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Full Length Research Paper

Analyzing the performance and the resource allocation of the dairy production in Rolim de Moura municipality, Rondônia, Brazil

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The present study aimed to calculate indicators of productivity of dairy farmers in the municipality of Rolim de Moura, Rondônia, in the north region of Brazil and to evaluate the efficiency of producers by the perspective of productive efficiency, technical and scale. The data is of primary nature, gathered through questionnaires sent to 77 farmers of the Rolim de Moura municipality. The sample for this research consists of producers that are part of an agreement with SUFRAMA for the installation of cooling units. The efficiency measures were predetermined for each production units *(Decision Making Unit* - DMU), using the technique of data envelopment analysis (DEA) and *DEA-EDIS* software v. 1.0. Initially, producers were divided according to the degree of efficiency and then compared by socioeconomic indicators in order to determine the level of the performance of the efficient and the inefficient producers. We concluded that in this group, there is a predominance of inefficient producers (efficiency scores less than 0.9), representing 83.12% of the sample. It is therefore a very low number of efficient producers (16.88% of the sample). In general, efficient producers showed successful production numbers. The main production factors that contributed to the inefficiency of producers were the operating expenses, productivity of both land and the herd, which was confirmed by the disadvantageous relationship between selling price and average cost of production. With this observation, milk producers considered technically inefficient should minimize the use of inputs mirroring for that of their benchmarks, because there is sufficient margin to support the reductions specified in the study presented.

Key words: Productivity, efficiency, livestock, milk.

INTRODUCTION

The economic, technological, political, social and cultural changes that occurred in recent decades have provided an environment of instability for the organizations. Strengthened strategical alliances are the path to survival in face of globalized markets. As a result, a series of demands, risks and opportunities emerge, establishing the need for organizations to undertake a broad overhaul in their structures and strategies to remain competitive.

The Brazilian agribusiness sector, likewise, has also been deeply influenced by all these changes. The dairy productive chain, as part of the agribusiness sector, has been one of the most affected by this new market reality. Until the year 1990, the productive model was characterized by a vast majority of small and medium producers with low level of expertise, organization and quality – but this scenario began to change. Production levels, quality and efficiency became a necessity and obliged producers to review their production method and management.

The Brazilian milk producer, in addition to improvements in productive activities and management, has been encouraged to adapt to the new legislation, which establishes technical standards of production, identity and status, and were implemented through the

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National Program for Improving Milk Quality (Programa Nacional Melhoria da Qualidade do Leite - PNQL). Despite the efforts of producers to professionalize their operations, the technical, managerial and normative demands of the dairy chain in Brazil have been growing. Additionally, there are remarkable impositions made by large industries and the ones made by the concerning legislation. Given this new scenario, producers have been lead to seek new technologies to increase their competitiveness. Moreover, this scenario suggests enormous difficulties for the small producers to remain in this sector, especially those that adopt technologies that are not much productive. The problem gets worse when the analysis includes the need for investment in technological change, resource-poor rural credit, and with high tax rates, as is the case in Brazil in recent years. (Revista, 2002: 60). It is believed that those producers who do not have enough land, financial resources, access to technology and management skills that are essential to grow and be competitive will be excluded from the activity.

This paper reviews the efficiency of milk producers of the municipality of Rolim de Moura in the state of Rondônia, in the north region of Brazil, in face of the changes occurred in the recent years through indicators and strategies adopted to improve production. In order to achieve our goals, primary quantitative and qualitative data was gathered through questionnaires. Our sample composed of 77 milk producers of the Rolim de Moura municipality, which are part of an agreement with the Superintendence of the Manaus Free Economic Zone project (Superintendência da Zona Franca de Manaus – SUFRAMA) that finances the installation of cooling units. The efficiency measures were predetermined for each of the production units *(Decision Making Unit* - DMU) using the technique of data envelopment analysis (DEA) and *DEA-EDIS* software v. 1.0. The deterministic methods used to measure performance usually involve non-parameterized mathematical programming models (including the DEA) in which there is no assumption regarding the variable “production process”. A function of “best practices” is built empirically from the observation of inputs and outputs. Differently of parameterized models, the objective is not to compare each unit with a non specified average, but to establish “best practices” norms, something that the units that are below the average may aspire (Norman and Stocker, 1991; Fried et al., 1993).

