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Agrarian Change in Brazil and in Three "Representative" States in the 1970s

by

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Abstract

The existence of large quantities of unused agricultural land in Brazil and the expected inverse relationship between farm size and various measures of production per land unit are documented. Reasons for the inverse relationship are deduced. Production is so large in small farm sizes because intensity of resource use overwhelms the fact that higher-valued crops are grown on large farms and yields tend to be higher there. The disproportionate contribution of small farms to total agricultural production and marketable surplus is measured and the supposition that capitalized intermediate and large farms seem destined to play a larger role in future production in Brazil is argued.

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Despite its enormous debt, Brazil is often represented as a Third World economic colossus. Indeed, it is now the eighth largest economy in the world; Brazil's gross national product (GNP) may surpass that of Italy by 1990. The country is often praised for having a positive trade surplus and, until recently, robust economic growth. While manufacturing achievements are usually credited as the essence of this process, farming has performed a vital supporting role. Graham, Gauthier, and Mendonça document postwar economic progress[1] in which agriculture grew at 4.5 percent a year on average from 1950 to 1965 and at almost 5 percent per year from 1965 to 1980. The other Latin American countries have poorer records.

These growth accomplishments are impressive, but agriculture in Brazil suffers from defects traceable to its highly inegalitarian pattern of resource and income distribution. While the subject of equity was hotly debated by economists in the 1970s,[2] it is doubtful whether any other country in the world illustrates the "growth with inequality" paradigm better than does Brazil.

Political demands resulting from this situation were suppressed until the 1980s; problems surfaced with the installation of José Sarney as the country's first civilian president in two decades, however. In fact, inequalities in agriculture were not a new phenomenon even in the 1970s. They had been well

documented for the early 1960s by a study (CIDA 1966) which concluded that repercussions from an inequitable distribution of land were responsible for premature migration of farm people to cities, lack of adequate farm-sector employment, waste of resources on the part of latifundistas, and poverty for the majority of those employed in the sector.

Most of the poor in rural Brazil had not been lifted by modern economic growth into an era of plenty; rather, a substantial and persistent underclass had appeared. Indeed, the military governments for two decades practiced a "hold the line" attitude on matters of equity while single-mindedly pursuing economic growth targets.

A distributional emphasis--taken from the agrarian reform plank of the platform of president-elect Tancredo Neves--was revived by President José Sarney after the elected president's death, only to be dropped a year or so later and completely abandoned under the new constitution, established in October 1988. In January 1989, in an austerity package, the Ministry of Agrarian Reform was eliminated.

Even so, the agrarian structure of Brazil and its implications for the nation's agricultural economy is a topic of continued interest. Agrarian structure is loosely defined as the institutional framework of agriculture, including, inter alia, farm-size and ownership patterns, corresponding economic status or class groupings (Kanel 1971), and certain associated factor-product and factor-factor relations. Land distribution, in the absence of more direct information, shows roughly what the size distribution of income in farming is likely to be. Contributions of farm persons to agricultural growth and their accrued benefits from agriculture vary according to their position in the agrarian structure. The agrarian structure may also facilitate the choice of technology. And, since the agrarian structure

acts as a sort of prism through which public goods must filter, the likely beneficiaries of government expenditure can be predicted by understanding it.

It is assumed that the introduction of low-cost, high-payoff, new farming technology is a primary reason for most change in contemporary agrarian structure in Brazil. But there are other influential factors, some of which occur concurrently, such as land speculation, government policies,[3] intergenerational subdivision, agricultural use of the frontier, and fear of future agrarian reform.

Our proposal in this article is modest: to delimit the canvas upon which an artist of Brazilian microeconomic detail might subsequently paint a portrait. More specifically, the objective of this paper is to make a tabular presentation of Brazilian agricultural census data (Censo Agropecuário 1970, 1980), which will provide a rudimentary description of Brazil's agrarian structure and the changes within it that are occurring. We focus upon analyzing and comparing published census data for 1970 and 1980.[4] There are some shortcomings in using this information. First, the data are aggregated and averaged across individual farms and the statistics presented should be so interpreted. (On the other hand, the census data observations form a statistical universe rather than just a "representative" sample.) A second limitation of the Brazilian census is that many data are combined across farm activities (for example, the value of fertilizer used in soybeans, corn, bananas, and so forth, is added and reported as fertilizer use for a particular farm-size group). Given the diversity of Brazil's agriculture, such aggregation may blur important distinctions about the nature of production in the various size groups in different regions of the country. Third, one may question the weather normalcy in 1970 and 1980. Several steps are taken to minimize potential distortions. The analysis utilizes national

level data as well as those for one representative state from three distinct farming regions--the northeast (Ceará), the western frontier (Mato Grosso),[5] and the southeast (Paraná). Additionally, data on cropping patterns and physical yields are provided by farm-size group for each of these three states. Finally, a check of production data reported by the Inter-American Bank[6] indicates that weather pattens during those years were relatively normal.

The first section of this paper describes the intercensal distribution of agricultural resources; in fact, it is a comparison of two snapshots of Brazil's agrarian structure taken a decade apart. An important question addressed is whether the land-distribution pattern has become more concentrated over time.

In a second section, we explore the use and productivity of inputs in Brazilian agriculture. Particular emphasis is given to variations in resource use and productivity by their position in the agrarian structure as defined by farm-size categories. Among the questions addressed are: (1) Do certain factor-factor relationships vary among the farm-size classes? (2) Does the usually accepted generalization of an inverse relationship between farm size and productivity characterize Brazilian agriculture and, if so, why? (3) How does land use vary across size groups? (4) What farm-size strata contribute most to agricultural growth.

We thereby provide a small step toward responding to the de Janvry critique of preceding studies of structural analysis: "the structuralist description of the latifundio-minifundio complex was a quantitative one centering on farm size rather than a qualitative one based on modes of production and social relations. The quantitative relation does not necessarily change as the qualitative one does, as the landlords become

large-scale capitalist entrepreneurs" (de Janvry 1981, pp. 147-48). This study moves in the direction of providing a qualitative interpretation of quantitative data from which it may be possible to make inferences regarding resource-allocation policy.

The Distribution of Agricultural Resources

The dramatic nature of the inequity problem in Brazil is frequently illustrated by the dated statistics of 1972, which the World Bank still used in its 1988 Development Report.[7] These data show the top 20 percent of the population obtaining 66 percent of total income while the bottom 20 percent receives only 2 percent. More recently, the World Bank has concluded, "Brazil has one of the most unequal distributions of national income in the world, and glaring disparities in the living standards, health status, and educational attainment of different segments of its population have persisted despite several decades of remarkable economic growth" (World Bank 1988a, p. 1). Langoni (1973) calculates that the Gini ratio describing income concentration in the decade of the 1960s rose for the workforce in the primary nonmining sector from .50 to .57, while the Brazilian publication, Reforma Agraria (1982), showed it as .58 in 1980. Skidmore (1988, p. 286) cites data which show inequality growing substantially between 1960 and 1970 but more slowly in the 1970s.

The consequence of inequitable distribution of incomes is set in context by the press. For example, a Washington Post article noted, "Brazil, whose enormous resources and dynamism make it Latin America's most viable nation, is seeing its urban slums wracked by violence, its countryside unsettled by land conflicts and its health and education services decayed by neglect" (Graham

1987). Others argue that distortions imperil Brazil's growth, rapid though it has been until lately. Periodic downturns between years of high growth indicate that Brazil's economic structure may not have a sufficiently firm foundation. The Economist asserts, "[Its] population grows by 2.3% a year, half of Brazilians are under 20; this produces 1.3m new workers each year; a real GDP growth rate of 6% a year is needed to absorb them; a personal savings rate of 25% is needed for that; [in 1986] personal savings fell to 15%, of which 3-4% went to service foreign debt and the bulk of the rest was needed by the government for its deficit and those of state owned companies" (Economist 1987. The Inter-American Development Bank reported that in 1987, Brazil's gross domestic product (GDP) rose by only 2.9 percent and "to a large extent, this deceleration reflected the fact that the stimulus to consumer spending . . . in 1986 . . . in the form of rising real wages and in a comprehensive price freeze could not be sustained" (IADB 1988, p. 361).

The distribution of land is one factor in determining the distribution of income in rural Brazil. The 1940 through 1980 census data indicate a lack of any noticeable move toward a more equitable distribution of land. In that period, the amount of agricultural land in the country rose from 197.7 million hectares to 364.8 million, and the number of properties increased from 1.9 million to 5.2 million (Table 1). In other words, the agricultural hectarage nearly doubled and the number of properties rose by about two-and-a-half times, thus reducing mean farm size from 103 hectares to 70 hectares. Because of the highly unequal land distribution, mean data by farm-size groupings are more revealing (Table 2).

An absolute drop in the rural population of the country began some time in the late 1970s, falling from 41.6 million in 1970 to 39.1 million in 1980.

TABLE 1

Property and Land Distribution, Brazil, 1970 and 1980*

FARM SIZE (in hectares)	NUMBER OF PROPERTIES PER CATEGORY			% PROPERTIES PER CATEGORY		
	1970	1980	% Change	1970	1980	% Change
Under 1	396,846	469,091	18	8	9	13
1 up to 10	2,122,784	2,128,928	0	43	41	-5
10 up to 50	1,592,538	1,625,381	2	33	32	-3
50 up to 200	557,183	652,107	17	11	13	12
200 up to 2,000	220,909	254,952	15	5	5	10
2,000 up to 10,000	13,933	18,351	32	0	0	25
10,000 and over	1,449	2,345	62	0	0	54
Nation	4,905,642	5,151,155	5			

FARM SIZE (in hectares)	TOTAL AGRICULTURAL HECTARES			% LAND PER CATEGORY		
	1970	1980	% Change	1970	1980	% Change
Under 1	236,093	280,003	19	0	0	0
1 up to 10	8,847,403	8,724,254	-1	3	2	-20
10 up to 50	36,167,681	37,136,292	3	12	10	-17
50 up to 200	53,602,425	62,030,046	16	18	17	-7
200 up to 2,000	108,312,985	129,154,744	19	37	35	-4
2,000 up to 10,000	50,788,449	67,521,295	33	17	19	7
10,000 and over	36,190,429	60,007,780	66	12	16	34
Nation	294,145,465	364,854,414	24			

* We have combined 15 censal categories into 7, making breaks where the most marked changes in type of labor use occurred. Helpful in this regard was the work of da Silva (1984, p. 74): "The primary economic distinction between the capitalist class and the peasantry is that capitalists by definition employ an equivalent or greater amount of hired labor relative to family labor in the process of commodity production." This follows Lenin (1964, p. 237): "The employment of hired labor is the principal manifestation of agricultural capitalism."

Source: Censo Agropecuário, VIII recenseamento geral, 1970, 25 vols. (Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística, 1975), Tables 1A and 1B; and Censo Agropecuário, IX recenseamento geral do Brasil, 1980, 26 vols. (Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística, 1983-84), Tables 1A and 1B. In subsequent tables, source will be cited simply as Censo Agropecuário, 1970 or 1980.

TABLE 2.A

Type of Labor per Hectare, Brazil, 1970 and 1980
(in person-months)

FARM SIZE (in hectares)	MEAN FARM SIZE (in hectares) 1970	1980	TOTAL LABOR PER HECTARE 1970	1980	% Change	PERMANENT WORKERS PER HECTARE 1970	1980	% Change
Under 1	.59	.60	56.54	49.25	-13	0.35	0.32	-8
1 up to 10	4.2	4.1	8.52	9.78	15	0.09	0.14	52
10 up to 50	22.7	22.8	1.94	2.21	14	0.06	0.11	69
50 up to 200	96.2	95.1	0.56	0.70	26	0.06	0.10	68
200 up to 2,000	490.3	506.6	0.17	0.23	37	0.05	0.09	56
2,000 up to 10,000	3,645.2	3,679.4	0.04	0.06	49	0.02	0.03	51
10,000 and over	24,976.1	25,589.7	0.01	0.02	90	0.01	0.02	109
Nation	59.96	70.83	0.71	0.71	1	0.05	0.07	51

FARM SIZE (in hectares)	UNPAID FAMILY LABOR PER HECTARE 1970	1980	% Change	TEMPORARY LABOR PER HECTARE 1970	1980	% Change	SHARECROPPER LABOR PER HECTARE 1970	1980	% Change
Under 1	53.11	45.33	-15	2.94	3.69	26	0.14	0.04	-70
1 up to 10	7.90	8.68	10	0.47	0.92	96	0.06	0.04	-28
10 up to 50	1.67	1.76	5	0.14	0.29	105	0.06	0.05	-14
50 up to 200	0.38	0.41	9	0.07	0.24	222	0.06	0.03	-28
200 up to 2,000	0.07	0.07	1	0.03	0.08	148	0.05	0.01	-34
2,000 up to 10,000	0.01	0.01	9	0.01	0.02	97	0.02	0.00	-51
10,000 and over	0.00	0.00	7	0.00	0.00	98	0.00	0.00	-90
Nation	0.58	0.52	11	0.06	0.11	83	0.03	0.02	-34

[continued]

TABLE 2.B

Type of Labor per Hectare, Cearaá, 1970 and 1980
(in person-months)

FARM SIZE (in hectares)	MEAN FARM SIZE (in hectares) 1970	1980	TOTAL LABOR PER HECTARE 1970	1980	% Change	PERMANENT WORKERS PER HECTARE 1970	1980	% Change
Under 1	.54	.55	59.07	51.97	-12	0.85	2.01	136
1 up to 10	4.2	4.1	9.32	9.96	7	0.08	0.25	224
10 up to 50	22.9	22.6	2.16	2.45	14	0.03	0.17	409
50 up to 200	94.7	93.4	0.65	0.85	31	0.03	0.11	311
200 up to 2,000	459.2	449.5	0.20	0.30	53	0.02	0.06	289
2,000 up to 10,000	3,473.0	3,427.7	0.06	0.11	92	0.01	0.03	157
10,000 and over	20,684.6	15,772.4	0.02	0.08	224	0.00	0.05	1949
Region	49.37	47.80	0.96	1.17	20	0.02	0.07	319

FARM SIZE (in hectares)	UNPAID FAMILY LABOR PER HECTARE 1970	1980	% Change	TEMPORARY LABOR PER HECTARE 1970	1980	% Change	SHARECROPPER LABOR PER HECTARE 1970	1980	% Change
Under 1	53.42	44.91	-16	4.22	5.00	19	0.58	0.06	-90
1 up to 10	8.03	8.07	1	1.14	1.60	41	0.07	0.05	-39
10 up to 50	1.70	1.63	-4	0.36	0.59	65	0.06	0.06	-5
50 up to 200	0.42	0.41	-5	0.14	0.28	96	0.06	0.06	7
200 up to 2,000	0.08	0.08	-9	0.06	0.11	104	0.04	0.05	18
2,000 up to 10,000	0.01	0.01	4	0.02	0.05	193	0.02	0.02	16
10,000 and over	0.00	0.00	40	0.01	0.02	159	0.01	0.00	-72
Region	0.74	0.73	-1	0.16	0.29	77	0.05	0.05	8

