ASPECTS OF SOYBEAN PRODUCTION RESTRUCTURING IN THE STATE OF PARANA, BRAZIL[1]

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ABSTRACT

Structural changes in soybean production in the Parana, Brazil, have been analyzed in the present paper. A quantitative method was used to detect impacts of soybean expansion over a variable called the Total Disputed Area (TDA). This variable when correlated with the Total Census Surveyed Area (TCSA) provided the Replacement Index (RI), a measure of the rate of farmland conversion from one agricultural use to another. Indicators were created and employed to analyze changes that occurred in the following time periods: 1970-75, a time of development characterized by modernization policies, high annual economic growth rates, and a drive to increase exports; 1975-80, when the framework of agribusiness was basically founded, as upstream and downstream industries were completed and existing processing facilities were redesigned; 1980-85, when agribusiness consolidated; and 1985-96, a period of increasing economies of scale and market segmentation. For different strata of farms, arranged according to size, it was possible to make inferences about the allocative movement of soybean on a set of activities and uses of agricultural soil. This focus revealed asynchronous movements between areas as one land use replaced another (greater in the '70s), and an increase in the scale of soybean grower of operations

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(greater in the '80s). The restructuring of Paraná's soybean culture found its source in microeconomic change (scale increase, and market segmentation, exemplified by the arrival of "organic soybean") rather than macroeconomic factors and/or sector policies.

Key-words: soybean crop, regional economy, State of Parana.

1. Introduction

One major characteristic of agricultural development in Parana, Brazil, is technological evolution. Innovations to improve organization, management, and production are rapidly introduced and accepted within the state. This ability to adapt and improve, combined with other factors, has made Parana a major contributor to Brazilian agricultural production. Parana has benefited from the soybean culture and is now responsible for 20-25% of Brazil's grain and soy production.

Soybeans were, and still are, a vector for the modernization of Brazilian agriculture. The soybean agroindustry has acted as a catalyst, introducing the country to modern agricultural inputs and capital goods while increasing the versatility of Brazil's agricultural processors. From the regional perspective, soybeans have transformed the country's Central-West into region of larger scale, highly structured, integrated farming operations, notably differentiated from Paraná's region, Brazil's South. As opposed to Paraná (and Southern states), where soybean shares economic importance with other activities, states located on the agricultural frontiers have made soybean the force behind the modernization of their productive chains'.

2. Objectives

The main objective of the present paper is the analysis of structural transformation in soybean production in Brazilian state of Parana. To

achieve this objective, statistical indicators were constructed through use of 1995-96 census data. These indicators were also used to form a more accurate perception of soybean's contribution to the Brazilian foreign trade account and the country's economic cycle, with a focus on Parana.

3. Hypotheses

The basic hypothesis of this paper is that economic activity directly connected with the production of soybean is increasing in scale. There are many reasons to believe that scale is increasing: a) decreased importance of government agricultural policies combined with a financial crisis in the farm cooperative system; b) increased importance of private, agricultural sector traders; and c) the asymmetrical availability of market information between larger and smaller farms, mainly regarding futures prices. The producer scale increase is a phenomenon more frequently observed in Brazil's Central-West and North regions, as companies invest to expand farming and mining operations. A hypothesis is also put forward that appears to conflict with the previous. This hypothesis is that there are soybean production segmentation possibilities, such as for "organic soybean", that favors smaller farms since its production is labor intensive.

Hypotheses can be formulated with respect to the replacement characteristics among different agricultural activities and alternative uses of agricultural land. First, the replacement indicator should provide a reasonable approximation of annual agricultural growth rates for regions having similar degrees of development and regional integration. Second, if this is true, then the replacement indicator for the state of Parana would indicate relatively higher pro-cyclical behavior related to economic growth when compared to the states in the recently opened agricultural frontier.

Finally, that with the data structure used in this paper, it should

be possible to show the influence of structural changes in the soybean crop on the "farm size-structure" [3] of Parana. If economics of scale is preeminent in soybean production, a process of concentration into larger farming units would be expected; and the region's "farm size-structure" would then become more concentrated. On the other hand, if structural change in the soybean crop is a process combining increased soybean production scale and market segmentation, then the changes in the farm size-structure would show which of the conflicting trends is more influential.

4. Methodology

The methodology proposed in this paper has been used by several authors such as Patrick (1975), Zockun (1978), Camargo (1983), Igreja *et al* (1988), Yokoyama (1988) and Yokoyama *et al* (1990) to analyze the components of variation in production (Patrick), area (Zockun and Camargo), or a combination of both (Igreja *et al*, 1988; Yokoyama, 1988; and Yokoyama *et al*, 1990).

