

Poverty-Environment Trap: A non Linear *Probit* Model Applied to Rural Areas in the North of Brazil

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Abstract: The present study analyses the relationship between rural poverty and environmental degradation, aiming to validate or to refute the poverty-environment trap thesis that asserts that poverty is a major cause of environmental degradation, forming a vicious circle situation. In this context, the present study analyses this relationship in Tocantins State, located in the Brazilian Legal Amazon Region and in which the main biome is cerrado (savannah). A non linear *probit* model was used to analyze this relationship and the results point towards a refutation of the hypothesis that rural poverty and environmental degradation is directly correlated, forming a poverty-environment trap situation. Moreover, the study is unprecedented in the region in question and the results show that this relationship is ambiguous and therefore policies that aim to alleviate the rural poverty do not have, necessarily, positive impacts on environmental preservation.

Key words: Poverty-environment trap · Probit model · Brazil

INTRODUCTION

Nowadays the global concern about the natural resources conservation leads to projects and researches that aim to identify the causes and the main consequences of environmental degradation as well as to search for alternatives and solutions to the problem. Hayes and Nadkarni [1] and Alier [2] point out that this environmental degradation occurs both in developed countries and in developing countries, in the urban as well as in the rural spaces and is a consequence of the pressure due to the production's increase and the population growth.

However, after the "Our Common Future" Report [3] the debate about environmental degradation in developed countries shifts its attention towards the fact that developing countries exert the most important role in the natural resources degradation. From Our Common Future, also so-called Brundtland Report, onwards the environmental degradation began to be associated and linked to the poverty level of the population, leading some scientists to analyze this topic aiming at detect some

relationship between the poverty condition and the degradation of the environment.

The Latin America became one of the targets of those studies once the continent comprises both rural and urban poverty conditions [4]. However, as the incidence of poverty is higher in rural areas [5], those areas started to be considered as potentials and, therefore, environmental foes. On one hand the rural population relies, to survive, on environment utilization. On the other hand, these natural resources are considered public goods, have common access and non defined property rights [6] and therefore some people tend to overuse it and thereby accelerate its degradation and exhaustion.

At this stand point, the rural poverty condition, beyond the acceleration of natural resources degradation, could create a vicious circle situation or a poverty-environment trap, i.e. a situation that perpetuates the poverty and the environmental degradation. Discussing some conditionings of rural poverty in Latin America, Echeverria [7] warns that a significant part of rural poor live in areas with low potential, including degraded zones.

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This population has a large dependency on the natural resources which are the base of their lives, but because of the limitations regarding the quality and quantity of these natural resources, this population lack another economic alternative and therefore destroy this base⁽¹⁾.

However, this vicious circle between poverty and environment is questioned by some authors. Broad [8] and Reardon and Vosti [9] for instance, tell us that this circle is analyzed from the point of view that the poverty condition is portrayed as a single concept and therefore under-represents the broad context behind it. In addition, aiming at break up with this concept, Reardon and Vosti [9] point out that the poverty condition can be characterized by several forms because it has not only one concept, i.e. the person can be considered poor in one aspect, educational level for example, but cannot be considered poor in relation of his/her income. Furthermore, the environmental degradation can be multidimensional implying in different linkages between the poverty condition and the environment.

Above all, it is important that the relationship(s) between the rural poverty and the environment be analyzed deeply and considers different scenarios. In this context, the present study aims at verify the vicious circle hypothesis or the poverty-environment trap thesis and therefore analyze the relationship between the poverty and the environmental degradation in the Palmas Green Belt, situated in the Tocantins State and located in the Brazilian Amazon Region.

Aiming at capture the complexity of the relationship, I tried to identify a range of socioeconomic as well as environmental variables which enabled me to better express the rural poverty conditions as well as the environmental degradation in the region. From my data base, the relationships were estimated based on a non linear *probit* regression model.