[continued]

TABLE 2.C

Type of Labor per Hectare, Mato Grosso, 1970 and 1980
(in person-months)

FARM SIZE (in hectares)	MEAN FARM SIZE (in hectares) 1970	1980	TOTAL LABOR PER HECTARE 1970	1980	% Change	PERMANENT WORKERS PER HECTARE 1970	1980	% Change
Under 1	.51	.38	50.58	96.95	92	0.98	3.54	261
1 up to 10	4.5	4.8	7.21	8.98	25	0.07	0.10	44
10 up to 50	22.9	23.9	1.90	2.21	17	0.05	0.08	50
50 up to 200	98.9	102.4	0.45	0.53	19	0.03	0.06	86
200 up to 2,000	665.6	649.8	0.08	0.11	38	0.0137	0.0327	138
2,000 up to 10,000	4,063.9	4,157.0	0.02	0.03	70	0.0075	0.0228	204
10,000 and over	21,339.6	24,967.1	0.01	0.01	75	0.0043	0.0087	102
Region	433.69	587.55	0.10	0.10	4	0.0006	0.0110	1648

FARM SIZE (in hectares)	UNPAID FAMILY LABOR PER HECTARE 1970	1980	% Change	TEMPORARY LABOR PER HECTARE 1970	1980	% Change	SHARECROPPER LABOR PER HECTARE 1970	1980	% Change
Under 1	49.27	91.07	85	0.32	2.16	567	0.0000	0.1731	-
1 up to 10	6.98	8.53	22	0.16	0.24	52	0.0063	0.0051	-19
10 up to 50	1.77	1.97	12	0.08	0.16	109	0.0042	0.0064	53
50 up to 200	0.38	0.42	9	0.03	0.05	62	0.0030	0.0039	27
200 up to 2,000	0.0529	0.0531	0	0.0086	0.0187	116	0.0009	0.0009	-3
2,000 up to 10,000	0.0072	0.0072	0	0.0026	0.0070	166	0.0002	0.0002	1
10,000 and over	0.0013	0.0012	-7	0.0015	0.0027	73	0.0000	0.0000	-12
Region	0.0811	0.0697	-14	0.0058	0.0061	6	0.0004	0.0004	11

[continued]

TABLE 2.D

Type of Labor per Hectare, Paraná, 1970 and 1980
(in person-months)

FARM SIZE (in hectares)	MEAN FARM SIZE (in hectares) 1970	1980	TOTAL LABOR PER HECTARE 1970	1980	% Change	PERMANENT WORKERS PER HECTARE 1970	1980	% Change
Under 1	.50	.42	62.26	61.14	-2	0.85	1.03	21
1 up to 10	5.4	5.4	4.64	6.61	43	0.07	0.12	66
10 up to 50	20.8	21.6	2.36	2.39	9	0.09	0.13	43
50 up to 200	90.9	92.7	0.74	0.83	31	0.12	0.17	42
200 up to 2,000	474.3	485.5	0.29	0.32	30	0.15	0.16	6
2,000 up to 10,000	3,491.5	3,408.3	0.10	0.13	63	0.07	0.08	5
10,000 and over	33,663.5	24,557.7	0.08	0.13	56	0.07	0.10	42
Region	26.38	36.09	1.65	1.36	-18	0.11	0.14	31

FARM SIZE (in hectares)	UNPAID FAMILY LABOR PER HECTARE 1970	1980	% Change	TEMPORARY LABOR PER HECTARE 1970	1980	% Change	SHARECROPPER LABOR PER HECTARE 1970	1980	% Change
Under 1	53.04	59.11	11	8.30	0.90	-89	0.07	0.10	46
1 up to 10	5.98	6.05	1	0.34	0.38	13	0.01	0.05	280
10 up to 50	2.05	1.88	-8	0.15	0.29	102	0.03	0.08	163
50 up to 200	0.44	0.41	-6	0.16	0.21	34	0.03	0.04	41
200 up to 2,000	0.06	0.06	-10	0.07	0.10	46	0.01	0.01	-18
2,000 up to 10,000	0.01	0.01	-11	0.02	0.04	122	0.00	0.01	242
10,000 and over	0.00	0.00	-14	0.01	0.02	177	0.00	0.00	-
Region	1.39	1.00	-28	0.13	0.18	36	0.02	0.03	82

Source: Table 1, above; Censo Agropecuário, 1970, Tables 16 and 20; Censo Agropecuário, 1980, Tables 20 and 22.

Meanwhile, because of city-based farm labor, total labor-months utilized during the year increased from 208 million to 260 million between 1970 and 1980, or by 25 percent nationwide.[8] There was an increase in labor-months employed in agriculture of 17 percent in Ceará and of 33 percent in Mato Grosso, and a decline of 8 percent in Paraná. The Paraná decrease in labor use corresponded with an especially high level and increased use of labor-saving technology.[9]

Agricultural land grew 8 percent in the 1950s, 18 percent in the 1960s, and 24 percent in the 1970s, indicating an increasingly viable frontier and the inexorable expansion of settlement. The total number of farms increased, but at a decreasing rate, during the same period--62 percent in the 1950s, 47 percent in the 1960s, and 5 percent in the 1970s--implying that large farms were established on the more recently added land.

The number of farms and the rural population are still growing in absolute terms in the traditional Northeast and the recently occupied frontier North. In the Southeast and South, the number of properties and rural population are declining, and in the recently settled Central-West, the number of properties is growing slowly. Agricultural land is growing in all regions, at a slow rate (between 0.5 and 0.6 percent a year) in the South and Southeast, and at a rapid rate in the two regions of recent occupation in the North and Central-West (3.9 and 7.9 percent, respectively).[10]

While the frontier is accommodating the high rate of Brazilian population growth and the concomitant increase of the workforce, settlement of the Amazon offers a highly dubious solution to Brazil's population problem. The development of the frontier acts as a safety valve by relieving social and political pressure, but it is putting Brazil's long-run economic future and the global ecosystem itself in serious jeopardy (Branford and Glock 1985);

this type of colonization delays the day when Brazil needs to confront its land-tenure problems on its already settled areas.

Landlessness is another aspect of the issue. According to Pomer (1988), there are about 3 million permanent, salaried rural workers, 5 million temporary agricultural workers, 1 million squatters, and 2 million renters and sharecroppers. While these numbers will decline as farm labor moves to cities, the temporary workers are already largely urban-based, seasonal farmworkers, or _bóias frias_.[11] Most of the Pomer group is in dire need of land. And Table 2 indicates that land available per farmworker dropped in nearly all farm-size groups between 1970 and 1980.

Thus, Table 1 shows that in the 1970s, additional agricultural land was most likely to augment the large farm-size categories. Furthermore, an agrarian structure exhibiting high land concentration in 1940 became more concentrated by 1980. In Brazil, unlike some other countries of the region, no land reform intervened to change the position or the shape of the Lorenz curve very much in forty years. The Gini coefficients, calculated from the agricultural censuses for 1940, 1950, 1960, 1970, 1975, and 1980, were .825, .837, .836, .838, .850, and .853. Between 1970 and 1980, the Gini coefficient increased in Paraná (from .69 to .73) and decreased slightly in Ceará (.78 to .77) and Mato Grosso (.93 to .90). Brazil's overall Gini coefficient for land concentration in 1980 was slightly higher than Guatemala's in 1979. The only country recording a higher Gini coefficient (considering census reports available in 1988) in Latin America was Paraguay, at .94.[12]

These findings on concentration roughly agree with observations in Brazilian regions by Hoffman (1982), who reports relative stability in farmland concentration in the country as a whole, but a slight tendency for the Gini ratio to rise in the South and to oscillate in the North.

Inequalities, Hoffman concludes, stem largely from growing interregional inequality, which is defined as an increase in the difference of mean farm size for various regions over time.

Characterizing Production and Productivity in Brazil's Agriculture

The agricultural economy of Brazil has been dominated by the fazenda and the plantation from colonial days.[13] Thus, it has usually been assumed that the agrarian structure of Brazil is bimodal (Johnston 1966; Johnston and Clark 1982); one can interpret Table 1 and Table 3 as an illustration of that point.

Inputs and Resource Allocation

In Table 3, the majority of the establishments (we have no choice but to assume that each is owned by a different individual, though this probably understates the concentration in the hands of a few, for some owners doubtless own more than one discrete property) are in the small-farm categories while most of the agricultural land is in the hands of large commercial farms. Cropland and capital are concentrated in middle- and large-sized properties. A higher percent of total labor is used on small farms than on large ones. Bimodality is not a strict dichotomy and is less so in 1980 than in 1970: the amount of labor and capital in the 50-to-200-hectare cohort is around one-fifth of the total, and that size group and the next larger one grew during the decade, when measured by percentage of total farm receipts and net income. These observations give some credence to those who believe that a capitalized family-farm sector is becoming more important in Latin American agriculture.

One noteworthy conclusion from Tables 3 and 4 is that a large number of labor resources are employed by small farms. Brazilian farms up to 50 hectares[14] account for 82 percent of the properties but only 12 percent of

TABLE 3

Percent of Inputs and Outputs, by Farm Size, in Brazil, 1970 and 1980

FARM SIZE (in hectares)	% OF TOTAL													
	Properties		Agricultural Land		Cropland		Labor		Capital		Total Farm Receipts		Net Income	
	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980
Under 1	9	8	0[a]	0[a]	1	1	6	6	1	1	1	1	2	2
1 up to 10	41	43	2	3	11	16	33	36	7	12	12	16	16	19
10 up to 50	32	33	10	12	27	35	32	34	20	29	27	30	32	34
50 up to 200	13	11	17	18	23	22	17	14	20	24	22	19	21	18
200 up to 2,000	5	5	35	37	29	22	11	9	32	20	29	16	24	21
2,000 up to 10,000	0[a]	0[a]	19	17	7	3	2	1	15	10	7	6	5	5
10,000 and over	0[a]	0[a]	16	12	2	1	1	0	6	3	2	2	0	2

a. 0 = less than 1%.

Source: Calculated from Censo Agropecuário, 1970, Tables 9, 27, 31, and 34; Censo Agropecuário, 1980, Tables 18, 29, 32, and 34.

TABLE 4

Percent of Inputs and Outputs, by Farm Size, in Ceará, Mato Grosso, and Paraná, 1980

FARM SIZE (in hectares)	FARM-SIZE GROUPINGS						
	Properties	Agricultural Land	Cropland	Labor	Capital	Total Farm Receipts	Net Income
Under 1	(3, 1, 2)[a]	(0, 0, 0)	(0, 0, 0)	(2, 1, 1)	(1, 0, 0)	(1, 0, 0)	(1, 0, 0)
1 up to 10	(45,32,45)	(4, 0, 7)	(11, 4,14)	(33,24,33)	(12, 1,11)	(19, 4,14)	(25, 7,17)
10 up to 50	(33,26,42)	(16, 1,25)	(25, 8,39)	(33,23,44)	(22, 4,31)	(27, 7,37)	(36,10,40)
50 up to 200	(14,17, 8)	(28, 3,21)	(43, 9,23)	(21,16,13)	(26,15,22)	(26, 8,22)	(28, 8,20)
200 up to 2,000	(4,18, 2)	(40,20,33)	(13,41,20)	(10,21, 8)	(29,22,29)	(21,35,22)	(14,28,19)
2,000 up to 10,000	(0, 4, 0)	(11,32,10)	(7,26, 3)	(1, 9, 1)	(8,37, 6)	(4,28, 4)	(-6,27, 3)
10,000 and over	(0, 1, 0)	(2,44, 4)	(1,12, 1)	(0, 6, 0)	(2,21, 2)	(1,19, 1)	(0,19, 0)

a. (Ceará, Mato Grosso, Paraná).

Source: Calculated from Censo Agropecuário, 1970, Tables 9, 27, 31, and 34; Censo Agropecuário, 1980, Tables 18, 29, 32, and 34.

the agricultural land, 39 percent of the cropland, and 28 percent of the capital. Capital is a scarce resource and land might be considered a severely rationed factor. Corresponding percentages for 1970 were 84, 15, 52, and 42, which show that claims on scarce resource by small farms became weaker during the 1970s.

Meanwhile, the farms of less than 50 hectares employ 71 percent of the clearly abundant resource, the agricultural workforce (this percentage was 76 in 1970). The use by small farms of labor instead of capital is to the general social benefit of the economy. If labor were not employed in small-farm agriculture, it might well transfer to cities and towns, where it would likely join swelling unemployment or the substantial informal sector there. While labor is doubtless "underemployed" in small-farm agriculture, this condition appears preferable to its being openly unemployed.

At the same time, there are several indicators that land use which permits rather large acreages to go idle even in light of underemployed labor, is a malady that especially plagues the middle- and large-farm sector. One indication is the impressive amounts of land in the "fallow or not utilized agricultural land" category (Table 5). Another sign (see Table 6) is the rather large amount of natural pasture, especially on large farms. About one-third of the agricultural land in Ceará and Mato Grosso is in natural pasture in 1980, while the figure is less than 10 percent in more commercially oriented Paraná. Of course, there is no way in which we can estimate how much natural pastureland is suitable for improved pasture or how much pastureland could be utilized for crops.

