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SÉRIE DE TEXTOS PARA DISCUSSÃO

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Abstract

The theory relating environmental degradation and a certain level of per capita income of a country is known as Environmental Kuznets Curve (EKC). This theory is based upon an environmental demand that would increase social control and government regulations as a society gets richer. However, little has been said about the variation of this theory in countries with great poverty and low level of education. The objective of this paper is to investigate if Brazilian poverty affects the EKC. We handle models involving dichotomous response variables to investigate if social and economic indicators - mainly income and education - affect the environmental demand and consequently the EKC. Our results permit to infer that increases in education level and of some social indicators can generate higher probabilities of changes on individual demand for environmental goods and services. These results can be disaggregated into three interesting findings: i) the Brazilian social problems - represented by low levels of education and of income – has affected demand for environmental goods and services and, consequently, the EKC; ii) the direct relationship between poverty and environmental degradation, as some international institutions have tried to stand out, does not seem to be so consistent; investments on education and on some basic services would increase demand for environmental goods and services even among the poorest sections of society; and iii) investments on social areas could guarantee an economic growth with low levels of environmental degradation, generating a "tunnel" in the EKC.

Key Words: Theory of the Environmental Kuznets Curve (EKC), economic growth, Brazilian social problems, environmental demand, models involving dichotomous response variables, social and economic indicators.

Category JEL: Q10 and O10

- **Initial Comments**

The relation between income level and environmental quality has been widely debated inside academic circles. There is no *a priori* reason to assume this relationship to be strictly monotonic. Actually, environmental quality may worsen with income within some ranges of income, but improve over others. Also, no one should expect the same relationship to hold for all dimensions of environmental quality (Boyce and Torras, 2002). Empirical evidences have stressed that environmental health will depend, among others factors, upon the development stage achieved by a given country. In its initial stages, a country is dependent upon agriculture and primary mineral resources with relative small pollution impacts.

As income of a country continues to grow with economic development, manufacturing production achieves larger share of national domestic production. In general, industrialisation starts with light industries (e.g. textiles) moving toward a phase of heavy industries (e.g. steel). This is a phase of medium level income, of increasing use of natural resources and intensification of environmental degradation. Finally, the development phase overcomes industrialization with services enlarging its share of national domestic product, while industrial share stabilizes. In this stage, it is observed a reduction of raw material utilization. However, it is also observed an increase on waste generation per unit of production.

It is in this context that the Environmental Kuznets Curve (EKC) arises[1]. The basic idea is quite straightforward: environmental pressure would decrease after certain level of economic development. We suggest that the main deficiency of the modelling sustaining EKC is that one does not observe clearly *why* the increase in income influences reduction of environmental degradation caused by any pollutant. Researchers have different arguments about possible elements that may correlate these variables. Some of them believe that environmental quality improvement occurs naturally with the process of economic development. In other words, environment improvement is endogenous to the process. However, others stress that an improvement in environmental indicators is a result of increasing demand for environmental quality. This demand grows with rising income and put

[1] It is also known as the "U" inverted curve.

pressure upon policy makers for more regulations and investments on environmental areas [EKINS (1997) and MUNASINGHE (1998)].

In spite of this lack of consensus on cause-effect relationship between income and improvement of environmental indicators, the great majority of scholars agree about the elements that act degrading the environment. It can be argued that degradation is related with scale, composition and technological effects [GROSSMAN & KRUEGER (1995)]. These effects relate themselves, respectively, with the increase of economic activity, with consumption and production structures and with adopted technological pattern. If the degradation intensity were constant among countries, one would expect that, by the scale effect, an increase in production of all them would increase environmental degradation at the same rate in the whole planet.

However, the scale effect could be reduced if composition and technology effects were sufficient intense to act in the opposite direction. Therefore, degradation could be reduced with economic growth as long as production would be transferred between sectors. This would be the case if the service sector would increase its participation relatively to the manufacturing sector. Another possibility would be changes in the consumption structure enabling a reduction in waste generation, for example. Moreover, some sectors could adopt technologies that would use less natural resources and that would pollute less.

Furthermore, GROSSMAN & KRUEGER (1995) themselves suggested that "an induced policy response" in the form of more stringent and more strictly enforced environmental standards, driven by citizen demand, has provided the strongest link between income and pollution. Following this reasoning, BOYCE & TORRAS (2002) investigated possible causal linkages between changes in income level and changes in pollution levels. These authors also pointed out that this connection hitherto remarkably absent from discussions of the EKC.