Theoretical Issues: The relationship between poverty and environment is analyzed from different points of view and approaches by several scientists. However, some of those approaches do not put into account the diversity of factors that are intrinsic to the poverty conditions as well as the environment resulting in general conclusions (and not specific) about the relationship. Those researches take part of the Sustainable Development's conventional literature and

they usually use some variables such as income to measure the poverty condition and soil erosion, for instance, to express the environmental degradation and thus show the limitations regarding two multidimensional phenomena such poverty and environment.

However, there are some studies that express the different dynamics of the relationship between poverty and environment aiming at enlarge the knowledge that this relationship does not follow one single behavior but might be characterized by several aspects depending upon the context in which it is embedded. What those studies show, in summary, is that the influence of poverty on the environment and vice-versa does not happened in one single direction but most probably depends upon the circumstances that prevail at the moment of the study in the region in question.

The conventional literature points out a strong and direct relationship between poverty and environment, i.e. the poverty condition imply the natural resources deterioration, once the poor depend on the natural resources to survive. This kind of survival stresses the overexploitation of the environment and therefore its exhaustion⁽²⁾. The unsustainable use of natural resources by the poor exceeds the resilience's capacity of the environment and it is characterized, especially, by some factors such as the short run horizon and the high level of risk aversion. Those factors imply that the poor search on the natural resources their "protection" against any eventual shock and/or natural/manmade catastrophe.

The conventional literature has the Brundtland's Report [3] as its main theoretical source and the vision that developing countries exert an expressive role in natural resources degradation prevails (even more expressive than the developed countries). The Report also brings the conception that the poverty is the major cause as well as effect of environmental degradation once a "world in which the poverty is endemic will always suffer from ecological catastrophes".

According to the Brundtland's Report the poverty condition generates, through the environmental degradation, a vicious circle (also known as poverty downward spiral, poverty trap thesis, poverty-environment hypothesis, etc) where the poverty condition leads to the natural resources degradation and thereby deteriorates the living standard of the poor and perpetuates the poverty condition.

⁽¹⁾ una gran mayoría de los pobres rurales vive en áreas de bajo potencial, incluyendo zonas degradadas, erosionadas o semidesérticas. Esta población tiene una gran dependencia en los recursos naturales que son la base de su sustento, pero por las limitantes en cuanto a la calidad y cantidad de estos recursos, cruzan el umbral de sustentabilidad y empiezan, por falta de otra alternativa, a destruir esta base". Echeverria (1998, p. 6)

⁽²⁾ Alier (1998) calls this overexploitation of natural resources by the poor as "Ecology of the poor" and "Ecology of survival".

According to Reardon and Vosti [9], the relationship between poverty and environmental degradation is still scientifically not much exploited. The authors state that the poverty-environment vicious circle is originated on Malthus's theory, where the population growth demands an area's increase for feedstock and therefore push the poor farmers towards the marginal lands accelerating the natural resources degradation. This degradation reduces the productivity and therefore the farmers become poorer. The vicious circle suggests that the poverty alleviation will, necessarily, reduce the environmental degradation.

Broad [8] shows that the conventional literature often presents a deterministic vision of the poverty-environment relationship, concluding that there is a negative impact of the former on the latter, i.e. the poverty condition is seemed as a primary cause of environmental degradation. Some statements such as "*poverty and environment connection. inseparable twins*", "*if one is poor, then one degrades*", "*poverty is one of the greatest threats to the environment*" can be found in the mainstream thought about the topic.

According to Prakash [10] some of the rural poor communities depend, to survive, on the biomass and the poverty measurement based on the income does not offer an accurate interpretation of the real poverty condition in comparison to those communities that do not depend on natural resources to survive. According to the author, the fact that an substantial proportion of poor communities live in degraded environments do not demonstrate, *per se*, that the poverty causes environmental degradation and vice-versa.

Meza *et al.* [11] based their work on the Brundtland's Report aiming at support their research hypothesis. The authors studied the relationship between the income and forests preservation. In this case, the outcomes suggest that this relationship is positive and direct, i.e. as better is the income *per capita*, the better are the conditions of forests (more preservation).

Based on those studies and researches which portrait different situations regarding the rural poverty and the environmental degradation, I start my research.