Benchmark

In 2008, the state of Rondônia produced 723 million liters of milk, which accounts for 43.42% of regional production and ranks first in milk production in the north region, alternating with the state of Pará for the lead over the years. From 1998 to 2008, while milk production in Brazil grew at average rate of 4.2% annually, in the state of Rondônia the production grew 8.54% per annum (Rodrigues et al., 2009). This performance is explained by the prevailing low production costs, together with factors such as the abundance of rainfall, poor use of manpower, market directed towards industrialization and especially, the low or no input being highly focused on one activity family farming. However, the lack of logistics and infrastructure that should be provided by the state as well as lack of technical assistance prevents the industry of the primary production of the milk supply chain from meeting the quality requirements of the dairy that multiply and increasingly specialize and limit the arrangement of milk production in the state (Paes-de-Souza, 2007).

Furthermore, according to the same author, this situation causes uncertainty, frailty and loss of competitiveness in the arrangement, directly affecting the segment of industrialization which being represented by dairy, suffer systematic supervision and punishment resulting from the lack of quality. However, in the analysis performed on the milk producers of state of Rondônia, it was noted that there are great difficulties in identifying factors that make producers more or less efficient. Nonetheless, using the model of efficient frontiers and a set of inputs shows that inefficient producers can reduce the quantity of inputs used in order to reduce inefficiency.

METHODOLOGY

The research was conducted using the “Data Envelopment Analysis (DEA)”, a tool that enables analytical and quantitative measure and evaluates efficiency. It can be regarded as an operational research technique of production units. It was initially developed by Charnes et al. (1978) to determine the relative economic efficiency of enterprises excluding the financial aspect, while dealing with multiple inputs and outputs. For Fitzsimmons and Fitzsimmons (2000), the “data envelopment analysis involves the use of linear programming to construct a boundary on the non-parametric data, where efficiency measures are calculated in relation to the border”. The DEA is one of the most appropriate tools to evaluate the efficiency compared to conventional tools because their results are more detailed than those obtained by other techniques as it better serves the recommendations of a managerial nature (Zhu, 2002). The advantages of DEA in comparison to other efficiency analysis techniques are justified by its characteristics (Marinho, 2001):

(1) DEA characterizes each decision making unit (DMU) as efficient and inefficient through only one summary measure of efficiency;
(2) It does not make judgments *a priori* over the values of weighing of inputs and outputs which would take DMUs to the best level of efficiency possible;
(3) It may rescind (but does not reject) from price systems;
(4) It exempts (but may accepts) pre-specifications of underlying production functions;
(5) It may consider systems of preferences of evaluators and managers;
(6) It bases itself in individual observations and not in medium values;
(7) It allows the incorporation in the analysis of inputs and of products valued in different measuring units;
(8) It enables the verification of optimal production values and consumption and rejects feasibility restrictions;
(9) It allows the observation of efficient units as reference to

inefficient units;
(10) It produces efficient allocated results, in the sense of Pareto.

For Macedo (2004), the most important feature of the DEA methodology “is the characterization of an efficiency measure, which makes the decision to be guided by a single indicator built from several different approaches to performance”. It is noteworthy that this greatly facilitates the decision making process, because instead of considering various indices to conclude about the performance of the company or unit under review, the manager uses only the DEA efficiency measure. In addition, there is other information extracted from this methodology that can be used to assist the company in pursuit of excellence.

Characteristics and limitations of the DEA method

According to Guedes (2002), the DEA, as a non parametrical evaluation method, has some distinct characteristics relative to other methods. In contrasting with parametric methods in which the objective is to optimize a simple regression plan, the DEA optimizes individually each one of the observations, one regarding the others, in order to determine efficiency frontiers. The traditional parametrical analysis applies the same production function to each observation. Therefore, the focus of the DEA is on optimizations as a counterpart to the estimations of parameters of statistical approximations used by other methods.

As to the application of the method, some conditions must be satisfied: i) the organizations that are under analysis must be homogenous, that is, perform the same tasks and have the similar objectives; ii) the organizations must act under the same market conditions; and iii) the variables (inputs and outputs) must be the same, presenting variations only regarding their intensity or magnitude (Golany and Roll, 1998). The methodology presents some positive characteristics that make it useful for efficient measurement. According to Charnes et al. (1996), these positive characteristics are: i) it operates with multiple inputs and outputs; ii) it is not necessary to estipulate the functional form; iii) it generates only one performance score relative to other units; iv) it differentiates efficient from inefficient units; v) it defines the resources and calculates the level of inefficiency of inefficient units; vi) it manages to detect specific deficiencies that may not be detected by other techniques.