Our research is one of very few studies to deal with the EKC in a context of a poor and unequal society[2]. The vast majority of EKC studies have been based upon countries where

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[2] Some countries present an enourmous social inequality. That is, there is a large difference among income levels, without having a significant number of poor people. However, the brazilian social reality presents a high level of poverty together with a high social inequality.

poverty and low level of education was not part of their reality. We argue that, the "poverty cycle"[3] of some countries, like Brazil[4], could change in the EKC's *rationale*. In a reality like this, it is possible, we argue, that the turning point where pollution would start declining can be higher than in a different social reality. Even more, the turning point may never exist. This could happen due to the fact that high levels of poverty may change preferences and, consequently, the demand for environmental services.

In such a context, some linkages that could explain the EKC would become biased, because the neediest portion of the population would be more concern in achieving their basic needs. Nevertheless, some key socio-economic variables, mostly education, may suggest that public investments in education and basic services may change the demand for environmental goods and services of a country and, thus, reduce the potential of degradation. Our results show that there is not a direct relation between poverty and environmental degradation, as some international institutions have frequently emphasised.

This research has, therefore, as its main goal to investigate whether the Brazilian social problem – manifested, among other factors, by a high concentration of income and by a low average educational level – can affect demand for the environment and, thus, a theoretical EKC. There is another relevant objective of this research. Besides to inquire whether the existence of a widespread poverty will put doubt upon the explanatory power of the ECK theory for the Brazilian reality, we also show evidence of a necessary interaction among socio-economic and environmental policies.

A frequently used indicator to evaluate EKC in developing countries is the deforestation rate. This indicator of environmental degradation expresses directly individuals' demand for environmental goods and services. In other words, the decision to conserve a forest areas eliminates any other type of alternative use of this natural resource. Thus, the use of

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[3] Brazil presents a high level of poverty represented by a great number o people living with low levels of income and of education.

[4]Brazil is a relevant case study for a research about the EKC. In spite of being one of the biggest economy among all countries, Brazil has not yet arrived at a level of high environmental degradation. The countryu detains one of the largest reserves of natural resources in the whole planet, being object of constant international pressures. On the other hand, Brazil has one of the worst income distributions of the world, better only of those of some African countries. This combination of factors

deforestation rates as indicators of environmental conservation enables us to test the relation between low levels of income and of education with the demand for environmental goods and services, and then with the EKC.

In order to do so, we use a data base generated through a contingent valuation method to check the relevance of socio-economic variables in the demand for environmental goods and services provided by the Carajás Region, in the Brazilian Amazon. These data reflect the willingness to pay to avoid further exploitation of mineral reserves of Carajás Region. We have used them to test two hypotheses: 1) socio-economic variables – mostly income and education – affect demand for environmental goods and services; and 2) the variable education is also significant in shaping the demand for environmental goods and services by those people who are willing to pay for conservation, but they do not have enough income to do so.

Econometric models with dichotomous dependent variable – Logit and Probit – are used to analyse whether these variables influence demand for environmental services. The paper has two main sections. The next section deals with evidences of the EKC, through a survey of theoretical studies. The second section presents our econometric results, as well as highlights consequences of our results for the EKC theory and for future public policies.

- **Income Level and the EKC.**

In a well known study, Munasinghe (1998) show how the willingness to pay (WTP) for an environmental good or service is influenced by income and by the level of environmental understanding of an individual. Actually this relationship was also exploited by LOPEZ (1994). For him, if producers do not pay for the pollution that they impose to the society, then an increase in production will invariably increase the pollution level. However, when these same producers pay the marginal social cost of pollution[5], then the relationship between emissions and income would become directly dependent of technology and of preferences.

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guarantees to Brazil a relevant position in the discussion of the relation between poverty and the environment.

[5]In other words, they incorporate in their costs the social damages of pollution.

If the preferences are homothetic, an increase in production would also generate an increase in the pollution level. However, when preferences are not homothetic, as is usually the case in most actual situations according to POLLAK & WALES (1992), changes in pollution due to economic growth depends upon the elasticity of substitution in production between pollution and inputs, as well as the degree of agent aversion to risk (that is, rate of marginal reduction of utility in the consumption of produced goods). As much larger the rate of decreasing marginal utility and the substitution in production, smaller should be the increase in pollution due to increments in production.

In this context, pollutants as the SO_2, that are controlled in many countries, would may have their effective price close to the optimum level. In these cases, the "U" inverted relation to income should occur. However, CO_2 effective price is, probably, far from the optimum level, evidencing a monotonic relation in the EKC. This may be happening due to a low elasticity of substitution and to the fact that the environmental damage is less evident, implying in an higher turning point in the EKC.

SELDEN & SONG (1994), however, have derived a "U" inverted curve by means of a "optimum path for pollution", using a model of growth and the environment proposed by FOSTER (1973). Actually, this model is similar to that by LOPEZ (1994), but adding the hypothesis that utility is additive in consumption and pollution. While LOPEZ (1994) and SELDEN & SONG (1994) haved developed models based on agents with infinite time span, JONHN & PECCHENINO (1994) develop an overlapping generation model, where pollution externalities have been generated more by consumption than by production activities. A pollution consumption model was proposed by McCONNELL (1997). He proposed that income elasticity of demand for environmental goods not necessarily defines any rule for EKC Model. In other words, pollution level could decrease even though elasticity were not positive.