This paper analyzes the degree of change in land use (the Replacement Index), and the allocative impact of the soybean crop in different size farms, as farmers allot more or less of their land to different uses. To accomplish this, a profile was created of various, annual and perennial conditions of unpopulated land, such as wild forest and bush tree land, planted forest and reforested areas, crop or pasture land, fallow crop-land, and unproductive terrain. The use of this complete ground-use profile innovates on similar methodology used by other authors that generally profiled only cropland. As proposed by Igreja & Camargo

[3] Editor's note: the author's phrase "farm size-structure" refers to the pattern of land holdings in a specific area (Paraná) as determined by an ordinal series of farm sizes, i.e., the largest 10% of farms in region X control 50% of that region's land; the smallest 10% of farms in region X control 1% of that region's land.
Increasing concentration in an area's farm size-structure means that a region's available land has become concentrated in the hands of the larger farms, i.e., that the largest 1% of the farms control a increasing percentage of the region's land.

(1992), and implemented by Cardoso (1995) and Cardoso *et al* (1996), this paper broadens a model's interpretative content by constructing a new indicator: the Replacement Index (RI) which identifies the total degree of replacement. This index is used to generate a numerical value linked with agricultural growth, the economic cycle, and other economic events.

Data were collected from the agricultural census of 1970, 1975, 1980, and 1995/1996. Procedures for obtaining the components of the total variation in area are (j = 1-11) for analyses by farm size and (j=12) for the entire state of Parana.

4.1. Model Description

To facilitate the modeling, let each one of the possible soil uses, such as agriculture, pasture (natural and sown), forest (wild and forestation/reforestation), and other, be represented by X_{ij}, where *i* is a specific land use and *j* is the area stratum. Thus,

X_{ij0} - is the area dedicated to the activity/land use X_i (i = 1-n), in the j^{th} stratum, initial period (0);

X_{ijt} - is the area dedicated to the activity/land use X_i (i =1-n), in the j^{th} stratum, in the i^{th} period;

Let, also, $TCSA_{T0j}$ be the total census surveyed area. j^{th} stratum, initial period (0), which can be represented as:

$$A_{T0j} = \sum_{i=1}^{n} X_{ij0}$$

So, for the t^{th} period we have $TCSA_{Ttj}$ - total census surveyed area, j^{th} stratum, t^{th} periodo

$$(\mathrm{TCSA}_{Ttj} = \sum_{i=1}^{n} \mathrm{X}_{ijt})$$

Variation in the total census surveyed area (TCSA) in a given j^{th} stratum can be expressed by a α_j factor, as follows:

$$\alpha j = \mathrm{TCSA}_{tj} / \mathrm{TCSA}_{0j} \qquad (1)$$

For a specified soil use X_{ij}, its total variation (measured in hectares) can be broken into the System Size Effect (SSE) and Substitution Effect (SE).

SSE measures the contribution of a global expansion in the area of the production system, at any level (Brazil, a given region, or different farm sizes). It works as if all the variation in the system were based on the expansion of all activities and soil uses, without considering change in the proportion of dedicated areas.

The Substitution Effect (SE) is a quantitative measurement of the degree of substitution, the increase or reduction in a given agricultural activity, or the soil use in terms of area allotted to the activity. SE is the most relevant indicator used in this paper, as it will give evidence of economies of scale and/or farm specialization in Paraná's soybean culture.

The System Size Effect (SSE) for the soil use X_i, j^{th} stratum, is given by the following expression:

$$\mathrm{SSE}_i = \alpha_i \mathrm{X}_{0i} - \mathrm{X}_{0i} \qquad (2)$$

The Substitution Effect (SE) is given by:

$$\mathrm{SE} = \mathrm{X}_{ti} - \alpha_i \mathrm{X}_{0i} \qquad (3)$$

By definition, the total obtained by adding (2) and (3) gives the total variation (TV) in soil use X_{ij}, in j^{th} stratum. That is:

$$TV_i = \alpha_i X_{0i} - X_{0i} + X_{ti} - \alpha_i X_{0i} \quad (4)$$

It is easy to demonstrate that the sum of the SE_i is equal to zero. Therefore,

$$X_{ti} - \alpha_i \sum_{i=1}^{n} X_{0i} = 0 \quad (5)$$

However,

$$X_{ti} = a_i X_{0i} \quad (6)$$

by substituting (6) into (5) one can obtain:

$$\sum_{i=1}^{n} \alpha_i X_{0i} - \alpha_i \sum_{i=1}^{n} X_{0i} = 0$$

Or,

$$\alpha_i \sum_{i=1}^{n} X_{0i} - \alpha_i \sum_{i=1}^{n} X_{0i} = 0 \quad (7)$$

as we wanted to demonstrate.