Contrarily, there are several optimistic points on land use that could be made from Tables 5 and 6. While agricultural hectares rose dramatically between 1970 and 1980, the amounts of land in the "unused and fallow" category

TABLE 5

Fallow or Unused Agricultural Land, Brazil, 1970 and 1980

FARM SIZE (in hectares)	FALLOW OR UNUSED LAND IN 1970 (ha.)	% OF TOTAL AGR. LAND	% OF TOTAL FALLOW OR UNUSED LAND	FALLOW OR UNUSED LAND IN 1980 (ha.)	% OF TOTAL AGR. LAND	% OF TOTAL UNUSED LAND
			B R A Z I L			
Under 1	4,895	2.1	0	4,625	1.6	0
1 up to 10	788,539	9.0	2.4	593,804	6.8	1.8
10 up to 50	5,624,318	15.6	16.8	4,594,370	12.2	13.7
50 up to 200	7,189,530	13.4	21.5	6,788,832	10.9	20.3
200 up to 2,000	11,871,069	11.0	35.5	11,114,144	8.6	33.2
2,000 up to 10,000	4,594,040	9.0	13.7	5,372,879	8.0	16.1
10,000 and over	3,338,070	9.2	10.0	4,965,601	8.3	14.9
Nation	33,410,460	11.4	100.0	33,434,255	8.5	100.0
			C E A R A			
Under 1	145	3.0	0.	52	1.3	0
1 up to 10	36,519	7.8	2.1	17,931	3.9	2.1
10 up to 50	261,822	14.2	15.1	141,621	7.6	16.7
50 up to 200	516,862	16.1	29.8	265,289	8.1	31.2
200 up to 2,000	697,283	14.7	40.2	340,838	7.3	40.1
2,000 up to 10,000	181,330	13.0	10.5	79,072	6.4	9.3
10,000 and over	38,900	9.0	2.2	4,930	2.2	0.6
State	1,732,861	14.3	100.0	849,733	7.2	100.0
			M A T O G R O S S O			
Under 1	5	1.8	0	19	4.6	0
1 up to 10	6,690	3.2	0.3	5,044	2.9	0.1
10 up to 50	89,295	12.6	3.7	48,460	7.1	1.3
50 up to 200	113,285	10.1	4.7	110,186	5.7	2.9
200 up to 2,000	524,580	6.4	21.9	747,128	5.7	19.8
2,000 up to 10,000	664,137	4.7	27.7	1,163,434	5.6	30.8
10,000 and over	996,548	4.7	41.7	1,697,550	5.9	45.0
State	2,394,540	5.2	100.0	3,771,802	5.8	100.0
			P A R A N A			
Under 1	47	1.9	0	101	2.1	0
1 up to 10	56,120	3.6	2.5	29,735	2.7	2.3
10 up to 50	723,112	16.0	32.8	375,258	9.1	28.9
50 up to 200	710,520	24.0	32.2	404,878	11.6	31.1
200 up to 2,000	537,570	14.1	24.4	363,014	6.8	27.9
2,000 up to 10,000	118,712	8.3	5.4	74,375	4.4	5.7
10,000 and over	57,645	13.2	2.6	52,556	7.9	4.0
State	2,203,726	15.1	100.0	1,299,917	7.9	100.0

Source: Table 1, above; Censo Agropecuário, 1970, Table 9; Censo Agropecuário, 1980, Table 18.

TABLE 6

Land Use: Crops and Pastures, Brazil, 1970-1980

FARM SIZE (in hectares)	% TOTAL LAND IN CROPS			% TOTAL LAND IN NATURAL PASTURE			% TOTAL LAND IN IMPROVED PASTURE		
	1970	1980	% Change	1970	1980	% Change	1970	1980	% Change
B R A Z I L									
Under 1	93	90	-3	2	2	-7	1	1	73
1 up to 10	69	64	-4	11	11	-8	4	6	39
10 up to 50	32	35	9	24	21	-14	8	11	29
50 up to 200	14	18	33	37	29	-23	10	15	46
200 up to 2,000	7	11	61	47	35	-25	12	21	67
2,000 up to 10,000	2	5	122	52	35	-33	11	20	90
10,000 and over	1	2	198	48	31	-36	6	11	91
C E A R A									
Under 1	83	84	1	3	1	-54	1	0	-42
1 up to 10	65	68	4	10	9	-8	0	0	6
10 up to 50	35	39	13	24	25	1	1	1	26
50 up to 200	21	25	23	32	32	-0	1	1	50
200 up to 2,000	13	17	35	38	38	-0	1	1	69
2,000 up to 10,000	8	15	87	39	39	1	1	2	174
10,000 and over	7	17	144	19	35	82	1	5	617
M A T O G R O S S O									
Under 1	90	78	-13	3	8	147	0	2	-
1 up to 10	82	82	1	2	2	-13	0	5	14467
10 up to 50	33	35	8	12	9	-24	0	26	9341
50 up to 200	9	15	58	33	17	-49	0	32	13107
200 up to 2,000	2	10	400	54	29	-48	0	34	43942
2,000 up to 10,000	0	4	745	65	37	-43	0	24	95501
10,000 and over	0	1	1659	102	37	-64	0	12	4176780
P A R A N A									
Under 1	71	71	1	12	3	-72	3	5	74
1 up to 10	80	76	-5	3	4	16	5	7	23
10 up to 50	48	58	21	7	7	-2	13	14	7
50 up to 200	23	40	71	13	10	-25	20	24	20
200 up to 2,000	14	23	63	19	13	-34	30	38	27
2,000 up to 10,000	5	11	114	25	12	-53	22	28	28
10,000 and over	0	10	18347	5	3	-32	7	5	-23

Source: Table 1, above; Censo Agropecuário, 1970, Table 9; Censo Agropecuário, 1980, Table 18.

remained just about constant. Countrywide, 11.4 percent of total agricultural land fell into this category in 1970, and 8.5 percent in 1980. Of the three states, areas and percentages in the "fallow or not utilized" category dropped in Ceará and Paraná--both dramatically. There was more land not utilized in Mato Grosso in 1980 than in 1970, which, due to its frontier nature, is to be expected. Indeed, the low 1970 percentage as well as the fairly low 1980 data are more surprising.

Also, there has been some conversion of natural pasture to improved pasture (Table 6). Land that was improved between 1970 and 1980 appears largely to be in the middle- and large-farm sizes. In terms of additional improved pasture, the Mato Grosso case is particularly dramatic. Moreover, proportionally more cropland appeared in the 1970s in larger farm sizes, even though the 1970 and 1980 figures were very low.

It may be estimated that 33 million agricultural hectares lie idle; as shown previously, there are at least 11 million landless or partially landless families in Brazil. This observation raises questions about the merit of a land-tenure structure that permits such wastefulness. To a landless family, 3 hectares is a king's ransom. What is more, percentage of natural pasture countrywide increases with farm size; it would be remarkable indeed if there were not some margin for converting some substantial fraction of this property to more intensive use. To argue otherwise, one would have to assert that even though the conversion from natural to improved pasture occurred at a rapid rate in large-farm sizes in the 1970s, the margin is now used up; it is highly unlikely that this is true. Except in Mato Grosso, Table 7 indicates that more improved pasture has been accompanied by an increase in carrying capacity. (We cannot explain Mato Grosso's erratic negative behavior in

TABLE 7

Livestock Head per Hectare Pasture, Brazil, 1970-1980

	1970	1980	% CHANGE	1970	1980	% CHANGE
	B R A Z I L			C E A R A		
Under 1	42.12	38.99	-8	52.88	113.69	115
1 up to 10	2.54	2.94	16	2.93	3.72	27
10 up to 50	1.07	1.31	23	0.82	1.03	25
50 up to 200	0.65	0.86	32	0.48	0.63	32
200 up to 2,000	0.48	0.69	44	0.30	0.45	49
2,000 up to 10,000	0.33	0.49	47	0.19	0.30	61
10,000 and over	0.22	0.29	32	0.15	0.25	72
Total	0.51	0.68	33	0.42	0.58	38
	M A T O G R O S S O			P A R A N A		
Under 1	169.30	19.20	-89	14.40	21.65	50
1 up to 10	14.26	2.00	-86	2.44	3.12	28
10 up to 50	3.06	0.46	-85	1.44	1.83	27
50 up to 200	1.14	0.33	-71	1.04	1.43	38
200 up to 2,000	0.48	0.15	-68	0.91	1.32	46
2,000 up to 10,000	0.33	0.12	-65	0.63	1.13	79
10,000 and over	0.30	0.16	-47	0.44	0.81	85
Total	0.35	0.15	-59	1.04	1.43	37

Source: Censo Agropecuário, 1970, Table 36; Censo Agropecuário, 1980, Table 35.

carrying capacity in light of its reduction in natural pasture and its increase in improved pasture.)

One surprise is the amount of unused and fallow land in the middle ranges of farm size in the country data and those for Paraná and for Ceará (Table 5). In Mato Grosso, the percentages of unused and fallow wasteland are relatively low, but largest percentages are in the largest sizes, as we expected but did not find for the other two states. Extension agents and agricultural technicians have noted that farmers can make more money by holding land for speculative purposes rather than investing in improved practices.[15]

The picture that emerges from these data is one of a great deal of unused land tied up in medium-sized farms and large estates while the small-farm sector is probably utilized to the point of exhaustion. Indeed, there is some indication that smallest farms were cutting back in land-use intensity in the 1970-to-1980 period, which may well be related to overuse of the land resource. They also seemed quite stable in size (Table 2), and this may mean that they have already reached some critical minimum area. The census does not tell us (but perhaps subsequent analysis will) whether land is immediately carved out at the frontier by large farmers or whether small farmers clear the timber and the brush only to be displaced later by large fazendeiros and/or speculators. We suspect that both practices are common and that we are not likely to find many stable peasant communities at the frontier.

Incomes and Productivity

The fact that the labor-intensive method of combining resources on small farms results in incomes above what would be expected by examining the proportion of nonlabor factors used is a further and perhaps more important test of the economic contribution of the small farm in Brazil. As Table 3

demonstrates, a large proportion of total agricultural production in the country originates on farms under 50 hectares; these farms--with 12 percent of the land--yield 40 percent of farm receipts and earn half of the country's net agricultural income.[16] Of the three states selected for comparison, two exhibit a pattern quite similar to the countrywide data (Table 4); only Mato Grosso, the frontier state, diverges from the pattern. Mato Grosso is the most classically bipolar case examined here; its land area is taken up preponderantly with large farms, and output is produced and scarce or quasi-scarce factors are used in their greater part by this large-farm sector. In Mato Grosso, farms that are over 200 hectares in size occupy 96 percent of the agricultural land, account for 79 percent of the cropland and 80 percent of the capital (and only 36 percent of the labor), and generate 82 percent of the gross receipts and 74 percent of the net income. In Ceará and Paraná, the small farm dominates this measure of agricultural performance, as in countrywide averages.[17]

Based on the countrywide data, it can be inferred that the 46 million hectares allocated in small-scale units (out of Brazil's 365 million hectares) produce between two-fifths and one-half of its agricultural product. These small farms cannot be dismissed as simply subsistence producers, farmers who consume their output and, hence, do not make a useful contribution beyond the farm gate to the country's economic development. Economic development requires that food be transferred in abundance, and cheaply, to the nonfarm sector, where it becomes a wage good. Table 8 shows that in all size groups, a mean of over 86 percent of total production is marketed. While marketable surplus approaches 100 percent in countrywide data on large farms, it is also substantial on small farms. Farms from 1 to 50 hectares in size market 78 percent of what they produce countrywide. On the basis of these data, the

tendency of some to regard small-scale producers as subsistence growers, who support themselves with their own production but have little excess to sell, is incorrect. Small producers are, indeed, quite integrated into the market.

This seems to contradict Furtado (1972, pp. 98-99), who writes, "In Brazil, the peasant community . . . exercised only a small influence in the process of accumulation."[18] On the other hand, without the wealth of data on the matter which the 1980 census provides, referring to farms under 100 hectares as "petty producers," da Silva (1978, p. 163) concluded: "petty production . . . is responsible for the greater part of the urban food supply."

Two other questions are now appropriate: Which of the seven size groups is responsible for the bulk of agricultural production. And, in which size cohort is production growing most rapidly? The most net income from a single category in 1980 was generated by the 10-50 hectare group (Appendix Table 1A), which produced almost one-third of net income in agriculture in the country. The percentage in 1970 from the same category was somewhat greater. The category that generated the most receipts was the 200-to-2,000-hectare farm, which accounted for about 30 percent, while in 1970, the 10-50 hectare group generated highest receipts. In Paraná and Ceará, the 10-50 hectare group generated the most net income and total receipts in both 1970 and 1980. In contrast to the other two states, in Mato Grosso, the 200-to-2,000-hectare category accounted for most farm receipts in 1970 and 1980 and most net income in 1980; most net income in 1970 came from the 2,000-to-10,000-hectare group. As Appendix 1B shows, export crops, usually considered high value (coffee, soybeans, sugar), and rice production are concentrated in the 10-to-2,000-hectare size group. Domestic crop production, often considered lower value (beans, manioc, and maize), is concentrated in the 1-to-200-hectare category.[19]

TABLE 8

Marketed Surplus as Percent of Gross Product, Brazil, 1980

FARM SIZE (in hectares)	BRAZIL	CEARA	MATO GROSSO	PARANA
Under 1	82	95	100**	83
1 up to 10	78	78	80	81
10 up to 50	78	72	84	83
50 up to 200	86	74	86	91
200 up to 2,000	93	74	96	95
2,000 up to 10,000	96	82	95	96
10,000 and over	96	100	97	1.05*
Country and regional averages	86	75	94	91

* Reporting error.

** .9973.

Source: Censo Agropecuário, 1980, Tables 32 and 33.

In the country as a whole, farms from 50 to 10,000 hectares grew (in terms of farm receipts and net income) at a faster rate than the under-50-hectare group. Similarly, in Mato Grosso, growth concentrated in the 200-to-10,000-hectare group, and, in Paraná, most rapid growth in total receipts was in the middle-sized and large farms (over 50 hectares and under 10,000 hectares); in Ceará, receipts in the over-2,000-hectare group grew fastest, but this was not matched with net income growth.

A general conclusion is that middle-sized farms (and in some cases large farms) appear to be poising themselves to play a larger role in Brazilian agricultural production. During the 1970s, they became more important economically by nearly all the measurements we use. This lends credibility to the work of the U.N. Economic Commission for Latin America and the Caribbean (CEPAL), which for the past ten years has been writing that agriculture in Latin America is modernizing (FAO 1978) and that the paradigm of strict bimodalism with small, undercapitalized peasant farms on one hand and unproductive estates on the other needs to be revised. The development of a more commercially oriented agriculture is probably in response to a need for export earnings, changes in conditions of internal markets attendant upon growth of a substantial middle class and city-based industries, the dissemination of green-revolution technology, and the fact that the threat of land reform may be first visited upon unproductive, idle, and underexploited lands (as it was in most extant reforms of the last three decades) (Thiesenhusen 1989).

Lehmann (1982a, 1982b) feels that the focus of this modernization appears to be on intermediate-sized farms.[20] Likewise, Scott feels there is a bright future for middle-sized farms in Brazil, because they are likely to grow crops with a high income elasticity of demand as well as exportables: "A

mix of entrepreneurial talent, low cost family labor and access to subsidized credit allows medium-sized farms to outperform larger capitalist farms because of labour market imperfections, and to outperform peasant farms owing to higher technical efficiency arising from capital market imperfections, superior land quality and greater managerial skills" (Scott 1985, p. 31).

However, while middle-sized (and some large) farms are modernizing in certain parts of Brazil, a surprisingly large percentage of production is still the domain of the small farm. The reasons for this small-farm production dominance in Brazil need to be explored. One plausible explanation is the existence of an inverse relationship between farm size and land productivity. Such a relation has been documented for different countries and different time periods[21] and is so frequently stated that it is almost accepted as a universal relationship. Tables 9 and 10 show an inverse relation between product per agricultural hectare and farm size in Brazil and in each of the three states.

