BRAZIL: AGRICULTURE AND AGRICULTURAL RESEARCH

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Brazil

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INTRODUCTION

The Brazilian economy has been expanding at a reasonably high rate for a fairly long period (Table 1). It had one of the higher rates of growth in the world in the period 1950–74, during which the gross domestic product expanded at an average rate of 7.1 percent.*

TABLE 1. AVERAGE OF FIVE YEAR RATES OF CHANGE (%)
(Gross Domestic Product)

Sector	*1950–54*	*1955–59*	*1960–64*	*1965–69*	*1970–74**
Agriculture	3.9	4.4	4.1	4.7	6.0
Industry	8.2	10.3	6.7	7.2	12.0
TOTAL	5.8	6.3	5.9	6.2	10.4

*For 1970–74, the data are preliminary estimates.
SOURCE: IBRE, Fundação Getúlio Vargas.

The economy lost its impetus for growth in the early 1960's, and in 1963 the growth in gross domestic product per capita was actually negative.** In that year Brazil experienced the highest rate of inflation in its history (an annual rate of 92 percent).

The post-1964 government chose a gradualistic approach to controlling

*A number of interpretations of this stagnation have been made. For a recent summary, see Baer and Maneschi.[5]

**General background on the Brazilian economy can be obtained in Baer[5] and Schuh.[38] A collection of essays which contain a more penetrating analysis of specific aspects of the Brazilian economy may be found in Ellis,[11] and Langoni.[25]

inflation in order to avoid a serious depression. However, the 1964–66 period, which was characterized by rather severe "containment" policies, was still difficult, particularly for the industrial sector. The economy did, however, experience a slight growth in this period, largely due to the high rates of growth obtained by agriculture. This sector benefited to some extent from the economic policies designed to reduce interventions in the market. The prices of agricultural products were freed, and as a consequence, agricultural production spurted ahead.

Since 1966 the economy has recovered its impetus for growth. In the period 1968–74, the growth rates were even higher than in the 1950's and attained levels in the range of 9.3–11.4.

An important aspect of the Brazilian economy in the post-World War II period was the sustained drive toward industrialization. This tendency goes back to the 1930's, but gained momentum after World War II when forced draft import substituting industrialization policies were vigorously pursued. In this period the agricultural sector also expanded, but at a lower rate than the industrial sector (Table 1). However, agriculture has performed reasonably well in this period, and has supplied substantial quantities of capital and a sizable flow of labour for the industrialization of the country.

It has been argued that the growth rates of agriculture would have been higher were it not for the set of economic policies adopted at the end of World War II and pursued up to 1964. These policies at best neglected the agricultural sector, and at worst discriminated heavily against it.*

The economic policies which stimulated industrialization, at the same time discriminating against the agricultural sector, reinforced the natural tendency for a re-allocation of labour from the farm to the non-farm sector. The result was a very rapid rate of urbanization, particularly during the 1950's and 1960's, with the result that the urban population became larger than the rural population in about 1965 (Table 2).

TABLE 2. URBAN–RURAL POPULATION TRENDS IN BRAZIL
(in millions)

Year	*Urban population*		*Rural population*		*Total number*
	Number	*Percentage of total*	*Number*	*Percentage of total*	
1940	12.8	31.2	28.4	68.8	41.2
1950	18.8	36.2	33.1	63.8	51.9
1960	32.0	45.1	39.0	54.9	71.0
1970	52.1	55.9	41.1	44.1	93.2

SOURCE: Data for 1940 and 1950: United Nations.[69]
Data for 1960: United Nations.[59]
Preliminary estimates for 1970 were provided by the IBGE.

*For an evaluation of the role of these general development policies on the agricultural sector, with special reference to Brazil, see Schuh.[33]

One of the characteristics of the economic development which resulted during the decade of the 1950's, was the very low rate of growth in employment in the industrial sector. Although industrial output was expanding at rates greater than nine percent per year, industrial employment was growing at a rate only slightly greater than two percent per year. The result was that a rather large flow of rural-urban migrants was channelled into the low productivity service sector, or accumulated as urban unemployed.