In order to allow for better visualization of income and eduaction level upon willingness to pay (WTP) for environmental goods, the following model provides evidences on how these variables explain endegenously the EKC. In this model, the economy is perfectly competitive, at first. In a second stage, it consideres some market imperfections. Suppose that an individual or a firm, in a certain country, wishes to maximize net benefits, in a situation where both benefits and costs are dependent of income level and of environment quality, that is:

$$\max BL = B(E,Y) - C(E,Y) \qquad (1)$$

where BL representes the net benefit to be maximized, while B and C are, respectively, benefits and costs. Both are function of the level of environmental degradatrion (E) and of income per capita (Y).

In any income level, individual wishes to maximize **BL** at the level where marginal benefit, or the willingness to pay for a certain environmentalk quality, is equal to marginal cost to obtain that level of environmental quality. The first order condition will garantee:

$$BM_g - CM_g = 0 \qquad (2)$$

where $BM_g = \partial B / \partial E$ and $CM_g = \partial C / \partial E$. A key aspect of this present research is , as mentioned before, to analyse how the equilibrium (in the point $(E^*, \bar{Y})$) is affected by changes in income. Thus differentiating in relation to income, we have:

$$BM_{gy} + BM_{ge}(\partial E / \partial Y)_{E=E^*} - CM_{gy} - CM_{ge}(\partial E / \partial Y)_{E=E^*} = 0 \qquad (3)$$

where $BM_{gi} = \partial BM_g / \partial i$ and $CM_{gi} = \partial CM_g / \partial i$ for i=Y, E.

Equation (3) relates (E) and (Y) at the level where environmental degradation (E*) is optimized for any income level. Thus, we have:

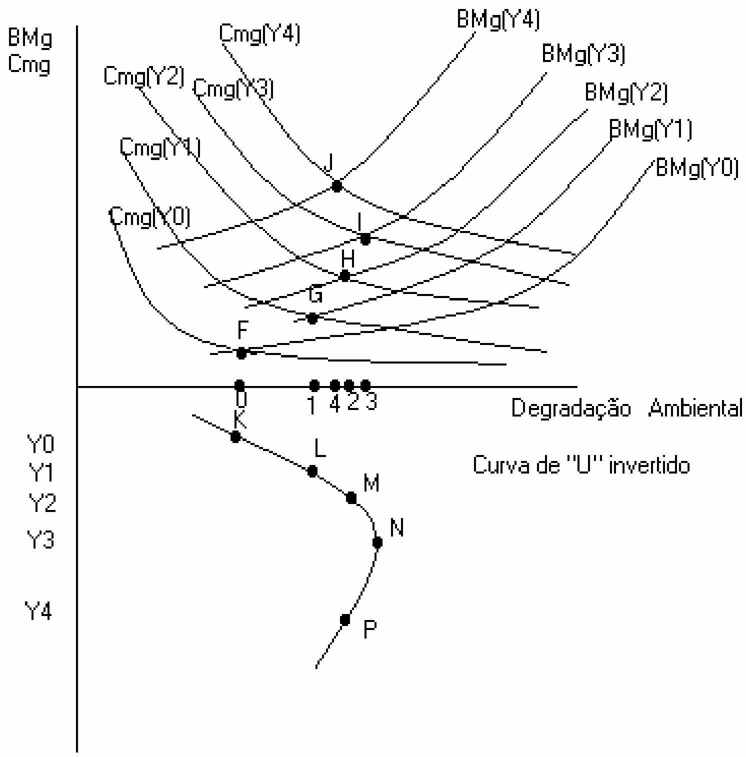
$$(\partial E / \partial Y)_{E=E*} = (BM_{gy} - CM_{gy})/(CM_{gE} - BM_{gE}) \qquad (4)$$

This equation shows that the sign of $(\partial E / \partial Y)$, according to the inverted "U" curve model, changes from positive to negative at a given level of income. Therefore, the sign of enviornmental degradation elasticity in relation to income *per capita* changes from positive to negative as income grows.