Why does such a relationship prevail? Carter offers two explanation: (1) a correlation between locational features and farm size, and (2) specific characteristics of farms in the different farm-size groups (for example, decreasing returns to scale and distinct factor use and allocation patterns). Appendix 2 presents a formal verification of the existence of an inverse farm-size-productivity relationship in Brazil in both 1970 and 1980, a pattern which persists across regions of the country. The findings are that an inverse relationship prevails even after controlling for land quality (using average land price as a proxy) and that there are constant returns to scale. Finally, the inverse relationship disappears if the regression controls for input-use intensities. This result supports Carter's second explanation. In

TABLE 9

Relationship between Land, Labor, and Capital Productivities, Brazil, 1980

(expressed as % of Under 1 Unit)

FARM SIZE (in hectares)	TOTAL RECEIPTS PER				NET INCOME PER			
	Ag. Land Hectare	Cropland Hectare	Labor Unit	Capital Unit	Ag. Land Hectare	Cropland Hectare	Labor Unit	Capital Unit
			B R A Z I L					
Under 1	100	100	100	100	100	100	100	100
1 up to 10	35	50	184	88	33	47	175	84
10 up to 50	18	47	428	72	16	41	369	64
50 up to 200	9	45	658	59	6	31	456	39
200 up to 2,000	6	47	1290	51	4	28	763	30
2,000 up to 10,000	3	50	2230	27	1	27	1213	15
10,000 and over	1	51	1950	22	0.1	6	219	3
National	7	47	-	55	5	34	363	39
			C E A R A					
Under 1	100	100	100	100	100	100	100	100
1 up to 10	11	14	58	98	15	19	79	130
10 up to 50	4	8	84	74	5	11	109	95
50 up to 200	2	7	129	60	2	6	141	55
200 up to 2,000	1	6	207	44	1	3	143	30
2,000 up to 10,000	1	4	370	25	neg	neg	neg	neg
10,000 and over	1	4	649	23	0.3	2	243	10
Regional	-	-	101	-	-	-	102	-

[continued]

[Table 9, Relationship between Land, Labor, and Capital, cont.]

FARM SIZE (in hectares)	TOTAL RECEIPTS PER				NET INCOME PER			
	Ag. Land Hectare	Cropland Hectare	Labor Unit	Capital Unit	Ag. Land Hectare	Cropland Hectare	Labor Unit	Capital Unit
			MATO GROSSO					
Under 1	100	100	100	100	100	100	100	100
1 up to 10	9	9	105	116	10	10	119	135
10 up to 50	3	9	184	68	3	8	167	64
50 up to 200	2	9	312	50	1	6	197	32
200 up to 2,000	1	8	1005	45	0.5	4	479	21
2,000 up to 10,000	0.6	11	1163	29	0.3	6	999	18
10,000 and over	0.3	16	1826	35	0.2	9	1059	21
Regional	0.6	10	630	39	-	6	371	25
			PARANA					
Under 1	100	100	100	100	100	100	100	100
1 up to 10	17	16	162	164	20	19	193	200
10 up to 50	12	15	318	148	13	16	331	156
50 up to 200	8	16	649	125	8	14	564	112
200 up to 2,000	5	18	1074	93	5	15	897	81
2,000 up to 10,000	3	19	1462	81	3	17	1308	75
10,000 and over	1	12	757	58	0.7	6	368	31
Regional	-	16	378	122	-	16	366	-

Source: Censo Agropecuário, 1980, Tables 18, 20, 22, 29, 32, and 34.

particular, both labor and percentage of land planted to crops have a significant impact on yield.

To support these findings, Table 6 shows that small farms crop a larger percentage of their area than do large farms and cropland yields more farm receipts and net income than whatever is produced (for example, livestock) on noncropped land. During the 1970s, there was an increase in the percentage of large-farm property that was cropped, and hence the residual between cropped land and total agricultural hectarage (which, presumably, includes farmland devoted to the farmstead, pasture, infrastructure, fences, irrigation works, forests, and so on) was reduced. Interestingly, the elasticity of output with respect to farm size in 1980 (.20) is only half of its 1970 value (.40). Countrywide, 90 percent of the land in the smallest-farm category was cropped in 1980; this figure dropped to 2 percent on the very large farms (Table 6). The relationship between the percent of total land in crops and farm size is indirect; on the other hand, the percent change in the former calculation from 1970 to 1980 is related directly with farm size. The subfamily units register a 3-percentage-point loss in total land in crops (a drop of 93 percent to 90 percent) while the land in crops doubled on the largest units (from 1 to 2 percent). The idea expressed earlier, that adjustments are being made to intensify production on middle-sized and large farms, is reinforced.

Greater cropping intensity goes hand in hand with greater labor use per hectare. Cropped land requires more labor than noncropped land; thus, small farms use more labor per unit of output than large ones. The heavier reliance on labor on small farms also reflects the abundance of an underemployed family labor force. As Tables 2 and 11 show, small farms countrywide use a much larger unpaid family-labor input than large ones. It is probably the case that the smaller farms (up to the "medium-sized" farm at least) use this

unpaid component of their labor force until its marginal product is close to zero. Farmers rely heavily on family labor in the small-size cohorts in Paraná and Ceará, but then family labor as a percent of the labor force falls precipitously (family labor is relied upon longer in Mato Grosso). When labor comes to represent an out-of-pocket cost for wages (or when there are real opportunities for family labor in an alternative job market), the farm-paid wage will be reduced only until that wage equals its marginal product. As wage labor comes to predominate, production per hectare drops sharply, as illustrated after the first three small-farm size cohorts or so in Tables 9 and 10. (Table 11 also shows the changing constitution of the farm labor force with declining family labor and sharecropping and increasing wage labor in all size categories.)

Other differences in resource allocation are also correlated with farm size. Countrywide, small farms are also more capital intensive than medium-sized or large farms (Tables 9 and 12). This is only roughly true when we scrutinize the states separately, however. In no case do farms over 200 hectares utilize more capital per agricultural hectare than the very smallest category. Fertilizer is probably the capital input with most influence on yield, and, in all cases, fertilizer per agricultural hectare is negatively correlated with farm size. This is not surprising: the smaller the farm, the higher the percent of cropland and, hence, the fertilizer needed per hectare. Not unexpectedly, when fertilizer per hectare cropland is examined, the 1980 relationship becomes quite direct countrywide. In commercial and highly capitalized Paraná, where cropland as a percentage of agricultural land is high through many sizes (Table 4), the picture is less clear. Omitting the tiniest farms, fertilizer use (Table 12) rises sharply from peasant through

TABLE 10

Brazil, Relationship between Two Product Measures per Factor Unit
(in constant 000 cruzeiros)

FARM SIZE (in hectares)	TOTAL RECEIPTS PER AGRICULTURAL HECTARE 1970	1980	% Change	NET INCOME PER HECTARE 1970	1980	% Change
			B R A Z I L			
Under 1	55.65	59.70	7	36.99	38.77	5
1 up to 10	16.47	20.99	27	10.54	13.00	23
10 up to 50	7.36	11.05	50	4.50	6.20	38
50 up to 200	3.22	5.43	69	1.59	2.45	54
200 up to 2,000	2.10	3.48	66	0.94	1.34	43
2,000 up to 10,000	0.96	1.65	72	0.45	0.58	31
10,000 and over	0.46	0.54	19	0.23	0.04	-83
Average	3.03	4.22	39	1.34	1.98	48
			C E A R A			
Under 1	50.70	110.91	119	23.54	49.86	99
1 up to 10	7.83	12.50	60	4.66	7.73	56
10 up to 50	2.65	4.35	64	1.60	2.58	51
50 up to 200	1.26	2.02	60	0.66	1.15	65
200 up to 2,000	0.70	1.33	90	0.30	0.41	27
2,000 up to 10,000	0.33	0.87	164	0.12	-0.67	-642
10,000 and over	0.10	1.13	997	0.0011	1.19	19
Average	1.38	2.51	82	0.74	1.15	55
			M A T O G R O S S O			
Under 1	122.23	190.46	56	79.54	111.98	41
1 up to 10	21.80	17.34	-20	12.49	11.51	-7
10 up to 50	7.61	7.55	-1	4.20	4.01	-5
50 up to 200	2.41	3.20	33	1.10	1.18	7
200 up to 2,000	0.82	2.11	158	0.36	0.59	66
2,000 up to 10,000	0.44	1.07	143	0.21	0.36	71
10,000 and over	0.28	0.52	86	0.12	0.18	50
Average	0.69	1.21	76	0.36	0.42	18
			P A R A N A			
Under 1	190.07	140.15	-26	83.78	73.66	-12
1 up to 10	16.79	24.46	46	10.27	15.36	50
10 up to 50	9.35	17.43	86	5.55	9.58	72
50 up to 200	5.08	12.34	143	2.07	5.67	175
200 up to 2,000	5.24	7.97	52	2.42	3.52	45
2,000 up to 10,000	2.19	4.21	92	0.91	1.99	119
10,000 and over	13.02	2.23	-83	11.39	0.57	-95
Average						

Source: Table 1, above; Censo Agropecuário, 1970, Tables 9, 31, and 34;

TABLE 11

Types of Labor and Change, Brazil, 1970-1980
(in person-months)

FARM SIZE (in hectares)	TOTAL LABOR			AS PERCENT OF LABOR FORCE IN AGRICULTURE											
				Family Labor			Permanent Hired Labor			Temporary Labor			Sharecroppers		
	1970	1980	% Change	1970	1980	% Change	1970	1980	% Change	1970	1980	% Change	1970	1980	% Change
B R A Z I L															
Under 1	11,414,001	14,313,617	25	94	92	-2	1	1	6	5	7	39	0	0	-66
1 up to 10	75,382,486	85,358,865	13	93	89	-4	1	1	32	6	9	71	1	0	-38
10 up to 50	70,014,329	81,935,215	17	86	80	-8	3	5	48	7	13	80	3	2	-24
50 up to 200	29,901,802	43,691,452	46	68	58	-14	11	15	33	13	22	70	8	5	-43
200 up to 2,000	18,290,832	29,809,839	63	39	28	-27	33	37	14	18	30	62	11	5	-52
2,000 up to 10,000	2,152,319	4,274,672	99	18	13	-27	51	52	1	21	32	51	9	3	-67
10,000 and over	451,389	1,424,742	216	9	5	-44	66	72	10	19	22	17	6	0	-95
Nation	208,040,406	259,801,050	25	81	72	-11	7	10	50	9	16	82	3	2	-34
C E A R A															
Under 1	281,946	201,835	-28	90	86	-4	1	4	168	7	9	35	1	0	-89
1 up to 10	4,345,515	4,564,581	5	86	81	-6	1	3	203	12	16	32	1	1	-43
10 up to 50	3,969,151	4,550,903	15	79	67	-16	2	7	347	17	24	45	3	2	-17
50 up to 200	2,091,491	2,805,434	34	65	47	-27	4	13	213	22	33	50	9	7	-18
200 up to 2,000	937,159	1,415,477	51	42	25	-41	8	21	154	28	39	33	21	17	-23
2,000 up to 10,000	80,639	137,569	71	16	9	-59	19	25	54	29	44	53	36	22	-40
10,000 and over	10,970	18,099	65	6	3	-59	10	66	532	34	28	-20	49	4	-92
Region	11,716,871	13,693,898	17	75	63	-17	2	8	245	17	25	47	5	4	-11

[continued]

[Table 11, Brazil, Types of Labor and Change, cont.]

FARM SIZE (in hectares)	TOTAL LABOR 1970	TOTAL LABOR 1980	TOTAL LABOR % Change	AS PERCENT OF LABOR FORCE IN AGRICULTURE: Family Labor 1970	Family Labor 1980	Family Labor % Change	Permanent Hired Labor 1970	Permanent Hired Labor 1980	Permanent Hired Labor % Change	Temporary Labor 1970	Temporary Labor 1980	Temporary Labor % Change	Sharecroppers 1970	Sharecroppers 1980	Sharecroppers % Change
MATO GROSSO															
Under 1	14,819	40,332	172	97	94	-4	2	4	88	1	2	248	0.00	0.18	-
1 up to 10	1,508,757	1,544,093	2	97	95	-2	1	1	15	2	3	22	0.09	0.06	-35
10 up to 50	1,343,338	1,520,624	13	93	89	-4	3	3	29	4	7	80	0.22	0.29	31
50 up to 200	500,120	1,035,221	107	85	79	-8	7	11	56	7	10	37	0.68	0.73	7
200 up to 2,000	623,410	1,379,464	121	69	50	-27	18	31	72	11	18	56	1.20	0.84	-30
2,000 up to 10,000	247,454	615,755	149	41	24	-41	43	77	79	15	24	56	1.01	0.60	-40
10,000 and over	152,991	360,168	135	18	10	-47	60	69	15	22	21	-1	0.31	0.16	-50
Region	4,390,889	6,495,657	48	85	70	-17	9	18	101	6	11	89	0.41	0.44	7
PARANA															
Under 1	151,038	289,726	92	85	97	13	1	2	23	13	1	-89	0	0	49
1 up to 10	10,070,055	7,291,865	-28	93	92	-2	1	2	61	5	6	9	0	1	269
10 up to 50	10,527,739	9,827,411	-7	88	79	-11	4	6	39	6	12	96	1	4	155
50 up to 200	2,164,679	2,887,045	33	57	49	-16	16	21	26	21	25	19	4	5	26
200 up to 2,000	1,111,663	1,731,057	56	21	17	-19	51	49	-5	24	31	31	4	3	-27
2,000 up to 10,000	132,047	211,348	60	8	5	-31	73	60	-18	18	31	73	2	4	167
10,000 and over	36,098	85,200	136		0	-45	89	81	-9	11	19	77	0	0	-
Region	24,193,319	22,323,652	-8	84	74	-13	7	11	58	8	13	65	1	3	121

Source: Table 1, above; Censo Agropecuário, 1970, Tables 16 and 20; Censo Agropecuário, 1980, Tables 20 and 22.