THE LABOUR MARKET

The Brazilian economy has historically had a rather mobile labour force. Even with such high mobility, however, sizable differentials in both wage rates and labour productivity persist. These differentials exist among economic sectors within the same region, and geographically within the same economic sector.

Data on these phenomena from an earlier period are presented in Table 3. These data are average wages for non-skilled labour working in the rural areas of selected states in Brazil. They document the large geographic differentials which exist in both agricultural and non-agricultural wages within the same state. Wage rates within the agricultural sector tend to have North-South patterns.

TABLE 3. MONTHLY WAGES OF UNSKILLED RURAL LABOUR, SELECTED STATES, 1959
(Cr$)

States	*Type of employment*	
	Agricultural	*Non-agricultural*
Maranhão	1.90	6.54
Ceará	1.61	2.92
Pernambuco	2.05	15.38
Bahia	2.06	7.83
Minas Gerais	2.30	24.19
Rio de Janeiro	2.85	19.40
São Paulo	3.65	67.82
Paraná	3.68	18.14
Santa Catarina	3.63	17.70
Rio Grande do Sul	4.30	18.90
Mato Grosso	3.24	2.70
Goias	3.30	2.13

SOURCE: Anuario Estatístico do Brasil.[15]

Variations in wages in the non-agricultural rural employment sector are much greater than those in agriculture. In addition, they do not have the same systematic North-South pattern.

Additional data on the substantial geographic dispersion of wage rates within the agricultural sector are presented in Table 4. These data, which are

taken from the survey made by the Getúlio Vargas Foundation, indicate that in addition to the large differences in wage rates among states, there are also sizable variations among *municipios* (counties) within the same state.

TABLE 4. VARIATION OF THE WAGE RATES OF HIRED LABOUR IN AGRICULTURE
(Based on *municipio* Averages, 1963-64.)

States	*Daily average wage rate** (Cr$)	*Standard deviation†*	*Coefficient of variation†*	*No. of municipios in the sample*
Minas Gerais	.43	.1140	27.0	38
São Paulo	.49	.1877	38.0	151
Espirito Santo	.23	.0633	28.8	24
Santa Catarina	.34	.0815	24.0	44
Rio Grande do Sul	.30	.0405	13.7	44
Pernambuco	.29	.0892	30.9	42
Ceará	.33	.1040	30.6	48
Seven States	.39	.1641	42.2	391

*Daily average wage rate was calculated for each *municipio* from the sample data. The average for the State is a simple average of the *municipio* averages.

†The *municipio* averages are used to calculate the standard deviations and coefficients of variation for the states. The *municipio* averages are used in calculating the same statistics of the seven-state average.

SOURCE: Fundação Getúlio Vargas, Survey, 1963-64.

The data on wage rates and average productivity tend to indicate that the labour market, in spite of the high rates of migration, is not performing its equilibrating function well. When one is restricted to wage rate and average productivity, however, there is little that one can say systematically. There is a presumption, however, that average productivities and wage rates would converge. If this convergence does not take place, it may be due to one or a combination of three reasons:*

1. As the economy expands, economic incentives are such that investments are induced in the capital-intensive sector. This could happen, for example, if the government were stimulating the growth of the industrial sector and if the capital-labour price ratio were different in the industrial sector. In essence, the capital stock outruns the flow of migrants.

2. Capital-labour substitution possibilities are limited in the expanding sector.

3. The rate of technical change in the expanding sector is more rapid than in the trailing sector. In this case labour productivity in the leading sector may outrun the trailing sector, even though migration is taking place at a rapid rate.

To gain more insights on the performance of the labour market we are going to draw heavily on recent studies which indicate some of the forces at work in the intersectoral labour market.

*For a more detailed discussion see Schuh.[7a]

Whitaker[41] attempted to explain why labour absorption declined so drastically in Brazilian industry in the 1950's. It appeared that during this period labour became increasingly sealed off from employment in the industrial sector, where rapidly rising returns to labour were observed (relative to other sectors).

An econometric model was formulated to explain the major determinants of demand for and supply of labour in the industrial sector. The model was estimated with cross-sectional data from 1950, for Brazil, the North and South regions, and for modern, traditional, and total manufacturing industry. State averages were used as observations. The statistical results were better for the model for Brazil as a whole.