It can be verified from equation (4) that it is reasonable to represent the WTP for environmental improvements by a curve of positive coefficients, that is $BM_{gE} > 0$. This explains why points representing higher levels of environmental degradation will have higher willingness to pay for an improvement in environmental quality. Furthermore, a curve of marginal cost for reverting environmental degradation has negative coefficient, that is, $CM_{gE} < 0$. This is explained as sucessive reduction in the level of environmental degradation will have increasing costs. For this reason, it is possible to say that the denominator of equation (4) will become negative and that the sign of expression $(\partial E / \partial Y)$ is opposite to the sign of numerator $(BM_{gY} - CM_{gY})$. Now it is necessary to analyse signs of the numerator. These environemnatl goods have income elasticity higher than normal market goods [BATEMAN *et al.* (1992)]. Further, due to unicity, these goods have a low elasticity of substitution.

The superior section of Figure 1 shows that BM_g and CM_g curves vary parametrically with income increases. Thus, at low levels of development and income, $BM_g(Y_0)$ and $CM_g(Y_0)$ intercept themselves at F.

Figure 1: EKC Behaviour



Source: MUNASINGHE (1998)

With economic growth and increasing income, curves of (BM_g) change upwards following different levels of income $Y_0 < Y_1 \ldots Y_4$. This means that (BM_g) >0, i.e., the willingness to pay for better levels of environemntal quality increases with income. Moreover, $BM_{gyy} > 0$, that is, the curve of (BM_g) moves upwards at a growing rate. People become more willing to appreciate enviornmental goods and services and are more willing to pay for them as their income increases [MUNASINGHE (1996)].

However, the behaviour of the marginal cost curve (CM_g) is not so simple to preview. The initial curve $CM_g(Y_0)$ is low because degradatrion, when there is a low level of economic development, is not relevant. However, as soon as the economy develops and income increases, supplanting initial stages of industrial development and experiencing increasing levels of pollution, marginal costs of environmental protection increases rapidly. This result may occur due to the fact that, in this phase of economic development, there occurs great use of natural resources and generation of pollution, with little use of knowledge and technology to save the environment.

Therefore, $CM_{gY} > BM_{gY} > 0$ when (Y) is low. However, with continuing economic development and with a country achieving the post-industrial phase, both available human resources and improved technological knowledge reduce environmental marginal abatement and protection costs with higher levels of income (technology effect). Another factor may be related with structural changes in the economy, with the service sector becoming responsible for a larger portion of a country's national gross product (composition effect). In a context like this, CM_{gY} shows a tendency to reduce with the increase in income and with a larger "environemntal consciousness", i.e., $CM_{gYY} < 0$.

All these arguments are to show that $(BM_{gY} - CM_{gY})$ would be positive in initial stages of economic development, but would become negative after a given level of income is achieved. Curves BM_g e CM_g intercepts at the equilibrium points F, G, H, I and J corresponding to maximization points of equation (2). Respective ordering pairs (E_i, Y_i) with i=0 a 4, define points K, L, M, N e P that form the EKC. Thus, changes in BM_g and CM_g curves show the result of this process upon the "U" inverted curve. (See the lower portion of Figure 1) .

In a cenario of competitive equilibrium, as described above, the Parentian optimum garantees that level of environmental degradation is the socially desirable in the whole curve. However, it is possible to identify situations where imperfections in the economy can provide a non optimum pattern or economically inefficient. Therefore, private BM_g e de CM_g curves, based on which consumers and producers choose, may differ from the social optimum curve, resulting in a degradation level higher than the socially desirable.

Market failures may affect the demand for environmental quality (BM_g). Lack of information about consequences of environmental degradation upon human health and well-being may be result of low educational level. This can result in a low willingness to pay by consumers. Social groups with low levels of education may be directly exposed to pollution and, as consequence, they may be not aware of damages being caused to their health. If this were the case, the increase of (BM_g) curve would happen at a lower rate, even when income increases. The final result of this process would be a degradation level higher than the social optimal.

There could be another environmental consequence of low educational level. Some economic agents (companies or individuals) may transfer their environmental responsabilities to other agents. Thus, in generating externalities when using natural resources or emitting pollution without paying anything or paying very little for it, they are transfering part of their costs to society as a whole. A significant part of this society may be ill informed about consequences of this degradation and, as consequence, does not put pressure upon government for more stringent and more strictly enforced environmental standards. As pointed out by BOYCE & TORRAS (2002), "induced policy response", driven by citizen demand, may provide the strongest link between income and pollution.

One can also mention a final situation relating poverty and the environment. As mentioned before, demand for environmental quality (BM_g) is related with the level of income of economic agents. Therefore, social problems may mean that part of population leaving below the "poverty line" would be much more concern in obtaining some basic needs – food, shelter, security -than to obtain a higher level of environmental quality. We investigate possible causal linkages between low level of income (and other social assets) and the level of environmental degradation. Therefore, in a country with great poverty the externalities related with the low level of pressure upon government and on environmental standards may cause severe inefficiency in the environmental protection decision.