TABLE 12

Capital Use per Hectare, Brazil, 1970 and 1980
(in constant 000 cruzeiros)

1) Countrywide

FARM SIZE (in hectares)	FERTILIZER USE PER HECTARE			FERTILIZER USE PER HECTARE IN CROPS			MACHINERY VALUE PER HECTARE			MACHINERY VALUE PER HECTARE CROPLAND		
	1970	1980	% Change	1970	1980	% Change	1970	1980	% Change	1970	1980	% Change
Under 1	0.86	1.04	21	1.00	1.25	26	1.17	1.58	35	1.26	1.75	39
1 up to 10	0.39	0.71	81	0.74	1.37	86	0.98	1.89	93	1.60	2.96	85
10 up to 50	0.26	0.64	143	1.04	2.34	124	1.04	2.93	182	3.21	8.30	159
50 up to 200	0.17	0.42	157	1.63	3.12	91	0.68	1.88	178	4.88	10.23	110
200 up to 2,000	0.13	0.34	169	2.46	4.70	91	0.46	1.25	172	6.61	11.20	69
2,000 up to 10,000	0.03	0.15	350	1.97	3.48	77	0.19	0.80	316	8.48	15.86	87
10,000 and over	0.01	0.05	679	0.69	3.76	444	0.08	0.24	208	14.44	14.93	3
Nation	0.13	0.31	142									

	TOTAL NON-LAND CAPITAL USE PER HECTARE			TOTAL NON-LAND CAPITAL USE PER HECTARE CROPLAND		
	1970	1980	% Change	1970	1980	% Change
Under 1	76.69	118.15	54	82.58	130.71	58
1 up to 10	28.57	46.44	63	46.63	72.67	56
10 up to 50	16.62	29.86	80	51.34	84.56	65
50 up to 200	9.53	18.28	92	68.70	99.41	45
200 up to 2,000	3.86	13.56	251	55.80	121.65	18
2,000 up to 10,000	4.31	12.08	180	190.99	240.67	26
10,000 and over	1.94	5.06	160	357.63	312.26	-13
Nation	8.34	15.22	82	72.95	113.05	55

[continued]

[Table 12, Brazil, Capital Use per Hectare, cont.]

2) Ceará

FARM SIZE (in hectares)	FERTILIZER USE PER HECTARE			FERTILIZER USE PER HECTARE IN CROPS			MACHINERY VALUE PER HECTARE			MACHINERY VALUE PER HECTARE CROPLAND		
	1970	1980	% Change	1970	1980	% Change	1970	1980	% Change	1970	1980	% Change
Under 1	0.78	1.08	39	1.30	1.70	31	1.71	1.91	12	2.07	2.29	10
1 up to 10	0.07	0.17	148	0.18	0.42	132	0.25	0.49	95	0.39	0.73	87
10 up to 50	0.02	0.04	120	0.12	0.23	86	0.13	0.40	221	0.36	1.02	184
50 up to 200	0.0060	0.0189	213	0.07	0.17	131	0.12	0.36	200	0.57	1.40	143
200 up to 2,000	0.0032	0.0150	373	0.06	0.13	104	0.12	0.44	266	0.95	2.58	171
2,000 up to 10,000	0.0011	0.0073	564	0.04	0.12	213	0.08	0.57	648	0.94	3.75	300
10,000 and over	0.0006	0.0026	312	0.03	0.06	88	0.15	0.79	409	2.18	4.54	109
Region	0.0088	0.0240	171	0.10	0.20	95	0.12	0.43	254	0.63	1.75	178

	TOTAL NON-LAND CAPITAL USE PER HECTARE			TOTAL NON-LAND CAPITAL USE PER HECTARE CROPLAND		
	1970	1980	% Change	1970	1980	% Change
Under 1	112.56	255.22	127	136.42	304.83	123
1 up to 10	16.83	29.80	77	25.89	43.95	70
10 up to 50	6.79	13.44	98	19.53	34.17	75
50 up to 200	4.19	8.99	114	20.26	35.93	77
200 up to 2,000	2.82	6.96	146	22.21	44.41	100
2,000 up to 10,000	1.85	7.60	310	18.45	50.33	173
10,000 and over	0.92	11.45	1141	12.97	66.00	409
Region						

[continued]

[Table 12, Brazil, Capital Use per Hectare, cont.]

3) Mato Grosso

FARM SIZE (in hectares)	FERTILIZER USE PER HECTARE			FERTILIZER USE PER HECTARE IN CROPS			MACHINERY VALUE PER HECTARE			MACHINERY VALUE PER HECTARE CROPLAND		
	1970	1980	% Change	1970	1980	% Change	1970	1980	% Change	1970	1980	% Change
Under 1	1.87	2.43	30	2.33	3.79	63	1.74	5.45	214	1.92	6.96	261
1 up to 10	0.0297	0.06	114	0.04	0.10	164	0.44	0.87	98	0.54	1.06	96
10 up to 50	0.0174	0.05	178	0.06	0.18	197	0.47	2.07	338	1.45	5.88	305
50 up to 200	0.0064	0.05	679	0.08	0.40	420	0.31	1.47	376	3.35	10.10	202
200 up to 2,000	0.0026	0.12	2942	0.25	1.17	359	0.13	1.24	841	6.54	12.30	88
2,000 up to 10,000	0.0021	0.05	2206	0.48	1.24	159	0.07	0.50	590	15.29	12.48	-18
10,000 and over	0.0002	0.02	10399	0.31	1.67	439	0.04	0.20	371	58.15	15.57	-73
Region	0.0022	0.05	2213	0.14	1.08	659	0.08	0.57	579	5.05	11.55	129

	TOTAL NON-LAND CAPITAL USE PER HECTARE			TOTAL NON-LAND CAPITAL USE PER HECTARE CROPLAND		
	1970	1980	% Change	1970	1980	% Change
Under 1	209.33	395.16	89	232.32	504.25	117
1 up to 10	17.17	30.70	79	20.98	37.25	78
10 up to 50	13.12	22.69	73	40.22	64.32	60
50 up to 200	8.08	13.19	63	87.41	90.42	3
200 up to 2,000	4.58	9.61	110	226.81	95.20	-58
2,000 up to 10,000	3.05	7.41	143	642.43	184.88	-71
10,000 and over	1.75	2.97	70	2343.18	226.14	-90
Region	3.06	6.30	106	185.59	128.63	-31

[continued]

[Table 12, Brazil, Capital Use per Hectare, cont.]

4) Paraná

FARM SIZE (in hectares)	FERTILIZER USE PER HECTARE 1970	1980	% Change	FERTILIZER USE PER HECTARE IN CROPS 1970	1980	% Change	MACHINERY VALUE PER HECTARE 1970	1980	% Change	MACHINERY VALUE PER HECTARE CROPLAND 1970	1980	% Change
Under 1	1.85	1.74	-6	2.97	2.80	-6	12.44	9.32	-25	17.61	13.08	-26
1 up to 10	0.37	0.88	137	0.62	1.43	129	0.97	2.46	154	1.20	3.22	167
10 up to 50	0.36	1.15	224	1.01	2.36	135	1.29	5.86	354	2.70	10.13	275
50 up to 200	0.36	1.16	223	2.05	3.27	60	1.32	6.82	415	5.66	17.01	201
200 up to 2,000	0.42	0.80	93	5.11	4.15	-19	1.05	3.27	210	7.57	14.40	90
2,000 up to 10,000	0.14	0.31	126	4.31	3.71	-14	0.40	1.04	162	7.40	9.07	22
10,000 and over	0.00	0.12	8197	2.74	2.56	-7	0.29	0.54	89	543.64	5.57	-99
Region				1.07	2.85	168				3.38	11.52	241

	TOTAL NON-LAND CAPITAL USE PER HECTARE 1970	1980	% Change	TOTAL NON-LAND CAPITAL USE PER HECTARE CROPLAND 1970	1980	% Change
Under 1	361.98	457.90	27	512.64	642.39	25
1 up to 10	36.51	48.44	33	45.45	63.43	40
10 up to 50	25.16	37.88	51	52.64	65.47	24
50 up to 200	16.98	31.96	88	72.57	79.77	10
200 up to 2,000	18.16	27.29	50	130.60	120.31	-8
2,000 up to 10,000	11.16	16.94	52	252.82	147.98	-41
10,000 and over	11.00	12.52	14	20,938.47	129.14	-99
Region						

Source: Table 1, above; Censo Agropecuário, 1970, Tables 9, 27, and 31; Censo Agropecuário, 1980, Tables 18, 29, and 34.

commercial farms, then drops on large and very large farms. The same U-shaped relationship is found in Paraná in machinery value per hectare cropland (in the other cases examined, the relationship is direct), demonstrating middle-sized-farm modernization in a state where middle-sized commercial farms are important. The ratio of capital to labor (Table 13) rises throughout all size categories.[22]

In most cases, the inverse relationship between cropland and farm size and the inverse relationship between labor and all nonland capital and farm size overwhelm the effects of other factors at work that would show higher land productivity on large farms. Large farms probably have more universal adoption rates of advanced technology, for they have more access to credit. We have shown that they tend to have more improved pasture (Table 6) and that they cultivate higher-valued crops (Appendix Table 1B). In fact, they also obtain, on average, better yields for a given set of inputs. This is evident from the coefficients of the regression model (Appendix 2) which controlled for resource-use differences among farm-size categories. The next section will provide more evidence on yields.

As in the discussion of farm receipts, while the small-farm sector is most highly productive, these farms are not the most dynamic in terms of productivity change. The land productivity data (Table 10) show the highest percent increases in total receipts per agricultural hectare for farm sizes ranging from 50 to 10,000 hectares. However, the larger farms in this range appear to have experienced more significant increases in production costs (this is evident in the net-income based productivity figures shown in Table 10, particularly those for the state of Ceará).

TABLE 13

Capital/Labor Ratio, Brazil, 1970 and 1980

FARM SIZE (in hectares)	1970	1980	% CHANGE	1970	1980	% CHANGE
	B R A Z I L			C E A R A		
Under 1	1.55	2.31	50	1.91	4.91	157
1 up to 10	3.27	4.75	45	1.81	2.99	66
10 up to 50	8.37	13.53	62	3.15	5.48	74
50 up to 200	16.65	25.96	56	6.45	10.52	63
200 up to 2,000	22.30	58.74	163	14.30	23.00	61
2,000 up to 10,000	99.17	190.80	92	32.10	68.57	114
10,000 and over	151.84	213.01	40	36.52	139.68	283
Total	9.79	2.24	118	4.33	8.30	92
	M A T O G R O S S O			P A R A N A		
Under 1	4.14	4.08	-2	5.81	7.49	29
1 up to 10	2.38	3.42	43	5.70	7.33	29
10 up to 50	6.91	10.25	48	10.84	15.84	46
50 up to 200	18.05	24.84	38	22.91	38.47	68
200 up to 2,000	60.06	91.13	52	62.21	84.23	35
2,000 up to 10,000	174.18	249.22	43	138.17	134.72	-3
10,000 and over	244.49	236.54	-3	133.41	97.44	-27
Total	31.87	63.29	99	12.99	22.62	74

Source: Censo Agropecuário, 1970, Tables 16, 20, and 27; Censo Agropecuário, 1980, Tables 20, 22 and 29.

Physical Production

Considering physical yield for major crops (Table 14) allows us to explore the distribution of production, of land productivity, and of output growth by farm size in more detail. Data on output, acreage, and yield are analyzed for seven crops. The analysis includes three principal export crops (sugar, soybeans, and coffee) and four principal food crops (rice, maize, beans, and manioc). In 1980, these crops represented the bulk of production for Brazil (all seven crops accounted for 70 percent of cropland with rice, corn, and soybeans accounting for 50 percent) and also for the states of Paraná (seven crops equal 94 percent of cropland with soybeans and corn equaling 65 percent) and Mato Grosso (seven crops equal 66 percent of cropland; rice and soybeans equal 53 percent).[23] The state of Ceará is, however, less well characterized by these seven crops (they equal only 28 percent of cropland).

Upon revisiting the issue of farm size and land productivity using the crop-specific data, the relationship between physical yield and area cultivated varies by crop and by region. Nationwide averages exhibit a direct relation between yield and farm size for export crops. The trend for rice and manioc is an inverted U-shape, favoring middle-sized farms, and corn and beans show no trend. In Paraná, export crops are also characterized by a direct relationship with the exception that soybean yields are greatest on the 10-to-50-hectare farms. Manioc production exhibits the inverse relation and other food crops show no trend. In Ceará, an inverse relation is observed for corn, coffee, and bean production and the remaining crops exhibit an inverted U-shape pattern. In Mato Grosso, rice and bean yields are inversely related to farm size but all other crops show no trend. These observations draw one to the conclusion that the noted inverse relationship between farm receipts

TABLE 14

Rates of Growth of Production, Area, and Yield, by Farm Size, 1970-1980[a]: Export Crops and Food Crops

FARM SIZE (in hectares)	EXPORT CROPS								
	Coffee			Soybeans			Sugar		
	Product.[b]	Area	Yield	Product.	Area	Yield	Product.	Area	Yield
BRAZIL									
Under 1	-.13	-.39	.44	1.69	1.21	.22	-.49	-.55	.14
1 up to 10	.92	.38	.39	.89	.15	.65	-.11	-.35	.36
10 up to 50	.91	.46	.31	3.28	1.12	1.02	.37	-.05	.43
50 up to 200	.96	.66	.18	9.39	4.35	.94	.98	.41	.40
200 up to 2,000	.70	.49	.14	10.24	5.63	.70	1.10	.67	.25
2,000 up to 10,000	.80	.18	.53	23.65	14.78	.56	1.94	1.39	.23
10,000 and over	.34	-.14	.55	68.95	44.82	.53	1.70	1.00	.35
Average	.86	.50	.24	5.75	2.56	.90	1.06	.54	.34
CEARA									
Under 1	-.89	-.77	-.55	-	-	-	-.80	-.81	.07
1 up to 10	-.38	-.33	-.06	-	-	-	-.08	-.49	.81
10 up to 50	.08	-.11	.21	-	-	-	-.28	-.47	.36
50 up to 200	1.52	.44	.75	-	-	-	.09	-.21	.37
200 up to 2,000	1.29	.60	.43	-	-	-	.22	-.19	.51
2,000 up to 10,000	-	-	-	-	-	-	-.40	.34	-.55
10,000 and over	-	-	-	-	-	-	-1	-1	*
Average	.19	.01	.18	-	-	-	-.04	-.34	.45

a. Growth rate is calculated simply as: $\frac{\text{1980 value - 1970 value}}{\text{1970 value}}$.

b. Product. (production) = rate of growth in gross physical output; area = rate of growth in hectares cultivated; yield = rate of growth of yields.

* Not grown in 1980.

[continued]

[Table 14, Rates of Growth of Production, Export Crops, cont.]

