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PRODUCTIVITY GROWTH AND TECHNOLOGICAL PROGRESS IN THE BRAZILIAN AGRICULTURAL SECTOR

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Abstract

Starting in the 1970's, the Brazilian agricultural sector has experienced an important process of modernization, whose principal effects include advances in technological progress and gains in productivity. The primary objective of this paper is to analyze technological progress and total productivity growth in the Brazilian agricultural sector during the period from 1970 to 1996. The methodology used here is based on the Malmquist productivity index and techniques in mathematical programming called Data Envelopment Analysis. The results show that significant progress was made in this sector of the economy but concentrated in only some regions of the country.

Keywords: total factor productivity; Malmquist index; Brazilian agricultural sector.

Resumo

O setor agropecuário brasileiro passou por um processo de modernização a partir dos anos 70, conseqüentemente, espera-se que exista uma contrapartida de progresso tecnológico e de ganhos de produtividade para o setor. Diante de tal fato tem-se como objetivo, neste estudo, avaliar o progresso tecnológico e o crescimento da produtividade total dos fatores (PTF) do setor agropecuário brasileiro ao longo do período de 1970 a 1996. A metodologia utilizada foi baseada no índice Malmquist de produtividade e nas técnicas de programação matemática denominadas de Análise de Envoltória de Dados (DEA). Os resultados alcançados foram condizentes com estudos prévios e apontam para progresso técnico e ganhos de produtividade para o setor, porém concentrados em algumas regiões.

Palavras-chave: produtividade total dos fatores; índice de Malmquist; setor agropecuário.

1. Introduction

From the beginnings of Brazilian colonization in the 16th century up to the 1960's, the exploration of the Brazilian Agricultural sector showed practically no continuity in terms of technological progress. The process of production was almost totally based upon intuition and common sense methodologies, that is, on the accumulation of knowledge in an unstructured way from the daily routines in the field or from previous knowledge brought to Brazil by immigrants. One of the most important aspects to be considered is the wide-ranging diversity of the Brazilian climate which demands that each region be explored in a different way if high levels of efficiency are to be reached (Santos, 1988).

In the early years of the 1950's, the crisis of agricultural shortfalls and a need for a larger contribution from the agricultural sector for exports brought to the forefront of political discussions the nature of the informal organization and backwardness of the sector which had already persisted for 400 years. Given this situation, finally in the 1960's and 1970's the government undertook a series of policies that would bring development to the agricultural sector (Alves & Contini, 1988).

The agricultural sector, pushed by external immigration and later by internal migration up to the middle of the 20th century, grew also through government land grant policies, the construction of roads and through the natural growth of the labor supply. Finally growth was enhanced with the establishment of several research institutes for the development of technologies more in line with Brazilian necessities. The increase in the internal availability of modern inputs like agricultural machinery and chemical fertilizers and insecticides became intense (Barros & Manoel, 1988).

The profound transformations that occurred in Brazilian agriculture as a function of the modernization process and the growth of the internal and external markets resulted in important advances for the sector. It became very apparent that the number of economically relevant products grew considerably. Actually, there are more than 45 agricultural products with large economic influence throughout the country. The situation today is quite different from that of several decades ago when only a very small number of products were in existence (Pereira *et al.*, 1998, 1998a e 2000).

All of the technological modifications that occurred caused great changes in the structure of the Brazilian agricultural sector, and probably alterations in productivity levels, that is, in the relation between how much is produced and how much is used as inputs, following the definition of Bedê & Santos (1994). This question has always occupied a very special place in the study of capitalism since Adam Smith who was impressed by the relationship between productivity gains and their repercussions on society. Recently this subject has gained a new spotlight owing to the expressive increase in competition caused by the recent phenomenon of globalization (Mattuella *et al.*, 1994).

Based on these considerations it is important to note that effective knowledge concerning the conditions of productivity for a given country is an essential ingredient for the analysis of the competitiveness of that country in world markets, and that this knowledge can point to solutions for sectors with difficulties in this respect.

