The Impact of a Family Farming Credit Program on the Rural Economy of Brazil

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Resumo – O artigo começa com uma breve revisão da literatura sobre medidas de crescimento da produtividade na qual se defende a aplicação, para tanto, do indice Tornqvist-Theil. Em seguida, o artigo faz um apanhado da alocação do crédito no programa brasileiro de apoio à agricultura familiar (PRONAF). O impacto dele é avaliado tendo-se em vista a comparação entre um grupo de produtos por ele beneficiado e um grupo de controle. O artigo conclui que o programa exerceu um impacto positivo em 1997 e 1998 e um efeito quase nulo em 1999.

Palavras chave: medidas de produtividade, impacto produtivo, Brasil, agricultura familiar.

Abstract – This paper begins with a brief survey about productivity growth measures in which we argument favorably to Tornqvist-Theil index. Next, it presents some features regarding the destination of credit loaned by the Brazilian Program to support family farming. The impact of the program is evaluated by comparing between a group of products benefited by it and a control group. The paper concludes that the program has had a positive impact for 1997-1998 and a negligible effect in 1999.

Key words – productivity measures, impact on output, Brazil, farming family.

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I. INTRODUCTION

In 1995, the Brazilian government founded the Program to Support the Family Farming (PRONAF) as an initiative to accelerate rural development by expanding the availability of agricultural credit to poor farmers. Unfortunately, up till now few studies exist that evaluate the benefits of PRONAF in terms of productive impact and this paper offers a tentative of clarifying this question based on available data. The methodological problems in assessing the impact of rural credit projects are usually pointed out in the literature. A set of problems are listed that mislead or at least difficult this kind of evaluation: the large variations in farmers' characteristics that invalidated models using an imaginary representative farm; the fungibility of money, i.e., the impossibility to discern whether loans result in additional resources for the purposes specified under projects; and the limited comparability of a group that received project funds with a control group that did not. Although all these microeconomic problems stress the complexity associated with evaluating and attributing benefits to agricultural project, they do not invalidate theoretical attempts to relate credit to incremental physical output or productivity [see Yaron *et al.*, 1997, p.88-89]. In fact, in cases like PRONAF in which the credit is loaned to a very specific clientele, with large social monitoring, these difficulties in measuring the impact of credit do not mean that credit has no impact or that it is impossible measuring production gains.[1]

The paper proposal is quantifying and attributing the benefits of PRONAF by an economic evaluation of the performance of the main products financed by the credit lines of this programme. Instead of using complex econometric studies based on in-depth farm survey for evaluation of the relationship between credit and production, the paper offer a study of the impact of PRONAF in terms of the measurement of productivity growth of its main crops.[2] The next section presents the theoretical questions related to the measure of productivity growth where we are augmenting the vantage and limitation of use a *Tornqvist-Theil Index* as a measure of multifactor productivity. The third section offers a complete survey about the amount of PRONAF credit and the distribution of credit among Brazilian States and products. These elements will be important in the follow section in which we employ a set of assumption based on the descriptive information data to tailor the available data for use in the selected performance measurement model. The conclusive part brings together the main results in a systematic evaluation of the productive impact of the program.

II. A MEASURE OF PRODUCTIVITY GROWTH

The earliest and most easily computable measures of productivity growth is the single factor measures, which focus on the productivity of a simple input, and implicitly suggests that this is the only scarce input. Although broadly used in agriculture, where productivity is motivated in terms of the output possible from a given amount of land, such measures ignore substitution of this input for others in response to relative price changes, and differences in technical efficiency and input composition at different scales of output production. Formally, the single factor productivity is measure by $\%\Delta(Y/A)/\Delta t \sim d\ln (Y/A)/dt = d\ln Y/dt - d\ln A/dt$ (where Y represents production, A is the single factor and t denotes time).

The single factor productivity seriously limits the interpretability of the measure as a welfare indicator. More complete multifactor measures, embodying changes in the use of other inputs, provide more clearly interpretable indicator of overall productivity but are more complex to motivate and construct. In the multifactor productivity measures the contributions of different inputs are combined by weighting their growth rates by their revenue shares, resulting in the overall measures of productivity growth e_{yt} = dln Y/dt - $\sum_j S_j$ dln v_j/dt, where v_j is the quantity of input j, S_j is the share of input j in the value of output, $S_j = p_j v_j / p_y Y$, p_j is the price of v_j, and p_y is the price of Y. This measure has alternatively been denoted an index of growth in total-factor productivity.[3]

Using the duality theory we can see the productivity growth measurement as a cost-side rather than an output- or primal-side measure. If a given output may be produced using less input once productivity growth has occurred, that output may by definition be produced at lower cost. Cost diminution for a given output level is *dual* to output augmentation for a given set of inputs. Paul [1999,p.44] shows that with constant return to scale this *dual* concept of productivity growth is equivalent to the original primal specification of productivity growth. The author also uses the Shephard's lemma to obtain this result. Looking to the primal expression of productivity growth, we easily demonstrate that the same expression is obtained as a straightforward result by representing the production process by a Cobb-Douglas production function. Notwithstanding, in this case the shares of inputs are constant and represented only by a parameter. When we bring together all these pieces of the productivity puzzle we conclude that the traditional expression for multifactor productivity growth is, in fact, a very restrictive approach in which a set of heroic supposition is made.

Beside the very restrictive supposition previously pointed out, we have other piece of the puzzle very difficult to untangle in empirical works. In practical application, we have problems of input fixities or restrictions that create a difference between short and long run behavior resulting in capacity utilization fluctuation. Another practical difficulty to use the traditional multifactor productivity growth expression is that the available data sometimes doesn't allow identifying all relevant productive factors. For instance, in the Brazilian agricultural the data set offers information about acreage, workers, fertilizers and tractors, but not all factor's data are easily available. Therefore, in the expression of multifactor productivity growth the supposition of shares sum equal to one is difficult to implement.

All this problems make innocuous the use of the traditional expression of "total" productivity in this paper. We prefer apply a more general productivity growth specification that can be obtained by assuming a flexible functional form for the production function that allows a less restricted representation of input substitution. For this, we choose the transcendental logarithmic translog function developed by Christensen, Jorgenson and Lau [1973], which places no *a priori* restrictions on substitution elasticities. The same authors in another paper, Christensen *et al*. [1971], make an empirical application in which they consider both the transcendental logarithmic transformation function and the transcendental logarithmic profit function under the assumption of constant returns to scale. These empirical studies suggest that the translog function should be employed in the absence of correct *a priori* information on the specific functional form [p. 256].

Thirtle and Bottomley [1992] outline the relationship between production functions and an index for the rate of change of multifactor productivity. Firstly, they stress the results of Everton, Landau and Ballou [1987] in which an approach to explained technical change called the two-stage decomposition is proposed, as opposed to the integrated approach. While in the integrated approach the determining variables, such as R&D, extension and farmer education, are used to explain the index of productivity, Everton *et al*. show that the two-stage decomposition method offers an equivalent measures of technological change by using economic accounting measures, which are bases on index number theory. This method drops the determining variables and imposes long-run equilibrium, in which no abnormal profits are made. Everton *et al.* also deduct the rate of change of multifactor productivity as given by the difference between the rate of change of aggregate output quantities and aggregate factor quantities: $\sum_i S_i\,((\delta Y_i/\delta t)/Y_i)dt - \sum_j C_j((\delta X_j/\delta t)/X_j)dt$, where $S_i = P_iY_i/\sum_i P_i Y_i$ and $C_j = R_jX_j/\sum_j R_j X_j$.(P_i and Y_i are price and quantity for output, and R_j and X_j are for input).

Thirtle *et al*. demonstrate that the same expression for the multifactor output variation can be obtained by a production function derivation of the productivity growth. If all input and output prices and quantities are observed, the productivity growth can be calculated, but this result applies exactly only to data that are generated continuously. Since economic data come in discrete observations, the previous results are approximated. The expression underlying the productivity growth measure define the *Divisia index* and in the discrete case we use an approximation of this index that is called *Tornqvist-Theil index,* and written as $½\sum_j(C_{jt} + C_{jt\,-1})\ \ln\,(X_{jt}/X_{jt\,-\,1})$ for the inputs and $½\sum_i(S_{it} + S_{it\,-1})\ \ln\,(Y_{it}/Y_{it\,-\,1})$ for the Tornqvist-Theil output index. Both of them are the logarithm of the ratio of two successive input (output) quantities weighted by a moving average of the share of the input (output) in total cost (revenue). Diewert [1976] demonstrated the correspondence between the Divisia (or Tornqvist-Theil when discrete) index and the translog function. Thirtle *et al.* didn’t have used a very specific production function to obtain their results, however Diewert showed that “the homogeneous translog function is the only differentiable linear function which is exact for the Tornqvist-Theil index” [p.120]. If productivity chance is Hicks–neutral and the underlying quadratic production technology is the translog, then the Tornqvist-Theil index is an exact measure rather than an approximation. Paul [1999, p.43] arguments that the translog function allows assessment of the determinants of the shares of inputs, since the shares depend on the marginal products, which in turn depend on all arguments of the production function. Many attributes of Divisia index are discussed by Hulten [1973], for instance, that the Divisia index is path independent in S.