In spite of presenting many positive characteristics, the DEA has some limitations. According to Niederauer (2002), as an extreme point method, the analysis is sensitive to noises such as measuring errors or extreme values; as the number of variable grows the chance of more units achieving maximum development also increases. Being DEA a non-parametrical technique, it becomes difficult to formulate hypothesis and statistics; and at last, it estimates well the “relative” performance, but it converges very slowly to the “absolute” performance as it is based on observed data and not on the optimal or desirable.

Location of study

This study was conducted in the municipality of Rolim de Moura, located in the Zona da Mata region in the state of Rondônia. The choice of the municipality as an object of study was motivated by the observation of a considerable volume of investments in dairy farming carried out by the federal and state governments.

Source data

The primary data refer to the year 2008 and were collected in 2009 and entered into the database developed on the Ms Access, 2003 version, of the Center for Interdisciplinary Studies on Sustainable Development in Amazonia, CESDA, as part of the project of assistance in monitoring the actions of municipalities and adjacent rural communities that hold milk cooling tanks financed by the Superintendence of the Manaus Free Economic Zone (Superintendência da Zona Franca de Manaus – SUFRAMA), which subsidizes the APL Milk in Rondônia.

Instruments and procedures for data collection

To collect the qualitative and quantitative data needed to evaluate the efficiency for this research, 108 farmers were interviewed of which 31 farmers were excluded for lack of consistency of information considered essential in the analysis. The research included 77 producers in the study, with application forms previously tested and prepared for this purpose.

Analysis methods

The analysis was developed at various stages. The first step was to establish the efficiency measures for each decision making unit (DMU) through data envelopment analysis (DEA) using the software DEA-EDIS v. 1.0 developed by Surco (2004). In the next stage, the producers were separated according to the degree of technical efficiency and compared according to socioeconomic variables and some technical and financial indicators in order to determine the profile of efficient and inefficient, identifying best practices, as well as those to be redirected.

Description of variables

To run the model, it was necessary to construct two data matrices, one containing the inputs used by producers and another related to the products. The matrix of inputs X of order ($k \times n$), consisted of k inputs, used by n producers. The Y array of products of order ($m \times n$,) is composed of m products, produced by n producers. In this study, five variables were used, corresponding to the inputs ($k = 4$), and one related to the products ($m = 1$). They are:

(i) Y1- Annual production of milk in liters.
(ii) X1- Area for the cattle measured in acres, and obtained by adding up the areas with pasture (natural and trained), sugar cane, grass and silage. This factor is important both for its influence on the production of green as for the high share of land value in the total capital of the company.
(iii) X2 - Total number of cows, considering both the lactating and the failed ones. This is an important variable, since several studies related to milk production of cows consider productivity as a performance measure of the activity.
(iv) X3 - Effective operational cost obtained by summing expenditures on hired labor, concentrates, minerals, maintenance of green fodder, silage, drugs, hormones, improvements and repairs of machines, milk transport, taxes, artificial feeding, materials milking, energy and fuel.
(v) X4 - Capital invested in improvements, machinery and animals.

These variables were also used by Arzubi and Berbel (2002), Gomes et al. (2003) and Roberts (2003). After organizing the data matrix, it was applied using the models in all the orientation input to obtain the efficiency measures, since it is intended to find the proportional reduction in input use by producers, without compromising production. To obtain the measures of technical efficiency for each producer sample it was drawn, first, the linear programming problem, assuming constant returns to scale. Then this measure of technical efficiency was decomposed into a pure

Table 1. Distribution of producers at two intervals for measurement of the efficiency and scale obtained in models that used the DEA methodology.