- **Poverty and environmental degradation: EKC and the Brazilian case.**

We hypothesize that variables such as education and income, among others social variables, are significant in economic models. This result, in a cenario of poverty as it is the case in Brazil, may affect demand for environmental goods and services and, consequently, a possible manifestation of the EKC. As a matter of fact those variables affect individual preferences and these, in turn, affect demand trough individual willingness to pay (WTP) for those goods and services. We use models with dichotomous dependent variables (*Probit*) and data from a contingent valuation exercise (related to the Brazilian Amazon region) to test our hypothesis.

MODELS

Models of dichotomous variables, or of binary choice, assume that individuals face alternatives choices of the type (0) e (1) or “no” or “yes”; that is, they face models with discrete (and not continuous) variables. These models may be used for studying decision to buy or not a good or for analysing the choice of a candidate to vote in a election. In order to do so, we need to obtain data on some individual attributes as age, education level, number of children, marriage status, among others, to model individual behaviour. One of a few models that can express these dichotomous variables is the linear probability model (LPM), as follows:

$$Y_i = \beta_1 + \beta_2 X + u_i \qquad (5)$$

where (X) is family income, (Y=1) if the family owns a house and (Y=0) if she does not. The conditional expectation of (Y_i) given (X_i), that is $E(Y_i|X_i)$, is interpreted as the conditional probability that the event will occur if (X_i) occurs, that is, $P(Y_i = 1|X_i)$. Thus, in the mentioned example $E(Y_i|X_i)$ expresses the probability that a family with income (X_i) owns a house. Therefore, one can infere that the i-th individual (i^n) has a answer function that can be represented by a random variable – Y_i – that, due to its dichotomous nature, may be represented by (0) ou (1) values.

From the definition of expectation, we have that:

$$\begin{aligned} E(Y_i) &= 0(1 - P_i) + 1(P_i) \\ &= P_i \end{aligned} \qquad (6)$$

And the basic assumption that $E(u_i) = 0$, garantees that $E(Y_i | X_i) = \beta_1 + \beta_2 X_i$, confirming that the conditional expectation of the model may be interpreted as the conditional probability of Y_i[6]. And as the probability P has to be in the interval (0,1), we got the restriction:

$$0 \leq E(Y_i | X_i) \leq 1 \qquad (7)$$

that is, a conditional (expectation) probability must stay in this interval.

Details of model specification can be found in the literature review by McFADEN (1973) and GUJARATI (1995). We have not used the LPM due to some limitations that may affect the final estimation result. According to GUJARATI (1995) the main problem with LPM is its assumption of a linear increase in (X), that is the marginal effect of (X) is constant for all estimative, a very unrealistic assumption. These difficulties suggest the use of alternative models of dichotomous regression. These models must garantee that $E(Y_i)$ is inside the interval (0,1) and that marginal effects of independent variables are not constant during estimation.

We need, therefore, a (probability) model that has two basic characteristics: i) as (X_i) increases, $P_i = E(Y = 1 | X)$ increases, but without going beyond the interval (0,1) and ii) the realtionship between P_i and X_i is no linear. These characteristics may be achieved in a cumulative distributive function (CDF) of a random variable[7]. The use of a CDF garantees a growing monotonic function and one may represent the probability distribution in relation to FDC, that is:

$$P_i = F(\alpha + \beta X_i) = F(I_i),^8 \qquad (8)$$

We have chosen a normal cumulative density functions for our model, kown as *Probit* model.

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[6]One assumes that these binary observations are available for these (n) indivíduals and also that they are independent from each other.

[7] A cumulative density function (CDF) of a random variable is the probability that it has a value smaler or equal to x , that is, a CDF is $F(X = x_0) = P(X \leq x_0)$.

PROBIT Model

Models with discrete dependcent variable are frequently specified as *index* function models. Suppose the decision of buying something. Economic theory emphasises that the individual will evaluate this decision based upon the obtained utilities, that is he/she will evaluate marginal costs and benefits of making that decision of buying. As marginal benefits are not observed, usually one models the difference between benefit and cost through a variable (Z*):

$$Z^* = \beta' X + \varepsilon \qquad (9)$$

In other words, it is not possible to observe the net benefit of buying, only whether the purchase was made or not. Then, we have:

Z=1 se $Z^* > 0$, (he/she bought) (10)

Z=0 se $Z^* \leq 0$, (he/she did not buy)

In (9), β' is an *index* function. Thus, as in the majority of cases it is not possible to preview how each individual will behaviour, it is more reliable to estimate a probability that an individual with some attributes will choose a given alternative. Models of qualitative choice are based upon a relationship between attributes that describe an individual and the probability that he/she will have a given choice. In this context, McFADDEN (1973) explains the *Probit* model through the analysis of utility theory, that is, based upon the rational choice behaviour.