Research Area: Aiming at do the field work and therefore form my database, the Green Belt region of Palmas city was chosen as a research area. This region is situated within the Tocantins State which is located the north of Brazil, also known as Brazilian Legal Amazon Region.

For the data collection, 45 specific questionnaires were applied to smallholders (so-called family farmers), who were, *a priori*, stratified on poor, intermediate and non poor, according to the local rural extension service. Following up statistical procedures, 15 smallholders of each strata (poor, intermediate, non poor) were selected randomly and interviewed. The questionnaires consist of items about socio-economic as well as environmental questions which are divided in "non- open" and "open" questions aiming at understand the poverty-environment linkages within the rural properties [12].

Variables Definition: Several approaches are being adopted in the field of poverty research in different regions and contexts and comprise quantitative and qualitative aspects as well. The poverty condition has being defined on a broad concept as a phenomenon of multiple dimensions with economic, cultural and social aspects and it is characterized by: (a) insufficient of income; (b) limited access of basic needs and (c) social exclusion and discrimination due the ethnic or gender origin [13].

The measurement of poverty through indicators that have only one dimension such as income, for instance, can lead to discrepancies in the interpretation of a broader phenomenon. Due the poverty's concept complexity and different perceptions and definitions, there is a high variation in estimative of poverty incidence even in studies carried out in the same region.

In the present study, I analyze a range of variables aiming at better express the socioeconomic conditions' diversity which can characterize the rural poverty situations in the Green Belt region in Palmas city, Tocantins State. This first range of variables can be seen in the table below.

In the same way, the environmental degradation is a multidimensional and complex phenomenon and therefore I used a broad range of environmental variables aiming at better express the diversity of conditions that can characterize the natural resources' degradation.

Because of the difficulty in the measurement of the environmental degradation, I analyzed those situations qualitatively, through the observation of practices that can imply in more or less degradation, characterizing a range of binary variables. In all cases, the variable assumes value equal to zero when the practices imply in more degradation and value equal to one when practices imply in less environmental degradation. The second range of variables can be seen in the table below.

Table 1: Socioeconomic variables

Name	Definition	Unit of measurement
INCOME	annual income <i>per capita</i>	R\$ (brazilian currency)
SIZE	size of the rural property	hectares
AGE	family head's age	years
EDUCATION	family head's years of study	years
HEALTH	family health's conditions, which varies from 1 to 5 according to the smallholder's statement; 1 refers to very bad conditions of health and 5 refers to very good health conditions	scale
MARKET ACCESS	market access, from 1 to 3, i.e. 1 when the smallholder has a bad access to local markets, 2 when the smallholder has a regular access and 3 when he/she has a good access to market	scale
INFORMATION ACCESS	access to information, from 0 to 3, i.e. 0 when the smallholder has no access to information means at all, 3 when he/she has all possible access to information, including rural extension courses, etc.	scale
CREDIT ACCESS	access to credit, from 0 to 5, i.e. 0 when the smallholder did not receive any kind of credit in the last five years and 5 when he/she received 5 credits in the last five years	scale
EXTENTION SERVICE ACCESS	rural extension service access, from 1 (very bad) i.e. the smallholder is not supported by the local extension service up to 5 (very good) when he/she is supplied for all possible rural extension service and often	scale
INFRA	goods and infrastructure within the smallholder's house, from 0 to 5, depending on the number of goods in the house such as bathroom, electricity, pumping water, etc	scale

Table 2: Environmental variables

Name	Definition
AGROTX	= 0, if the smallholder uses agro toxin = 1, otherwise
DEFOR	= 0, if the smallholder does deforestation = 1, otherwise
TERRAC	= 0, if the smallholder does not apply terracing systems = 1, otherwise
INT CRO	= 0, if the smallholder does not apply intercropping = 1, otherwise
ORG FE	= 0, if the smallholder does not apply organic fertilization = 1, otherwise
SO COV	= 0, if the smallholder does apply do soil covering = 1, otherwise
LIMING	= 0, if the smallholder does not apply liming = 1, otherwise
REFOR	= 0, if the smallholder does not do reforestation = 1, otherwise
NO TILL	= 0, if the smallholder does not apply no-tillage systems = 1, otherwise
GA HAN	= 0, if the smallholder does not manage the garbage in a sustainable way = 1, otherwise

The *probit* model⁽³⁾: In the present study I estimate the relationship between rural poverty and environmental degradation using the socioeconomic as well as the environmental variables described previously. Aiming at identify the existence (or not) and when pertinent verify

the direction of possible relations between the variables. For thus purpose, I estimate several non linear regression models (*probit*) where the independent variables are the socioeconomic indicators and the dependent variable is a binary variable expressing the environmental degradation.

