Market assisted land reform in NE Brazil: a stochastic frontier production efficiency evaluation[♦]

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Resumo: Esse artigo trata de uma avaliação do Programa Piloto de Reforma Agrária Cédula da Terra, cuja concepção, mecanismos e operação representam uma mudança em relação ao modelo tradicional de desapropriação. As terras distribuídas pelo programa são adquiridas no mercado por associações de produtores, e um conjunto de incentivos é estabelecido para se obter maior eficiência no uso dos recursos. O objetivo desse artigo é o de caracterizar as fontes da ineficiência técnica e alocativa em um conjunto de 309 beneficiários de cinco estados do Nordeste brasileiro. Procurou-se estimar uma função de produção potencial segundo a metodologia de Battese e Coelli (1995), usando o software FRONTIER 4.1 (Tim Coelli, 1996). A principal conclusão é a de que assistência técnica, capital humano (anos de escolaridade) e crédito reduzem a ineficiência técnica e alocativa dos beneficiários.

Abstract: We evaluate the "Cédula da Terra" Pilot Project, a land reform project whose conception, mechanisms and operational structure is different from traditional agrarian reform based on expropriation. The land distributed by the project, is first acquired by the agricultural producers associations, and a given set of incentives is established to obtain a better efficiency use of resources. The main objective of this article is to characterize the sources of technical and allocative inefficiency from a cross section of 309 beneficiaries from five states in NE Brazil. We estimated a potential production frontier following the methodology of BATTESE and COELLI (1995), using the software FRONTIER 4.1. (Tim COELLI, 1996). The main conclusion is that technical assistance, human capital (years of schooling) and better access to credit reduce inefficiency, or thus increase technical and allocative efficiency of the beneficiaries.

Palavras-chave: Reforma Agrária, Capital Humano, Assistência Técnica, Crédito Rural, Fronteira Estocástica.

Key-words: Land Reform, Human Capital, Technical Assistance, Rural Credit, Stochastic Frontier.

JEL Codes: Q15 Land Reform

Área ANPEC: Área 5 Economia Regional e Economia Agrícola

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1. Potential Production Frontier: Considerations about Technical Inefficiency

The aim of this paper is to characterize the sources of technical and alocative inefficiency in a sample of five North-Eastern Brazilian States subject to a Land Reform pilot project – the "Programa Cédula da Terra (PCT)". This project is financed through World Bank funds, and its evaluation was done by a research group of the (NEA) Nucleus of Agricultural Studies from (UNICAMP) Universidade de Campinas at the Instituto de Economia (IE).

We evaluate the "Cédula da Terra" Pilot Project, a land reform project whose conception, mechanisms and operational structure is different from traditional agrarian reform based on expropriation. The land distributed by the project, is first acquired by the agricultural producers associations, and then a given set of incentives is established to obtain a better efficiency use of resources.

We estimated a potential production frontier accordingly to the methodology explained in BATTESE and COELLI (1995), using the software FRONTIER 4.1.

The data used is a cross sectional gathering of 309 valid observations, reported by the beneficiaries of the Cédula Program (PCT) till last September 2003.

The technical efficiency might be defined as the maximum output for a producer that can be attained given some level of inputs, and some set of available technologies.

Allocative efficiency refers itself to the adjustment of inputs and outputs as a consequence of relative price changes. It shows the ability of the producer to combine inputs and outputs in optimal proportions given prevailing prices.

Economic efficiency is a situation in which technical and allocative efficiency is combined. The analysis presented in the section of technical and allocative efficiency evaluates these efficiencies starting from the value of output, which was generated by the use of productive inputs (namely land, labour and working capital) and conditioned by the use of socio-economic variables – which we further explain below. Thus, technical and allocative efficiency is evaluated simultaneously, because the value of output depends not only of quantities produced but also on the set of prevailing prices.

The traditional efficiency analysis has been performed using two approaches: econometric methods (as it is done in this paper – stochastic frontier estimation) and non-parametric methods – Data Envelopment Analysis (DEA)

2. Econometric Specification of the model

Stochastic frontier production models might be specified in the following way:

$$Y_i = f(x_i;\beta).\exp(V_i - U_i) \text{ with } i = 1,..., N.$$

where Y_i stands for production of the i^{th} pilot project, x_i are inputs and β are the parameters of production. The random component V_i is a white noise shock, which shifts the potential production frontier. The other random part U_i represents technical

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inefficiency and we try to explain it within the model. Its distribution is non-negative, unilateral and might usually be, a half-normal, an exponential or a truncated normal.

The distribution of V_i is bilateral and reflects random effects, measurement errors and omitted variables errors.