The productivity growth analysis on the article is made by taking the two discrete indexes above to output and input, and considering the differences between them: $e_{yt} = ½\sum_i(S_{it} + S_{it\,-1})\ \ln\,(Y_{it}/Y_{it\,-\,1}) - ½\sum_j(C_{jt} + C_{jt\,-1})\ \ln\,(X_{jt}/X_{jt\,-\,1})$. This measure is restrictive because the approach imposes equilibrium, Hicks-neutral technical change and constant return to scale. However, because the translog is a flexible functional form, there are no further restrictions imposed by the specification of the underlying production relationship. For example, if the production function was Cobb-Douglas, which is separable in outputs and inputs, the first-order conditions for profit maximization require that the cost shares C_j remain constant over time. In this case, the input index becomes $\sum_j C_{jt}\ \ln\,(X_{jt}/X_{jt\,-\,1})$. Taking exponents of this expression gives $X_t/X_{t-1} = \Pi_j\ (X_{jt}/X_{jt\,-\,1}).C_j$. So the geometric input index, which is a special case for Tornqvist-Theil input index is exact for Cobb-Douglas. We can show that Laspeyres and Paasche indexes are exact for the restrictive linear production function (and others), these arithmetic indexes implies that all inputs (or outputs) are perfect substitutes. Note that the Tornqvist-Theil index allows to measure the productivity growth take into account a multiproduct setting, and for instance to be used for comparison between a particular basket of products beneficiary of a program of credit and a control group of products that did not significantly receive funds. Having covered the choice of functional form for the index, we will apply them to our goal of to evaluate the productive impact of PRONAF. For this, we will have to solve many conceptual issues involved in adjusting the aggregate agricultural accounting data, and the data from credit, to make it suitable for productivity index calculation.

III. OVERVIEW OF CREDIT

This paper does not deal with all the features of PRONAF but focuses on its credit segment. Table 1 presents amounts related to PRONAF disbursements between 1997 and 2000. We divided the applied resources between the modality of credit and non-credit. In the latter, the values quantify the allocation of funds to specific intentions like infrastructure and support services to small cities. These lines are not a credit but a grant. The former line has the characteristics of banking credits. In this case, loans are granted to farmers through banks that have to follow government directives when allocating the funds. In nominal terms, the resources applied as credit fell between 1997 and 1998, rose in 1999 and rose again in 2000 overtaking 2.5 billion Reais in the last year. The number of contracts rose from 486 thousand in 1997 to more than 717 thousand in 1999. As we are seeking the productive impact of the credit program, we need a data set that contains enough information to allow a broad study of productivity. The IBGE's data is the traditional reference related to agricultural information in Brazil. It offers two kinds of bases: the *Farming Census* that occurred each five years (the last one was for 1995-seconf half to 1996-first half), and the monthly continuos data.

Table 2 presents the share of main products in the distribution of PRONAF credit between 1997 and 1999. We can see that tobacco, soybean and corn largely are the destination of funds. There are few variations during the sequence of years. It is easy to conclude that there was a substitution: an amount of soybean credit was changed by an additional amount of credit to corn in 1999. Other characteristic of PRONAF that we are taking into account into a study on productivity is the distribution of credit by States of federation. Table 3 shows the share of States for 1997 to 1999. According these data the three Brazilian Southern States concentrate more than two third of the credits. Despite the importance of these States, other ones significantly also take up share within PRONAF credit. The State of Minas Gerais strongly has take part in PRONAF, although its share has been decreasing from 16 to 10 percent during the period in question. In spite of the concentration of the total credit among few States, the State share analysis per product shows a better distribution of the credits [table 4]. While the Brazilian Southern States are the main target for credits to corn, soybean, tobacco (products that keep the majority of funds), others States are important in relation to specific products. In general, States that have tradition as regards the production of certain commodities are the most helped for the credit to them. For instance, the State of São Paulo for persimmon or Bahia for coconut.

The outreach of PRONAF credit can be appreciated by using a comparison between the funds loaned and the previous farmers' demand to financing. The last IBGE Farming Census is very opportune because it was made when the program was just on the beginning so there was not impact on the rural credit market. The Census offers the financing granted by Brazilian States of federation, but not by products. It is possible to discriminate on the Census' data information regarding the demand to credit by segments classified as family farming. The Census classifies the rural estates according two sets: the property directed by boss (patron organization) and the family farming. According to its criteria the patron organization are real estates with permanent employees and/or more than five temporary ones. The remaining is the family farming properties. The distribution function of rural income of the properties about all the States is rightly asymmetric (or positive-asymmetric). In this kind of distribution, the average is bigger than the median. Using this fact, within each group (patron or family farming) different segments gain a label in function of their position taking into account the values of the average and the median. The *fa* is the segments in the family farming set with gross monetary income above the average; the *fb* presents nominal income between the average and the median and the *fc* belonging to the same set has income below the median.[4] Table 5 shows the average values of the gross nominal income in each segment according to the Census and inflated values.

Serving the *fb* and *fc* group represents the main target that a program towards poor family farmers ought to do. However, not ever this had been in fact the emphasis of the program in question. Therefore, in our research about outreach it is important to distinguish these segments from other ones. Table 6 presents the demand to rural credit served in 1995-96 according to the IBGE Farming Census. It also shows the credit loaned to poor family farmers (*fb* and *fc* segments) at the same period. The table also indicates the amount of credit loaned within PRONAF in comparison with Census rural financing information (in percentile). It is important to pay attention on the relationship between the loans that served the poor family farming in the Census data and the volume of credit loaned within PRONAF since 1997. A lot of important details are summarised by this table. We can see for instance that some Brazilian States with agriculture-based economy such as the centre-western States that gain lots of credit according to the Census has low share within the PRONAF. The fact is explained since the States in question have patron-organized agriculture very traditional on this place of Brazil. With regarding to the assessment of the impact of PRONAF funds on to substitute or to create more formal loans, the data do not allow knowing whether or not in each State the program has resulted in an expansion of total rural credit. The three States of Rio de Janeiro, Rondônia and Santa Catarina represent cases in which the PRONAF loans overcome the previous offer of formal credit according IBGE. Obviously in these cases we are sure that a growth of the formal credit had occurred. In relation to the past state of affairs, the impact of PRONAF loans also was significantly on the States of Espírito Santo (65.11 percent on average), Minas Gerais (56.79 percent) and Rio Grande do Sul (90.76 percent). Whether the comparison is made with the credit served to poor segments *fb* and *fc* of the family farmers before the program operation (data of Census), the States of Espírito Santo, Maranhão and Minas Gerais present the best relationship between program's loans and past poor family farmer financing. The Southern Brazilian States have indexes that indicate what would be the expansion of credit to the specific target in question if all the loans were allocated only to poor family farmers between 5 and 10. They are not in special position but behind those quoted States and also Pernambuco, Piauí and Rio de Janeiro.

Finally, it is lacking into this section about the overview of PRONAF credit to address additional information as regards other purposes of the credit contracts. The data set itemises the destination of loans to other targets beyond specific products. For instance, credits to fertilizers, tractors, micro-tractors, farm equipment (irrigation pumps, combines etc.), automotive harvester, mechanised patrol-harvester, mechanised patrol-tractors and mechanised patrol-other machines. The credit distribution among these inputs shows large predominance of the item farm equipment. The second main item in amount of loans, among the selected inputs, is the tractors, nevertheless in 1999 the item fertilizer, until then without importance on credit, ties with tractors as target of loans. We should retain great part of the present overview of the PRONAF credit in the following analysis of the program's impact on productivity.

IV. THE IMPACT OF CREDIT

The ultimate purpose of this section is quantitatively to assess the impact of the expansion of subsidized agricultural credit on the Brazilian family farming. The main absence in the data set that difficulties a serious study about the impact of credit is the data with regarding to allocation of credit among crops. Therefore, on credit by product, we have only information about PRONAF; the data about credits loaned to each product into the entire set of products in the Brazilian agriculture are absent. The main problem in studies like this is the choice of a group of control. We do not have individual data to classify borrowers into those who face credit from PRONAF and who do not. The traditional procedure at this case is using some variable as an instrument. For instance, Binswanger and Khandker [1995] use the number of branch officer as an instrument in the case of India. In Brazil, even whether the identification problem is solve we do not have enough information to analyze the credit level granted to control group, we don't have statistics about formal credit per product or per individual farmer, and we don't know whether or not the expansion of subsidized credit causes a reduction in other lines of formal credit or in informal credit.