This means that if *i* varies from *1* to *m*, the sum of the SEs obtained for each of the X_i soil uses, in the j^{th} stratum is null. This is an inherent condition of the model, by construction, as the proportional growth in area for certain soil uses (in a k^{th} set, that varies from *1* a *p*) is equal to areas withdrawn from other soil uses (in a set given as *L=p-1* to *m*).

Because of the perfect symmetry between the positive and negative allocative effects, one can add all the substitution effects of the same sign and express the following identity:

$$\sum_{k=1}^{p} (X_{tjk} - \alpha_i X_{0jk}) = - \sum_{L=p-1}^{n} (X_{tjL} - \alpha_i X_{0jL}) \qquad (8)$$

Both sides of this equation can be identified as the Total Area Disputed among all the soil uses considered in the j^{th} stratum (TDAj). This variable can be related to the Total Census Surveyed Area (TCSAj) as an important aggregate indicator of conversion of areas, here called the Replacement Index (RIj). When we relate the values obtained for the Substitution Effect (SE) for each soil use to the Total Disputed Area (TDA) we obtain a measure of the effect of that specific soil use (measured as percentage) on the allotment of land, which can be positive or negative, depending on whether that type of soil use has increased or decreased. This measure will be called the Allocative Effect (AE) of a specified soil use (AEX_{ij}). This paper will focus on the Allocative Effect of the Soybean Crop (AESoybean) according to the size of productive units, as a means of determining the prevalence of economies of scale.

5. Results and Discussion

5.1. Farm Size-Structure

The State of Parana shows a farm size-structure less concentrated than the Brazilian norm or even the norm in the recently opened farming and grasslands areas of the country's Central-West region. In comparison with the Brazilian norms, Paraná's smaller farms control a higher percentage of land and larger farms a smaller percentage of land. Within Paraná, the smaller 50% of all farms (a stratum) occupy 7.0%–8.5% of the Total Census Surveyed Area (TCSA), while in Brazil this stratum of

farm occupies only 2.0–3.0% of the TCSA. On the other hand, the largest 1% of all farms in Paraná occupy 30.0%–34.0% of TCSA, while in Brazil, the largest 1% of all farms occupy 43.0%–45.0% of the TCSA. However, relative to Parana, the change in this indicator over time has been a smooth path of increasing concentration, at least up to the middle of 80's, as Tables 1, 2 and 3 highlight. Beginning with the period 1970 to 1975 and comparing it to the 1975-1980 and 1980-1985 periods, Paraná's larger 1% of farms stratum has maintained a relatively stable participation in TCSA (between 33.0% and 34.0%). But, Parana's larger 5% of farms have controlled a higher percentage of TCSA as time passed, 55.4% in the 1970-1975 period, 56.4% in the 1975-80 period, and 56.9% in the 1980-85 period; and the smaller 50% stratum has controlled less of the TCSA as time passed, from 8.4% in the 1970-1975 period to 7.1% of in the 1980-85 period.

The concentration increase observed from 1970 to 1985 was partially reversed from 1985 to 1996 (Table 4). Between the mid -'70s and 1996, the Total Census Surveyed Area increased 2.0%, to 15.95 million hectares while the number of farms decreased 22.6% to 369.8 thousand farms (resulting in an increase in the average farm size, from 32.73 ha/farm to 43.12 ha/farm, an increase of 31.7%). Perhaps, more than the concentration level itself, the perception of this path of concentration in the farm size-structure supports social movements in favor of land reform and is a major factor encouraging conflicts involving land ownership and control. The state of Parana has been in the forefront of land reform conflicts over the last few years.

Table 1- Number of Farms, Total Census Surveyed Area (TCSA), 1975, and Total Disputed Area (TDA) from 1970 up to 1975, in State of Parana, Brazil.

Stratum (ha)	Nº of Farms	%	% cumul	ATR (1.000 ha)	%	% cumul	ATD (1.000 ha)	%	% cumul
less than 10	237068	49,6	49,6	1286,8	8,2	8,2	162,6	6,0	6,0
10-20	109243	22,9	72,5	1537,5	9,8	18,0	230,0	8,5	14,5
20-50	85501	17,9	90,4	2626,0	16,9	34,9	469,1	17,5	32,0
50-100	24142	5,1	95,5	1684,2	10,8	45,7	341,7	12,7	44,7
100-200	11381	2,4	97,9	1580,9	10,1	55,8	328,2	12,2	56,9
200-500	6892	1,4	99,3	2115,5	13,6	69,4	393,6	14,6	71,5
500-1.000	1940	0,4	99,7	1361,0	8,7	78,1	200,6	7,4	78,9
1.000-2.000	885	0,2	99,9	1220,2	7,8	85,9	149,5	5,6	84,5
2.000-5.000	364	0,1	100,0	1068,7	6,8	92,7	165,5	6,1	90,6
5.000-10.000	69	0,0	100,0	489,2	3,1	95,8	114,4	4,2	94,8
10.000 or above	30	0,0	100,0	660,8	4,2	100,0	140,8	5,2	100,0
TOTAL	477515	100,0	100,0	15630,8	100,0	100	2696,0	100,0	100,0
1% largest	4775	1	1	5256,4	33,6	-	885,7	31,7	-
5% largest	23876	5	5	8567,8	55,4	-	1525,4	56,6	-
50% smaller	238758	50	50	1310,6	8,4	-	166,2	6,2	-

Source: basic data from Censo Agropecuário (1970-1975) (IBGE).