One should notice that the value of the (stochastic) frontier´s production in the model is given by:

$$Y_i^* = f(x_i;\beta).\exp(V_i).$$

The objective of this model is to explain technical efficiency (TE_i) as a random component which is determined by the relation between effective and potential production:

$$TE_i = {Y_i}/{Y^*},$$

$$TEi = {f(x_i,\beta).\exp(V_i - U_i)}/{f(x_i,\beta).\exp(V_i)} = \exp(-U_i)$$

The estimation method of some alternative models was suggested by SHARIF and DAR (1996) and WANG et al. (1996), as a two steps procedure (2SLS). First the production frontier was estimated, then they regressed the technical inefficiency components (errors) on the characteristics of households. Nevertheless, the estimates of this model, accordingly to COELLI (1996) were inconsistent – thus they (and we) adopted a method of (iterative) Maximum Likelihood in which the explanation of technical inefficiency is given by a linear combination of the variables. The most common used and quoted software in the literature is FRONTIER 4.1. – and so we used it in our estimates.

The model here adopted follows the specifications of Model 2 from Frontier 4.1, the so-called technical efficiency effects (TE_i) (BATTESE and COELLI, 1995). It might be written as:

$$Y_{it} = X_{it}\,\beta + (V_{it} - U_{it}),$$

where Y_{it} is the log output of the ith agricultural firm on period t; X_{it} is a (kx1) transformation vector of the quantities of the ith firm's inputs on period t; β is a (kx1) vector of unknown parameters and V_{it} has a i.i.d. and $N(0, \sigma_v^2)$; and $U_{it} \sim N^+(m_{it}, \sigma_u^2)$, where $m_{it} = Z_{it}\delta$, Z_{it} is a producer's specific variables vector that might influence his productive efficiency. The software FRONTIER 4.1 also gives the solution to the STEVENSON's (1980) model, a particular case in which T=1 – that is exactly what happens with our only cross section sample.

The likelihood function is explained as a function of the model's parameters variance: $\sigma^2 = \sigma^2_u + \sigma^2_v$, in which we define as $\gamma = \frac{\sigma^2_u}{\sigma^2_u + \sigma^2_v}$. The model yields a better goodness of fit whenever as γ goes to 1, because a greater part of the model's variance is explained by the technical inefficiency components.

One should notice that the algorithm present on FRONTIER 4.1, given the $\beta's$ estimated by OLS for a starting procedure, adopts then an initial estimate of $0 < \gamma < 1$ for the start of the Maximum Likelihood function iterative procedure.

The model estimated makes use of a Cobb-Douglas production function. Starting from the original specification and then applying logs, we end up with:

$$\ln Y_i = \beta_0 + \sum_i \beta_i . \ln x_i + V_i - U_i$$

$$m_{it} = Z_{it}\delta$$

in which the x_i are the production inputs, the z_i stand for the technical inefficiency explanatory variables and the noises u_i and v_i have the already defined stochastic properties. The terms with $\beta's$ are production function parameters, the terms with $\delta's$ are parameters of the explanatory technical inefficiency variables, as specified before. **Table 1,** next page**,** presents the definitions for the set of variables used in the model:

Table 1: Definition of variables used for the production´ s frontier model of the beneficiaries from PCT ("*Programa Cédula da Terra*")

	Variables of the Production Function
VP	Value of agricultural production, which includes animal, vegetal production, derivatives and other products; individual and social production; monetary and non-monetary production. Values in current "*Reais*" (R$). Value of production destined to be sold based on producer´s declared price. Value of non-monetary production (destined to self-consumption) obtained by the inputation of prices in the following order: selling prices declared by the beneficiary, when part of the production is sold; average selling prices declared by other beneficiaries on the same project; average selling prices declared by other beneficiaries of the same municipality; the same for microregion, mesoregion, State and set of the five states.
Land	Area of used land with permanent and temporary crops, pastures and others in hectares (ha).
Labor	Working days inside and outside the parcel, but within the project, resident dwellers, third parties and members of the family non-residents in the dwelling.
Inputs	Total spending with variable inputs such as feed, sillage, palm, grain, salt, vaccines and medicines, seeds, fertilizers and correctives, agro-toxic products, packages, fuels and lubrificants and water for irrigation. All in current "Reais" (R$).
	Explanatory varibles of technical inefficiency
MG	*Dummy* which equals 1 for "Minas Gerais" state project beneficiaries.
MA	*Dummy* which equals 1 for "Maranhão" state project beneficiaries.
CE	*Dummy* which equals 1 for "Ceará" state project beneficiaries.
BA	*Dummy* which equals 1 for "Bahia" state project beneficiaries.
SC	Level of schooling measured by years of beneficiaries´ study.
TA	*Dummy* which equals 1 for beneficiaries who obtained monthly technical assistance between August/2002 and July/2003.
CRE	*Dummy* which equals 1 for beneficiaries who obtained at least one ***credit*** approval (exception for PCT) since the beginning of the Project till July 2003.
VPS	Value of ***social***[1] agricultural production, monetary and non-monetary production, obtained in society. Value in Current "Reais" (R$).
SLFC	Value of agricultural production destined to ***self-consumption***, in current "Reais" (R$).