One of the interesting findings of this study was that the agricultural labour market is linked to the industrial labour market, with a stronger link found with the traditional sector than with modern industry. This suggests that failure of employment opportunities to grow in the industrial sector can affect the well-being of rural people.

The statistical evidence of the influence of education in this study was not strong. However, the results suggest that an increase in education increases both the demand for and the supply of labour to industry. The implication for the agricultural labour market is that an increase in education will possibly decrease the supply of labour to agriculture.

Increases in technology and capital stock both have a strong positive impact on employment. If the product market effect is considered, the effect is much less, but still positive, unless the demand for the product is inelastic. Moreover, increases in the price of labour should lead to substitution of capital for labour, as evidenced by the relatively large wage-elasticity of demand. This is more true in traditional than in modern industry, which is consistent with the analysis of labour absorption in the manufacturing sector.

In a recent study Saylor[56] estimated a two-equation model for the labour market of the state of São Paulo. The data cover the period 1948–70. The study uses the model developed by Schuh to examine the supply and demand for labour in the state of São Paulo. The supply and demand functions are simultaneously estimated using two stage least squares. The wage elasticity of demand is less than one in both the short and long run, but the wage elasticity of supply is estimated to bs 3.0. Important shift variables in the demand function were prices received by farmers relative to prices paid, increase in land productivity, and a rural legislation dummy variable (the minimum wage legislation was approved at the end of 1963 but its enforcement, to a significant degree, started only at the end of 1964). In the supply function, an immigration variable and a time trend variable were important shift variables. An off-farm income variable was also statistically significant but had an unexpected sign.

The estimated coefficient for the minimum-wage variable indicates an annual reduction of employment of the order of magnitude of 100,000 workers when the supply elasticity is three.

Saylor suspects that this is an upper limit. But even if the reduction is half

of that—50,000 workers—the impact is still substantial. On the other hand, the estimated coefficients suggest an annual increase between ten percent and 25 percent for the agricultural real wage. Putting the employment reduction and wage increase together, the conclusion is that if the minimum wage brought about an increase of 25 percent in the real wage it was at the expense of a substantial decrease in employment between 153,000 workers (9.6 percent of the rural labour force in 1953) and 345,000 workers (21.6 percent of the rural labour force in 1963) in the short and long run, respectively.

An increase in the productivity of land is in line with greater utilization of labour. The response, however, is inelastic both in the short and in the long run, .10 and .20, respectively. The estimated coefficients are in Table 5.

TABLE 5. STRUCTURAL SUPPLY AND DEMAND EQUATIONS. REGRESSION COEFFICIENTS, STANDARD ERROR OF ESTIMATES, DURBIN-WATSON STATISTICS (D.W.), STATE OF SÃO PAULO 1948–70
(Model estimated in log form)

Variables	*Supply equation*	*Demand equation*
Constant	−.044	.827
Real Rural Wage	.169	−.424
	(.118)	(.151)
Prices Received/Prices Paid	—	.293
		(.069)
Productivity Index	—	.105
		(.056)
Trend	−.041	—
	(.015)	
Labour Force (lagged one year)	.938	.529
	(.108)	(.126)
Off-farm Income	.197	—
	(.083)	
Immigration	.029	—
	(.017)	
Dummy Variable (Minimum Wage)	—	−.035
(1948–62 = 0; 1963–70 = 1)		(.009)
D.W.	1.754	1.947

SOURCE: Saylor.[16]

Saylor gives an interesting interpretation of this result. Given a production function like the following:

$$Y = F[f(K_T, T), G(K_L, L)]$$

where

K_T = Capital associated with land (T)

K_L = Capital associated with labour (L)

There is a high rate of substitution between K_T and T and K_L and L. But the rate of substitution between K_T and L is low. Although the present econometric model does not directly measure the rate of substitution between K_T

and L, the low coefficient of productivity index indicates that the rate of substitution between K_T and L is low. A recent work of Sanders[25] measures the elasticity of substitution between K_L and L. He found it equal to 1.5 for Brazil and 1.1 for São Paulo, which is consistent with a high rate of substitution between K_L and L.