Considering the importance of measuring agricultural productivity, the development of this area in Brazil is still in the initial stages. Very little research related to this area has been developed up to the present time. Feijó & Carvalho (1994) point out that there has been very little interest in this subject, principally up until the beginning of the 1990's. However, from the mid 1990's research in this area has grown relatively fast motivated by international free trade and the concurrent increase in world competition.

The relationship between productivity and the level of competitiveness rests on the fact that rationality in production is the determining factor of the power of companies to compete. Following Porter (1991), a company can become more competitive if it adopts strategies that reduce costs and differentiates its product. In the case of product differentiation, the question of productivity is indirectly relevant because high productivity means lower costs and pricing advantage compared to near substitutes.

However, in the case of pure cost competition, the presence of high productivity indexes is fundamentally important for competitive advantage. This case is represented by sectors that produce commodities like certain minerals and most agricultural products. For emerging countries like Brazil, whose exports depend upon widely available natural resources, the question of productivity must be analyzed.

The measurement of productivity in the literature presents two groups of indicators (Villela & Silva, 1994): partial factor productivity that considers only one production factor and total factor productivity that considers most of the factors of production. The indexes for partial productivity are easier to calculate than the total indexes. Among the most used of the partial indexes are those for labor productivity and capital productivity. Even though these indexes are widely used, they may cause biased results if not analyzed in a more general context (Bonelli *et al.*, 1994; Hoffmann & Jamas, 1990). This occurs because the modern productive process is very complex in the sense that in the majority of cases there is no one principal factor of production but rather many interrelated factors that should be analyzed jointly.

In the case of indicators for total productivity, the most used today are from Tornqvist and Malmquist. These indicators are not biased like the partial indicators are, but reach their formulation through differing methodologies. The Malmquist index makes it possible to distinguish between productivity gains from technological progress and technical efficiency in situations with multiple products and multiple inputs, whereas the Tornqvist index is not as thorough (Pereira *et al.*, 2000).

The scarcity of analyses of productivity in Brazilian agriculture has also been cited by Gasques & Conceição (1997). Moreover, the existing literature contains serious limitations, either excessively out of date or because of the careless use of partial indexes or measuring inputs and products only in monetary terms. With this in mind, the present paper is an attempt to contribute to the state of the art of productivity analysis, proposing the investigation of the evolution of the technological frontier and the total factor productivity in Brazilian agriculture as a result of the intensive use of modern inputs.

2. Methodology

2.1 Method of analysis

The methodology of analysis adopted here is based on the Malmquist index for total factor productivity. This index has several desirable characteristics among which the most important being that the use of monetary values are reduced to a minimum and multiple inputs and products are allowed. The fact that physical values are allowed in the analysis eliminates the need to establish prices for the inputs and products and, consequently, the analysis through time becomes more consistent without the need of deflating data with dubious price indexes. This last advantage has been pointed out by Thirtle *et al.* (1996) who considers this quality to be especially important in studies in emerging economies where in general price indexes are poorly constructed and for the most part distorted.

Another quality of the Malmquist index is the possibility of separating out two distinct components: an index for technical efficiency and an index for the shift in the technological frontier through time as first demonstrated by Färe *et al.* (1995). The Malmquist index has gained widespread acceptance, however it has been rarely used in Brazil. Pereira *et al.* (1995) have used the Malmquist index to study productivity in Brazilian university hospitals.

The index is calculated as a function of the distance obtained by means of mathematical programming using the non-parametric methods of "Data Envelopment Analysis" (DEA). These techniques are based on Farrell (1957) and Charnes *et al.* (1978) and Banker *et al.* (1984). After these publications and principally in the 1980's DEA gained worldwide recognition (Seiford, 1990; Seiford, 1996). In Brazil, the utilization of these techniques began in the 1990's (Pereira *et al.*, 1995).

