b_i^* per month in 10 years for reducing the nitrogen load to the Baltic Sea by a_i tons per month?". Hokby and Soderqvist (2003) showed that the virtual price per ton reduced nitrogen load which was calculated by b_i^*/a_i ranged between 0.000383 to 2.32 and the median as well as the mean virtual price per ton reduced nitrogen load were 0.31 and 0.547. And Ebert (2003: 440) also showed that the virtual price of environmental services could be an alternative to marginal willingness to pay for environmental services (that is identical to λ in our model).

V. Conclusion

Establishing a simple consumer decision model in which consumers encounter a pollution production function and need to decide the preferred share of income devoted to pollution abatement and control, our model has proven successfully that the share of income devoted to pollution abatement and control will rise as income grows (the so-called "luxury" good), as long as the income elasticity of WTP for environmental improvement is positive, and there is no need for the income elasticity of WTP to exceed one. Two seemingly contradictory findings on environmental quality, Kristrom and Riera's (1996) "normal" good versus Pearce and Palmer's (2001) "luxury" good, are thus reconciled.

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環境品質對消費者而言是奢侈財？亦或正常財？

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摘　要

Kristrom and Riera（1996）發現歐洲各國消費者對環境品質改善願付價格的所得彈性普遍地皆介於0和1之間，因而認為環境品質為正常財；然而根據OECD各國投入環境改善支出的所得彈性顯著地大於1的實證數據，Pearce and Palmer（2001）認為環境品質應為奢侈財。本文藉由建構一個直覺上易理解的靜態模型成功地調和並解釋 Kristrom and Riera（1996）和Pearce and Palmer（2001）兩個看似矛盾的實證現象。

關鍵字: 環境品質、正常財、奢侈財