Immigration contributed significantly to the agricultural labour force. As was shown before, the state of São Paulo has been a net gainer of population for a long period. In the period covered by the study, part of the population that migrated to São Paulo was incorporated first into the agricultural labour force and later moved to the cities.

The coefficient of adjustment in the supply equation is very small, approximately equal to 0.06. In a different context, Huffman[22] showed that this coefficient is positively influenced by the level of education, amount of information, and other variables not so closely related to the labour force. His findings seem also to apply to the supply of labour, since, as it will be shown, the level of education of the agricultural labour force is very low and until recently very little information was provided to the workers about the conditions of the agricultural labour market.

To the best of our knowledge Saylor is the first to succeed in estimating a two-equation model for the agricultural labour market, but his results cannot be generalized for Brazil as a whole. The agriculture of São Paulo and its industrial and services structure are quite different from the rest of the country on a number of counts. Further, Saylor uses a concept of total agricultural labour force. He does not separate the hired labour force from the other components: family and operator labour. In a state where the hired labour is a high proportion of the total agricultural labour force, as seems to be the case in São Paulo, his specification of the supply equation is acceptable. But if that is not the case, (as in a majority of the Brazilian states), it is necessary to specify different functions for the supply of hired labour and family labour. Alves[1] has shown that the variables of the demand equation enter into the supply equation in the case of family labour. In essence, they measure the income available for hiring labour and family use. It is only after knowing this that the head of the family can decide how much labour will be offered to the farm enterprise. This is nothing more than to recognize that in the case of family labour, the decisions on how much labour to offer to productive activities are intertwined with decisions on how much labour to utilize on the farm and to offer to non-farm activities.

Alves[1] divided the labour market into two sectors: the subsistence sector and the commercial sector. In the first sector are the farmers that do not hire labour. For the first sector, only an employment equation is estimated. For the second sector a three-equation model of the market is specified: one demand equation and two supply equations (family and hired labour).

Conceptual models for the subsistence sector are based on the idea that the head of the family allocates his and the family's time to work and leisure within the constraints of the resources he commands and the technology used. The

conceptual models for the commercial sector are based on the theory of demand for a factor of production and the theory of supply of labour to an industry. They also take into consideration the fact that the decision on how much family labour to offer to productive activities is intertwined with decisions on how much labour to utilize on the farm and to offer to non-farm activities. The data used to estimate the model are from a cross-sectional sample, and do not permit the disentangling of the short-run and the long-run elasticities. The models were estimated with data of four groups of states: Group 1—Pernambuco and Ceará; Group 2—Minas Gerais and Espirito Santo; Group 3—São Paulo; and Group: 4—Santa Catarina and Rio Grande do Sul. The sample included 1771 "*estabelecimentos*" and 391 "*municipios*." For the purpose of the study it is obviously a very small sample. The estimated coefficients for the subsistence sector are in Table 6.

TABLE 6. STATISTICAL RESULTS FOR THE SUBSISTENCE SECTOR

Variables	*Group of states*	*Statistical results (Regression coefficients and R^2)*
Physiological (L) Possible Maximum of Family Labour	Group 1	.68*
	Group 2	.89*
	Group 3	.77*
	Group 4	.97*
Education (E)	Group 1	—.06
	Group 2	—.18
	Group 3	.20**
	Group 4	.41**
Inventory Value (V)	Group 1	.16
	Group 2	.20*
	Group 3	.01
	Group 4	.60
R^2	Group 1	.55
	Group 2	.93
	Group 3	.98
	Group 4	.93

* Statistically significant at the 1% level

** Statistically significant at the 5% level

L The number of working days in the year multiplied by the number of man-equivalents in the family produces the estimate of L.

E The school grade of the head of the family, measured in the following way: Illiterate=1; incomplete elementary school=2; elementary school=3; high-school=4; technical school =5; BS=6.