The product oriented Malmquist index presented below is based on research from Caves *et al.* (1982), Färe *et al.* (1995) and Fried *et al.* (1993). The index following the works cited, expresses the change in total factor productivity between year t e t+1 for production unit k and is computed using the product distance $D_o^t(x^t, y^t)_k$ and is defined as

$$M_o(x^{t+1}, y^{t+1}, x^t, y^t)_k = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})_k}{D_o^t(x^t, y^t)_k} \left[\frac{D_o^t(x^{t+1}, y^{t+1})_k}{D_o^{t+1}(x^{t+1}, y^{t+1})_k} \times \frac{D_o^t(x^t, y^t)_k}{D_o^{t+1}(x^t, y^t)_k} \right]^{1/2} \qquad (1)$$

The index (1) is then broken down into two sub-indexes. The first, outside of the parentheses, measures the change in the index of efficiency of a given production unit between periods t and t+1. In this way, the behavior of technical efficiency in relation to changes in the production frontier through time is analyzed. Therefore, the index can be less than, equal to or greater than one depending on whether technical efficiency is falling, or remaining constant or increasing, respectively. The second sub-index, the square root of the expression in parentheses in equation (1), quantifies technical change or better to say the change in technology. This index can assume values that are less than, equal to or greater than one, depending upon whether technological regression is occurring, or no change in technology or technological advancement, respectively.

In this way, the Malmquist productivity index is obtained by multiplying together these two sub-indexes. Calculating the overall index as a combination of two sub-indexes is an important analytical tool, because this permits knowing if an increase in productivity comes from technical progress or from the index of efficiency, or both working simultaneously.

This index depends on the calculation of four different functions of distance, for each one of the units i and for each period t. In this way, each function of distance is calculated i times for each period of time, requiring a data bank with matrices for inputs $X = (x_1, ..., x_n)$ and for products $Y = (y_1, ..., y_m)$, realized by each producing unit $i = (1, ..., I)$ in time $t = (1, ..., T)$.

The functions of product distance $D_o^t(x^t, y^t)_k$ are computed by solving the following linear programming problem:

$$[D_o^t(x^{it},y^{it})_k]^{-1} = \text{Max } \theta \quad (2)$$

$$\begin{aligned} \text{constrained by } \; \theta y^{kt} &\le \lambda^{it} Y^{it}_m & m &= 1,...,k,...,M \text{ (products)} \\ \lambda^{it} X^{it}_n &\le x^{kt}_n & n &= 1,...,k,...,N \text{ (inputs)} \\ \lambda^{it} &\ge 0 & i &= 1,...,k,\ldots,I \text{ (producers)} \end{aligned}$$

where λ^{it} is a vector of intensity that shows how the combinations of (x^{it},y^{it}) can be arranged.

This problem is solved i times according to the number of observations (x^{it},y^{it}). Since $(x^{it}, y^{it}) \in P^t$ (the same technology), then the values of the distance function are all less than or equal to one. The problem for $[D_o^{t+1}(x^{it+1},y^{it+1})_k]^{-1}$ is similar to that for period t. The only difference is that the data belong to period t+1.

The linear programming problem for calculating the other two distance functions is a bit different from that presented above. In the last two problems it was necessary to mix the different time periods. That way, (x^{kt}, y^{kt}) does not belong to technology P^{t+1}, to which it is being relatively compared. The same happens in the case (x^{kt+1}, y^{kt+1}), because it does not belong to P^t. Therefore the distance function for a unit in period t+1 is compared to the technology in period t and vice-versa.

2.2 Inputs and products

Due to the fact that the agriculture sector is so important for all the economies of all the regions and states of Brazil, it will be necessary to consider all regions and states as production units. Production units will be defined as the states in Brazil, DF (Distrito Federal), that is, the region of the capital of Brazil – Brasilia, several groupings of states into regions, and Brazil as a whole. It is important to point out that these production units will be defined for the base year 1970, therefore not taking into account the recently formed states of Mato Grosso do Sul and Tocantins.

The products being considered are y^{it}_1, representing the aggregate of agricultural production, and y^{it}_2, representing the aggregate of cattle breeding, both representing about 90% of the total value of all agricultural and cattle breeding production in Brazil.

The aggregate of production for these two sectors is constructed based on the quantities produced for each product in each year, and the average price of the product as registered in the agricultural census of 1996. This allowed for the use of physical quantities for each product and a common factor for aggregating for all the years. Proceeding in this way, problems related to monetary correction through time were reduced, along with monetary policies that devalued or changed the name of the currency, because the products have a common factor of aggregation in all the observed periods.