Table 2 - Number of Farms, Total Census Surveyed Area (TCSA), 1980, and Total Disputed Area (TDA) from 1975 up to 1980, in State of Parana, Brazil.

Stratum (ha)	N° of Farms	%	% cumul	TCSA (1.000 ha)	%	% cumul	TODA (1.000 ha)	%	% cumul
less than 10	214995	47,4	47,4	1108,7	6,8	6,8	143,2	5,8	5,8
10-20	104693	23,1	70,5	1484,7	9,1	15,9	181,4	7,3	13,1
20-50	85207	18,8	89,3	2624,6	16,1	32,0	418,1	16,9	30,0
50-100	25131	5,5	94,8	1758,8	10,7	42,7	332,9	13,5	43,5
100-200	12361	2,7	97,5	1716,8	10,5	53,2	296,7	12,0	55,5
200-500	7720	1,7	99,2	2371,5	14,5	67,7	318,2	12,9	68,4
500-1.000	2268	0,5	99,7	1578,7	9,6	77,3	217,5	8,8	77,2
1.000-2.000	1017	0,2	99,9	1393,3	8,5	85,8	213,7	8,6	85,8
2.000-5.000	431	0,1	100,0	1251,5	7,6	93,4	177,8	7,2	93,0
5.000-10.000	62	0,0	100,0	428,8	2,6	96,0	69,8	2,8	95,8
10.000 or above	27	0,0	100,0	663,1	4,0	100,0	103,8	4,2	100,0
TOTAL	453912	100	100	16380,5	100	100	2473,1	100	100
1% largest	4539	1	1	5540,9	33,8	-	812,9	32,9	-
5% largest	22696	5	5	9238,4	56,4	-	1368,9	55,4	-
50% smaller	226956	50	50	1278,3	7,8	-	163,9	6,6	-

Source: basic data from Censo Agropecuário (1975-1980) (IBGE).

Table 3 - Number of Farms, Total Census Surveyed Area (TCSA), 1985, and Total Disputed Area (TDA) from 1980 up to 1985, in State of Parana, Brazil.

Stratum (ha)	Nº of Farms	%	% cumul	TCSA (1.000 ha)	%	% cumul	TDA (1.000 ha)	%	% cumul
less than 10	229015	49,1	49,1	1129,7	6,8	6,8	125,4	9,4	9,4
10-20	102538	22,0	71,1	1458,4	8,7	15,5	127,4	9,6	19,0
20-50	84180	18,1	89,2	2598,3	15,7	31,2	194,8	14,6	33,6
50-100	25529	5,5	94,7	1787,1	10,7	41,9	131,8	9,9	43,5
100-200	12729	2,7	97,4	1773,8	10,6	52,5	135,1	10,2	53,7
200-500	8232	1,8	99,2	2529,3	15,1	67,6	167,9	12,6	66,3
500-1.000	2464	0,5	99,7	1714,6	10,3	77,9	109,9	8,3	74,6
1.000-2.000	1052	0,2	99,9	1426,1	8,5	86,4	144,7	10,9	85,5
2.000-5.000	407	0,1	100,0	1170,5	7,0	93,4	46,4	3,5	89,0
5.000-10.000	62	0,0	100,0	418,0	2,5	95,9	41,0	3,1	92,1
10.000 or above	27	0,0	100,0	693,0	4,1	100,0	104,4	7,9	100,0
TOTAL	466235	100,0	100,0	16698,8	100,0	100,0	1328,8	100,0	100,0
1% largest	4662	1	1	5622,0	33,7	-	459,7	34,6	-
5% largest	23312	5	5	9493,8	56,9	-	731,8	55,1	-
50% smaller	233118	50	50	1188,0	7,1	-	130,5	9,8	-

Source: basic data from Censo Agropecuário (1980-1985) (IBGE).

It seems that, under the pressure land reform associations, programs of land/housing settlement, like the "Vilas Rurais" (*Rural Villages*), could be contributing to the relative reduction in the concentration of Paraná's farm size-structure. In the 1985-96 period, the 50% smaller stratum's share of the TCSA increased to 7.7%, and the TCSA share of the largest 1% farms stratum decreased to 29.8% (Table 4). In any case, recent figures do not show a clear trend regarding the smallest farms (less than 10 hectares) and the corresponding area under their control. What does became clear through examination of Table 4's figures is the recent tendency of decreasing importance of the 1% and 5% largest farms (both in absolute and relative terms) in number and area under control.