[1] Social agricultural production is the result from production done in the Associtation´s lands.

3. *Descriptive Statistical Analysis of the variables*

We proceeded to a brief descriptive analysis of the data to use in the model. Below we present descriptive tables of the more relevant variables of the model and its graphics with an adjusted normal distribution.

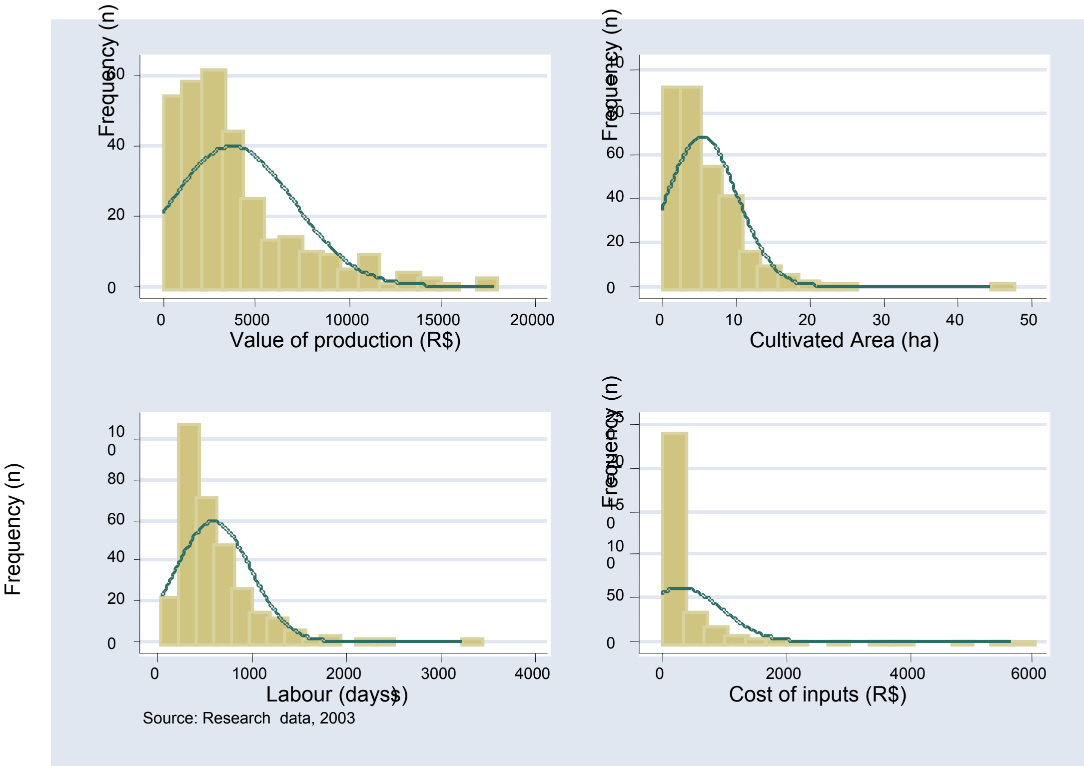
Table 2: Descriptive Statistics of the Model

Descriptive Statistics of the Model			
Average Dependent Variable		Standard error	Dispersion Coeffic.
VP	3.760.02	3.304.87	88%
Production Function´s Variables			
Land (ha)	5.546109	4.752374	86%
Labour(days)	593.0288	397.085	67%
Inputs ($R)	312.2208	672.4479	215%
Explanatory Variables			
SC (years)	1.88179	2.725171	145%
VPS (R$)	541.6903	1265.965	234%
SFLC (R$)	1746.619	2016.401	115%
N. Obsv.	313		

In **Table 2** we report that the value of agricultural production has a high dispersion (88%), that the average parcel (or plot) of land is of small dimension (5,5 ha) with a dispersion of 86%. Labour (in days) is the variable with the smallest dispersion (67%) when compared to all the rest and inputs have a very high variability (215%). Thus, we might conclude that in the production function labour is the most stable production factor.

As to what refers to explanatory variables, we only analysed variables which weren't dummies, because it allowed keeping average and standard error analysis more intuitive.