Let us suppose that the in dividual will buy or not according to the utility *index,* that we denote (I). This utility *index* is determine by the explanatory variables. Therefore, the bigger (I) the higher will be the probability of an individual buying the good. Suppose also that (I) is a linear function of the explanatory variable (x), such that:

$$I_i = \alpha + \beta X_i \qquad (11)$$

[8] Sendo (F) a CDF.

where (X_i) is income of the I^n individual. Thus, each individual would have a critical value to his/her correspondent indice (I_i*). This critical value is not observed, but if we assume that it normally distributed with the same mean and variance, it is possible to estimate parameters in equation (11). We will have, then, if the indice value (I) for a given individual is bigger than the critical (I_i*), he/she will buy the good and if the indice value is smaller, the good will not be bought.

In relation to our *Probit* model we are testing two hypotheses: 1) how socio-economic variables – mostly income and education – affect demand for environmental goods and services; and 2) is the variable education also significant in shaping the demand for environmental goods and services by those people who are willing to pay for conservation, but they do not have enough income to do so. This model specification is very relevant because few studies deal with the EKC in a context of a poor and unequal society.

The inovation of this model is to inquire whether the existence of a widespread poverty will put doubt upon the explanatory power of the EKC theory for the Brazilian reality, and also show evidence of a necessary interaction among socio-economic and environmental policies.

DATA

Data to run dichotomous variable models were provided by MENDONÇA[9] and resulted from his doctor thesis at the Colorado School of Mine. The original research was design to estimate the willingness to pay in relation to impacts caused by installation and operation of mineral projects in Carajás, in the Brazilian Amazon. There were 673 observations. Sample data had been obtained in Brasília (Brazilian capital) and variable estimatives had been compared with those from the *Anuário Estatístico do DF*, 1995-1996 from CODEPLAN (1998) to verify the representativeness of selected sample. In so doing it became clear that the sample does not present any significative distortion [MENDONÇA (1998)].

To use this data base is relevant in the present paper once we want to put on evidence the importance of socio-econoimic variables, in particular education, to determine the willingness

[9] Mendonça, F. A. The Use of Contigent Valuation Method to Assess the Environmental Cost of Mining in Serra dos Carajás: Brazilian Amazon Region. Colorado School of Mines, 1998, pp. 219.

to pay for environmental goods and services. Nevertheless, the main advantage in using these data of Brasília is related with the possibility of observing the behaviour of differet income groups from the same geographical area. In other words, all levels of income are represented in the Brazilian capital, what garantees the quality of our results.

Probit model that will be run has as dependent variable the individual willingness to pay (WTP) to avoid new large scale projects in the Carajás region. However, in analysing the contigent valuation data bank one notices a large proportion of WTP equals to zero (72%). It is relevant to notice that 35% of those with zero WTP said that they were WTP for environmental conservation, but did not have enough income to do so (MENDONÇA, 1998). We hypothesized that these explanations would be another relevant information for our research in this study. Therefore, answers explaining their no contribution given by those with zero WTP – individuals that do have a demand for environmental conservation, but have no financial conditions to do so – will also be used as dependent variable in a second run of our models.

In other words, our empirical exercise will have two stages. In the first one, we correlated WTP and relevant socio-economic variables, in particular education, through *Probit* model. In the second stage, using the same models, we correlate those socio-economic variables found significant in stage one with those individuals who manifested demand for environmental conservation but had zero WTP[10]. Therefore, for each stage it will be run a *complete model* (15 variables) and a *limited model* (only with directed related variables). Explanatory variables are described in Table 1, with its expected signal for each stage model.

RESULTS

Table 2 has as dependent variable the willingness to pay for environmental goods in the Carajás region (WTPCA) and marginal effects of explanatory variables determine the probability that variation of one unit of its measure, taking all other variables in their average,

[10] To construct a dependent variable to stage 2, those who answer that are unable to contribute received (1) and all other respondents received (0).

garantees the existence of willingness to pay for environmental goods in that region[11]. Tables 3 has as dependent variable - DZEXPCA – the behaviour of those individuals that have no enough income, but would be willing to protect the environment. The idea is to confirm the importance of variable “education” for these individuals with environmental concern but without enough income.

According to GUJARATI (1995) there have been many tentatives to obtain measures that would garantee the adjustment quality of dichotomous variable measures. Thus, a *log likelihood* to test if all model coefficients are equal to zero is na important statistics to analyse the model. In the first stage, using a *Probit* model one may observe, for the complete model, a *log likelihood* of - 343.7728 and a significance level of (.0000) that garantees that the model is significant. It is interesting to observe that only variables *cavpret, fahead, contyp, educat, ocutyp, income* and *age* were significant in this model. In order to illustrate the marginal effect of each coefficient let us take the variable related to education - *educat*.