Table 4. - Number of Farms, Total Census Surveyed Area (TCSA), 1996, and Total Disputed Area (TDA) from 1985 up to 1996, in State of Paraná, Brazil.

Stratum (ha)	Number of Farms	%	% Cumul	TCSA (1000 ha)	%	% Cumul	TDA (1000 ha)	%	% Cumul.
less than10	154620	41.8	41.8	792.1	5.0	5.0	182.0	8.0	8.0
10-20	85799	23.2	65.0	1233.4	7.7	12.7	257.0	11.3	19.3
20-50	77279	20.9	85.9	2399.4	15.1	27.8	386.4	17.1	36.4
50-100	25227	6.8	92.7	1773.1	11.1	38.9	266.9	11.8	48.2
100-200	13482	3.6	96.3	1885.9	11.8	50.7	256.7	11.3	59.5
200-500	9339	2.5	98.8	2858.5	17.9	68.6	278.6	12.3	71.8
500-1,000	2611	0.7	99.5	1806.2	11.3	79.9	314.9	13.9	85.7
1,000-2,000	1029	0.3	99.8	1405.4	8.8	88.7	145.9	6.4	92.1
2,000-5,000	357	0.1	99.9	1021.6	6.4	95.1	83.9	3.7	95.8
5,000-10,000	47	0.1	99.9	326.2	2.1	97.2	62.1	2.7	98.5
more than10,000	17	0.0	100.0	444.7	2.8	100.0	31.0	1.5	100.0
TOTAL	369807	100.0	100.0	15946.5	100.0	100.0	2265.4	100.0	100.0
1% largest	3698	1	1	4753.0	29.8	-	594.0	26.2	-
5 % largest	18409	5	5	8574.7	53.8	-	1013.3	44.7	-
50% smaller	184904	50	50	1227.4	7.7	-	272.7	12.0	-

Source: basic data from *Censo Agropecuário* (1985-1996) (IBGE).

Tables 1 to 4 show the Total Disputed Area (TDA) according to farm size strata for the state of Paraná. The change in TDA between different farm size strata is similar to the change observed in Total Census Surveyed Area (TCSA) between farm size strata. It is important to note that the 50% smallest farms' percentage of the Total Disputed Area has continuously increased, from 6.2% to 12.0%. The reasons for this incremental ratio will be discussed in the next section.

5.2. Total replaced area

This paper's Replacement Index (RI) is an agricultural growth indicator that can predict structural changes. This can be accepted if one assumes that replacement of one soil use by another makes sense as a necessary condition for changes in the production profile. Results obtained for the RI in Paraná present a markedly pro-cyclical standard when compared with the general economy's movement. There is a strong relation between the higher values of RI observed in the first half of the '70s and the economy's rapid growth, which was fostered by export stimulating macroeconomic policies in effect in Brazil since the end of the '60s. The growth of soybean production in Paraná came at the expense of coffee production; perhaps the most drastic conversion from one crop culture to another that has ever occurred in Paraná. The expansion of the soybean crop occurred in consonance with the institutional inclination to modernize agricultural production, begun in the '60s. From approximately the mid-'70s on, the expansion of soybean was strongly driven toward newly opened agricultural areas, mainly in Brazil's Central-West region. From 1975 to 1980, under a new organizational and institutional framework (known as "agribusiness complexes," in accordance with Kageyama *et al*, 1990, and others), the RI decreased. Between 1985 and 1996, the direction of change in the RI reversed, increasing significantly during this 11 year period (Table 5).

Table 5 - Replacement Index (RI)[1] in the State of Parana, Brazil, from 1970 to 75; 1975 to 80; 1980 to 85 and 1985-96

Stratum	Replacement Inedex (RI) (in %) Period			
(ha)	1970-75	1975-80	1980-85	1985-96
less than 10	12,64	12,92	11,10	20,98
10-20	14,96	12,22	8,73	20,84
20-50	17,87	15,93	7,50	16,11
50-100	20,29	18,93	7,37	15,05
100-200	20,76	17,28	7,62	13,61
200-500	18,60	13,42	6,64	9,75
500-1.000	14,74	13,78	6,41	17,43
1.000-2.000	12,25	15,34	10,15	10,38
2.000-5.000	15,49	14,21	3,96	8,21
5.000-10.000	23,39	16,28	9,81	19,04
more than 10.00	21,31	15,65	15,06	6,97
TOTAL	17,25	15,10	7,96	14,21
1% largest	16,28	14,67	8,18	12,50
5% largest	17,80	14,82	7,71	11,82
50% smaller	12,68	12,82	10,98	22,22