FARM SIZE (in hectares)	EXPORT CROPS								
	Coffee			Soybeans			Sugar		
	Product.[b]	Area	Yield	Product.	Area	Yield	Product.	Area	Yield
				MATO GROSSO					
Under 1	-	-1	-	-	-	-	-.84	-.91	.77
1 up to 10	8.57	8.94	-.04	21.28	8.92	1.25	-.89	-.93	.48
10 up to 50	3.72	4.41	-.13	98.30	29.25	2.28	-.82	-.85	.19
50 up to 200	7.71	7.20	.06	515.15	153.53	2.34	-.70	-.77	.31
200 up to 2,000	5.37	6.63	-.17	2630.68	868.32	2.03	-.26	-.61	.86
2,000 up to 10,000	4.51	4.09	.08	2604.31	885	1.94	8.17	14.09	-.39
10,000 and over	-.08	5.80	-.81	-	-	*	41.79	1.45	.64
Average	4.72	5.80	-.16	670.70	258.79	1.59	2.25	1.45	.33
				PARANA					
Under 1	3.41	1.69	.64	.50	0	.50	1.4	.50	.66
1 up to 10	2.06	.86	.65	.66	-.21	1.10	.99	.29	.55
10 up to 50	3.59	1.22	1.07	6.54	2.30	1.29	.48	.15	.28
50 up to 200	2.55	.93	.86	25.25	14.36	.71	1.56	1.03	.26
200 up to 2,000	.94	.07	.82	22.85	15.40	.45	1.33	1.10	.11
2,000 up to 10,000	-	-	-	-	-	-	-	-	-
10,000 and over	-	-	-	-	-	-	-1	-1	*
Average	2.15	.71	.84	9.71	4.24	1.04	2.25	1.45	.33

* Not grown in 1970.

[Table 14, Rates of Growth of Production, Food Crops

FARM SIZE (in hectares)	FOOD CROPS											
	Rice			Beans			Manioc/Cassava			Corn/Maize		
	Product.	Area	Yield	Product.	Area	Yield	Product.	Area	Yield	Product.	Area	Yield
BRAZIL												
Under 1	.62	.36	.19	.003	.04	-.03	-.09	-.25	.22	-.07	-.06	-.01
1 up to 10	-.01	-.15	.17	-.07	-.06	-.003	-.18	-.28	.15	-.09	-.22	.17
10 up to 50	-.07	-.23	.21	.11	.04	.06	-.31	-.38	.12	.14	-.11	.28
50 up to 200	.35	.17	.21	.44	.25	.15	-.23	-.32	.14	.43	.11	.28
200 up to 2,000	1.04	.82	.12	.42	.23	.15	-.22	-.33	.16	.61	.26	.28
2,000 up to 10,000	2.47	2.81	-.09	.60	.29	.25	-.20	-.16	-.04	.72	.37	.26
10,000 and over	7.29	8.93	-.17	.74	.96	-.12	.02	-.13	.18	.79	.76	.02
Average	.53	.32	.16	.14	.07	.07	-.24	-.33	.13	.23	-.03	.27
CEARA												
Under 1	.29	.51	-.15	-.22	1.69	-.71	-.56	-.49	-.14	-.37	-.18	-.22
1 up to 10	2.30	.74	.90	.34	5.02	-.78	-.23	-.39	.25	-.003	.0	-.02
10 up to 50	.67	.32	.26	.36	5.82	-.80	-.34	-.48	.27	.10	.09	.01
50 up to 200	.58	.32	.20	.45	6.41	-.80	-.32	-.50	.37	.27	.19	.07
200 up to 2,000	.06	-.06	.13	.38	5.91	-.80	-.41	-.53	.26	.30	.19	.09
2,000 up to 10,000	-.13	-.57	1.04	.35	4.97	-.77	.13	-.15	.33	.26	-.07	.37
10,000 and over	-.33	1	-.66	-.82	1.18	-.92	-1	-1	*	3.16	1.75	.52
Average	.96	.35	.46	.37	5.65	-.79	-.31	-.46	.27	.14	.11	.03

* Not grown in 1980.

[continued]

[Table 14, Rates of Growth of Production, Food Crops, cont.]

FARM SIZE (in hectares)	FOOD CROPS											
	Rice			Beans			Manioc/Cassava			Corn/Maize		
	Product.	Area	Yield	Product.	Area	Yield	Product.	Area	Yield	Product.	Area	Yield
MATO GROSSO												
Under 1	-.23	-.35	.18	-.45	-.47	.03	1.93	.45	1.02	.73	.19	.45
1 up to 10	-.34	-.41	.12	-.15	-.07	.24	-.36	-.45	.16	-.25	-.44	.35
10 up to 50	-.27	-.34	.11	.45	.20	.21	-.30	-.46	.28	-.13	-.33	.29
50 up to 200	.61	.52	.06	.82	.56	.16	-.02	-.23	.27	.53	.23	.24
200 up to 2,000	6.96	6.40	.08	.47	.41	.04	-.14	-.31	.25	.77	.48	.24
2,000 up to 10,000	14.84	12.74	.15	.87	1.15	-.13	-.48	-.55	.14	1.43	.91	.20
10,000 and over	21.41	2.66	-.18	.51	.22	-.55	-.25	-.40	.35	1.76	.03	.27
Average	2.53	2.67	-.04	.41	.22	.16	-.25	-.40	.25	.30	.03	.26
PARANA												
Under 1	.54	.16	.32	1.33	1.11	.11	1.40	.91	.26	.91	.58	.21
1 up to 10	-.59	-.64	.16	-.30	-.32	.03	-.18	-.38	.34	-.22	-.37	.24
10 up to 50	-.44	-.55	.22	.003	-.13	.16	-.41	-.53	.26	.11	-.14	.30
50 up to 200	-.07	-.28	.30	.53	.15	.33	-.28	-.34	.13	.57	.18	.33
200 up to 2,000	.20	-.11	.35	.46	.08	.36	-.12	-1.8	.08	1.09	.49	.41
2,000 up to 10,000	.37	.12	.23	1.13	.53	.40	2.44	.61	1.14	.95	.61	.21
10,000 and over	-	-	-	12.33	9.2	.31	-1	-1		3.78	4.93	-.19
Average	-.37	-.51	.28	-.07	-.18	.13	-.33	-.46	.25	.14	-.12	.30

and farm size arises not because of yield but because small farms use more land for crops and more labor per hectare, and this latter likely means more dense planting, more careful cultivation, and more plantings during each year.

Differences in enterprise mix and yields also affect the productivity of labor. Table 9 shows that a direct relationship exists between farm size and output per worker. The combination of cultivating a greater share of export crops, using more land for noncrop activities which have a high yield per worker and using capital instead of labor on crops, could explain this relationship.

Throughout this essay, farm-size strata have been compared with respect to various measures of resource use and productivity. These comparisons cannot be completely interpreted without consideration of differences in enterprise mix across farm sizes. Resource use and productivity will vary with farm activity (animal versus crop production and, for example, soybeans versus manioc). Table 6 demonstrates that large farms engage proportionately less in crop production activities. The census data for the seven crops selected for this study (Appendix Table 1B) indicate that, nationwide, the middle-sized farms (50 up to 2,000 hectares) are responsible for the bulk of export crop and rice production. While this size of farm also produces a substantial amount of corn, the 10-to-50-hectare farm produces the largest percent of the nation's corn and rice. The small-farm group (0 to 50 hectares) produces the bulk of beans and manioc. FAO (1986) shows that units up to 50 hectares in size contribute most significantly to the production of millet, potatoes, herbs, vegetables, and tobacco and that units up to 200 hectares contribute most to the production of fruits and nuts. A general conclusion is that the small farms produce food crops whereas the medium-sized farms produce export commodities and the more commercial food crops.

Another issue can also be addressed at this juncture: What are the sources of this output growth?[24] Does the expansion of agricultural production reflect improved agricultural practices or simple expansion? Table 15 summarizes the relative contribution of yield and area growth to output growth.[25]

The data for the seven crops indicate that in the three states, area expansion contributes more to output growth than does increased yields.[26] The national average figures indicate a somewhat stronger impact of yield growth.

In order to generalize these observations on the sources of growth, a simple regression was run using data from each farm-size group for the 23 Brazilian states. The model (Appendix 3) examines the influence of various factors on the change in farm receipts from 1970 to 1980. The results clearly indicate the significance of expansion of cropland (positive coefficient) and of pastureland (negative coefficient for the southeastern states and a positive coefficient for the other areas). The other variables measure changes in the intensity of input use. These factors, which affect yields, have no statistically significant effect on output expansion. The yield increases observed in the crop-specific data are likely attributed to technological change (for example, the adoption of new crops and crop cultivars together with green revolution technology). The unexplained variation in the regressions may be associated with such technological change and with random variation in yields. Not surprisingly, the unexplained variation is highest in the southeast (38 percent), is significant in the northeast (23 percent), and is small in the frontier and northwestern areas.[27] Thus, the conclusion that area expansion contributed relatively more to output growth than yield in the 1970s is supported. This finding agrees with that of Graham et al. (1987).

TABLE 15

Relative Contributions to the Rates of Growth of Production from Area Expansion and Yield Increases

CROP	AREA EXPANSION[a]	YIELD INCREASE	CROP	AREA EXPANSION[a]	YIELD INCREASE
BRAZIL			**CEARA**		
Export crops			Export crops		
Coffee	.58	.42	Coffee	.05	.95
Sugar	.51	.49	Sugar	100	0[b]
Soybeans			Soybeans	-	-
Food crops			Food crops		
Beans	.50	.50	Beans	100	0[c]
Rice	.60	.40	Rice	.37	.63
Manioc/cassava			Manioc/cassava	100	0[b]
Corn/maize			Corn/maize	.79	.21
MATO GROSSO			**PARANA**		
Export crops			Export crops		
Coffee	100	0[c]	Coffee	.33	.67
Sugar	.64	.36	Sugar	.74	.26
Soybeans	.39	.61	Soybeans		
Food crops			Food crops		
Beans	.54	.46	Beans	1.00	0[b]
Rice	100	0[c]	Rice	1.00	0[b]
Manioc/cassava	100	0[b]	Manioc/cassava		
Corn/maize	.10	.90	Corn/maize		

a. Figures are rate of growth of area (or yield) as a fraction of rate of growth of output.

b. There was a slight increase in yield but a large decrease in area, which meant a negative growth rate of output.

c. There was a decrease in yield, but area expansion was great enough that output growth was positive.

Conclusions

Inequitable distribution may not be much ameliorated by growth, as the classic writings of Simon Kuznets (1966) affirm.[28] Government action is frequently required. Indeed, economic growth itself may be limited by inequitable distribution, if for one reason or another the export sector fails to respond and growth comes to depend on finding some latent demand dynamism in the domestic market. Also, if growth or policy do not distribute some income benefits to the poor, the potential exists for bringing contending groups to a political flash point, the issue transported, as it were, from the domain of economics to that of politics. This often happens when the poor, together with some members of the middle class, perceive that the incomes of the already well-to-do are continuing to grow while those of the middle and poor groups are stagnating or expanding too slowly. Where the military has control, repression may follow. Thus, it is still unclear whether a political explosion will occur in Brazil, or whether tensions can be alleviated by the fact that a progressively decreasing proportion of the total population is engaged in farming.

Efforts of the Brazilian government to pursue a solution to inequity and its socioeconomic consequences have been slow. Even before the constitution was set in place, the government announced cutbacks in farmland allocated to reform from 62 million acres promised in 1985 to 2.7 million acres in 1988. Certain segments of the Roman Catholic Church, with fragments of the peasant population and the intellectual middle class, continue to argue for agrarian reform. Meanwhile, land invasions continue in 1988 as peasants take the rural equity issue into their own hands.

This paper examines agricultural census data in an attempt to make observations which may illuminate somewhat the way in which agrarian structure is changing in Brazil. For example, one major question in the debate about appropriate agrarian policy is whether improving labor productivity is more important in the course of development in Brazil than is improving land productivity. The former, labor productivity, is greater on large farm units while the latter, land productivity, is more favorable on small farms. Answering the question would be difficult if marketable surplus were markedly different on large and small units. As we have shown, however, over three-quarters of production is marketed even on small farms. While it is true that large farms were making improvements to their farm enterprises in the decade of the 1970s, most labor is still concentrated in the smaller farms while most capital is concentrated in the medium-sized and large ones. The attempt to maximize labor productivity in a Brazilian setting would probably succeed only at the expense of more unemployment and/or more severe underemployment. While labor is relatively abundant in the economy, capital is relatively scarce. Given Brazil's serious debt problem, practices which economize on capital seem especially well-suited for agriculture. We have shown that as nonland capital (especially "machinery value") per hectare of cropland increases, labor use per hectare tends to decrease. This is a phenomenon that affects the country overall as well as the three sample states.

Furthermore, whether Brazil is really a land-scarce economy is an unresolved issue. Indeed, government policies treat land as a very abundant factor. It is not taxed very much, nor is much encouragement for land to produce more built into Brazil's incentive structure. For example, Binswanger argues that land is wastefully used partially because income-tax laws virtually exempt agriculture, thus converting it into a tax shelter.

Especially at the frontier, urban investors and corporations are competing vigorously for land to establish livestock ranches, he claims. But tax treatment even makes it attractive for wealthy individuals to buy land from small farmers in areas of well-established settlement. Large farms are able to profit because they receive subsidized credit and utilize it well (Binswanger 1987).

Thus, when new lands come into production, they appear at the large-farm end of the scale and are not at the disposition of either the landless or the land poor. For the present, while surplus labor exists, it is extremely important for production per hectare to increase. When labor is more fully employed, it will become more important than it is at present to stress increasing labor productivity.

In summary, this preliminary examination of Brazil's agrarian structure between 1970 and 1980 shows: (1) a high and growing concentration of agricultural land in Brazil, with large amounts of land still being added to production mainly on large farms as the frontier expands; (2) a labor-absorptive, small-farm sector, coupled with declining land availability to smaller farms, a sector which paradoxically is responsible for a major part of agricultural production and uses capital relatively sparingly; (3) a middle- and large-farm sector which uses land and capital quite extensively and labor sparingly, but appears to be changing more rapidly than the small-farm sector; (4) an inverse relationship between farm size and agricultural receipts per unit land, which is associated primarily with more intensive resource use; (5) a direct relationship between physical crop-yields and farm size for many crops; (6) a pattern in which the larger farms seem to be adjusting more rapidly (but from very low levels) to new conditions as is witnessed by observing variables such as the percent of total land cropped and

fertilizer use per hectare exhibit an inverse relationship with farm size and while the percent change in these variables from 1970 to 1980 shows a direct relationship with farm size; meanwhile, the small-farm sector may be nearing a point of overuse or even exhaustion of land; (7) a factor-use paradigm in which capital is being substituted for labor, especially on middle- and large-farm sizes in commercial areas; (8) a labor-force composition that is changing as the role of family labor diminishes and sharecropping disappears, both being replaced by wage labor; (9) an inverse relationship between farm size and product per hectare because intensive factor use on smaller units overwhelms high yields and higher-valued crops on bigger ones; and (10) a settlement pattern in which expansion onto new land was, in the 1970s, of greater importance to increased production than higher yields.