The composition of y^{it}_1 is made up of 18 temporary products (cotton, peanuts, rice, irish potatoes and sweet potatoes, sugarcane, onion, beans, tobacco manioc, corn, soybeans, tomato, wheat, pineapple, mauve, jute, mamona) and by 21 permanent products (avocado, cotton arboreo, agaves, banana, cacao, coffee, cashew fruit, cashew nuts, coconut, mate tea, guarana, oranges and limes, papaya, passion fruit, mango, apples, tangerines, grapes, black pepper and peaches). This classification is from the Brazilian Geographic Institute IBGE. Needless to say each one of the states and regions studied does not produce all of the products listed above. Some states are strictly specialized in a very few products, whereas other states are more generalized, producing practically everything. Products like coffee, soybeans, sugarcane, oranges, corn, beans, rice, bananas e cacao participate with approximately 70% of the value of y^{it}_1. However, the production of the products with the exception of cacao is concentrated in the South Southeast and Center-west regions of the country. Therefore, it is absolutely necessary to add to the aggregate products like cotton, arboreo, mauve, jute, and guaraná, which are important products in the North and Northeast of Brazil. Following this procedure, the aggregate y^{it}_1 represents more than 90% of the value of agricultural production for the sum of all the regions in Brazil. Consequently, the sample is not dependent on the predominance of one or two regions alone.

For the cattle breeding and similars sector, y^{it}_2 is composed of the production of large animals (bulls, cows and milk), of medium size animals like pigs and small animals (chickens, hens and eggs). These products are important in all the regions of Brazil and represent more than 90% of the total value of this sector.

In relation to inputs, four were selected: land, labor, machines, and others. The aggregate variable x^{it}_1, which corresponds to land, is measured by hectares used for permanent plants, temporary crops, and natural and planted pasture. Labor (x^{it}_2) was quantified as the population that performs economic activity in the field. Machines (x^{it}_3) is represented by available horse power (HP). The available HP corresponds to the HP on tractors. The aggregation procedure is the same used by Ávila & Evenson (1994). Other inputs (x^{it}_4) include the total value for spending on diesel oil, seeds, fertilizers and other chemicals, medicinal supplies, vaccines, animal rations, salt and insecticides (All values are in prices from December of 1995. The price index used is the general price index of internal available goods and takes into account the several changes in the currency system during the period under analysis.).

This basket of inputs is similar to that used in the pioneering work of Hayami & Ruttan (1970) and adopted by Ávila & Evenson (1994), being very common in the literature that analyzes the agricultural sector of any country. It is important to emphasize that the factors of production are measured in real terms, as physical quantities. Only the factors called others are expressed in monetary terms. The calculation of the three main factors as physical quantities is very fortunate for the analysis to follow, because the construction of a monetary aggregate for these factors would have dubious consequences for the results shown later. The use of physical quantities increases dramatically the consistency of the present analysis where a relatively extensive period of time is being analyzed. In the case of the 4th factor others, the use of monetary values is not so serious because the makeup of this factor is relatively homogeneous throughout the country and the prices for these products are easily obtained.

The data for all the variables were taken from the agricultural census for all the Brazilian states and several other publications (FIBGE; 1972, 1981 and 1996; 1970, 1975, 1980, 1985 and 1995-1996).

3. Results and Discussion

In the following pages the principal results from the application of the Malmquist model of total factor productivity are presented and discussed for the Brazilian states, the federal district of Brasilia, regions and for Brazil as a whole.

The Malmquist index is constructed for the periods 1970-80 e 1970-96.

In table 01, one can observe that the states of Paraíba, Paraná, Pernambuco, Rio Grande do Norte, Ceará, Pará, and the Federal District of Brasilia demonstrate tendencies that evidence the shift of these states in the direction of the technological frontier, that is, the increase in the index of efficiency.

Table 01 – Indexes for the change in technical efficiency for states, 1970-80 and 1970-96. Arranged in descending order.