Only when we are sure that the farmer faces a credit constraint, additional credit supply can raise input use, investment, and hence output. The rural production is an outcome of both the supply of subsidized credit (net of the effect of reduced other sources of credits) and variables such as weather, prices and technology. We have many econometric problems to disentangle all this factors. Nevertheless, this paper adopt a way that in part avoids excess of technical econometric difficulties and takes into account the amount and outreach of available data. It is true that this analysis is more indicative than conclusive but it lights up the question of PRONAF credit impact. The previous section showed that we have three main product financed by PRONAF: tobacco, soybean and corn. We don't know how many percent the loans from this program represents into the total formal credit granted to these three products. In the case of tobacco, we value that the large part of credit is from PRONAF, and in the case of corn. The rationale is that 96 percent of the cultivation of tobacco occur on Brazilian southern States with a family-farming basis; while 46 percent of corn are from this part of Brazil and if we include the States of Minas Gerais whose share in PRONAF was 10 percent in 1999 than the percentile will arise to 60 percent of the total production. In the case of soybean, its production is not so specific to the southern States (47 percent) since the centre-western States also are important (38 percent of the total production). The structure of production on this area of Brazil is not family farming but patron organization. Taking into account this entire picture, we assume the supposition that all the loans to this group of three products are from PRONAF, and that other cultivation do not receive credit from PRONAF.[5] According this supposition, the group of control is a selected 28 crops products, with easily gathered information on the IBGE's data set, either in Census and continuous data,[6] and the favouring group of products is tobacco, corn and soybean, which received subsidised credit.

This assumption may be quite reasonable and it allows evaluating the impact of credit within PRONAF on production in terms of a cross section in which a comparison between basket of main products favored by program's credit and a control group of products are made. We are following two procedures: (i) Examining the evolution of average partial productivity index for each group and seeing whether by each year the selected group has a productivity growth above the average of the control group; (ii) we are making the main task of this paper that is to apply the Tornqvist-Theil index of multifactor productivity and to make a comparison between the main PRONAF products and the remaining ones in terms of growth of productivity. A set of hypothesis will be proposed to allow the use of the available data in these measures.

We start providing the sources of data to all variable involved in the production and productivity growth analysis carried out by the article. The annual crop output for 28 agriculture products within a control group and the three favored crops during the 1990's are bringing from IBGE, Produção Agrícola Municipal-SIDRA, available on Internet. The values of the produced commodities are important too for calculation of the Tornqvist-Theil output index; therefore they are bringing from the same source for 1990's by each product within the control group in question and PRONAF group. We also intent on this part of the paper to make a calculation of the partial productivity index by each product so we need information about two main inputs: plant area[7] (available on the same source) and workers assigned to each commodity.

Unfortunately, we do not have the latter set of numbers, since only the Census offers so detailed data. Nevertheless, the paper uses the Census information about workers held in each of the agriculture product on December 31, 1995, and it adopts the assumption that he same share are maintained in other years. Making use of the percentile presented on Census, we can estimate a series of workers allocated to agriculture during the 1990's regarding the two baskets of products. The supposition is that the labour would be distributed among the different product with the same share of a reference year. We have disregarded the variables that can cause reallocation of this factor among products during the years. Table 7 presents the IBGE labour information used to estimate of labour by basket of crops into our calculation ahead.

In accordance with the paper's agenda, we intend now to bring together the previous data to obtain partial productivity index and the Tornqvist-Theil output index for the entire basket. Table 8 presented the average annual growth of single factor productivity by group for plant area as the input. It shows the performance of each group in terms of this simple measure. For PRONAF group, the output per area coefficient annually arose 2.5 percent on average since 1995; a better performance than the 1.7 percent for the control group by using the same measure. This result suggests a positive impact of PRONAF on production. Notwithstanding, in this group the productivity growth patter is very oscillating during the 1990's. Table 9 provides the measure of productivity growth by control group and PRONAF group for labour as single factor, in which the average annual growth is calculated. For control group, the patter is the same as the previous representation, except in 1996 when the growth is strongly positive into the new approach. On this group, both single factor indicator of performance show a positive average growth of productivity since 1995: with area as factor the average is 1.7 percent and with labor the number is 3.0 percent per year on average. Other result that must be stressed is the negative performance in 1998.[8]

For PRONAF group, it is important too to evaluate whether or not the productivity evolution is nearly the same for labour as the single factor. The main different between the two inputs into the single factor measure occurs in 1996, which has presented a negative growth according the single factor productivity using area, and now it arises with labour on productivity calculation. The productivity in 1998 is again decreasing however the fall is smaller in the new context. On average, the single factor index arose the same 2.5 percent since 1995. Whether we consider the average of the control group for sake of comparison using the same criterion whose single factor is labour, the target basket benefited by PRONAF has a worst performance, below the 3.0 percent on average for control group. Therefore, the calculation shows two different conclusions:

if the criterion of single factor measure is area, the PRONAF group of beneficiary crops has better performance; if the criterion is labour, the opposite result prevails.

Beside the previous comparison between the performances regarding two different single factors we should mind our main task that is to consider whether or not in each case the PRONAF group has a better performance than the control group for each year, especially since 1996 when the program began. Both single factor measure of productivity growth lead to the same striking conclusion: overall, the tree main products benefited by PRONAF have a performance superior the control group in 1997 and 1998 according this measure. The paper suggests that this is an indicator of the impact of PRONAF on production. The performance of the target group is inferior in 1999 as regards both measure and while the index for area maintains this result in 1996, the one for labour shows identical performance for both groups in this year.[9] It is important to see whether this result is maintained in a more sophisticating productivity study, as supplied by a multifactor analysis. Now we can take advantage of the Tornqvist-Theil productivity growth index that presents desired characteristics as a flexible functional form for the production function, despite the remaining limitation as the equilibrium and Hicks-neutral technical change supposition, as well as the hypothesis of constant return to scale. Table 10 provides a Tornqvist-Theil measure of multifactor productivity growth that suggests a different conclusion as regards the evolution of productivity to both groups. The output index is obtained by using data from IBGE/SIDRA.

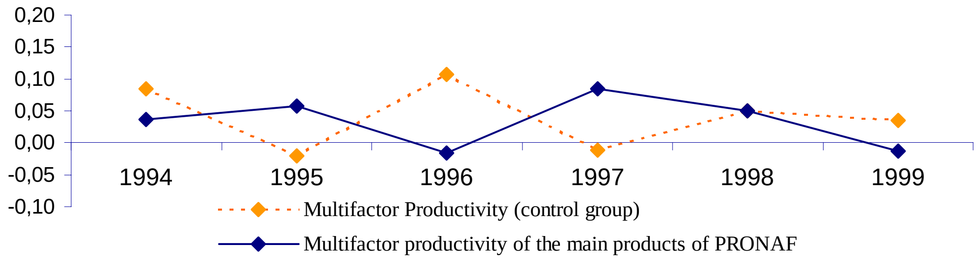
Regarding the input index, we have used a set of data from different sources tailored to our calculation. We bring together information for selected inputs, therefore our initial task is to estimate the amount of machines, fertilizers, tractors and toxic inputs that we can associate with the production of each crop within the control and PRONAF baskets. Since we do not have detailed information about each crop by year the paper suggests to pick up the more specific data supply by last IBGE Farming Census and based on it to determine the share of each product and, by adding up, the share by group on the total purchase of the inputs by farmers. The Farming Census shows the number of rural establishments that use the input and the total amount of ones that does declare to adopt it by each crop. Based on these amounts we can calculated the share in percentile of each product within the basket and so the share of the groups within the total purchase of input [table 11]. The Census does not offer information about machines, however we can use data from soil preservation and irrigation as a proxy and get the average share of these proportions as the percentile for machines. For fertilizers we adopted information about chemical fertilizers, organic fertilizer and limestone use. We assume the average of these percentiles as the relative participation on total purchase of fertilizer. Combining aggregate number from different sources with the constant share supposition we obtain the theoretical series of inputs quantities to the two groups[10] [table 12].

The next step for the calculation of input index is to collect data about prices of inputs. From Getúlio Vargas Foundation we obtained information about prices of land and wages paid. The former uses the price of land renting and the latter adopts the agricultural labour payment for managers as a proxy for wages. Information as regards prices of machines, fertilizers and tractors are not directly available but easily we can use exchange relationships supply by different sources to estimate prices. The toxic inputs prices actually are index number present by CONAB. For control group, whether we take into account this more complex measure the assessment of productivity growth is more favorable, with a 3.2 percent average growth since 1995, and only 1995 and

1997 with a modest negative number (-2.1 and -1.1 percent respectively). Not surprising, the multifactor measure shows a growth in 1998.

The index of multifactor productivity growth is depicted on graphic 1 where it presents a comparison between target group and control. As regards this more appropriated evaluation, the results in terms of comparison between Pronaf and control groups are not very different. The superiority of performance in 1997 is kept, however in 1998 it is not so clear (4.96 against 5.01 percent, technically a tie). The conclusion that the subsidized loan of PRONAF does not have impact in 1996 is reinforced (the control group had a growth on productivity very above the PRONAF group), and it is maintained the fact that in 1999 the products benefited by PRONAF presented a growth on productivity below the control group. Looking for evolution of PRONAF group performance during the 1990's, the 1997 and 1998-years present a high growth in productivity, especially in 1997 when the growth was above 8 percent. The negative growth in 1996 was modest (-1.2%) and the average for 1995 to 1999 was 3.3 percent very similar to the control group. However, if we consider just the period 1997 to 1999 the scores are 4.0 against 2.5 percent on annual average favorable to PRONAF group. Undoubtedly the performance of PRONAF main beneficiary products is superior during the relevant year since 1997.