1 Ratio between Total Disputed Area (TDA) and Total Census Surveyed Area(TCSA) (see tables 1 to 4)

Table 5 shows that the trend for the RI for different farm sizes changes over the years. In the initial period the RI for largest farms is greater than for the smallest holdings, but this trend has reversed in the latest period. This recent, greater degree of dispute among alternative soil uses on the smaller farms is occurring at the same time as agricultural policy instruments that supported those farm strata are being phased out. Perhaps, Parana's well-structured cooperative system and the condensed links of its agribusiness chains are factors countervailing the recent lack of traditional agricultural policies and facilitating the replacement and substitution between alternative soil uses on smaller

and average size farms. This especially relates to activities that, in general, have had an important role in the diversification of Paraná's agriculture sector: dairy production, tobacco, fruit, small coffee plantations, and organic soybeans.

5.3. Allocative effect of the soybean crop

The Allocative Effect of the Soybean Crop (AESoybean) on the Total Disputed Area (TDA) has declined over the periods analyzed. The AESoybean was 30.02% of TDA in the 1970-1975 period, 16.64% in the 1975-1980 period, and a negative 6.52% of TDA in the 1980-1985 period. In the 1985-1996 period, the AESoybean recovered to approximately the same level found in the 1975-1980 period, 16.05% of TDA. The figures for each size strata's AESoybean show that soybean was initially an important substitute for coffee and rice on small and average size farms, and mainly a substitute for natural grasslands on larger sized farms (to see detailed picture of substitution standards, see Tables AI.1 and AI.2). Table 6 shows that from 1970 to 1975 that AESoybean was almost 65% of TDA for farms between 10 and 20 hectares and more than 45% of TDA in the 500-1,000 hectare stratum. However, from 1970 until 1985, the AESoybean trend is a decreasing one, especially noticeable on the smaller farms. AESoybean increases in the 1985-1996 period, most noticeably in the larger farm strata, stressing soybeans' important role on larger farms. (Table 6).

Table 6 - Allocative Effect of the Soybean Crop (AESoybean)[1] in State of Parana, Brazil, correlated with Farm Size Structure, from 1970 to 1975, 1975 t to 1980, 1980 to 1985 and 1985 to 1996.

Stratum	Period			
(ha)	1970-75	1975-80	1980-85	1985-96
less than 10	50,13	-32,96	-10,97	9,42
10-20	64,13	-11,52	-7,18	14,35
20-50	59,64	18,66	-0,93	6,87
50-100	56,72	26,51	4,03	9,56
100-200	56,04	29,13	-6,78	8,12
200-500	51,48	25,11	-8,83	3,28
500-1.000	45,51	15,04	-3,57	18,87
1.000-2.000	26,51	25,23	-22,12	28,74
2.000-5.000	18,09	10,61	8,86	12,13
5.000-10.000	9,11	-0,73	-13,20	4,27
more than 10.000	0,77	6,72	-0,80	-0,17
TOTAL	30,02	16,64	-6,52	16,05

1 Ratio between Allocative Effect of Soybean Crop (AESoybean) and the Total Area Disputed (TDA).

Source: basic data from Censo Agropecuário (1970-1996) (IBGE).

Apparently, the reinforcement of positive AESoybean for larger farms, in a movement concentrating soybean production which began in the mid-'70s, directly correlates the behavior of the productive structure of soybean to the farm size-structure, which also became more concentrated up to the mid '80s.

In the 1985-1996 period, the Allocative Effect of Soybean indicators showed two tendencies: the strengthening of the positive and significant allocative effects of soybean on larger farms, and the not negligible impacts of substitution of soybean on farms up to 20 hectares.[4] These figures suggest a segmenting of the structure of soybean production in state of Paraná, perhaps due to the rapidly growing export value of the organic soybean specialty crop.

Therefore, the results of this paper, mainly the AESoybean index, seem to be in accordance with the general trends outlined in the hypotheses section: consolidation of the economies of scale, and segmentation of a export commodity that had depended on the advantages of mass production to drive profits. Unfortunately, it is not clear what each of these dual, apparently contradictory production tendencies, one favoring increased scale and the other biased toward product differentiation, contributes to the observed deconcentration in Paraná's farm size-structure found over the period studied.

The correlation between yield behavior and farm size shows the value of economies of scale in Paraná's soybean production (Table 7). In the initial period (1970-75), as soybean was adapted to the conditions in Paraná, the yield variation seems to be more pronounced in the smaller and average size farms. In the later periods, however, especially the most recent (1985-96), the yield growth was more evident on the larger farms.