Level of efficiency (E)	Technical efficiency Number of producers		Efficiency of scale (number of producers)
	Constant returns	Variable returns	
E=1.0	08	15	08
0.9 ≤ E< 1.0	05	06	40
0.8 ≤ E< 0.9	06	08	09
0.7 ≤ E< 0.8	06	06	06
0.6 ≤ E< 0.7	11	12	08
0.5 ≤ E< 0.6	06	04	02
0.4 ≤ E< 0.5	13	08	02
E < 0.4	22	18	02
total	77	77	77
Measures of efficiency			
Average	0.57	0.66	0.86
Standard Deviation	0.26	0.27	0.17
Minimum	0.17	0.19	0.28
Maximum	1.00	1.00	1.00

measure of efficiency and an efficiency of scale, through the formulation of a new linear programming formulation, assuming variable returns when it is identified the bands of returns to scale in which producers are operating. Considering that:

$$EE = \frac{ET_{RC}}{ET_{RV}}$$

Where EE is the measure of scale efficiency; ETRC is the measure of technical efficiency in the model with constant returns, and ETRV is the measure of technical efficiency in the model with variable returns. The inefficiencies of scale occur when producers are operating in the bands of increasing or decreasing returns- that is outside the range of correct production. In those operating outside the optimum range, it was identified in which range of returns to scale they are located in order to determine the motion to be adopted in the design of production to reduce inefficiency. To identify the band of incomes responsible for the scale inefficiency, a linear programming problem was formulated with constraints of non-increasing returns to scale.

RESULTS AND DISCUSSION

The results are presented in two sections. In the first one, the technical efficiency and the scale of the milk producers is presented. In the second section, the groups of efficient or inefficient producers are identified. Lastly, the analysis of economic and productive technical performance between groups of efficient and inefficient producers is made.

Technical and scale efficiency of the producers

The results of the technical efficiency measures with constant returns and variables and the efficiency measures are shown (Table 1). In average, the producers had an efficiency of 0.57 under the assumption of constant returns. In other words, the producers could reduce expenses with minimum input in 43% and yet be able to produce on the same level. Individual measures showed that of 77 producers, 8 are operating with efficiency equal to one, meaning that only 10.38% of producers achieve maximum technical efficiency. The maximum technical efficiency implies that there is no other producer more efficient producing in the same level using the same combination of inputs. Above the efficiency average of 0.7, we observed that 25 producers (or 32.5% of the sample) and 35 producers or 45.5%, have efficiency measure below 0.5.

To capture the effect of production scale in the degree of technical efficiency, the assumption of constant returns and obtained the models with variable returns to scale was loosen-up by adding the convexity constraint on the models with constant returns to scale. When considering these returns variables, the number of efficient producers rose from 8 to 15. As noted earlier, a condition for the producer to present maximum technical efficiency with constant returns to scale is that their technical efficiency, when considering variable returns is also maximum. This means that out of the 15 producers with technical efficiency equal to one in the model with variable returns, 8 of them are equally efficient in the model with constant returns. In addition, the standard deviation of the average in the model with variable returns was higher than that calculated in the model with constant returns. This indicates a higher concentration of producers in the strata of greater efficiency measures, which can be observed.

As with constant returns, the number of producers with average technical efficiency of more than 0.7 was 25,

Table 2. Daily production, dairy herd size, area for cattle and measurement of technical efficiency of producers in the sample separated by a production scale (Rolim de Moura, 2008).

Specification	Optimal (Constant)	"Suboptimal" (Crescent)	"Supra-optimal" (Decrended)
Number of producers	8	56	13
Production (liter/day)			
Average	143	59	107
Minimum	39.5	13	56
Maximum	298	150	256
Total number of Cows (cab.)			
Average	43	37	53
Minimum	12	3	31
Maximum	89	146	120
Number of cows in lactation (cab.)			
Average	26	19	24
Minimum	4	2	11
Maximum	62	140	41
Area for the cattle (ha)			
Average	17.25	59	93.28
Minimum	8.39	13	33.59
Maximum	57	150	162.13
Technical efficiency			
Constant Returns	1	0.51	0.59
Variable Returns	1	0.62	0.61

while in the case of variable returns that number rose to 35, or approximately 40%. At the other extreme, the number of producers with technical efficiency below 0.5 increased from 35 (constant returns) to 26 (variable returns).