APPENDIX TABLE 1A

Income Generation

1) Countrywide

(A)
FARM RECEIPTS PER CATEGORY
(constant 000 cruzeiros)

	1970	1980	Difference	% Change
Under 1	13,139,082	16,717,460	3,578,378	27
1 up to 10	145,716,457	183,096,730	37,380,273	26
10 up to 50	266,319,489	410,263,208	143,943,719	54
50 up to 200	172,540,391	336,566,688	164,026,297	95
200 up to 2,000	222,417,293	449,790,669	222,373,376	98
2,000 up to 10,000	48,865,003	111,516,652	62,651,649	128
10,000 and over	16,475,240	32,506,875	16,031,635	97
Nation	890,472,955	1,540,458,282	649,985,387	72

(B)
NET INCOME PER CATEGORY
(constant 000 cruzeiros)

	1970	1980	Difference	% Change
Under 1	8,731,984	10,855,145	2,123,161	24
1 up to 10	93,277,421	113,436,928	20,159,507	22
10 up to 50	167,062,674	230,148,889	63,086,215	38
50 up to 200	85,285,061	151,758,898	66,473,837	78
200 up to 2,000	101,676,337	172,913,876	71,237,540	70
2,000 up to 10,000	22,606,936	39,403,523	16,796,587	74
10,000 and over	8,449,409	2,382,600	-6,066,809	72
Nation	487,089,820	720,899,859	233,810,040	48

	(C) % NET INCOME PER CATEGORY			(D) % FARM RECEIPTS PER CATEGORY		
	1970	1980	% Change	1970	1980	% Change
Under 1	2	2	-14	1	1	-25
1 up to 10	19	16	-16	16	12	-25
10 up to 50	33	32	-4	29	27	-9
50 up to 200	17	21	23	19	22	16
200 up to 2,000	20	24	18	25	29	17
2,000 up to 10,000	5	5	21	5	7	35
10,000 and over	2	0	-80	2	2	17

[continued]

[Appendix Table 1A, Income Generation, cont.]

2) Ceará

(A)
FARM RECEIPTS PER CATEGORY
(constant 000 cruzeiros)

	1970	1980	Difference	% Change
Under 1	242,004	430,678	188,674	78
1 up to 10	3,649,909	5,723,499	2,073,590	57
10 up to 50	4,882,908	8,072,050	3,189,142	65
50 up to 200	4,047,848	7,681,648	3,633,800	90
200 up to 2,000	3,328,303	6,245,360	2,917,059	88
2,000 up to 10,000	462,336	1,083,622	621,286	134
10,000 and over	42,071	250,392	208,321	495
Region	16,655,379	29,487,249	12,831,870	77

(B)
NET INCOME PER CATEGORY
(constant 000 cruzeiros)

	1970	1980	Difference	% Change
Under 1	112,350	193,607	81,257	72
1 up to 10	2,173,874	3,541,246	1,367,372	63
10 up to 50	2,946,085	4,781,357	1,835,272	62
50 up to 200	2,112,573	3,791,515	1,678,942	79
200 up to 2,000	1,445,247	1,932,702	487,455	34
2,000 up to 10,000	160,958	-827,181	-988,139	-614
10,000 and over	482	40,792	40,310	8370
Region	8,951,568	13,454,038	4,502,470	50

	(C) % NET INCOME PER CATEGORY			(D) % FARM RECEIPTS PER CATEGORY		
	1970	1980	% Change	1970	1980	% Change
Under 1	1	1	15	1	1	1
1 up to 10	24	25	5	22	19	-11
10 up to 50	33	36	8	29	27	-7
50 up to 200	24	28	19	24	26	7
200 up to 2,000	16	14	-11	20	21	6
2,000 up to 10,000	2	-6	-434	3	4	32
10,000 and over	0	0	-100	0	1	236

[continued]

[Appendix Table 1A, Income Generation, cont.]

3) Mato Grosso

(A)
FARM RECEIPTS PER CATEGORY
(constant 000 cruzeiros)

	1970	1980	Difference	% Change
Under 1	35,813	79,232	43,419	136
1 up to 10	4,563,724	2,980,559	-1,583,165	-30
10 up to 50	5,383,981	5,188,216	-195,765	3
50 up to 200	2,687,900	6,240,886	3,552,986	148
200 up to 2,000	6,693,018	27,597,914	20,904,896	340
2,000 up to 10,000	6,244,513	22,226,826	15,982,313	280
10,000 and over	5,951,589	14,828,088	8,876,499	166
Region	31,560,539	79,141,721	49,548,676	167

(B)
NET INCOME PER CATEGORY
(constant 000 cruzeiros)

	1970	1980	Difference	% Change
Under 1	24,854	46,582	21,728	87
1 up to 10	2,789,430	1,979,436	-809,994	-29
10 up to 50	3,172,884	2,757,806	-415,078	-13
50 up to 200	1,310,720	2,304,110	993,390	76
200 up to 2,000	3,100,710	7,701.963	4,601,253	148
2,000 up to 10,000	3,186,896	7,461,943	4,275,047	134
10,000 and over	2,664,338	5,039,519	2,375,181	89
Region	16,249,832	27,291,359	11,041,527	68

	(C) % NET INCOME PER CATEGORY			(D) % FARM RECEIPTS PER CATEGORY		
	1970	1980	% Change	1970	1980	% Change
Under 1	0	0	12	0	0	-12
1 up to 10	17	7	-58	14	4	-74
10 up to 50	20	10	-48	17	7	-62
50 up to 200	8	8	5	9	8	-7
200 up to 2,000	19	28	48	7	35	414
2,000 up to 10,000	20	27	39	20	28	42
10,000 and over	16	19	13	19	19	-1

[continued]

[Appendix Table 1A, Income Generation, cont.]

4) Paraná

(A)
FARM RECEIPTS PER CATEGORY
(constant 000 cruzeiros)

	1970	1980	Difference	% Change
Under 1	461,098.8	664,177.0	203,078.2	44
1 up to 10	26,410,054.0	26,997,358.0	587,304.0	2
10 up to 50	42,412,501.8	71,618,456.0	29,205,954.2	69
50 up to 200	14,825,295.3	42,870,283.0	28,044,987.7	189
200 up to 2,000	19,958,267.4	42,588,706.0	22,630,438.6	113
2,000 up to 10,000	2,952,294.8	7,077,301.0	4,125,006.2	140
10,000 and over	5,700,023.8	1,476,281.0	-4,223,742.8	-74
Region	112,719,535.9	193,292,562.0	80,573,026.1	71

(B)
NET INCOME PER CATEGORY
(constant 000 cruzeiros)

	1970	1980	Difference	% Change
Under 1	203,244.6	349,067.0	145,822.4	72
1 up to 10	16,156,624.5	16,954,572.0	797,947.5	5
10 up to 50	25,197,412.6	39,357,402.0	14,159,989.4	56
50 up to 200	6,030,397.2	19,704,055.0	13,673,657.8	227
200 up to 2,000	9,222,563.2	18,785,547.0	9,562,983.8	104
2,000 up to 10,000	1,227,248.0	3,345,070.0	2,117,822.0	173
10,000 and over	4,984,300.4	378,961.0	-4,605,339.4	-92
Region	63,021,790.5	98,874,674.0	35,852,883.5	57

	(C) % NET INCOME PER CATEGORY			(D) % FARM RECEIPTS PER CATEGORY		
	1970	1980	% Change	1970	1980	% Change
Under 1	0	0	9	0	0	-16
1 up to 10	26	17	-33	23	14	-40
10 up to 50	40	40	-0	38	37	-2
50 up to 200	10	20	108	13	22	69
200 up to 2,000	15	19	30	18	22	24
2,000 up to 10,000	2	3	73	3	4	40
10,000 and over	8	0	-95	5	1	-85

APPENDIX TABLE 1B

Distribution of Crop Production by Farm Size
(% of total produced by each size class in 1980)

FARM SIZE (in hectares)	COFFEE	SOYBEANS	SUGAR	RICE	BEANS	MANIOC/ CASSAVA	CORN/ MAIZE
			B R A Z I L				
Under 1	0.0	0.0	0.0	1.7	1.1	4.2	0.3
1 up to 10	9.9	4.0	1.7	11.6	25.9	33.8	14.5
10 up to 50	30.4	29.3	7.8	14.5	39.3	40.0	41.1
50 up to 200	29.4	25.7	14.3	20.9	21.3	15.3	22.3
200 up to 2,000	28.0	34.8	55.1	35.9	11.3	6.1	19.1
2,000 up to 10,000	2.2	5.1	17.2	12.2	1.1	0.5	2.3
10,000 and over	0.1	1.1	3.8	3.2	0.1	0.1	0.4
			C E A R A				
Under 1	0.2	0	0.2	0.7	0.6	1.1	0.4
1 up to 10	17.9	0	18.98	42.3	29.9	37.4	25.1
10 up to 50	38.99	0	23.1	29.5	32.99	30.2	32.1
50 up to 200	33.8	0	28.3	19.7	22.6	19.2	24.4
200 up to 2,000	8.9	0	29.2	7.6	12.7	11.1	15.9
2,000 up to 10,000	0.2	0	0.3	0.2	1.2	1.0	1.5
10,000 and over	0	0	0	0.0	0.0	0	0.4
			M A T O G R O S S O				
Under 1	0	0.0	0.0	0.0	0.0	1.3	0.1
1 up to 10	22.3	0.98	0.5	5.6	29.96	20.8	15.1
10 up to 50	38.4	5.7	1.6	5.9	33.8	26.1	19.4
50 up to 200	24.3	9.8	1.6	6.8	17.3	19.6	14.8
200 up to 2,000	10.7	50.5	5.2	44.2	13.7	23.0	27.7
2,000 up to 10,000	2.4	23.7	26.1	25.9	3.9	6.7	16.97
10,000 and over	1.96	9.3	64.9	11.6	1.3	2.5	5.97
			P A R A N A				
Under 1	0.0	0.0	0.0	0.2	0.2	0.9	0.1
1 up to 10	17.2	4.2	0.9	21.2	32.3	25.7	21.1
10 up to 50	41.4	33.3	6.8	40.8	48.1	57.4	46.97
50 up to 200	19.5	32.1	13.5	17.5	14.7	13.3	18.3
200 up to 2,000	20.1	27.7	59.3	15.7	4.3	2.3	11.9
2,000 up to 10,000	1.7	2.5	19.5	4.0	0.3	0.3	1.1
10,000 and over	0.1	0.3	0	0.6	0.0	0	0.3

Appendix 2: The Inverse Farm-Size-Productivity Relationship

The methodology used in this study is somewhat an amalgamation of techniques used in previous studies. Several regression models were estimated to document the existence of the inverse relation in Brazilian agriculture and to test various hypotheses about why such a relation exists. The inverse relation was verified using the following regression equations:[29]

(1) $LGPH = \alpha o + \beta_1 LAS + \beta_2 LPrice + \varepsilon_i$

(2) $LGPH = \alpha_o + \alpha_1 D_1 + \alpha_2 D_2 + \alpha_3 D_3 + \alpha_4 D_4 + \alpha_5 D_5 + \beta_1 LPrice + u_i$

(3) $LGPH = \alpha oLAS + \alpha_1 R_1 + \alpha_2 R_2 + \alpha_3 R_3 + \alpha_4 R_4 + e_i$

where $LGPH = \alpha o + \beta_1 LAS +$ gross value of output per hectare,[30]

LAS = average farm size,

$LPrice$ = the average price of land per hectare,

D_i = dummy variable representing the five farm-size groups with an average farm size greater than 1 hectare,

R_i = dummy variable representing region (1 = southeast, 2 = northwest, 3 = northeast, and 4 = São Paulo), and

ε_i, u_i, and e_i are stochastic disturbance terms.

Appendix 2, Table 1, reports the results of estimating these equations. The coefficients of (1) show that the elasticity of yield with respect to farm size is negative and that land quality has a significant, positive effect on yield. The coefficients of (2) confirm the inverse relationship in a more descriptive fashion. They show that each successive farm-size group (from small to large) is characterized by significantly lower mean yields. Equation

(3) shows us that after controlling for region, the elasticity of yield with respect to farm size is still negative and statistically significant.

Equation (3) is also interesting because it demonstrates statistically significant differences in yields across regions. São Paulo, as expected, stands out as an area of significantly greater yield than all others.[31] The northern areas are the least productive. For the southeast and the southwest frontier regions, the intercept does not differ significantly in 1980. Comparison of the coefficients estimated using 1970 data suggest that the southwest frontier is catching up in productivity whereas the northwest is lagging. Note that the pattern differs slightly when net income is the regressor instead of gross product; the southeast intercept is more similar to São Paulo and the northeast intercept is closer to that of the frontier states.

One plausible explanation for the inverse relation is that the production function exhibits decreasing returns to scale. The following Cobb-Douglas production function was used to assess the nature of returns to scale:

$$(4)\quad LGP = \alpha o + \beta_1 LNLC + \beta_2 LLab + \beta_3 LHa + \beta_4 LF + \varepsilon$$

where LGP = the natural log of gross value of output,

LNLC = the natural log of the value of nonland capital,

LLab = the natural log of labor months employed,

LHa = the natural log of agricultural hectares, and

LF = the natural log of the value of fertilizer used.

If constant returns to scale characterizes production, then $\beta_1 + \beta_2 + \beta_3 + \beta_4 = 1$.

Therefore, by estimating a second equation in which this restriction is imposed, one can test for CRTS:

$$(5)\quad (LGP - LNLC) = \alpha o + \beta_2(LLab - LNLC) + \beta_3(LHa - LNLC) + \beta_4\ (LF - LNLC) + \varepsilon$$

The results of estimating (4) and (5) indicate that the hypothesis of CRTS cannot be rejected[32] (see Appendix 2 Table 2).

Finally, two further regressions were estimated to test the hypothesis that differences in farm-size specific allocational pattern can explain the inverse relation.

$$(6)\quad LGPH = \alpha o + \beta_1 LAS + \beta_2 LLabH + \beta_3 LFTP + \beta_4 LNLCH + \beta_5 LPTP + \beta_6 LPrice + \varepsilon$$

$$(7)\quad LGPH = \alpha o + \alpha_1 D_1 + \alpha_2 D_2 + \alpha_3 D_3 + \alpha_4 D_4 + \alpha_5 D_5 + \alpha_1 LLabH + \alpha_2 LFTP + \alpha_3 LNLCH + \alpha_4 LPTP + \alpha_5 LPrice + e$$

where LGPH, LPTP, LAS, and LPrice are defined as before, and

LLabH = log of labor used per hectare,

LFTP = log of value of fertilizer used per hectare cropland,[33]

LNLCH = log of nonland capital value per hectare,

LPTP = log of the percent farmland cultivated in temporary and permanent crops, and

ε and e are stochastic error terms.