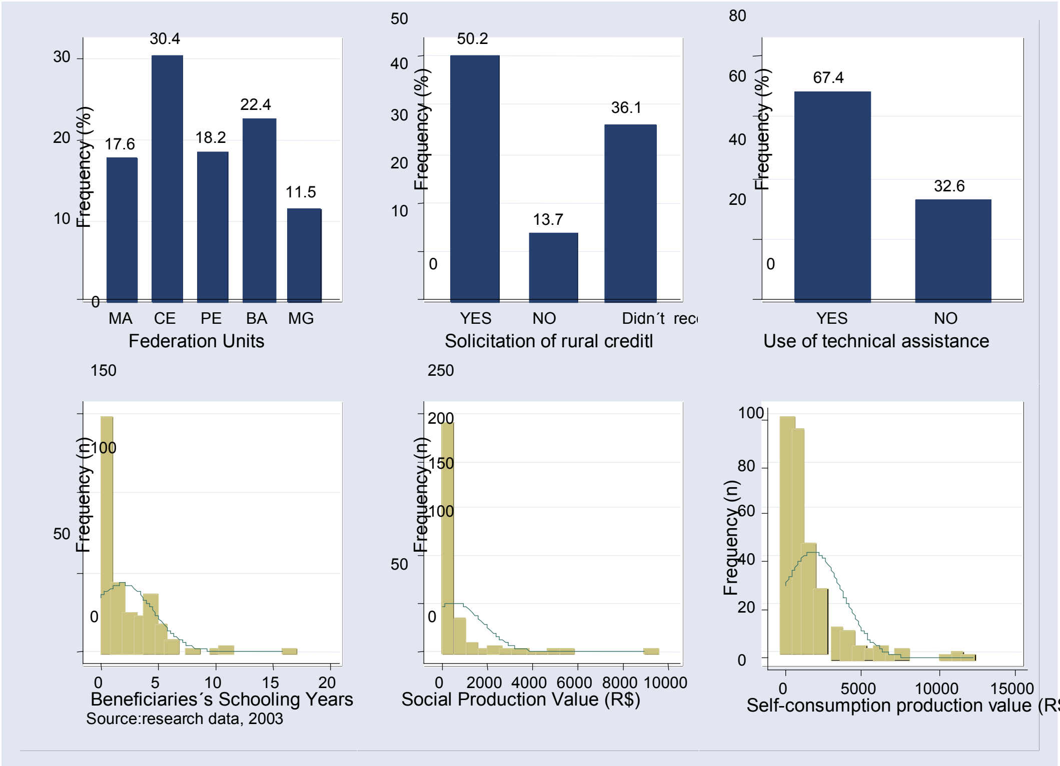
Thus, schooling years have a very low absolute value (1,88 years) with a considerably high dispersion (145%). One should stress that the value of social production (VPS) has the highest coefficient of dispersion (234%), as long as self-consumption has the highest mean value (R$ 1.746,00), with a smaller dispersion (115%).



Graph 1: Distribution of production function´s variables

One might visually confirm that the value of production and cultivated area have distributions which might be approached by the truncated normal distribution, by observing these graphics related to the production function.

The distribution of labour (days) presents data more concentrated around the mean. Nevertheless, the cost of inputs presents a distribution very concentrated around the first frequency class and with a very high dispersion. Thus, in the future, it will be necessary to test analytically the hypothesis of normality for the production function. This wasn't done due to time constraints. Anyway, these variables sustained a good adjustment of the production function model – as we can observe next on **Table 3**.



Graph 2: Descriptive Distributions of Explanatory Variables

The first graph, related to the sample projects´ distribution amongst the Federation units, stresses that the highest share of observations is from the "Ceará" state. Notice that "MA" stands for "Maranhão" state, "CE" for "Ceará", "PE" for "Pernambuco", "BA" for "Bahia" and "MG" for "Minas Gerais".

The solicitation of rural credit might be interpreted as "YES" (required credit at least once), "NO" as didn't require, and the third option as "Didn't receive", Nevertheless the variable used in the model was a simple dummy as "1" received and "0" didn't receive.

Most of the sample households (around 60%) received technical assistance (technical guidance and support). The variable used in the frontier model was the one that represents monthly technical assistance (22% of sample) – which became a determinant factor to explain inefficiency.

The distribution of schooling years reveals itself biased towards values below its means of 1,88 years. One should notice that education has been a major income determinant for rural households, as several international studies show – thus, this justifies the inclusion of this variable in the model – see for instance KAGEYAMA and HOFFMAN (2000) for Brazil. This study finds that schooling above the first degree is a determinant factor of rural income.

The distribution of the value of social production is much skewed and it is very difficult to affirm that it follows a normal type.

The value of self-consumption presents again a pattern of bias below the average.