Units	1970-80	1970-96
1- Federal District	1,409	1,409
2- Paraíba	1,346	1,345
3- Paraná	1,160	1,215
4- Pernambuco	1,236	1,235
5- Rio G. do Norte	1,045	1,208
6- Ceará	1,178	1,177
7- Pará	1,344	1,176
8- Alagoas	1,013	1,013
9- Rondônia	1,000	1,000
10- Acre	1,000	1,000
11- Amazonas	1,000	1,000
12- Roraima	1,000	1,000
13- Minas Gerais	1,000	1,000
14- Espírito Santo	1,000	1,000
15- Rio de Janeiro	1,000	1,000
16- São Paulo	1,000	1,000
17- Santa Catarina	1,000	1,000
18- Mato Grosso	1,000	1,000
19- Goiás	1,000	1,000
20- Sergipe	1,000	0,925
21- Rio G. do Sul	0,849	0,898
22- Maranhão	1,000	0,802
23- Amapá	1,028	0,729
24- Piauí	0,800	0,663
25- Bahia	0,992	0,565

The performance represented by these indexes could illustrate productivity gains for these units (values greater than one), if they are not characterized by technical regression. However, for the states of Amapá, Maranhão, Piauí, Sergipe, Bahia and Rio Grande do Sul, one notes that these states have distanced themselves from the technological frontier (values less than one). This means deterioration in productivity if technical progress is not sufficient to compensate for this loss. In the other states, the distances from the frontier remained constant during the period under study.

As far as technical progress goes, one can observe in table 02 that the states of Mato Grosso, Goiás, Minas Gerais, São Paulo, Rio Grande do Sul, Santa Catarina, Paraná, Rio de Janeiro and the Federal District experienced pronounced technological development. For the states of Sergipe, Rondônia, Piauí, Pernambuco, Ceará, Rio Grande do Norte and Alagoas technological development was moderate. Finally, for the states of Acre, Amazonas, Roraima, Amapá, Maranhão, Paraíba and Bahia technological regression was the case.

Table 02 – Indicators for technical change at the state level. 1970-80 and 1970-96.

Units	1970-80	1970-96
1- Mato Grosso	1,838	7,378
2-Federal District	2,304	6,855
3- Goiás	2,057	5,247
4- São Paulo	2,172	3,501
5- Rio G. do Sul	2,040	3,242
6- Santa Catarina	2,769	3,427
7- Minas Gerais	2,118	3,005
8- Rio de Janeiro	1,981	2,907
9- Paraná	2,015	2,397
10- Sergipe	1,745	1,404
11- Rio G. Norte	1,288	1,268
12- Pernambuco	1,438	1,263
13- Rondônia	0,968	1,255
14- Alagoas	1,227	1,251
15- Espírito Santo	1,804	1,246
16- Piauí	0,747	1,053
17- Ceará	0,849	1,039
18- Paraíba	1,157	0,967
19- Pará	0,861	0,873
20- Amapá	1,115	0,839
21- Bahia	0,866	0,801
22- Maranhão	0,423	0,417
23- Roraíma	0,335	0,413
24- Acre	0,517	0,392
25- Amazonas	0,302	0,227

Still with respect to table 02, it is important observe that the units, which show gains in technological progress in the periods under analysis, belong to the central west, southeast and southern regions of Brazil, and the units that major characteristic is technological regression belong to the north and northeast of the country.

The Malmquist index for total factor productivity can be obtained from the product of the technological change index and the efficiency index, as shown in equation 01. From the results contained in tables 01 and 02, one can easily verify that the component of technological change is characterized by magnitudes much superior to the component that measures efficiency This is an indication that the overall gains in productivity occurred owing to technological progress and not because the individual units moved closer to the frontier.

Table 03 – The Malmquist Index for total factor productivity for Brazilian states, 1970-80.