Appendix 2 Table 3 presents the coefficients of equations (6) and (7), which clearly indicate that the inverse relation becomes insignificant[34] when one controls for variation in input-use intensity. This supports the "mode of production" explanation of the inverse relation. In particular, the higher use of labor by small farms and their greater propensity to cultivate crops are significant explanatory factors.

APPENDIX 2, TABLE 1

Existence of the Inverse Farm-Size-Productivity Relation

	EQUATION (1)	EQUATION (2)	EQUATION (3)
Intercept	.099 (.765)*	1.402 (7.993)	3.568 (15.697)
LAS	-.195 (-14.396)	—	-.351 (-17.728)
LPrice	.796 (27.088)	.614 (23.34)	--
S_2	--	-.628 (-4.746)	--
S_3	--	-1.326 (-9.145)	--
S_4	--	-1.836 (-12.347)	--
S_5	--	-2.224 (-15.441)	--
S_6	--	-2.757 (-17.306)	--
R_1	--	--	.343 (1.45)
R_2	--	--	-1.470 (-5.893)
R_3	--	--	-.467 (-2.061)
R_4	--	--	1.203 (3.304)
R^2	.83	.90	.59

* Figures in parentheses are t-statistics for 5% significance level.

APPENDIX 2, TABLE 2

EQUATION (4)		EQUATION (5)	
Intercept	1.62 (4.55)*	Intercept	1.18 (9.48)
LNLC	.32 (8.88)	(LLab - LNLC)	.44 (22.63)
LLab	.44 (19.77)	(LHa - LNLC)	.05 (2.61)
LHa	.05 (2.57)	(LF - LNLC)	.19 (11.51)
LF	.18 (11.27		
R^2	.94	R^2	.68
$\Sigma\beta_i$	1		

* Numbers in parentheses are t-statistics for the 5% significance level.

APPENDIX 2, TABLE 3

	EQUATION (6)	EQUATION (7)
LAS	-.02 (-1.6)*	--
S_1	--	.03 (.18)
S_2	--	.13 (.68)
S_3	--	.25 (1.09)
S_4	--	.41 (1.55)
S_5	--	.44 (1.42)
LLabH	.37 (11.06)	.48 (8.86)
LNLCH	.04 (1.63)	.04 (1.54)
LFTP	.07 (1.70)	.08 (1.92)
LPTP	.14 (2.81)	.13 (2.44)
LPrice	.42 (9.48)	.40 (8.78)
Intercept	.54 (2.81)	.26 (.87)
R^2	.93	.93

* Numbers in parentheses are t-statistics for the 5% significance level.

Appendix 3

A simple regression model[35] was used to identify the main sources of agricultural output expansion in Brazil over the 1970-80 decade. The regression equation was derived from the hypothesis that changes in output can be attributed to land expansion, more intensive input use, technological change, and/or stochastic variation.

$$(1)\quad DGP = \alpha o + \beta_1 DTP + \beta_2 DPasture + \beta_3 DL + \beta_4 DF + \beta_5 DNLC + SM + SL + \varepsilon$$

where DGP = the change in gross value of agricultural production from 1970 to 1980,

DTP = the change in hectares of cropped land from 1970 to 1980,

DPasture = the change in hectares of pastureland from 1970 to 1980,

DL = the change in labor per hectare of cropped land from 1970 to 1980,

DF = the change in fertilizer per hectare of cropped land from 1970 to 1980,[36]

DNLC = the change in nonland capital per hectare of cropped land from 1970 to 1980,

ε represents unexplained variation attributable to technological change and stochastic variation,

SM = dummy variable representing medium-sized farms, and

SL = dummy variable representing large, commercial enterprises.

The 1970 and 1980 Brazilian agricultural census data are given for fifteen farm-size categories and by state. Farm size was further grouped into three broad categories: small farms (0 up to 50 hectares), medium-sized farms (50 up to 200 hectares), and large farms (200 up to 10,000 hectares). The data were

also arranged by region: region 1 (northeast), region 2 (southeast), and region 3 (west).[37]

The regression model was estimated separately for each region and includes dummy variables to distinguish among the farm-size groups. The estimation results are presented in Table 1.

APPENDIX 3, TABLE 1

NATION	REGION 1 (Northeast)	REGION 2 (Southeast)	REGION 3 (Northwest)
Intercept	151071.86	3740177.19	152764.34
	(1.43)	(5.02)	(1.39)
DTP	23.75	37.47	18.57
	(13.77)	(10.19)	(13.68)
DPasture	1.25	-8.84	1.24
	(2.95)	(-1.91)	(2.49)
DL	-18761.3	-190257	2451.22
	(-.63)	(-1.46)	(.25)
DF	68775.55	300571.45	-49528.1
	(1.34)	(1.24)	(-.55)
DNLC	1779.08	-8542.61	199.68
	(.57)	(-1.52)	(.31)
SM	-108147	-1430437	-26016.3
	(-.75)	(-1.10)	(-.12)
SL	-351032	-3352383	-197006
	(-2.98)	(-3.34)	(-.99)
R^2	.77	.62	.93

* Figures in parentheses are t-statistics for the 5% significance level.

Notes

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1. Graham et al. (1987) show that the decade of the 1970s was marked by dramatic growth of agricultural exports. Much of this expansion rested on soybeans or processed soybean products, and these export crops began to displace food crops in southern Brazil. Land consolidation and mechanization accompanied this process, which also saw sharecropping give way to more central farm management.

Work at Brazilian experiment stations helped to make import substitution possible, just as agricultural research was instrumental in developing appropriate cultivars for export. Sugar, for instance, was converted to gasohol to produce fuel as a substitute for imported petrol. Also, agricultural inputs such as machinery, fertilizers, and other chemicals came to be manufactured domestically. While this saved on foreign exchange, it often increased farm operating costs. Concomitantly, the national agricultural research agency (EMBRAPA) was reorganized and funding for it expanded.

Another development of the 1970s was the vigorous unfolding of agriculture into the Amazon region and the Campo Cerrado. Two general production trends characterize the 1970s: expansion at the extensive margin on the frontier, and investment in the inputs and the knowledge that made more intensive farming possible. Graham et al. believe that "the long gestation period characteristic of all agricultural research implies that the major impact of this investment will become apparent only by the mid to late 1980s." The investigation in the present article confirms that it is very likely that the full impact of this technological package had not been felt by 1980. See also Abelson and Row (1987).

2. See, for example, Denslow and Tyler (1984), and their bibliography; and Skidmore (1988, pp. 285-88)).

3. For example, Binswanger (1987) argues that land in Brazil is wastefully used partially because income-tax laws virtually exempt agriculture, thus converting it into a tax shelter. Especially at the frontier, urban investors and corporations are competing vigorously for land to establish livestock ranches, he claims. But tax treatment even makes it attractive for wealthy individuals to buy land from small farmers in areas of well-established settlement. Large farms can make profits because they receive subsidized credit and utilize it well. When credit for exports dried up in the 1980s, production was affected (Castro de Rezende 1988).

4. The published agricultural census has been taken since 1920 and is available decennially from 1940. However, only the most recent two issues are rich enough in detail to be used in this analysis.

5. Mato Grosso was divided in the 1970s, so data from Mato Grosso and Mato Grosso do Sul are added for a 1980 comparison with Mato Grosso in 1970.

6. Annual reports of the Inter-American Development Bank serial, Economic and Social Progress in Latin America, which discuss 1970 and 1980 data, do not reveal extraordinarily divergent agricultural performance for those years.

7. See, for instance, World Bank (1988b), Table 26, pp. 272-73.

8. The decrease in rural population is not inconsistent with the increase in labor use; many farmworkers reside in urban areas and, therefore, are not counted as part of the rural population. See Saint (1981).

9. This will be shown later, in Table 13.

10. See Tollini and Veiga (1985), Cuadro 3, p. 28.

11. Neusa Bombo and Rosemarie Brunelli have defined the bóia fria, literally, one who carries a cold lunch, as "a person of periodic employment and informal work relations, who lives outside of the farm on which he works, usually in the urban periphery of nearby towns or cities." This quotation is from W. S. Saint (1981).

12. See the serial issued by the Food and Agriculture Organization of the United Nations (Rome), "Information on National Plans." No. 1 was issued in January 1979, and No. 21, in December 1981; this serial continues to be issued periodically.

13. See Holloway (1977), Eisenberg (1977), and Reis (1977).

14. Fifty hectares is the upper limit for Ortega's (1982) "peasant farm." See also Ortega (1985) for updated version of the CEPAL article. Lehmann (1982b, pp. 251-52) usually draws the line at 50 hectares but sometimes at 10 hectares.

15. We are grateful to John Fett, whose fieldwork provided this insight (1988 personal correspondence).

16. Operating costs, used in calculating net income in this study, do not include an imputed value to family labor. We admit, of course, that some farms, which are nearby suburbs of large cities and are small and highly capitalized, are hidden in this category. Were we to impute a value to family labor, resulting "profits" would probably turn negative for smaller-sized farms with heavy reliance on unpaid family labor. Since deciding the value of unpaid labor is so arbitrary and controversial, we have skirted the issue in this paper.

17. In Paraná, farms under 50 hectares account for 89 percent of properties, 32 percent of the agricultural land, 53 percent of the cropland, 77 percent of the labor, 42 percent of the capital, 51 percent of total receipts, and 57 percent of net income. In Ceará, 81 percent of the properties are under 50 hectares, and this small-farm category accounts for 20 percent of the agricultural land, 36 percent of the cropland, 66 percent of the labor, 35 percent of capital, 47 percent of total receipts, and 62 percent of net income.

18. "Accumulation" probably occurs not on the farm, where consumption takes up most incomes, but in urban areas because of the cheap food that is transferred.

19. This categorization of crops as "export" and "domestic" was given by Salvador Trevisan at a seminar, based on his forthcoming Ph.d. thesis in Rural Sociology at the University of Wisconsin, held in Madison, 9 November 1988.

20. See also Gómez and Pérez (1979), and López Córdovez (1982).

21. For example, see Berry and Cline (1979), Cornea (1985), Carter (1984), and Bhalla (1988).

22. In Brazil and Ceará, particularly; while this relationship is initially the same in Mato Grosso and Paraná, it falls again in these latter two states just before the largest farm category.

23. In 1970, the seven crops accounted for approximately the same proportion of total cropland with the exception that Mato Grosso was better characterized by these crops in 1970 (86.3 percent compared to 65 percent). Mato Grosso experienced declining areas devoted to rice, beans, and corn and increasing hectarage of soybean cultivation.

Unfortunately, the census data recording does not permit one to look at the specific allocation of cropland hectares among the various crops by farm size. Respondents to the crop-specific questions about area and quantity harvested reply according to the size of the cultivated plot whereas the figures for total cropland hectarage are based on the size of establishment. Thus, it is only valid to report the ratio of area planted in a specific crop to total cropland area at the aggregate level.

24. Graham et al. (1987) use a different method of calculating growth rates for area, yield, and output. Therefore, their results differ from ours. Most notably, Graham et al. report substantially larger increases in output growth for all crops except coffee. Our method indicates a positive growth rate for coffee production while theirs suggests that it was negative. Similarly, the growth rates for area and yield differ from ours in magnitude and in a few cases in sign.

25. By definition, $Q_i = A^*_i Y_i$, where Q = total production, A = area cultivated, y = yield, and i indicates the time period. This implies that $Q + \Delta Q = (A + \Delta A)^*(y + \Delta y)$. Thus, one can express the change in production as $\Delta Q = \Delta Y^* A1 + \Delta A^* Yo$, where 1 indicates the later time period and o indicates the initial time period.

26. The exceptions to this observation are corn production in Mato Grosso and coffee production in Ceará and Paraná.

27. In addition to Brazil's more popularly familiar incursions into the Amazon, a major reason for the increase in agricultural land during the 1970s was the opening up of the Campo Cerrado, a huge area in the states of Goiás, Mato Grosso, Mato Grosso do Sul, and Minas Gerais that was once considered of little agricultural value. Prior to 1970, this land pastured livestock on sparse vegetation. The virgin soil is acid, has aluminum toxicity, and is practically devoid of available phosphate; deficiencies of magnesium, potassium, and trace minerals are common. Through experimentation it was found that with the addition of limestone, phosphate, and other fertilizers, varied crops could be cultivated with excellent results. In 1970, about 3.6 million hectares in the Cerrado were growing upland rice, corn, and beans, but yields were poor. Only 9,000 metric tons of soybeans were produced. By 1980, the area tilled had expanded to 5.9 million hectares, and 2.2 million metric tons of soybeans were harvested. By 1985, the four states were producing 6 million tons or one-third of the Brazilian production. Estimates of arable land in the Cerrado range from 50 million to 110 million hectares, and expansion of agriculture in this area is steady. See Abelson and Rowe (1987), p. 1450.

28. See Kuznets (1966), esp. pp. 160-219.

29. All regression models were estimated for both 1970 and 1980 and using both GP and NY as the dependent variable. Only 1980 results for GP are presented for the sake of brevity, though any differences are noted.

30. All variables are expressed in natural logs.

31. The test for significant differences among the coefficients α_1 to α_5 is of the following form.

Ho: $\alpha_1 \quad \alpha_2$ $\qquad t = \dfrac{\hat{\alpha}_1 - \hat{\alpha}_2}{\text{var}(\hat{\alpha}_1) + V(\hat{\alpha}_2) - 2\,\text{COV}(\hat{\alpha}_1, \hat{\alpha}_2)}$

Ha: $\alpha_1 = \alpha_2$

32. The relevant test statistic is:

$$F = \frac{N - K}{K_1} \quad \frac{R^2 - R^{2*})}{1 - R^2}$$

where N = the number of observations in the sample,

K = the number of parameters in the unrestricted model,

K_1 = the number of parameters restricted, and

$R^{2*} = R^2$ from restricted model.

33. Fertilizer use is measured on a basis of cropland hectarage to give a more accurate measure of intensity of application.

34. Equation (7) shows slight evidence that it begins to reverse direction.

35. This is a descriptive model in the sense that it identifies factors which significantly influence growth but it is not based on any theoretical model of agricultural production. The model presented here allows general statements to be made about the sources of growth. Analysis based on the estimation of a production function is called for. The authors are undertaking this task and the results will be presented in a subsequent paper.

36. Fertilizer intensity was measured by fertilizer use per hectare cropland instead of per agricultural hectare since noncrop activities generally do not require fertilizer application.

37. Northeast includes the states of Pernambuco, Piaui, Rio Grande do Norte, Sergipe, Ceará, Paraíba, Alagoas, Bahia, and Maranhão; southeast includes the states of Espírito Santo, Minas Gerias, Paraná, Santa Catarina, São Paulo, Rio de Janeiro, and Rio Grande do Sul; west includes the states of Acre, Amazonas, Goías, Pará, Roraima, Amapa, Rondônia, and Mato Grosso.

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