It is useful to remind that I observed the environmental degradation qualitatively, expressing it in a range of several binary variables. In all cases, it takes value equal to zero when the practices imply in more degradation and value equal to one when the practices imply in less environmental degradation.

On the other hand, the independent variables used are those presented previously in this paper, which enable me to characterize the individual's socioeconomic conditions. As a general rule, higher values of these variables point out towards individual's better living standard. Hence, when the signs of the estimated coefficients from the models are positive, the relationship between rural poverty and environmental degradation is direct, i.e. more poverty is linked to more degradation and vice-versa. But when the coefficients are negative, the relation is the inverse, i.e. more poverty is related to less environmental degradation.

In the presence of binary dependent variables the simplest model is the linear probability model, estimated by the ordinary least square method. In this case:

⁽³⁾Based on Gujarati (2002) and Greene (2008).

$$y = \beta_0 + \beta_1 x_1 + \dots + \beta_k x_k + e$$

Being p the probability of y assume a value equal to one:

$$E(y) = p = \beta_0 + \beta_1 x_1 + \dots + \beta_k x_k$$

In the linear probability model the estimated coefficients express the effect of unit variations in the independent variables about the probability of the dependent variable takes value equal to one. The problem is that these effects are constant and the more x_i increases, the probability p continues to increase (when $\hat{\alpha}_i$ is positive, otherwise it continues to decrease) under a constant ratio. However as $0 \leq p \leq 1$ it is impossible to have a constant increase rate.

Besides that, the linear probability model presents heteroskedastic errors and therefore the estimated coefficients are not efficient and therefore the hypothesis tests and the confidence intervals might be non valid.

Aiming at overcome those problems, I consider the non linear *probit* and *logit* models. In these cases the slope is not constant and the probabilities are restricted to the $[0, 1]$ interval based on probability density functions. The *probit* function is related to the standardized normal probability distribution whereas the *logit* function is related to the logistic distribution.

As these models are non linear models, the coefficients estimation should be done by the maximum likelihood method. In general, the estimated coefficients in *probit* e *logit* models are slightly different and the choice between them might be done based on the researcher convenience. On the present study I chose the *probit* model considering that the errors have a normal distribution.

In this way:

$$p = F(\beta_0 + \beta_1 x_1 + \dots + \beta_k x_k)$$

Where p is the probability of y take value equal to one and F is the *probit* function, non linear in the β_i

The effect on a unit variation in x_i about the probability p of y to be equal to one is given by:

$$\text{and } \frac{\partial p}{\partial x_i} = \frac{\partial F(t)}{\partial(t)} \cdot \frac{\partial t}{\partial x_i} = f(\cdot) \beta_i$$

(a) as $f(\cdot)$ is a probability density function, its value is always positive. Moreover, the sign of $\partial p / \partial x_i$ is determined by the sign of β_i ;

(b) as x_i varies, the value of $f(\cdot)$ also does. Thus, the effect of a unit variation in the independent variables on the probability of the dependent variable relies in the independent variables' levels. Hence, aiming at estimate the coefficient's effects in the *probit* model it is necessary to choose some level to the independent variables as a reference.

RESULTS AND DISCUSSION

In this section I discuss about the results from the estimation of ten regressions which were run considering the *probit* model discussed previously. Each regression comprises a binary dependent variable that express the environmental degradation as a function of the socioeconomic independent variables that express the rural poverty situations. The STATA software was used to run the regression analysis.