[4] It is of note that the supply of organic soybeans has increased dramatically over recent years due to high market value of this soybean product (*PARANÁ exports organic soybean are 30% more expensive*, F.S.P., Agrofolha, 02 abr. 1997).

Table 7- Percentage of Variation in Soybean Yield, according to Farm Size-Structure, State of Paraná, Brazil. Period 1970 to 1975, 1975 to 1980, 1980 to 1985 and 1985 to 1996.

Stratum	Period			
(ha)	1970-75	1975-80	1980-85	1985-96
less than 10	70,80	23,20	-11,20	38,60
10-20	85,60	23,90	-13,10	35,80
20-50	99,20	13,10	-10,70	31,30
50-100	76,10	6,20	-8,00	30,70
100-200	44,80	5,80	-5,40	30,30
200-500	43,70	3,60	-1,60	30,10
500-1.000	65,50	2,20	2,60	35,60
1.000-2.000	-2,98	7,10	6,40	40,80
2.000-5.000	31,40	-0,40	13,40	41,20
5.000-10.000	2,20	4,80	25,60	14,50
more than 10.00	...	137,70	-7,90	62,20
TOTAL	84,50	10,60	-5,80	33,70

Source: basic data from Censo Agropecuário (1970-1996) (IBGE).

6. Conclusions

This paper has presented structural change indicators for the agricultural economy in the state of Paraná, emphasizing the restructuring of soybean production. Hypotheses regarding the replacement of areas and the Allocative Effect of soybean over different sizes of farming activity were proven to be in correct direction.

Parana is a major player in all the most important phases of Brazilian agricultural and agribusiness development. The state was incorporated into Brazilian agricultural production several decades ago and now boasts a developed transportation infrastructure of highways, rail lines, and ports to take advantage of its strategic location. Parana

has a strong cooperativist organization and consolidated agribusiness links.

Although, the generally decreased Replacement Index values found over the analyzed period (Table 5) imply that Parana shows a pro-cyclical replacement pattern (probably, dissimilar to states in the Central-West region). The increasing scale found on larger soybean farms seems to precisely reflect the pattern found in the agroindustrial complex development model: larger farms getting larger. These evolutionary characteristics of Paraná's soybean agribusiness are also consistent with increasing inequality in the farm size-structure, which probably aggravated agricultural unemployment in Parana, at least through the mid-1980s.

With Parana's dynamic clearly supporting the trend toward market segmentation, the state's Replacement Index is likely to show higher values, to the extent that a single agricultural crop can be differentiated and generate several products. Organic soybean and the other products made from soy, each with its own uses and/or demand structure, have turned a single crop into various ones.

Innovation and the diffusion of new technology, especially biotechnology, can also stimulate this process of segmentation. The introduction of genetically modified soybean, resistant to certain weed killers, would be more pronounced on larger farms and cause their scale to increase, given the capital-intensive nature of the modification. On the other hand, the effect of increased organic soybean cultivation would be more pronounced on smaller farms.

The advantages of the procedure adopted in this paper, the construction of indicators, is that it clearly expands analysis. When one looks only at the census data on soybean area distributed among farm size strata, one sees that farms of up to 20 hectares controlled 12% of the area planted in soybean in both 1985 and 1996: it appears nothing changed. But, in allocative terms things did change, those farms presented a positive change in the Allocative Effect of Soybean Crop

index over those years. In any case, in order to improve interpretative efforts, there is a strong need to revise the statistical systems, making them versatile enough to incorporate new data and capable of anticipating new trends.

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Table A1.1.- Replacement Index (RI = [TDA/TCSA]. 100) and Allocative Effect of Natural Grasslands (AENG), Cultivated Pastures (AECP), of Permanent Crops (AEPC), Coffee (AECoffee), Orange Trees (AEOrange), Annual Crops (AEAC), Cotton (AECotton), Rice (AERice), Beans (AEBeans), Maize (AEMaize), Soybean (AESoybean), Affor./Reafforestation (AEReaff.) and Wild Forests (AEWF), for the Period 1970 up to 1985, State of Paraná, Brazil.

Stratum	Replacement Index and Allocative Effect (in %)						
(ha)	RI	AENG	AECP	AEPC	AECoffee	AEOrange	AEAC
10 or less	15.65	5.67	23.41	-42.70	-50.90	0.79	23.69
10-20	25.64	1.05	13.21	-35.14	-39.28	0.03	46.13
20-50	36.39	-4.92	8.48	-13.25	-14.37	-0.08	60.75
50-100	43.01	-9.92	9.69	-7.76	-8.56	-0.04	68.47
100-200	42.70	-13.87	18.38	-10.21	-10.97	-0.02	65.54
200-500	35.59	-16.46	28.32	-14.05	-14.82	-0.02	54.21
500-1,000	30.68	-22.98	40.03	-12.37	-13.02	-0.01	41.42
1,000-2,000	28.77	-44.88	41.34	-10.43	-14.00	0.01	29.33
2,000-5,000	27.47	-43.62	24.80	-3.37	-7.11	0.01	24.50
5,000-10,000	26.98	-75.02	8.25	4.90	-1.48	0.01	8.95
10,000 or more	35.98	-8.22	-1.48	15.00	0.07	0.00	8.14
TOTAL	33.77	-13.02	24.08	-16.61	-19.08	-0.05	24.87

cont.