[11]Coefficients of *Probit* model do not express directly marginal effects as in the case of usual regression models. In order to inffer about marginal effects of each variable in the model it is necessary to transform all other variables into their average. These variables have to be transformed into their average because the probability curve is not linear and, therefore, the position of each variable will influence the observed probability. Consequently, marginal effects showed in tables 2 and 3 express the probability that the variation of each variable makes the dependent variable be equal to (1).

Table 1

Used Variables in Models[12]

Variables	**Description**	**Expected Signal** 1.º	2.º
Income	**Gross Monthly Income:** 1) less than R$ 120; 2)R$ 120 – R$ 360; 3) R$ 360 – R$ 600; 4) R$ 600 – R$ 1200; 5)R$ 1200 – R$ 1800; 6) R$ 1800 – R$ 2400; 7) R$ 2400 – R$ 3000; 8) R$ 3000 – R$ 3600; 9) more than R$ 3600.	+	-
Educat	**Education Level:** 1) No education; 2) No Completed Elementary; 3) Elementary; 4) No Completed High School; 5) High School; 6) No Completed College; 7) College Degree; 8) Others.	+	+
Age	**Individual age.**	-	-
Ocutyp	**Occupation type**: 1) Formally employed or autonomous; 0) Other types of occupation.	+	-
Numhoh	**Number of family members.**	-	+
Nhohinc	**Number of family members with any form of income.**	+	-
Fahead	1) If respondent is one of the responsible for the family. 0) Otherwise.	-	+
Contyp	Type of respondent residence: 1) House or apartment; 0) Otherwise.	+	-
Hstate	State of origin of the respondent: 1) Amazonic Region; 0) other regions.	+	+
Protnat	Opinion related to environment conservation: 1) Brazil needs to improve and increase environmental protection actions; 0) Otherwise.	+	+
Envprob	Consider **:** 1) the destruction of Amazon, of the forest and extinction of animals the most relevant environmental problems nowadays; 0) Otherwise.	+	+
Visamz	Visits to Amazonia: 1)Have visit Amazonia; 0) Otherwise.	+	+
Cavis	Visits to Carajas: 1)Have visit Carajás ; 0) Otherwise.	+	+
Caloc	About location of Carajás: 1) Individuals that answered correctly; 0) Otherwise.	+	+
Cavpret	Intention of visiting Carajás in the future: 1) Have this intention; 0) Do not have intention.	+	+

[12]These variables have the same denomination found in the original data bank in order to facilitate any comparison between studies.

Table 2

Stage 1 - Marginal Effects of *Probit* Model

Dependent Variable WTPCA

COMPLETE MODEL		**LIMITED MODEL**	
Log Likelihood -	-343.728	**Log Likelihood -**	-348.8006
Chi – squared -	106.1167	**Chi – squared -**	101.6418
Degrees of Freedom -	15	**Degrees of Freedom -**	6
Significance level	.00000000	**Significance level**	.00000000
Observations	**673**	**Observations**	**673**
Variables	**Marginal Effect**	**Variables**	**Marginal Effect**
Constant	-.134578784 (-1.335)	Constant	-.114906077 (-1.580)
Pronat	.433945237 (1.196)	Cavpret	.0663840047* (1.811)
Hstate	.031081708 (.212)	Fahead	-.1317248092*** (-2.868)
Envprob	.019992387 (.571)	Contyp	.1156177671*** (2.594)
Visamz	.062728227 (.969)	Educat	.0288221827** (2.240)
Cavisit	.181234662 (1.475)	Income	.0493514760*** (3.586)
Caloc	-.035079792 (-.855)	Age	-.0077419355*** (-4.415)
Cavpret	.06573602* (1.751)		
Nunhoh	-.007635713 (-.711)		
Nhohinc	.011323944 (.603)		
Fahead	-.125023765** (-2.567)		
Contyp	.107835268** (2.389)		
Educat	.0292194655** (2.200)		
Ocutyp	-.0111812612 (-.295)		
Income	.0499655170*** (3.326)		
Age	-.0783689395*** (-4.309)		
		Note: Significance Levels: ***1%, **5%, *10%.	