First of all I tried to identify the existence (or not) of a relationship between the socioeconomic and the environmental indicators as well as to verify the direction of those relations. I did the hypotheses tests, identifying the coefficients that differ from zero considering a significance level up to 20% and the coefficient's signs can be seen below.

First of all, observing the first row we can verify that the signs alternate both positive and negative regarding the variable that express the usage of agro toxin. The increase of the independent variable income leads to an increase in the probability of agro toxin's usage, i.e. decrease the probability that the dependent variable takes value equal to one. Thus as the

Table 3: Signs of the estimated coefficients

	INCOME	LAND SI	AGE	STUDY	HEALTH	MARKT	INFO	CREDIT	EXT SE	INFRA
AGROTX	-			+				-	+	
DEFOR				-		+	+	-		-
TERRAC		+		-		+				
INT CRO	+	-			+			+		
ORG FE	+	-	-					+		+
SO COV				+					-	
LIMING								+	-	
REFORE	-	+	+		+		+	-	-	-
NO TILL							-		+	+
GA HAN										

socioeconomic conditions get better and therefore alleviate the poverty situation, the probability that an individual adopts environment friendly practices diminishes, i.e. increase the environmental degradation scenario.

The positive signs point out that the increase in these variables' level tends to increase the probability of dependent variables take values equal to one. I can conclude, for instance, that an increase in the years of study as well as in the extension service access decreases the probability of using agro toxin. The negative sign of credit access variable means that the better the access one has to loans and credit the higher the probability of agro toxin's use. The row regarding the agro toxin implies an ambiguous relationship between rural poverty and environmental degradation once one can observe an alternate of positive and negative signs.

In the second row which corresponds to the variable that expresses the deforestation one can see that there is predominance of negative signs. In this case, higher levels of independent variables lead to a decrease in the probability of an individual adopt environment friendly practices. The higher the educational level and the better the access to credit as well as the infrastructure, the higher the probability of an individual degraded the environment through deforestation. Now, the results point towards an inverse, non direct, relationship between poverty and environmental degradation.

In rows related to terracing, intercropping, organic fertilization and no-tillage system, one can notice that there is predominance of positive signs and therefore express a direct relationship between higher levels of independent variables with the probability of smallholders undertake those practices. Thus, the results show that there is a positive relationship between poverty and environmental degradation, i.e. the socioeconomic conditions' improvement has as consequence the adoption of more friendly practices. In remaining rows, one can observe an alternate of positive and negative signs as well suggesting an ambiguous relationship between rural poverty and the degradation of the environment.

When the results in the columns are observed, one can see that there are some negative and positive signs related to the independent variable income. Those positive signs point out that an increase in the income's level tends to increase the probability of the dependent variables "intercropping" and "organic fertilization" take value equal to one. The negative signs, on the other hand,

express that an increase in the income's level tends to diminish the probability of "agro toxin" and "reforestation" take value equal to one.

Regarding the independent variable "access to information", one can notice that the better the access to information the lower the probability of the dependent variable "no-tillage system" take value equal to one, i.e. the lower the probability of an individual apply this system and therefore be more environmental friendly. This result might show a shortcoming regarding the information about benefits of this practice by the local rural extension service.

Once can also observe that as more (an better) an individual has access to extension service the lower is the probability that this individual uses agro toxin and higher is the probability to apply no-tillage systems. However it is also higher the probability of not apply soil covering practices. In the majority of situations there are an alternate of positive and negative signs suggesting an ambiguous relationship between rural poverty and environmental degradation.

Hence one can notice, in the present study, that the relationship between rural poverty and environmental degradation is characterized by the relation among specific indicators showing the relationship's dynamics and context-specificity. Thus one can refute the hypotheses that there is a strong and direct relationship between these multidimensional phenomena as the poverty-environment trap thesis assures. The results here discussed go parallel to those founded by Broad [8] as well as Reardon and Vosti [9] that "not all environmental degradation in developing countries is linked to poverty; for example, pollution as an externality of the agriculture of richer farmers or forest or commons overexploitation by large and capital-intensive lumber and cattle operations can ravage the environment without the poor's lifting a hand".

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