Stratum	Replacement Index and Allocative Effect (in %)						
(ha)	AECotton	AERice	AEBeans	AEMaize	AESoybean	AEReaff.	AEWF
10 or less	28.65	-29.13	6.70	-7.12	3.87	2.79	-0.64
10-20	11.10	-15.19	0.42	-3.34	29.91	2.34	-12.95
20-50	4.74	-5.80	0.17	-3.97	39.67	1.73	-20.11
50-100	1.71	-2.55	-0.48	-0.82	41.90	1.55	-17.22
100-200	1.22	-1.75	-0.67	0.85	40.03	1.61	-15.36
200-500	0.70	-1.62	-0.69	2.25	35.42	3.69	-15.67
500-1,000	0.48	-1.32	-0.75	3.95	27.87	8.24	-21.87
1,000-2,000	0.23	-0.33	-0.04	5.77	16.94	18.15	-13.89
2,000-5,000	-0.50	-1.72	-0.11	3.23	16.96	31.83	-23.60
5,000-10,000	-0.62	-0.24	-0.04	1.10	2.68	47.34	14.75
10,000 or more	0.00	0.85	0.05	1.36	3.04	72.99	-58.41
TOTAL	0.96	-6.38	-5.95	-10.43	28.53	10.20	-14.29

Source: basic data from Censo Agropecuário (1985 e 1995-96)

Table AI.02.- Replacement Index (RI = [TDA/TCSA]. 100) and Allocative Effect of Natural Grasslands (AENG), Cultivated Pastures (AECP), Permanent Crops (AEPC), Coffee (AECoffee), Orange (AEOrange), Annual Crops (AEAC), Cotton (AECotton), Beans (AE Beans), Maize (AE maize), Soybean (IESSoybean), Afforestation/ Reafforestation (AEReaff.), and Wild Forests (AEWF), Period from 1985 up to 1996, State of Paraná, Brazil.

Stratum (ha)	RI	AENG	AECP	AEPC	AECoffee	AEOrange	AEAC
10 or less	22.98	10.34	49.22	-15.13	-18.26	2.92	-57.36
10-20	20.84	11.48	45.58	-18.72	-19.37	1.54	-53.10
20-50	16.11	10.56	57.08	-9.42	-10.49	1.45	-62.63
50-100	15.05	6.42	58.72	-3.76	-5.95	1.45	-50.82
100-200	13.61	4.26	55.64	-6.68	-8.41	0.93	-40.88
200-500	9.75	-7.05	44.18	-6.98	-9.01	0.98	-18.07
500-1,000	17.43	-23.15	-25.23	-4.89	-4.86	0.36	76.76
1,000-2,000	10.38	-15.02	-23.45	-12.22	-5.93	0.27	85.51
2,000-5,000	8.21	-43.25	-9.73	-9.56	-2.41	0.38	82.74
5,000-10,000	19.04	-4.81	-31.43	-10.80	-0.23	-0.01	93.98
10,000 or more	6.97	11.12	-14.44	-77.29	-0.35	0.00	-7.87
TOTAL	14.21	2.37	52.12	-14.13	-12.37	1.26	-32.21

cont.

Stratum (ha)	AECotton	AEBeans	AEMaize	AESoybean	IESRefl.	IESMN
10 or less	-27.76	-35.62	-1.96	9.42	1.33	13.20
10-20	-24.26	-18.85	-5.95	14.35	1.32	16.92
20-50	-17.16	-9.03	1.34	6.87	1.37	17.10
50-100	-10.79	-5.20	6.27	9.56	1.86	13.15
100-200	-8.83	-4.49	13.97	8.12	2.54	9.69
200-500	-5.30	-1.83	30.20	3.28	-0.02	13.25
500-1,000	-2.75	0.70	21.33	18.87	-6.08	1.83
1,000-2,000	-0.95	5.70	34.80	28.74	-6.08	9.10
2,000-5,000	-1.46	0.81	42.16	12.13	4.23	-15.27
5,000-10,000	0.00	-0.46	-0.93	4.27	4.01	-45.27
10,000 or more	0.00	-0.06	0.39	-0.17	23.68	30.41
TOTAL	-15.15	-12.77	8.70	16.05	-2.74	10.11

Source: basic data from Censo Agropecuário (1985 e 1995-96).