Graphic 1. Growth of multifactor productivity
inputs: plant area, labour, tractors, machine, fertilizer and toxic input.



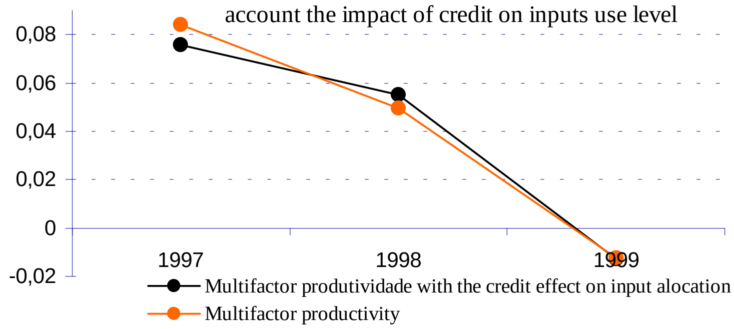
The achieved results on performance analysis may be improved by relaxing the basic assumption of constant share of input (except area) equalized to the uses found on Farming Census. A new drill can be carried out in which the employ of resources to the production of target crops is conditioned by credit. This approach takes into account the effect of credit on allocation of factors and addresses the question of credit effectiveness. As regards the evaluation of credit effectiveness, we should consider the possibility of substitution between the subsidized credit and other sources of financing like other supplies of formal credit, informal one or borrowers' own resources. Disregarding a more detailed analysis of allocation of credit resources, this paper will suppose in the next drill that on target group of PRONAF the subsidized loan granted by this program is employed on production in addition to other previous sources of financing (formal, informal and own resources). In this setting in which we are ignoring the substitution effect for calculation of input index, we will add the previous amount of inputs (used in the context of performance calculation without the credit effect on factor allocation) by an additional use of inputs allowed from purchase financing with subsidized credit.

Unfortunately, we do not have data about the PRONAF loans that was intended for each input purchase by the tree main target crops. If we had these numbers, we would calculate the new input index by using the previous value and quantity of inputs plus the part purchased with PRONAF resources. A conjectural method is employed that allows an approximate calculation. First, we have used dada about share of products on input purchases (from Farming Census) and information about relative purchase of inputs by the PRONAF group (table 11) to obtain quantities of inputs by each product for the four inputs. Second, based on data for input prices (table 13) we can obtain information about the values by crop of theses inputs during the selected years. The next step is to bring together information about PRONAF credit in order to estimate how much loan is allocated to specific inputs by product. By the way, we start from information about the values of loan specify to inputs by southern Brazilian States according Ministry of Agrarian Development. This information is important since the States in question receive the majority of PRONAF credit to the selected product.[11] Analysis that is more detailed can be reach by calculating the percentile share of each input on total PRONAF loans by States. The Ministry of Agrarian Development supplies information about loans by product and by southern States. By using data about loans for each input by southern Brazilian States and information regarding values of loans by State (from the same source) table 14 presents the shares in question by States.[12]

Information about the total PRONAF loans by input as regards all the Brazilian States is presented on table 15. Finally, the last step before our estimation of the share of PRONAF loans to specific input by product is to build a table where the share of the Brazilian Southern States on loans to the tree main products of PRONAF are presented. Bringing together all these data it is possible to do a reasonable estimation since our supposition was accept. Table 16 suggests the composition of loans to input by tobacco, corn and soybean. The methodology to obtain this data is to weight two fundamental information: the share of each States on loans to inputs (table 14) and by each product the share of the tree southern States on overall PRONAF credit (table 17).[13]

The next step is to add to the previous input's values the ever calculated values for machines, fertilizes and tractors. As regards the labour input, our proposal is to relate to labour the entire remaining part of the credit not specific for inputs, i.e., 100 minus the sum of values for each column on table 14. Applying these percentiles to total loans we obtain the effect of credit on wages of labour.[14] Table 18 shows the sum of the tree products, for each input, before and after the credit effect. The input prices are recurring and the theoretical quantities of inputs in the new setting are showing. The calculation of the new input index and the Tornqvist-Theil productive growth is represented on table 19 and the new numbers are compared with the old ones on graphic 2.

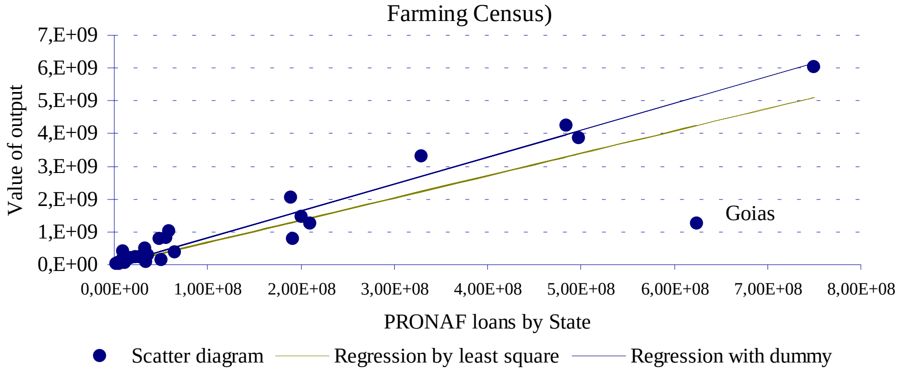
Graphic 2. Growth of multifactor productivity for PRONAF group take into account the impact of credit on inputs use level



The new productivity growth measure in which we take into consideration the effectiveness of credit on input allocation involves a small change on the previous result. The rate of growth in 1997 falls from 8.4 to 7.6 percent. Even so, it is very bigger than the same rate as regards the control group (-1.2 percent). Therefore, although the new analysis has kept the superiority of the target group in 1997 at the new context it weaken the advantage of group favored by PRONAF in this year. At other hand, the improvement of productivity growth in the new setting reinforces the thesis that even in 1998 the target products of PRONAF loans have had a superior growth in productivity. The conclusion for 1999 is the same of the previous analysis. Both suppositions about the degree of effectiveness of credit conduct to the same conclusion reinforcing the idea that the impact of PRONAF credit on productivity was positive in 1997 and 1998.[15]

Up till now the productivity analysis was doing based on the *dual* side. We have fixed the amount of output by each product according the data from IBGE and speculated about what the amount of input that allows this level of production. We did it first with and second without the assumption of substitution of credit. Now, for sake of to complement the analysis we would like to carry out a new approach based on *primal* side: to fix the input and to estimate different level of output on alternative setting. On the *primal* analysis of the productivity impact of PRONAF credit, by asking how would be the performance of favored group of crops if these products did not have taken advantage of subsidized credit allows making the evaluation. In order to perform the analysis we need to know a relationship between credit and value of production. We are not supposing a well-established theoretical relation between credits loaned and output level reached. In fact, we only look for an empirical relationship based on a statistic regression by use of available data. First, we apply a series of loans by Brazilian States in 1996 according last IBGE Farming Census and the values of production by States for a large group of temporary and permanent crops found on IBGE/SIDRA for the same year.[16] By using a cross section, we can find a coefficient for explanatory variable, which measures the impact of credit on production. The scatter diagram is showing on graphic 3 and two econometric estimations are carrying out according two different assumptions about the functional form.

Graphic 3. Relation between credit and production (according to IBGE Farming Census)

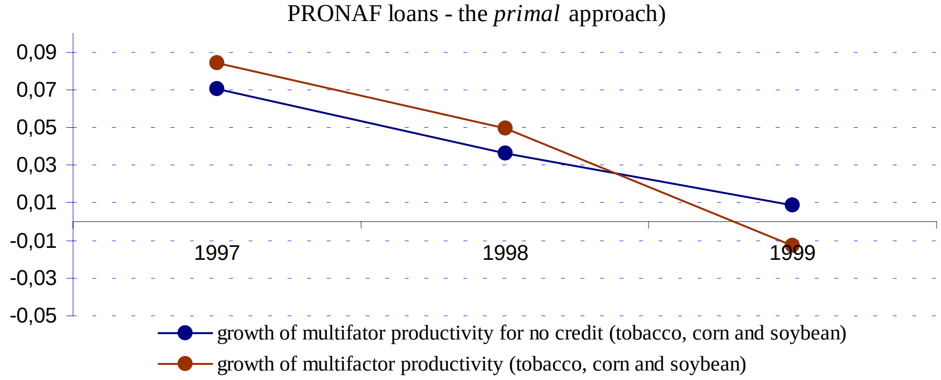


Scatter diagram revels that the points are near a line by ignoring the case of the State of Goiás. We have carried out an econometric estimation on the case of a linear equation that is used to predict value of production. It was estimate with the least square technique. We also have analyzed the situation in which we add a new independent variable, a *dummy*, to take care of the effect of the outlying point for the States of Goiás.