Units	1970-80	Annual growth	Period growth
1- Federal District	3,246	12,5%	225%
2- Santa Catarina	2,769	10,7%	177%
3- Paraná	2,336	8,9%	134%
4- São Paulo	2,171	8,1%	117%
5- Minas Gerais	2,118	7,8%	112%
6- Goiás	2,059	7,5%	106%
7- Rio de Janeiro	1,981	7,1%	98%
8- Mato Grosso	1,838	6,3%	84%
9- Espírto Santo	1,804	6,1%	80%
10- Pernambuco	1,777	5,9%	78%
11- Sergipe	1,745	5,7%	75%
12- Rio G. do Sul	1,73	5,6%	73%
13- Paraíba	1,557	4,5%	56%
14- Rio G. do Norte	1,346	3,0%	35%
15- Alagoas	1,243	2,2%	24%
16- Pará	1,156	1,5%	16%
17- Amapá	1,145	1,4%	15%
18- Ceará	0,999	0,0%	0%
19- Rondônia	0,968	-0,3%	-3%
20- Bahia	0,858	-1,3%	-14%
21- Piauí	0,596	-3,5%	-40%
22- Acre	0,516	-4,0%	-48%
23- Maranhão	0,423	-4,7%	-58%
24- Roraima	0,335	-5,2%	-67%
25- Amazonas	0,302	-5,4%	-70%

The Malmquist indexes shown in table 03 for the period 1970-80 show negative annual growth rates for Rondônia (-0,3%), Acre (-4,0%), Amazonas (-5,4%), Roraima (-5,2%), Maranhão (-4,7%), Piauí (-3,5%) e Bahia (-1,3%). Of the twelve largest indexes, ten are from the regions in the south, southeast and central west of Brazil. Likewise, for the results from the period 1970-96, the whole period under analysis (table 04), the states of Acre (-1,8%), Amazonas (-2,2%), Roraima (-1,8%), Amapá (-1,3%), Maranhão (-2,0%), Piauí (-1,0%) and Bahia (-1,7%) persist with annual growth rates that are negative.

Table 04 – The Malmquist index for total factor productivity for the Brazilian states, 1970-96.

Units	1970-96	Annual growth	Period growth
1- Federal District	9,66	9,1%	866%
2- Mato Grosso	7,378	8,0%	638%
3- Goiás	5,247	6,6%	425%
4- São Paulo	3,501	4,9%	250%
5- Santa Catarina	3,427	4,9%	243%
6- Minas Gerais	3	4,3%	200%
7- Paraná	2,912	4,2%	191%
8- Rio de Janeiro	2,906	4,2%	191%
9- Rio G. do Sul	2,91	4,2%	191%
10- Pernambuco	1,561	1,7%	56%
11- Rio G. do Norte	1,531	1,7%	53%
12- Paraíba	1,3	1,0%	30%
13- Sergipe	1,299	1,0%	30%
14- Alagoas	1,267	0,9%	27%
15- Rondônia	1,255	0,9%	26%
16- Espírito Santo	1,246	0,9%	25%
17- Ceará	1,224	0,8%	22%
18- Pará	1,026	0,1%	3%
19- Piauí	0,698	-1,0%	-30%
20- Amapá	0,611	-1,3%	-39%
21- Bahia	0,452	-1,7%	-55%
22- Roraima	0,413	-1,8%	-59%
23- Acre	0,392	-1,8%	-61%
24- Maranhão	0,335	-2,0%	-67%
25- Amazonas	0,227	-2,2%	-77%

Furthermore, for the whole period, the data show that the hegemony of the southern regions (south, southeast, and central west) of Brazil is maintained with the exception of the state of Espírito Santo where a fall in productivity was experienced. For the ten largest indexes, nine are from the southern regions, noting the very large difference between Rio Grande do Sul in ninth place and Pernambuco in tenth.

Another important result is the fact that even though the states of Piauí, Amapá, Acre, Maranhão, Amazonas and Roraima are characterized by negative growth rates for total factor productivity. There seems to exist a slight tendency for turning this trend around, as is shown in table 05 where one can see that the negative growth rates diminish for these states. Roraima, for example, reached a negative rate of –5,2% annually in the period 1970-80, but for the whole period 1970-96 the rate is less negative (–1,8%). The state of Bahia seems to be the exception as the only state whose negative growth rate became more negative comparing the two periods.

Table 05 – States with negative growth rates for total factor productivity, 1970-80 e 1970-96.