It was also observed that the average technical efficiency with variable returns was higher than the average with constant returns. These better results were found due to the fact that the model with variable returns does not take into account the existence of scale inefficiency. The measure of scale efficiency is obtained by the ratio between the measures of technical efficiency, the models with constant returns and variable returns. If this ratio is equal to one, the producer is operating at optimal scale. Otherwise, the producer is technically inefficient, since it will be operating at optimal scale and may be operating with increasing or decreasing returns to scale. It should be noted that the optimal scale for the DEA technique relates to operating with constant returns to scale and not necessarily at the minimum average cost curve in the long run. As it can be seen in Table 2, out of the sample of 77 producers, 56 are in the range of increasing returns, which represents about 73% of the sample. This implies that these producers can increase their technical efficiency by increasing the size of its production. Furthermore, 13 producers are operating in the range of diminishing returns, representing 17% of the sample. These producers can increase their technical efficiency, if they reduce the size of production.

Meanwhile, after separating the producers for production scale, several variables were analyzed related to the size of the activity. The data in Table 2 refers to the average of these variables for the producers separated according to the scale of production. Results indicate that 56 producers are operating below optimal scale, that is - they could increase production with decreasing costs. If these producers increased the size of production to achieve optimal scale, they could increase the technical efficiency, from 0.51 to 0.62 on average. This represents an average increase of 11 percentage points in the measure of technical efficiency. Furthermore, 13 producers are operating above optimal scale, that is - they are spending a lot of what they produce. If producers started to operate in optimal scale, it would result in an increase of two percentage points in the measure of technical efficiency. Interestingly, even when operating

Table 3. Distribution of farmers according to level of efficiency.

Variable	Efficients	Inefficients
Number of producers	13	64
Sample (%)	16.88	83.12
Average efficiencey	0.98	0.48

outside the optimal scale, the average technical efficiency of the largest producers (supra-optimal) is significantly higher than that of small (suboptimal).

Identifying groups of efficient and inefficient producers

The classification of efficient and inefficient producers was made according to the measurements obtained by the assumption of constant returns. Efficient producers were those who obtained efficiency scores above 0.9, and those with inefficient efficiency measures below that measure. Following these definitions, there were 13 efficient producers, equivalent to 16.88% of the sample, and of these, five showed efficiency measure less than 1. Likewise, the group of inefficient represents 83.12% of the sample, equivalent to 64 producers (Table 3). It is observed that the average technical efficiency is 0.98 for efficient producers since producers are included in this group with efficiency measures between 0.9 and 1.0. So there is no violation of the efficiency hypothesis, as described previously. For the inefficient producers it was noted that the average efficiency is 0.48, which indicates the possibility of reduced use of inputs by 52%, maintaining the same level of production.

Roberts (2003) while analyzing milk producers in Rondônia obtained an average of efficiency inferior to the actual study; the inefficient group presented technical efficiency measure of 0.39, which indicates that the utilization of inputs may be reduced in up to 61%, although they continue to produce the same amount. As to the efficient group, the average calculated for technical efficiency was of 0.91, meaning that the utilization of inputs may be reduced in up to 9%. However, Silva (2007) while analyzing the milk producers of the state of Ceará (in the northeastern region of Brazil), realized that the average technical efficiency of the set of producers was of 80.16%; the group of less efficiency achieved 51.95% and the one with more efficiency achieved 95%, meaning that the volume of inputs could be reduced in 5%. To Gomes et al. (2005), a level of efficiency above 70% cannot be considered low; however, it demonstrates that there is still room for increases in productivity by means of efficiency increase.

Profile of efficient and inefficient producers

Note that virtually all measures were conducive to efficient producers, which have average annual production of 40,748.8 L, considering the joint product of the activity converted into milk equivalent, while inefficient producers have annual production of 25,020.02 L, a difference of 63% (Table 4). The relationship between lactating cows and the total number of cows also showed difference between efficient and inefficient producers, 59 and 45%, respectively. Efficient producers gained productivity of lactating cows from 6.1 to 4.2 L and efficient producers / milk cow / day for the inefficient producers, considering a lactation of 300 days. If we considered the total number of cows in the herd, it is observed that the productivity of cows is 3.3 liters to 2.1 liters and efficient cow / day for the inefficient. The productivity of dairy cows is 45% higher for the efficient producers, so that there are produced 6.1 L, compared with 4.2 L produced by inefficient producers. Thus, by observing the productivity of the herd, it is noticed that the higher the productivity measured for this indicator, the better the degree of efficiency of firms with producers with higher efficiency to produce on average 10 , 57 l / cow / day, considering a lactation period of 300 days.