The estimated coefficient for explanatory variable “loan” is 6.79 at the first specification and 8.19 at latter. Both cases the parameters are significant at level of 5 percent or better on a two-tail test (T statistic). However, the R-square shows that in the former model only 77 percent of variation in dependent variable is accounted for by the regression equation while on the latter 96 percent is did. Both cases the Durbin-Watson statistic suggests the accepting of the null hypothesis of zero autocorrelation of residuals (using the traditional region of acceptance of the null hypothesis for d_u to $4 - d_u$ [see Kane, 1968, p.368]). On the model with dummy the F-statistic suggests absence of heteroscedasticy. We appreciated the use of the software Eviews 3.0 that provides us tools for evaluating the quality of your specification along a number of dimensions. Finally, we choose the model with dummy since the better R-square. The estimated coefficient 8.19 suggests a relationship between credit and value of output that we will apply in the primal analysis to estimates the hypothetical effect of absence of PRONAF credit on production.

The adopted methodology substitutes the real values at production series by the hypothetical values that take into account the reduced output due to the absence of credit (using the estimated coefficient). For sake of calculation, whether the value of production became negative as the value linked to credit is subtracted, we assign zero to it like the case of tobacco. Applying this method, we obtain a new output index. Taking the same input index for the case in which it is supposed null effectiveness of credit, the differences between output and input indexes result on a new Tornqvist-Theil index. Table 19 provides the output index that considers the effect of absence of PRONAF credit on production, and the series of the growth of multifactor productivity regarding the same effects. Graphic 4 illustrates the theoretical impact of PRONAF credit absence on evolution of productivity growth. Regarding the select crops favored by PRONAF, the graphic compares this performance with the previous case in which the real series of production is considered (the first analysis). Clearly, in 1997 and 1998 the productivity growth would be smaller if the impact of hypothetical absence of credit on production level was accounted. Note that the intuitive result of smaller productivity growth on absence of credit is not observed in 1999. By comparing the performance of PRONAF main benefitted crops, under the assumption of no credit, with the control group (theoretical also not helped with this special credit), we have 7.0, 3.6 and 0.8 percent of annual growth for 1997 to 1999, respectively by first group, against –1.2, 5.0 and 3.5 percent by latter control group. It means that without the credit in question the target group would have poorer performance than control group in 1998 and 1999. In the last year the result is the same with or without credit, however the positive impact of credit regarding 1998 is stressing by this exercise.

Graphic 4. Multifactor productivity growth (with hyphotetical production for no PRONAF loans - the *primal* approach)



A final simulation before the conclusion of the paper redoes the previous calculation but now instead of to consider the credit on value-of-production estimated coefficient by using a series of very general information from Census, the new approach looks rightly the data about credit and value of production for the selected PRONAF main products (supplied by Ministry of Agrarian Development/BACEN and IBGE/SIDRA). By each year, we can see a relation that can be fitted by a positive line. *For tobacco case*, the econometric regression by least squares suggests a R-square above 0.93 for each year and the parameters are significant at level of 5 percent or better on a two-tail test (T statistic). Other tests reveal absence of autocorrelation of residuals and homogeneity of variance. The estimated coefficient for explanatory variable is 4.01, 3.81 and 4.44 for 1997, 1998 and 1999 respectively. Each coefficient means a regression line. For all years, the new estimated parameters on average are smaller than the previous one by using Census (exactly halfway: 4.09 against 8.18 percent). Appling for each year the respective estimated coefficient for tobacco and using it for calculation the value of reduced production enables new series for input index and a new multifactor productive growth index [see table 19][17].

V. CONCLUSION

Although the single factor productivity index is an unsatisfactory measure, it can be useful since many other characteristic of the specific sector of the economy into which this criterion is applied can be carefully observed. The analysis must be following by independent addressing of different dimension as substitution of inputs, scale biases, capacity utilization, internal and external economies, and market structure that may invalidate the conclusions of partial measure. It is true that these problems are less critical regarding agricultural production in which many studies assume absence of effects that weaken the simple analysis. Faced with the impossibility of a study bases on in-depth survey that separates all these factors the paper chose to complement the single factor analysis by using a multifactor measuring very general and with less restrictive assumptions. The Tornqvist-Theil index is a tool that allows a general measuring of performance for multiple inputs and outputs setting.

First, the paper applies the single factor criterion to a control group and to a selected group of main crops favored by PRONAF. Both cases the group's average was addressing regarding this measuring. The main conclusion either by using output per hectare or output per labour is that on average the growth of partial productivity is positive in 1997 and 1999 and negative in 1998 either for control group or PRONAF main products basket. Other result shows that the PRONAF favored crops partial productivity growth has been superior to control group in 1997 and 1998. This important result is the same regarding the more sophisticated analysis by using the multifactor measuring. However, the multifactor measure also suggests that the productivity growth of the beneficiated group in 1997 and 1998 is also very high at above 5 percent per year. After to reach these results taking into account a restrictive assumption of constant share of inputs during the 1990's at the same level of Farming Census' description, the paper offer two more acute examination by relaxing the previous supposition and adopting a new *dual* analysis in which the use of input increase in proportion of credit loaned. Other refinement considers a new *primal* analysis by which the level of output is decreasingly affected at hypotheses of absence of program's credit. Both exercises do not contradict the former model but do reinforce its main claims.

TABLES

Table 1. *Resources applied by PRONAF non-credit and credit modality (in current Reais).*

Year	1997	1998	1999	2000
Non-credit[a]	41,167,692.00	184,162,444.00	192,382,225.00	*

Banking credit	1,407,724,178.00[b]	1,357,950,605.00[b]	1,644,599,264.64[b]	2,620,000,000.00[c]
Number of contracts[b]	486,435	644,051	717,619	*

[a] *Source*: Ministry of Agrarian Development, Resultados Conquistados 97/99.
[b] *Source*: Ministry of Agrarian Development/BACEN, Crédito Rural do PRONAF 97/99.
[c] *Source*: O Estado de Sao Paulo Newspaper, Suplemento Agrícola, January 3, 2001. * data not available.

Table 2. *Share of the main products financing by PRONAF (in percentile).* [a]

Product / Year	1997	1998	1999	Product / Year	1997	1998	1999
Tobacco	33	32	31	Manioc	3	3	4
Soybeans	20	25	16	Cotton	3	2	1
Corn	16	19	27	Banana	1	1	
Coffee	9	4	5	Tomato	1	1	
Bean	4	4	6	Grape	1		
Wheat	3	3	2	Pineapple	1	1	1
Rice	3	3	3				

[a] *Source*: Ministry of Agrarian Development/BACEN.

Table 3. *Share of the Brazilian states of federation on PRONAF credit (percentile).* [a]

State / year	1997	1998	1999	State / year	1997	1998	1999	State / year	1997	1998	1999
Acre				Maranhão	1	1	1	Rio de Janeiro	1	1	1
Alagoas			1	Mato Grosso	1	1	1	Rio Grande do Norte	1	1	
Amapá				Mato Grosso do Sul	1	1	1	Rio Grande do Sul	31	33	29
Amazonas				Minas Gerais	16	12	10	Rondônia	1	2	3
Bahia	5	6	3	Pará				Roraima			
Ceará	1	1	2	Paraíba		1		Santa Catarina	16	16	16
Distrito Federal				Paraná	15	13	16	São Paulo	3	2	4
Espírito Santo	2	2	3	Pernambuco	1	2	1	Sergipe		1	1
Goiás	1	1	2	Piauí	1	1	2	Tocantins			

[a] *Source*: Ministry of Agrarian Development/BANCEN. Crédito Rural do PRONAF 97/99.

Table 4. *Some Brazilian States Share on PRONAF credit per product.* [a]

State / product	Banana	Bean	Coffee	Corn	Cotton	Grape	Guava	Manioc	Onion	Orange	Papaya	Passion fruit	Peanut	Pineapple	Rice	Soybeans	Sweet potato	Tobacco	Tomato	Wheat
Alagoas	4				1			1		7		24	2	2	1		3	1		
Bahia	20	18	13	2	14	1	33	28	1	23	13	1	2	22					11	
Ceará	8	4		1	19		1	1			30	6	9		7		1		5	
Espírito Santo	1		17									3							2	
Maranhão	1	2		1				23					1	5	20					
Mato Grosso	1				4	1								1	14	1				

Minas Gerais	11	1	32	1	10	1	3	2	6		13	15	1	8	1		2		16	
Paraíba	5	1			10			2			17		14	17	1		2			
Paraná	1	22	13	26	33	39	1	14		6		1	29		2	40		9	6	56
Pernambuco	28	4		1	1	1	49	3		1	11	15		15	2		2		7	
Piauí		13		2	1			7							13					
Rio de Janeiro	2		1				8	3			1	19		9			20		15	
Rio Grande do Norte	4	1			3			5			10			16			4		1	
Rio Grande do Sul	2	13		45		35			34	16			2	1	20	57	13	59	6	44
Rondônia		1	19												2					
Santa Catarina	6	12		16		7			58			8			5	1	7	30	9	
São Paulo	2	2	4	2	2	16	4	1	1	23	1	4	45			1	34		18	
Sergipe		5		1				1		22			5	2	6		11			

[a] *Source*: Ministry of Agrarian Development, Crédito Rural do PRONAF 97/99. Data supplied by BACEN that controls PRONAF cost and part of investments.