V The sum of the value (in Cr$) of land, permanent crops, buildings, animals, farm machinery and equipment. Debts were not discounted. For further details *see:* Alves.[1]

In the subsistence sector, there are indications that family labour is used to the limit of its capacity in all groups of states except Group 4. This implies that there is little room for improving the income of the subsistence farmer by

programmes with the goal of an increase in production through more intensive use of family labour. Education appears to affect the level of labour used in the farms, although in some regions it has a positive effect and in others a negative effect. In the Northeast and East, an increase in education decreases employment on the farm, other things being equal, while in São Paulo and the South it increases employment. The difference in response to this variable may be related in part to the difference in the economic environment among regions. For example, the coefficient for education was not significantly different from zero in the Pernambuco and Ceará (Northeast) group. This may reflect the fact that education attainment is very low in that region, and consequently, there was not enough variance in the variable to identify a significant relationship.

However, if the negative coefficient for that region is accepted as the probable direction of influence for that variable, there is some consistency with the results for the East (Minas Gerais and Espírito Santo). Both regions are characterized by an excess of agricultural labour, and have experienced sizable out-migrations during most of the post-World War II period. If this out-migration is viewed as a desirable goal, then the statistical results indicate that an increase in education can contribute to attaining that goal.

The positive coefficient for São Paulo and the South (Rio Grande do Sul and Santa Catarina) indicates that the effect of an increase in education is to increase agricultural employment. This suggests that education may raise the productivity of labour in farm activities. One factor that makes this finding plausible is that there is more new production technology available for adoption in the southern part of the country. If education of the labour force is complementary to the generation and adoption of new production technology, then it might well increase the level of employment, particularly if that new technology involves the adoption of new varieties and improved cultural practices as in the case of Santa Catarina and Rio Grande do Sul.

The inventory asset was used as a proxy for each on hand in the theoretical model. It was believed to be the only proxy that would be suitable across a wide range of farm types and farm sizes. The statistical support for the variable is not strong. The coefficient does have the expected sign that was postulated in the conceptual model, although in at least two of the four regions the relationship is rather weak.

Finally, the statistical results provide some support for Johnson's fixed asset theory. The ability of the included variables to explain the level of employment within agriculture suggests that family labour is treated as a fixed asset. This is at least supportive evidence for the existence of sizable imperfections in the labour market, a basic postulate of the Johnson work.

Policies such as education, which open a wider range of opportunities to the labour force, would be one possible measure to cope with the labour market imperfection, as well as subsidies to facilitate migration and changes in employment. If part of the imperfection is a result of restrictions to entry in off-farm employment, these should also be reduced and eliminated.

The statistical results for the models of the commercial sector were

reasonably good for Pernambuco and Ceará (Group 1) and Santa Catarina and Rio Grande do Sul (Group 4). They were very weak for Minas Gerais and Espírito Santo (Group 2). For São Paulo (Group 3) the statistical results were only reasonably good for the supply of family labour. From the analysis of the commercial sector the following results were separated:

1. One of the interesting results obtained was the large elasticities obtained for agricultural wage in the demand equation when the parameters of this equation were properly identified. Three implications of this finding stand out:
   (a) Measures designed to shift the supply curve of labour to the left in order to raise income are going to have a relatively large effect on employment and a relatively smaller effect on wage rates.
   (b) Policy measures which raise the agricultural wage by administrative decree (minimum wages, for example) are likely to have a very large employment effect.
   (c) Policies which affect the labour-capital price ratio more generally would also appear to have a large employment effect, since the results indicate that capital and labour are substituted for each other fairly easily in production. This has important implications in Brazil, for an important policy instrument for agricultural development is the extension of credit at highly subsidized real rates of interest. Given the demand elasticity obtained, these policies probably have negative employment effects.

2. The land variable is a consistently strong variable in the demand equation. There is strong evidence that an increase in land per farm increases the demand for labour by those farms.

3. A significant coefficient for education is found only in Region 4, Santa Catarina and Rio Grande do Sul. The elasticity in that region is fairly large indicating that education has a fairly large effect on the demand for labour.

4. The coefficient of the labour intensity variable (or product intensity variable) indicates that an increase in labour intensity of the product mix does increase the demand for labour. Moreover, the response is greater than one in every case for which satisfactory results were obtained. These results suggest that a shift in the labour intensity of the product mix is one means of increasing employment and wage rate in agriculture.