Units	1970-80	1970-96
1- Bahia	-1,3%	-1,7%
2- Piauí	-3,5%	-1,0%
3- Amapá	1,4%	-1,3%
4- Acre	-4,0%	-1,8%
5- Maranhão	-4,7%	-2,0%
6- Amazonas	-5,4%	-2,2%
7- Roraima	-5,2%	-1,8%

One should consider, however, that the negative growth rates that the units present do not necessarily mean that these states have reduced their level of production. Aggregate agricultural production for the state of Bahia, for example, increased by 16% from 1970 to 1996, and cattle breeding by 118% in the same period. The negative growth rate is due to the enormous increase in inputs for the factors of production, 18%, 61%, 1464% e 327%, respectively. These numbers demonstrate clearly why the partial indexes for factor productivity are sometimes misleading. For instance, the factor land increased by only 18% and if compared to cattle breeding which increased by 118% this partial productivity measure incorrectly demonstrates a large increase in productivity.

In table 06 results are aggregated for regions in Brazil. The northern region is characterized by negative rates of growth for total factor productivity but declining, that is, tending to be positive. In the northeastern region of Brazil, the annual rate is positive for the period 1970 to 1980 but negative for the whole period indicating that total factor productivity was in decline up to 1996. These poor indicators for the northeast region were due essentially to the poor performance of the states of Bahia and Maranhão, both with a relatively large representation for the region and large negative growth rates.

Table 06 – The Malmquist index for total factor productivity for Brazilian regions, 1970-80 e 1970-96.

Units	Malmquist Index 1970-80	Annual growth rate 1970-80	Period growth rate 1970-80	Malmquist Index 1970-96	Annual growth rate 1970-96	Period growth rate 1970-96
1- North	0,85	-1,40%	-15%	0,80	-0,71%	-20%
2- Northeast	1,07	0,68%	7%	0,83	-0,62%	-17%
3- Southeast	2,13	7,86%	113%	3,55	5,00%	255%
4- South	2,20	8,20%	120%	3,24	4,63%	224%
5- Center west	1,95	6,91%	95%	6,24	7,30%	524%
6- Brazil	2,10	7,71%	110%	3,39	4,81%	339%

Still referring to table 06, the largest growth rates for total factor production for the period 1970-80 are for the southern and southeastern regions, and when the whole period is considered the growth rates are less but remain positive. In the central west region the tendency is exactly the opposite, with growth rates being greater in the whole period than in the period 1970 to 1980. This is probably due to the fact that in the 1970's the technological base for the central west region is very small as this territory is considered to be backward frontier, but at the end of the 1980's the modernization process in the region is the most intense for all of Brazil.

At the greatest level of aggregation for Brazil as a whole, the period 1970-80 show the largest rate of growth for total factor productivity; however, the growth rate remains positive but smaller for the whole period. This performance reflects the representativeness of the south and southeast regions for Brazil as a whole.

4. Final Considerations

In the present study, for the period analyzed, the process of technological evolution did not occur uniformly throughout all the regions and states of Brazil. In some regions productivity growth was very positive and basically constant for the whole period, whereas for other regions growth was negative. This conclusion concerning the disparity between regions and states was to be expected. For Monteiro (1985), the generation of agricultural technology is directly related to special interest groups who work intensively in the south and southeast regions of Brazil and more recently in the center west. In this context, the governmental policies that offer financial incentives for the production of exportables are more appropriate for the southern and southeastern regions where exportables are easily produced. In the case of the multinationals, agricultural production does not need large budgets for research and development due to the fact that the climate found in the south and southeastern regions of Brazil are similar to those of the home country. This fact also holds for certain areas in the central west region. Moreover, the important and decisive actions of rural enterprise in these advanced regions of Brazil has been relatively successful in finding local solutions to regional agricultural problems, whereas the north and northeast have remained at the margin of technological development presenting therefore negative growth rates for total factor productivity. These negative rates are not surprising. In studies realized by Monteiro (1985) production per hectar for cotton in the northeast fell more than 50% between 1940 e 1980.

To conclude, some comments on the overall growth rate for total factor productivity are necessary, considering that the rate was 7,71% annually from 1970-80 and 4,81% from 1970-96. One should consider that productivity is a fundamental factor for competing effectively in world and domestic markets, and that Brazil possesses even today an incredible potential for advances in the agricultural and cattle breeding sectors (Gasques & Conceição, 1997).

In general, the results of this research are that a part of the Brazilian agricultural sector is relatively advanced and competitive, but that this development has not spread to all regions of Brazil.

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