Table 3

Stage 2 - Marginal Effects of *Probit* Model

Dependent Variable DZEXPCA

COMPLETE MODEL		**LIMITED MODEL**	
Log Likelihood -	-266.6729	**Log Likelihood -**	-288.5607
Chi – squared -	65.16558	**Chi – squared -**	22.21287
Degrees of Freedom -	15	**Degrees of Freedom -**	3
Significance level	.00000000	**Significance level**	.000058904
Observations	673	**Observations**	673
Variables	**Marginal Effect**	**Variables**	**Marginal Effect**
Constant	.992991954 (.726)	Constant	.029997065 (.352)
Pronat	.0841980428* (1.829)	Educat	.031478605* (2.240)
Hstate	-.0392845610 (-.172)	Income	-.074523908*** (-3.817)
Envprob	.0448070654 (.981)	Age	-.002847998 (-1.516)
Visamz	.0259016230 (.262)		
Cavisit	.1823996545 (1.108)		
Caloc	-.0347683557 (-.610)		
Cavpret	-.13563361*** (-2.867)		
Nunhoh	-.003009434 (-.226)		
Nhohinc	-.018051224 (-.716)		
Fahead	.13928017* (1.885)		
Educat[13]	.030028480* (1.651)		
Ocutyp	-.13577189*** (-2.658)		
Income	-.04740737** (-2.120)		
Age	-.005174695** (-2.514)		
Note: Significance Levels:			
***1%, **5%, *10%.			

[13]Variable *Contyp* presents a high correlation with variable *Educat*. We exclude it from complete models with dependent variable DZEXPCA.

For this model, the marginal coefficient for education (educat) was, aproximatelly, (0.29). This means that the probability that an increase in one unit in the variable education will increase in 2.9% the chance that the individual presents a WTP to avoid new large scale projects in Carajás. Putting in a different way, a change in individual education from a level of "non education" to a level of öne year of elementary school", keeping constant all other variables in their average, increases in 2.9% the chance of this individual to have a positive WTP. This is a significant result, given that there are only eight intervals for the variable education in our model, allowing for a very relevant influence in the determination of the WTP for these environmental goods and services.

Furthermore, if we take the marginal effect for the main explanatory variable in the model – income – we observe that an increase of one unit increases in 5% the chance of a positive WTP, keeping other variables in their average. Once more, considering that there are nine intervals for the variable income, one may notice that its effects are very significant upon the dependent variable.

As far as signs of coefficients are concerned, it was observed that they are those expected for all significative variables, with exception of *Cavpret* in the table 3. Nevertheless, results confirm the importance of some socio-economic variables in the determination of WTP for environmental goods and services related to Carajás. It can also be observed that by the *log likelihood* the models were accepted. Finally, the importance of the limted model is to demonstrate that similar results can be achieved with a simpler model. Analyses of marginal effects of this second model can be in a similar fashion as the one done for the first model.

Results in Table 3 are those for models in the second stage of our econometric exercise. These models, as mentioned before, have as dependent variable the behaviour of those individuals who have an environmental demand, but do not have financial resources to pay for it. Both models are significant and analyses of their marginal effects must be done in a similar fashion to that of previous models. It is important to point out that variable education was significant at the 10% level. This empirical evidence suggests that environmental consciousness may grow as individual has more years of formal education. Literacy appears to be parfticularly strong predictor of environmental externalities.

- **Concluding Remarks**

Econometric results achieved through these two stages and eight models allow us to test our hypotheses in this study. First, it is clear the importance of socio-economic variables, in particular income and education, in the determination of willingness to pay for environmental goods and services. Second, the variable education is determinant in the behaviour of those individuals who present an environmental demand, but are unable to materialise it due to lack of financial resources. This suggests that an increment of individual wellfare, particularly in education, will have a positive effect upon demand for environmental quality. It seems that Grossman and Krueger (1995) and Boyce and Torras (2002) are correct in believing that citizens'demand and "vigilance and advocacy" are critical in inducing policies and technological changes with reduce degradation and pollution.

The main objective of this study was to provide evidence on how the Brazilian poverty – manifested on a high concentration of income and a low level of education – might have affect environmental demand and, therefore, the Environmental Kuznets Curve (EKC) in Brazil. Having deforestation as indicator of environmental degradation we showed variables influencing demand for environmental goods and services. A reduction in deforestation rate means that individuals are prefering to conserve environmental assets instead of finding alternative uses for them. Our resuilts also indicate that Brazilian poverty do affect demand for environmental conservation in the Carajás region. Income concentration and difficulties in the access to education affect deforestation rates in Brazil, at least indirectly through their effects upon willingness to pay for conservation.

Some questions must be discussed after our findings. Some international institutions have identified poverty as the cause of environmental degradation. They also suggest that economic growth would be the basic solution for this problem. It seems from our study results, that reduction in poverty level should deserve, at least, equivalent attention. Reduction of social problems through increasing access to basic services by the poorest section of the population shall increase significantly the demand for environmental goods and services. Economic growth without distributive effects will not have similar impacts upon environmental demand.

Improvement of income, education and other social capital assets can lead to the formation of a “tunnel” in the Environmental Kuznets Curve, avoiding excessive growth of environmental degradation before it starts declining. Reduction of social and environmental vulnerability would garantee a more equitable pattern of economic growth. Equity – reduction of degradation and of poverty – and efficiency must receive equivalent consideration in allowing communities to achieve their goals through a process of effective sustainable development.

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