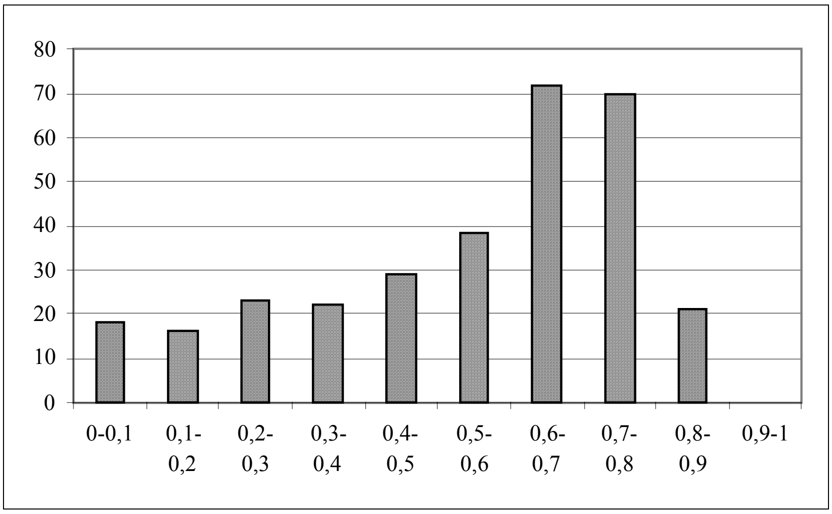
4. Results of the Model

The parameters´ estimations results are shown on Table 3. The value found for γ is near 1 and it is significantly different from zero, thus leading us to the conclusion that there exists a high level of technical and allocative inefficiency. Graph 3 presents the distribution of beneficiaries accordingly to their degree of technical efficiency, measured between the relation of potential and effective production (TE_i) as depicted above. One should remark a higher concentration around the efficiency levels of 60% to 80%, even though there are a higher number of producers below 50%. One perceives, thus, high heterogeneity and high inefficiency.

Table 3: Results of the efficient frontier production model´s for the beneficiaries of (PCT) "Programa Cédula da Terra"

Parameter	Coefficient	Standard error	*t-ratio*
Production Function			
Const	0.81498234E+01	0.18336618E+00	0.44445620E+02[3]
Log Land	-0.94764106E-09	0.15489413E-09	-0.61179921E+01[3]
Log Labour	0.32970832E+00	0.61786554E-01	0.53362471E+01[3]
Log Inputs	0.35411607E-09	0.16372147E-09	0.21629177E+01[2]
Inefficiency Explanatory Variables			
Const	0.97548995E+00	0.81808204E+00	0.11924109E+01
MG	-0.10435214E-07	0.81683476E-08	-0.12775184E+01
MA	-0.88520603E-09	0.76959237E-09	-0.11502271E+01
CE	0.10847668E-07	0.53239732E-08	0.20375137E+01[2]
BA	0.73663693E-09	0.71537487E-09	0.10297216E+01
SC	-0.15632321E+01	0.80377935E+00	-0.19448523E+01[1]
TA	-0.50202264E+01	0.24055359E+01	-0.20869472E+01[2]
CRE	-0.44089913E+01	0.19443393E+01	-0.22676039E+01[2]
VPS	-0.11723769E+01	0.56630320E+00	-0.20702283E+01[2]
SFLC	-0.18471073E+00	0.11115760E+00	-0.16617014E+01[1]
σ^2	0.27500643E+01	0.11017865E+01	0.24960047E+01[2]
γ	0.87437607E+00	0.53754672E-01	0.16266048E+02[3]
Log Likelihood Function		0.39807131E+03	
LR test (dist χ^2(12;1%)=26,12)		0.91367528E+02[3]	
Total observations		309	

[1] 10% significant
[2] 5% significant
[3] 1% significant



Graph 3: Frequency of beneficiaries (number of beneficiaries) accordingly to their technical efficiency (0 to 1)

In the specified and estimated model, the factor which most determines production is essentially labour, whose estimated parameter is high and statistically significant. Land and inputs, have almost no weight in the determination of the value of production, because these estimated parameters are almost zero. This result is coherent for the target-public of land reform farmers, because they use labour intensive technology and a low use of external inputs.

One should take notice that the variable we used for land is ***used area*** and not ***available*** (or disposable) ***area***. Accordingly to the estimated model, an increase in area used wouldn't have a significant impact on the value of production output – thus leading us to conclude that there are other variables as determinants of output, namely those associated with explaining technical and allocative efficiency. Most of the "assentados" (farmers who were granted land) of the PCT (Cédula Program) use still a very small fraction of the land they have available to them, and thus wouldn't have constraints to output growth using this available factor. As it shall be shown afterwards there is still a very large output growth opportunity independently of growing explored area.