Table 5. *Annual Average Monetary Income of real estates (Reais).* [a]

Segments of family farming	Annual Average Monetary Income	Inflated values of AAMI[b]
fa	8,494.00	11,486.66
fb	1,527.00	2,065.01
fc	392.00	530,11

[a] IBGE. Censo Agropecuário 1995-96.
[b] Brazilian Inflation index (IGP-M) that was employed in the calculation: 1997:8.02%; 1998:4.36%; 1999:10.73%,2000:12.57% *Source*: BACEN – Boletim do Banco Central, 1998, 1999 and 2000.

Table 6. *Loans to rural real estates (total and family farming fb and fc). Percentile of previous credit served by PRONAF (comparison with total and fa + fb).*

	Loans to rural real estates [a]		PRONAF credits in comparison with previous credit demand served by banks[b] (%)			PRONAF credits in comparison with previous fb and fc credit served by banks[b] (%)		
	Total	fb and fc	1997	1998	1999	1997	1998	1999
Espírito Santo	56,034,516	3,085,337	40.34	60.34	94.65	732.70	1,095.85	1,719.07
Goiás	624,520,172	37,713,102	2.38	2.33	4.73	39.43	38.64	78.40
Maranhão	36,358,743	981,877	26.34	47.96	50.68	975.28	1,776.08	1,876.70
Mato Grosso	200,455,859	7,046,079	3.96	5.80	11.46	112.67	165.00	326.05
Mato Grosso do Sul	191,456,949	5,165,322	5.86	7.28	19.19	217.09	269.75	711.38
Minas Gerais	328,896,396	6,450,945	70.62	49.59	50.18	3,600.49	2,528.13	2,558.16
Paraná	484,138,972	37,275,250	43.92	36.22	55.01	570.47	470.48	714.54
Pernambuco	48,818,775	2,499,398	40.06	65.95	40.78	782.56	1,288.07	796.62
Piauí	50,199,105	1,806,474	33.00	35.58	73.74	917.05	988.82	2049.02
Rio de Janeiro	9,252,684	875,225	90.90	96.17	132.09	960.95	1,016.65	1,396.40
Rio Grande do Sul	497,736,994	49,813,693	87.33	90.18	94.77	872.64	901.10	946.95
Rondônia	17,383,434	4,483,729	96.46	124.69	255.56	373.97	483.42	990.79
Santa Catarina	209,726,479	33,836,057	109.44	102.73	125.82	678.31	636.78	779.85
São Paulo	749,986,029	39,462,026	4.79	3.99	8.92	91.08	75.86	169.55
Tocantins	34,319,748	1,606,490	14.48	9.97	16.64	309.32	213.04	355.58

[a] *Source*: IBGE. Censo Agropecuário 1995-96.
[b] In accordance with data from table 4 (all products). * Data not available.

Table 7. *Workers held in each selected agriculture product on December 31, 1995.* [a]

CONTROL GROUP						PRONAF GROUP	
Apple	18,39	Juta	28	Pineapple	31,29	Tobacco	457,682
Banana	355,03	Mamona	11,99	Potato	64,95	Corn	983,719
Bean	1,298,05	Mango	72,35	Rice	776,01	Soybean	432,862

Black pepper	15,12	Manioc	1,431,23	Rubber	6,04	**Total**	**1,874,263**
Cashew nut	140,29	Melon	11,44	Sugar cane	579,13		
Cocoa	189,91	Onion	56,23	Tea	60		
Coconut	94,98	Orange	188,70	Tomato	108,10		
Coffee	753,24	Papaya	14,54	Wheat	3,78		
Cotton	150,39	Passion fruit	34,74	**Total**	**6,477,535**		
Grape	58,63	Peanut	11,96				

[a] *Source:* IBGE, Censo Agropecuário, 1995-1996.

Table 8. *Growth of Partial Productivity (product/hectare).* [a]

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999
CONTROL GROUP									
Average	0.059	-0.030	0.002	0.065	-0.001	-0.013	0.056	-0.111	0.152
PRONAF GROUP									
Corn	-0.021	0.233	0.061	-0.043	0.134	-0.074	0.079	0.025	-0,015
Soybean	-0.106	0.273	0.043	0.018	0.016	0.020	0.025	0.025	0.009
Tobacco	-0.118	0.143	0.049	-0.073	-0.044	-0.041	0.169	-0.224	0.267
Average	-0.081	0.217	0.051	-0.032	0.035	-0.032	0,091	-0,058	0,087

[a] The partial (single factor) productivity is measure by $\%\Delta(Y/A)/\Delta t \sim d\ln (Y/A)/dt = d\ln Y/dt - d\ln A/dt$ (where *Y* represents production, *A* is the single factor and *t* denotes time).

Table 9. *Growth of Partial Productivity (product/labour).* [a]

Year	1993	1994	1995	1996	1997	1998	1999
CONTROL GROUP							
Average	-0.016	0.0753	-0.018	0.058	0.049	-0.036	0,097
PRONAF GROUP							
Corn	-0.005	0.082	0.114	-0.053	0.100	-0.081	0.024
Soybean	0.172	0.103	0.034	0.046	0.123	0.197	-0.072
Tobacco	0.140	-0.229	-0.126	0.186	0.226	-0.140	0.158
Average	0,102	-0,015	0,007	0,060	0,150	-0,008	0,037

[a] The partial (single factor) productivity is measure by $\%\Delta(Y/A)/\Delta t \sim d\ln (Y/A)/dt = d\ln Y/dt - d\ln A/dt$ (in which *Y* represents production, *A* is the single factor and *t* denotes time).

Table 10. *Tornqvist-Theil productivity growth index.*

Year	Tornqvist-Theil output index [a]	Tornqvist-Theil input index [b]	e_{yt}	Tornqvist-Theil output index [a]	Tornqvist-Theil input index [b]	e_{yt}
	CONTROL GROUP			PRONAF GROUP		
1991	0.0581			-0.0779		
1992	-0.0104			0.2591		
1993	-0.0514			0.0680		
1994	0.0835	-0.0009	0.0844	0.0689	0.0329	0.0359
1995	-0.0247	-0.0041	-0.0206	0.0520	-0.0052	0.0573
1996	-0.0324	-0.1387	0.1063	-0.1356	-0.1198	-0.0158
1997	0.0112	0.0228	-0.0116	0.1229	0.0389	0.0840
1998	0.0355	-0.0147	0.0502	0.0538	0.0042	0.0496
1999	0.0903	0.0553	0.0351	0.0343	0.0469	-0.0126

[a] Using the formula $0.5*\Sigma_i\ [p_{it} Y_{it}/\Sigma_i\ p_{it}Y_{it} + p_{i(t-1)}Y_{i(t-1)}/\Sigma_i\ p_{i(t-1)}Y_{i(t-1)}\ ]*\ \ln\ (Y_{it}/Y_{i(t-1)})$

[b] Using the formula $0.5*\Sigma_i\ [r_{it} X_t/\Sigma_i\ r_{it}X_{it} + r_{i(t-1)}X_{i(t-1)}/\Sigma_i\ r_{i(t-1)}X_{i(t-1)}\ ]*\ \ln\ (X_{it}/X_{i(t-1)})$

Table 11. *Share of inputs used.* [a]

Soil preservation	Irrigation	MACHINES [b]	Chemical fertilizer	Organic fertilizer	Limestone	FERTILIZERS [c]	TRACTORS	TOXIC INPUTS
CONTROL GROUP								
26.477	40.755	33.616	31.822	27.642	27.450	28.971	21.774	34.342
PRONAF GROUP								
26.552	5.309	15.930	22.829	13.816	27.783	21.476	21.750	21.177

[a] *Source*: IBGE, Censo Agropecuário, 1995-1996. Percentile of real estates which use the input/techniques in proportion to total amount of ones that does declare to adopt it.
[b] Average between the percentile of "soil preservation" and "irrigation".
[c] Average between the percentile of "chemical fertilizer", "organic fertilizer" and "limestone".