As for the productivity of land, it appears that as the inefficient producers produce 453.33 liters / hectare / year, efficient producers produce 1412.32 liters / hectare / year, which corresponds to a productivity of 211% efficient on top of the inefficient. In relation to land productivity, efficient producers had 211% higher over the inefficient, which must be explained by the smaller area available for the first. On the subject of cost, the difference is even greater: for every liter of milk produced by efficient producers, the operating cost is R $ 0.19, while for the inefficient producers it has an operational cost of R $ 1.24 per liter of milk, generating a difference of 552% for most inefficient. Concerning capital, it was found that for every liter of milk produced the efficient immobilize R $ 0.52, versus R $ 1.38 observed for the inefficient, thus representing a 165% higher performance. Furthermore, is was discovered that efficient producers have greater relative cost with family labor, as the average difference between productivity and labor-intensive total is 47% higher for the efficient producers. However, they have better use of factors of production.

Conclusions

Cattle milk represents an important segment of agribusiness in the economy of the state of Rondônia. Research on efficiency becomes important in order to contribute to increased productivity and also to determine the possible determinants of inefficiency and the means to increase efficiency, such as presentation of technological and socio-cultural profiles of efficient and inefficient producers, indicating practices that positively influence efficient producers. Thus, it is expected that the results also reflect the situation of the municipality and similar regions, given the small variability in their

Table 4. Performance of dairy production in the municipality of Rolim de Moura, RO.

Performance indicator	Unit	Efficients	Inefficients	Efficient/ Inefficient (%)
Volume of annual production (average)	Liters	40,748.80	25,020.02	62.86
Lactating cows / total cows	%	59%	45	31
Production per lactation	Liters/cow lactation	1,832.99	924.52	9.26
Productivity lactating cows	Litros/cow lactation/day1	6.1	4.2	45
Total yield of cows in the herd	Liters/cow/day1	3.3	2.1	57
Land productivity	Liters/hectares/year	1.412,32	453.33	211
Productivity of manpower	Liter/R$	2.14	1.45	-47
Productivity of invested capital	Liter/R$	0.52	1.38	165
Productivity operating cost (TOC)	Liter/R$	0.19	1.24	552
Product. Reverse capital assets	R$/Liter	0.52	1.38	-165

*Considering lactation of 300 days.

production structure. This study, as characterized previously, tried to acquaint with the producers of milk regarding its efficiency as well as the conditions that influence the variation of efficiency indices. The analysis shows that producers have distinct competitive advantages among the factors of production: area, amount of cows, capital investment, and operating cost. This situation is accentuated even more when two producers are compared. The main production factor that contributed to the inefficiency of producers was operating expenses confirmed by the disadvantageous relationship between selling price and average cost of production. With this observation, milk producers considered technically inefficient should minimize the use of inputs mirroring that of their benchmarks because there is sufficient margin to support the reductions specified in the study presented.

The permanence of inefficient producers in activity may be due to the high cost of exit, given the existence of a productive structure consisting of fixed assets, which hampers or prevents the change of activity by producers and non-ownership of production costs as key element in decision making. The reduction or even elimination of inefficiency of the inefficient producers does not require investments of resources, but the opposite, as this can be achieved by reducing costs through the reduction and optimization of the use of inputs. Attempting to increase production by optimizing resources utilization would only lead to management problems that created the inefficiency problem in the first place: making production smaller and more appropriate for the milk farmers to manage seems to be the best solution to reduce losses and generate more efficiency. The residency of the producers in the property explained by the greater social interaction of producers increases the level of education, of participation in producer organizations, of access to information and training, and technical assistance, which also affects the greater level of efficiency.

However, some variables like education and technology adoption cannot always be achieved in the current generation of producers, which makes it necessary to invest in the participation of the producer's offspring in order to guarantee the continuity of the activity (most producers are currently in advanced age and have small participation of family members in non administrative activities).

Therefore, the fundamental element to obtain efficiency is individual knowledge of the production costs allied with the optimization of the use of productive resources and the adoption of appropriate technology, considering that the generation of inefficiency comes from unnecessarily excessive expenditures made during the productive process. We have determined that several improvements to the dairy in the town of Rolim de Moura would be more efficient in the use of inputs, especially the increase of technological level such as technical assistance, which leads the producer milk to the best technique using the factors of production available. So far, the objectives were achieved, making contributions to the subject, both for academia and for the producers, who own a tool for the decision.

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