The use of variable inputs is still a low, or almost nil, use for the PCT beneficiaries. Again increases in output are, accordingly to the model, more related to other conditionings – independently to the use of these variable inputs.

The relevant variables which enable a reduction in technical and allocative efficiency are therefore, those which might increase the value of output using the same common base of resources: monthly technical assistance, the number of schooling years (human capital), rural credit and the output of social production (measured in value).

The analytical relationship between higher technical assistance and higher output is a direct one, because it enables them to increase the potential production; that is they use new techniques, and/or in a better way older techniques, thus using in a more efficient manner production, which finally shortens the gap between actual and potential production. Technical assistance might also have a decisive role in the choice of products and/or in the access to markets at better prices, thus yielding a direct impact on the value of production.

A higher level of schooling years (one of the forms of human capital) also reduces technical and allocative efficiency, because it allows an easier access to more modern land use techniques (e.g. chemical fertilizers) and a better organization of the productive process itself. A higher level of schooling has also been recommended as an important element to increase the ability of obtaining and processing information, be as it may a necessary toolkit for the adoption of green revolution technologies or as for the practice of sustainable technologies intensive on the use of low external inputs. Besides, it gives access to better prices and to the adoption of higher value products.

Credit is also a productive factor which mitigates technical inefficiency, because it enables a better access to use resources, in a way which effectively increases the productivity in the farm, besides enabling the adoption of higher value products. Even though variable capital (the one which enters in the production function) isn't significant to explain the value of production, this credit is also aimed to the investment expenditures (fixed capital). Thus, the credit variable reflects an integrated view of the program (Cédula), and it allows surpassing the question of collateral inexistence, which is always crucial as a loan guarantee. Credit might be related to better ways of accession to commercial flows and prices, given that when we contract a debt we increase the incentive to generate monetary income. The immediate consequence might be the search for better markets and better valuations of production, thus seeking a higher efficiency in the use of resources.

In the model technical and allocative inefficiency decrease when the value of social production – value of output in society – increases. This fact is related to the use of common resources (pertaining to farmers´ Associations), especially the resources devoted to it by PCT (Cédula), which enabled the creation of better use opportunities in society with higher availability of fixed and variable inputs, technical assistance, better land tillage, pastures, and better genetic bred animals, better access to markets and better prices. This occurs even in situations when the output isn't totally collective, namely, the initial start up costs of exploring the fields, irrigation, and so on, were realized in an associative way, but afterwards the field was divided among farmers with the objective of individual production.

The parameter of production value for self-consumption presented a lower level of statistical significance than the others reported before, but we cannot ignore this variable as a determinant of inefficiency, even for this lower level. The negative sign of SFLC means that an increase in the production for self-consumption leads to a reduction of both technical and allocative inefficiency. This stresses the conclusion that the increase of subsistence income (destined for self-consumption) allows the producer an escape from a poverty trap and assures a minimum level of subsistence, thus gathering resources to produce more efficiently.

The variables which presented the lowest significance level were: *dummies* for Minas Gerais, Maranhão and Bahia. The regionalization by state is not a good specification to establish differences amongst technical and allocative efficiency. There is heterogeneity, even within states, in terms of production systems. The model might probably be improved by the use of proxies which might represent areas with lesser heterogeneity or specific production systems. One should notice that the *dummies* reflect the analysis in comparison with the omitted variable (the Pernambuco state), so thus the only states in which there are differences is in "Ceará" when compared to "Pernambuco", because it is statistically significant, nevertheless its value is near zero so its impact on inefficiency is nil.

By a question of multicolinearity we didn't include the dummy for Pernambuco state, but one should take care that this variable is still present as a comparison of this omitted variables with the other states and this might be relevant because of drought in that Pernambuco for our sample period.

It is remarkable that by comparing the explanatory variables of technical inefficiency, the ones with higher impact are monthly technical assistance, credit and schooling years – the parameters´ values are respectively (t-ratios in parenthesis) -5,0 (-2,1), -4,4 (-2,3) e -1,6 (-1,9). One observes that the impact of 4 years of schooling is approximately equal to the technical assistance, thus revealing the importance of education as a long run policy objective.

The model's specification process obeyed a general to specific approach, because as it is recognised in the econometric literature, this procedure assures a higher probability of finding the "true" model. We tested several variables which we might expect a priori significant and which would reduce and explain technical inefficiency.

In the choice of the effectively used variables we constructed a correlation matrix between variables in order to avoid correlation between estimators and we eliminated those variables whose correlations were higher in order to keep good statistical properties for the model.