Table 12. *Data about quantities of inputs.*

Years	1992	1993	1994	1995	1996	1997	1998	1999
ALL CROPS								
Machines [a]	4,431	5,235	7,724	5,122	3,602	5,663	6,125	5,491
Fertilizers[b]				10,839,371	12,247,600	13,834,064	14,668,570	13,689,482
Tractors [c]	11,727	21,396	38,491	17,584	10,291	15,731	18,676	19,205
Toxic inputs[d]				13,371,338	15,811,018	19,307,270	22,943,927	26,101,144
CONTROL GROUP								
Plantead area [e]	33,784,509	32,922,260	33,405,028	33,268,166	28,531,739	28,844,399	28,100,398	29,878,818
Labour [f]	7,092,524	7,021,709	6,992,212	6,962,714	5,992,356	6,036,861	5,881,149	6,253,355
Machines[g]	1,490	1,760	2,597	1,722	1,211	1,904	2,059	1,846
Fertilizers[g]				3,140,310	3,548,292	4,007,912	4,249,680	3,966,025
Tractors[g]	2,553	4,659	8,381	3,829	2,241	3,425	4,066	4,182
Toxic inputs[g]				4,591,933	5,429,759	6,630,428	7,879,314	8,963,554
PRONAF GROUP								
Plantead area [e]	23.696.801	23.906.226	26.387.620	26.179.048	23.125.858	24.333.624	24.912.327	25.830.014
Labour [f]	2,052,209	2,031,720	2,023,183	2,014,648	1,733,878	1,746,754	1,701,699	1,809,397
Machines[g]	706	834	1230	816	574	902	976	875
Fertilizers[g]				2,319,765	2,621,144	2,960,668	3,139,263	2,929,725
Tractors[g]	2,551	4,654	8,372	3,824	2,238	3,421	4,062	4,177
Toxic inputs[g]				2,831,712	3,348,374	4,088,792	4,858,944	5,527,563

[a] In units. *Source*: ANFAVEA – Associação Nacional dos Fabricantes de Veículos Automotores. The data include automotive harvester, micro-tractors and retroexcavators.
[b] In metric tons. *Source*: ANDA – Associação Nacional para Difusão de Adubos. Fertilizers included: ammonia sulfate, urea, nitrocalcium, ammonia nitrate, calcium and magnesium nitrate, ammonia sulfonitrate, sulfanitro, superphosphate simple, superphosphate triple, phosphate mono-ammonic, phosphate di-ammocic, termophosphate, partially acidify phosphate, potassium chloride, potassium sulfate, potassium and magnesium sulfate, sodium salitre, potassium salitre, potassium nitrate and complex fertilizers.
[c] In units. *Source*: ANFAVEA – Associação Nacional dos Fabricantes de Veículos Automotores. For tractor with wheels.
[d] The SINDAG (Sindicato Nacional das Indústrias de Produtos para Defesa Agrícola) offers values in current dollar in each year (including sales of insecticide, acaricide, fungicide, herbicide and other toxic inputs). Using the annual average exchange series from the Central Bank of Brazil (0.9160; 1.044; 1.0779; 1.1603; 1.8140 Reais/$) we calculated amounts in Reais. Dividing these values by an index price IPP (Índice de Preços Pagos pelos Produtores) supplied by CONAB (Companhia Nacional de Abastecimento), we obtained quantities of toxic inputs for each year. Therefore, the numbers on the table refer to indefinite unit.
[e] Source: IBGE, Produção Agrícola Municipal, SIDRA.
[f] *Source*: IBGE. PNAD - Pesquisa Nacional por Amostra de Domicílios, 1995 a 1999. Workers who are 10 years old or more held in agriculture in a reference period of 365 days, regarding the main economic activity. These numbers are obtained take into consideration the same Census share on total agricultural workers.
[g] Using the respective percentile on table 12.

Table 13. *Data about prices of inputs (in current Reais).*

Years	1993	1994	1995	1996	1997	1998	1999
Planted area [a]	1.71	107.47	102.00	105.19	115.78	115.12	127.40
Labour [b]	42.72	2,096.04	3,492.00	3,874.68	4,218.60	4,399.56	4,619.64
Machines [c]			62,723.30	65,613.64	77,343.89	86,505.55	100,045.18
Fertilizers[d]			255.86	291.93	312.02	311.62	425.65
Tractors [e]			27,495.75	24,668.52	28,042.27	29,537.21	32,544.20
Toxic inputs[f]			105.20	113.88	121.77	129.47	163.08

[a] Prices of land renting for cultivation in Reais/hectare/year. *Source*: FGVDADOS, Getúlio Vargas Foundation.
[b] Annual agriculture labour payment to managers. *Source*: FGVDADOS, Getúlio Vargas Foundation.
[c] Average price for automotive harvester. The amounts are calculated using the exchange relationship (quantities of each product required against a harvester) supplied by Ministry of agriculture – DERAL. Taking into account the prices derived from tables 10 and 11 to rice, corn, soybean and wheat, we calculated the price of harvester associated with each of these commodities and so we obtained the average of these amounts.
[d] Average price in tons of fertilizers. The amounts are calculated using the exchange relationship (quantities of each product required against one ton of fertilizer) supplied by Ministry of agriculture – DERAL. Taking into account the prices derived from tables 10

and 11 to cotton, rice, bean, corn, soybean and wheat, we calculated the price of one ton of fertilizers associated with each of these commodities and so we obtained the average of these amounts.

[e] Average price for tractors of 75 WP (2x4). The amounts are calculated using the exchange relationship (quantities of each product required against a tractor) supplied by Ministry of agriculture – DERAL. Taking into account the prices derived from tables 10 and 11 to cotton, rice, bean, corn, soybean and wheat, we calculated the price of tractor associated with each of these commodities and so we obtained the average of these amounts.

[f] IPP (Índice de Preços Pagos pelos Produtores) for toxic agricultural inputs calculated by CONAB (Companhia Nacional de Abastecimento). Index number base: August 1994 = 100.

Table 14. *Share on loans to inputs for each Southern Sates (percentile).*[a]

	1997			1998			1999		
Credit to inputs as percentile of total credit	MACHINE	FERTILIZER	TRACTOR	MACHINE	FERTILIZER	TRACTOR	MACHINE	FERTILIZER	TRACTOR
Paraná	8.63	0.05	1.26	1.11	0	0.09	0.06	0	0.02
Rio Grande do Sul	4.52	0.05	1.93	1.55	0.01	0.43	0.46	0.00	0.06
Santa Catarina	1.34	0	1.04	0.02	0	0.15	0.06	0.41	0.04

[a] Values on table 17 divided by the total amount of annual PRONAF credit to respective State showed on table 4.

Table 15. *Values (in current Reais) and share percentile of loans to inputs with regarding all the Brazilian States.*[a]

insumos	machines [b]	% [c]	fertilizantes	% [c]	tratores[d]	% [c]
1997	44,207,441.73	3.14	525,433.71	0.04	17,155,604.87	1.22
1998	11,135,116.95	0.82	98,754.05	0.01	3,675,213.65	0.27
1999	4,405,429.21	0.27	915,092.00	0.06	1,182,705.99	0.07

[a] *Source*: Ministry of Agrarian Development. Crédito Rural do PRONAF 97/99.

[b] Sum of the values for automotive harvester, farm equipment, mechanized patrol – other machines and m.p.-harvester.

[c] The percentile takes into account the total amount of PRONAf loans on table 1 (banking credit).

[d] Sum of values for micro tractors, p.m. tractors and tractors.

Table 16. *Share of loans to inputs by product (percentile)* [a]

	1997			1998			1999		
States /inputs	MACHINES	FERTILIZERS	TRACTORS	MACHINES	FERTILIZERS	TRACTORS	MACHINES	FERTILIZERS	TRACTORS
Corn	3.73	0.03	1.40	1.23	0.01	0.30	0.27	0.07	0.05
Soybean	6.23	0.05	1.61	1.37	0.01	0.30	0.29	0.00	0.04
Tobacco	3.96	0.04	1.63	0.98	0.01	0.30	0.29	0.13	0.05

[a] For each year and product combination, the input share is calculated by weighted the share of States on loans to inputs (table 15) using the share of the tree southern States on loans to corn, soybean and tobacco (table 18 below); and since the sum is lesser than 100 percent the part of other States are take into account whose amounts are picking up from table 16. For instance, in 1997 for machines we consider: 0.08*8.63+0,28*1.34+0.64*4.52 = 3.96 for tobacco. In 1997 for corn the southern States adding up 82 percent of PRONAF loan, so we should use a 18 percent weight applied to the value of table 21 (share of machines on loans in 1997): =0.14*8.26+0.35*1.34+0.33*4.52+0.18*3.14 = 3.73 for corn.

Table 17. *Share of Brazilian Southern States on loans to the tree main products of PRONAF (percentile)* [a]

State / year	1997	1998	1999	1997	1998	1999	1997	1998	1999
		Tobacco			Corn			Soybean	
Paraná	8	09	11	14	28	26	43	35	41
Santa Catarina	28	34	30	35	8	16	0	0	0
Rio Grande do Sul	64	56	56	33	54	45	53	61	56

[a] *Source*: Ministry of Agrarian Development. Crédito Rural do PRONAF 97/99.