The variable use of chemical or organics inputs (variables 139 and 139a of the questionnaire) would lead to a better soil use and in principle to higher productivities. Independently of the statistical quality of the variables at stake one should take notice that the productive systems amongst different states are so different: some are intensive, others might be extensive, and thus this might lead to effects cancelling off amongst them. Henceforth, in the future the series might be reformulated to account these discrepancies between states in order to obtain better adjustments.

Other variable we tried and we found it wasn't significant was the participation in technical courses (variable 187 of the questionnaire). Even though with the correct expected sign (reduction of technical inefficiency), the parameter didn't present statistical significance. It might seem a paradox, once monthly technical assistance was the most relevant technical inefficiency explanatory factor, how come that participation in technical courses didn't show up as relevant? One should notice that this latter variable has a higher demand for human capital (formation) and that in fact the schooling of these farmers is so low – thus this might explain why technical courses didn't reduce technical and allocative efficiency.

We also tried to evaluate the impacts of the different performed types of productive activity (animal vs. vegetable) thus creating a variable which was the share (%) of animal production in total production (animal + vegetable). The differences between these two types of production didn't seem relevant, as the variable was reported as non-significant.

Age is a proxy for experience (accumulated human capital) but didn't also shown as significant. In this context one must analyse the farmer's age under two different effects: **i)** a **pro-efficiency effect** – older farmers implied more experience with inputs use, irrigation techniques, seed selection and **ii) anti-efficiency effect** – the older farmer is more risk averse and denies to try new techniques. In our analysis we didn't obtain success to know which effect came to be dominant, or even if the two effects balanced each other.

In this line of reasoning we analysed other variables such as seed certification (variable 137 of the questionnaire), irrigation (variable 143 of the questionnaire) and both weren't significant. Such finding isn't striking, once we recognize that these variables are associated to a capital intensive use and as we already reported the capitalization level is too low.

We also tried in the model the use of fodder (var.133 of the questionnaire), which we might expect to reduce technical inefficiency. Again this parameter didn't show up as significant.

5. Final considerations

The beneficiaries of PCT (Cédula) to generate production depend mainly on the more intense use of labour, resource which is available at low cost. The use of variable inputs and land didn't show up as determinants factors of production. This might be explained by various reasons or causes. As it was stressed by BUAINAIN et alii (1999, 2002) the beneficiaries face credit restrictions to perform the needed investments which would change qualitatively the productive structure, and the resources from the credit system (SIC) didn't show up as sufficient, for most part of the project, to cover the minimum pack of investment productive services. This restriction implied a partial and fragmented adoption of potential technologies which might have a more substantial impact on production, or the installation of some irrigation infrastructure, but seldom was the complete pack used. On the other side, much of productive investments which incorporate a new level of technology have not yet matured, and thus the current traditional production adopted by familiar farmers in the region is still going on as before. As it is known, these traditional systems use few, and in most cases none, technology and external inputs, and thus respond mainly to the use of labour.

The finding that production doesn't respond to the used land has a simple explanation. Those systems are based on a consortium of mixed cultures and rotation with animal breeding. Producer farm slices of declared area as cultivated or in production, which reduces the sensitivity of this variable to area variations. The research group wasn't able to find the use of declared land as cultivated, nor to find the effective level of pasture use. Other relevant explanation is the sensitivity of production to the environmental conditions and climate conditionings. On the half-arid ("semi-árido" region) the use of bigger areas, with low productivities are combined with regions were the production is more intensive. More than a research error, this result reflects the fact that bigger areas are used with extensive systems, of low value generation, and other smaller areas, such as meadows (cultivated plains) tend to a higher intense use. Thus, this is the determinant weight of labour in the generation of production value.

This result cannot be used to justify the abandonment of the use of external inputs or to justify a strategy to make forth a more intense use of land. One should notice that this result reflects, a priori, a set of restrictions on the use of these factors – and does not reflect a intrinsic producer's rationality – thus, the level of factor's use is low and its impact is residual. Land is a factor which exists as a "stock" and will surely be determinant on the expansion of production, but not necessarily on the value of production, as reported by the model.

The fact that the production function is just a function of labour is consistent with the analysis that a more intense use of labour would lead to a theoretical expansion path on which the optimal rule would be marginal labour productivity matching wage. As labour marginal productivity is very low, this analysis is coherent with the existence of very low equilibrium wages in this factor market.

Land and capital on the current phase of the process do not pose themselves as active restrictions on the production function, which is related to the under-utilization of the soil (as it results from the comparison between ideal and effective land parcel).

We estimated also models using the fraction of ideal land (in stead of effective) and the results reported on Table didn't change qualitatively.

The analysis of technical efficiency stresses important elements to understand the constraints on production. Firstly, the two main factors which reduce technical inefficiency are monthly technical assistance and the access to credit. One should remark the renowned precariousness of the technical assistance service in most states, and even though this conditioning of the farmers, probably those who had a better service, were able to reduce technical and economic inefficiency. This is once more a confirmation which is present and is repeated over and over again in the literature and on the political claims of the farmers. This reveals that access to land, by itself, isn't enough to have a efficient resource use and high production, because farmers do face dire external restrictions. Secondly, our analysis shows up the importance of education, even with the very low schooling levels that characterize the beneficiaries of the PCT (Cédula). Education interacts with technical assistance, eases up the apprenticeship and the absorption of new concepts, and also contributes to a better credit access, without even mentioning better access to global markets.

The main policy conclusions are that one should increase credit and technical assistance as first line priorities on the reduction of technical inefficiency. Secondly, one should reinforce education policies with longer term results. These variables condition the ability to obtain better prices, to reach better markets, to adopt new products and techniques which might not only raise productivity, but also raise the value generated by production.

The model presented might be improved by including variables that show different production systems and/or distinct regional environment, markets within reach and other which stress different socio-economic environments. Besides, the established variables to estimate the production function might be restructured in order to reflect products and inputs (land, labour and capital) derived from individual and collective use, or even to distinct production systems. Data and time constraints curtailed this kind of procedures.

6. References

BATTESE, G. E. and T. J. COELLI (1995), "A model for technical inefficiency effects in a stochastic frontier production function for panel data", *Empirical Economics*, 20: 325-332.

BECKER, G. (1993), *Human capital: a theoretical and empirical analysis with special reference to education*, 3rd edition, University of Chicago Press, USA (1st edition - 1964)

BRITANNICA (1993), "Land reform and tenure", Macropedia Knowledge in Depth, vol.22, 15th edition, pp. 540-547 ;

BRITANNICA (2001), "Land reform and tenure", edition Super Deluxe in CD Rom, Merrian Websters Collegiate, Tenth edition, US Patent #5,241,671.

BUAINAIN, A.M.; SILVEIRA, J.M.F.J. da; ARTES, R; MAGALHÃES, M. M; BRUNO, R.,(1999a). Avaliação Preliminar do Cédula da Terra. Convênio IE/Unicamp, NEAD-MDA e Banco Mundial. mimeo, 321p.

BUAINAIN, A.M.; SILVEIRA, J.M.F.J., SOUZA FILHO, H.M; MAGALHÃES, M. M. (1999b). "Community-based land reform implementation in Brazil: a new way of reaching out the marginalized?", Paper presented in Bonn Seminar/Global Development Network, Bonn, November mimeo, 106p. htpp://www.gdnet.org.

BUAINAIN, A. M.; SILVEIRA, J. M. F. ; MAGALHÃES, M. M; ARTES, R.; SOUZA FILHO, H. M.; NEDER, H. D.; LEON, F.; PLATA, L. A. (2002). Perfil dos Beneficiários PCT e INCRA-2001- Relatório de Pesquisa. Convênio FECAMP/NEAD-MDA. mimeo, 393p.

BUAINAIN, A. M; FONSECA, R. B.; PEDROSA, D.; BAZIN, F.; NEDER, H.; SOUZA FILHO, H. M; SILVEIRA, J.M.; MELO, M.; MAGALHÃES, M.; VITAL, M.; ROCHA DE SOUSA, M.; BUAINAIN, V. (2003), Estudo de Avaliação de impactos do programa Cédula da Terra. Relatório Final, Convênio FECAMP/NEAD-MDA- World Bank, mimeo, 213 p.

COELLI, T. (1996), "FRONTIER Version 4.1: A computer program for stochastic production and cost frontier estimation", Department of Econometrics, University of New England, Armidale, NSW.

KAGEYAMA, A and HOFFMANN (2000) "Determinantes da renda e condições de vida das famílias agrícolas no Brasil", Economia, vol.1, n.2: Julho/Dezembro, ANPEC, Campinas, SP.

KAWAGOE, Toshihiko (1999), "Agricultural land reform in post-war Japan: experience and issues", World Bank Policy Research Working Paper 2111, May, Washington D.C.

SHARIF and DAR (1996), "An empirical study of the patterns and sources of technical inefficiency in traditional HYV rice cultivation in Bangladesh", *Journal of Development Studies*, 32, 612-619.

STEVENSON, R. E., (1980), "Likelihood function for generalized stochastic frontier estimation", *Journal of Econometrics*, 13, 57-66.

WANG, J., CRAMER J. L., WAILES, E.J. (1996), "Production efficiency of Chinese agriculture: evidence from rural household survey data", *Agricultural Economics*, 15, 17-28.