Table 18. *Credit effect on quantity of inputs.*

	1996 [a]	1997	1998	1999
MACHINES				
Previous Amount (Reais)	37,650,165.85	69,775,283.64	54,795,263.13	87,513,817.41
Credit effect	53,810,197.50	91,214,913.81	60,563,352.45	88,958,276.80
Price	65,613.64	77,343.89	86,505.55	100,045.18
Quantity.	820	1,179	700	889
FERTILIZERS				
Previous Amount (Reais)	767,857,703.30	927,003,687.70	981,658,123.50	1,251,397,856.00
Credit effect	768,003,449.90	927,199,492.30	981,698,282.90	1,251,805,598.00
Price	291.93	312.20	311.62	425,6544886
Quantity	2,630,780	2,972,615	3,150,335	2,940,896
TRACTORS				
Previous Amount (Reais)	55,214,191.09	95,944,378.80	119,978,470.30	135,937,061.90
Credit effect	60,574,249.38	103,308,120.80	121,460,239.90	136,183,287.10
Price	24,668.52	28,042.27	29,537.21	32,544.20
Quantity	2,456	3,684	4,112	4,185
TOXIC INPUTS				
Previous Amount (Reais)	396,356,546.40	97,894,354.10	629,111,223.4	901,467,353.4
Credit effect	396,356,546.40	497,894,354.10	629,111,223.4	901,467,353.4
Price	113.88	121.77	129.47	163.08
Quantity.	3,480,475	4,088,894	4,859,065	5,527,649
LABOUR				
Number of workers	1,733,877	1,746,755	1,701,700	1,809,397
Previous	6718219386	7368859687	7486730338	8358762289
Credit effect	7038487635	7809074545	7971311678	8870536058
Price.	3,874.68	4,218.60	4,399.56	4,619.64
Quantity.	1,816,534	1,851,106	1,811,843	1,920,180

[a] For 1996 we use the same share of 1997 and the amount of PRONAF credit showed on Silva [1999].

Table 19. *Tornqvist-Theil productivity growth index for the tree main products financed by PRONAF.*

Year	Tornqvist -Theil output index [a]	Tornqvist -Theil input index [b]	TT input index – credit effect on inputs [b]	TT output index – no PRONAF credit [a]	TT output index – no PRONAF credit (tobac. coef.) [a]	e_{yt}	e_{yt}'	e_{yt}''	e_{yt}'''
1991	-0.0779								
1992	0.2591								
1993	0.0680								
1994	0.0689	0.0329				0.0359			
1995	0.0520	-0.0052				0.0573			
1996	-0.1356	-0.1198				-0.0158			
1997	0.1229	0.0389	0.0473	0.1093	0,0944	0.0840	0.0756	0.0704	0.0554
1998	0.0538	0.0042	-0.0013	0.0405	0,0525	0.0496	0.0551	0.0363	0.0483
1999	0.0343	0.0469	0.0473	0.0555	0,0197	-0.0126	-0.0130	0.0087	-0.0271

[a] Using the formula $0.5*\Sigma_i [p_{it} Y_{it}/\Sigma_i p_{it}Y_{it} + p_{i(t-1)}Y_{i(t-1)}/\Sigma_i p_{i(t-1)}Y_{i(t-1)}]* \ln (Y_{it}/Y_{i(t-1)})$

[b] Using the formula $0.5*\Sigma_i [p_{it} v_t/\Sigma_i p_{it}v_{it} + p_{i(t-1)}v_{i(t-1)}/\Sigma_i p_{i(t-1)}v_{i(t-1)}]* \ln (v_{it}/v_{i(t-1)})$

e_{yt} => growth of multifactor productivity for hypothesis of constant share of inputs use.

e_{yt}' => growth of multifactor productivity take into account the effects of PRONAF credit on use of inputs.

e_{yt}'' => growth of multifactor productivity with effects of eliminating PRONAF credit on production.

e_{yt}''' => growth of multifactor productivity with effects of eliminating PRONAF credit on production (for tobacco).

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NOTES

[1] Binswanger and Khandker [1995] argument that better rural credit markets lead to a higher volume of agricultural output than would be attainable with a less developed credit system by two effects: **the liquidity effect of credit**, in which additional credit supply can raise input use and hence output; and **the consumption smoothing effect of credit** in which better credit facilities help farmers smooth out consumption and, therefore, increase the willingness of risk-averse farmers to take risks and make agricultural investments.

[2] This study use only public information easily gathered. Any data are obtained *in locu* using a sample of farms. This represent a limitation of the research, however it has the merit of to built a method of evaluation of specific social credit initiatives by employing macro-data broadly useful in other context.

[3] Although this is the more common term, multifactor productivity is the more accurate title, since some non-conventional inputs (such as R&D expenditures) are excluded from the calculations.

[4] In general, the properties with negative gross monetary income are not productive enterprises, but places for weekend leisure, and can be ignored by the analysis.

[5] This statements obviously is an approximation that is not so far from reality taken into account that 61 percent of the total credit loaned into this programme was toward the Southern States in 1999, or that on average more than 62 percent of the production of the three products are made in those States that have a family farming structure, and 74 percent of PRONAF credit were granted to these products in 1999.

[6] The products inside the control group are: apple, banana, bean, black pepper, cashew nut, cocoa, coconut, coffee, cotton, grape, *juta*, *mamona*, mango, manioc, melon, onion, orange, papaya, passion fruit, peanut, pineapple, potato, rice, rubber extractable, sugar cane, tea, tomato and wheat.

[7] Plant area is used instead harvested area, as usual in other studies, because we consider that the criterion of planted area better grasps the productive effort and opportunity cost.

[8] Although this information has been gathered in both partial productivity measuring, we should mind the limitations of single factor productivity index that ignores substitution of inputs among other problems.

[9] The subsidized loans from PRONAF is important since 1996, although in this year the total value of loans was circa 650 million Reais very under the 1,637 million in 1997. Take into account the time gap we would expect that the productivity impact of program happen a favorable performance growth from 1997 on. This is what the analysis are indicating except in 1999.

[10] To obtain a set of input series, the paper takes the supposition of constant share during the years in question, i.e., the same proportion of purchases found on Farming Census between 1995 and 1996 is supposed to prevail for other 1990's.

[11] As the data set do not offer information about "machines", we add the values of the categories automotive harvester, farm equipment, mechanized patrol/other machines and m.p./harvester for this item. For "tractors" the values added up micro tractors, p.m. tractors and tractors itself. Tractors are an item directly available on the data set of Ministry; it does not supply information about toxic inputs.

[12] The large part of credit contracts are not specific to the purchase of specific inputs, therefore the borrower seems to have a substantial room of maneuver in the use of subsidized credit, at least in terms of the record of information by banks.

[13] Since the sum of the weights is lesser than 100 percent the part of other States are take into account whose amounts are picked up from table 15. Table 16 explains in bottom note the detail of the calculation. Note that these percentiles on table 17 take into account all the credit granted by PRONAF (banking credit). It is crucial to obtain these percentiles since they allow calculating the value of loans by selected input and product. The values reached by this method can be directly added to the previous values related to each input for the target products and so it provides a measure of productivity growth that consider a more realistic approach into the calculation of input index. The two previous approach of calculation of Tornqvist-Theil index allow locating the real rate of productivity growth inside the area between two borders: the measure without the credit effect on allocation of inputs (first drill in the paper), and the measure with complete effectiveness. The first assumption is an extreme one since after to the beginning period of PRONAF credit operation on ahead the effect of subsidized credit on relative allocation of inputs among different crops is ignored. This is equivalent to the supposition of null effectiveness. The latter assumption implies perfect effectiveness of credit.

[14] As we do not have specific information for toxic input, we kept unchangeable the values for these inputs.

[15] Some criticism is admitted with regarding the paper's supposition that the evolution of productivity of the tree products tobacco, corn and soybean can be representative of the overall program outreach. Mainly since 38 percent of soybean has occurred on centre-western States where only 5 percent of loans are intended. Many causes can be quoted on an explanation of why the growth of productivity of the basket of PRONAF main products was an exceptional one. It is difficult to untangle in empirical work all the piece of the puzzle in order to separate what should be related to subsidized credit and what is due to, for instance, the technological improvement thanks to the new genetically modified seed. The credit cannot be seen as an input. The productive impact of credit is to allow the adoption of new technologies not available when the farmer does not take advantage of facilities supplied by special credit program. The loans from PRONAF have facilitated the access to new technology and the productivity growth analysis approach is looking for to measure this fact. It is translated by a change on the production function. The conclusion of the previous analysis suggests such change, but additional study should complement the preliminary addressing supplied by this paper.

[16] For both groups, 61 products are included.

[17] In the new setting the productivity growth falls ever more in 1997 to 5.5 percent, regarding 1998 the growth nearly stays at the same level (4.83 against 4.96 to actual production series). Surprisingly, the drill revels some benefic impact in 1999 since the growth with actual series (-1.26 percent) is better than the theoretical growth for no credit (-2.71 percent by using the tobacco coefficient). While this last exercise keeps the conclusion about 1997-year (now with less emphasis) that the productive impact of PRONAF has been positive, it weaken the same favorable conclusion regarding 1998 and suggests that the impact in 1999 can be positive in terms of a with or without credit comparison. More accuracy in this calculation about the impact on output level of absence of subsidized credit cold be reached by using not just the estimated coefficient for tobacco but by taking into account a weighted average of coefficients for tobacco, corn and soybean. Notwithstanding, the relationship between PRONAF credit and production cannot be well fitted by a linear regression regarding this other crops. The scatter diagram for corn and for soybean suggests a clearly non-linear relationship between PRONAF credit and values of production on these crops. The explanation is that some States has a patron-organized basis on production so the farmers do not take advantage of the subsidized family farming credit. For instance, while the State of Mato Grosso produces 20 percent of soybean it receives only 1 percent of the program credit to soybean on average (see table 3). Obviously, the estimation by least square is not significant in theses cases.