5. The expected non-farm wage was one of the strongest variables in the supply of labour equation (family labour). The results suggest that an increase in expected non-farm income reduces the quantity of labour supplied to agriculture. However, the elasticity tends to be less than one, which indicates that the effect is not large. In any case, the results suggest that increasing the expected non-farm wage can reduce employment in agriculture, which, other things being equal, will assist in raising the wage rate in agriculture.

6. The study of the structure of the labour market indicates that the forces acting in the labour market have induced the Brazilian population to migrate, searching for new regions where salaries are higher. This fact induced the present study to look into the internal migration flows in the country.

POPULATION

With its 8.2 million square kilometers and its population, measured in 1970, of about 95 million people, Brazil should not be a country with a very serious population problem. However, it needs to be considered that while its average population density overestimates the man/area ratio in the Brazilian Amazon, it does not show at all the problems faced by people living in places like São Paulo, one of the largest urban centres of Latin America, or even the overall situation faced by people living in the Brazilian Northeast.

In the fifties the Brazilian population experienced its highest rate of growth up to that point. The overall average was about 2.5 percent per year. In regional terms this rate of growth varied from a low of 1.93 percent in the Eastern region up to a high of 3.71 percent in the Middle West.

In the sixties the growth rates were still higher. The overall rate of growth reached 2.9 percent a year, on an average. Around this average, the extremes had the same locations. The Eastern states had the lowest rate of population change, about 1.5 or 2.0 percent and the Middle Western states the highest with a rate of population growth of 5.6 percent a year.

With such a pattern of population change, one would expect to have some action toward population growth orientation, or at least some guide to population movements.

The interregional population changes in Brazil can be seen as a by-product of other developmental policies. People move around, the birth and death rates show differing figures from year to year as a consequence of policies related to other problems, or at least to the development of other resources.

Some examples will illustrate this statement. In building Belo Horizonte, one of the largest Brazilian urban centres, Contagem, a satellite town in its neighbourhood, was also planned to be its industrial area. In their development process both Belo Horizonte and Contagem drew from the state's interior large numbers of migrants. These two towns, especially Contagem, are among the fastest growing centres in the country.

The building of Belo Horizonte also greatly influenced the neighbouring agriculture, Schulze.[4] The second example of the same nature is of São Paulo and Osasco.

The third and, in terms of the size of migration flows, the most important in Brazilian population history, is the migratory movement that was initiated towards the state of Paraná in the forties and fifties. This was induced by the settlement of that state, a land development process pulling in the migratory flows. The flow into Parana is still very lively. Paraná is among the states with the highest population gains from the migration process.

A more familiar example is the tremendous population pull originated with the building of Brasília. Here one can see not just the construction of the city, but the whole idea of land resources development and the colonization of the country's Western lands. The development of the Brazilian Midwest is widely known. In terms of its population effects it can be seen as a trend towards re-directing the migratory flows.

The population increase of that region draws many people from the Northeast and from the Southeast (mainly Minas Gerais, a state closeby). The major effects of these movements have been the releasing or avoiding the intensification of the demographic pressure upon large cities such as Rio de Janeiro and São Paulo.

The move towards the West will bring about new concepts of population nuclei and will make the colonization of the region a fact in the near future.

A distinct characteristic of the Paraná Midwest examples is that in these cases the flows were generated by the opening up of new agricultural opportunities, while in the first two examples the pull factors were basically in the industrial-urban, or at least in the non-agricultural sector.

Considering the overall situation, the rate of population growth, although high, does not seem to be a major problem. To compensate for the unevenness of its distribution one also notes the relative population mobility which shows a considerable responsiveness to the forces that act in the labour market.

As for age distribution, one sees a concentration of people in the low and inactive age groups, Table 7. The age pyramid shows that the male population of between 15 and 49 years adds to a total of about 21,590,000.

TABLE 7. AGE, RURAL–URBAN AND SEX COMPOSITION OF THE POPULATION

(population in thousands)

Age group	*Total population*	*% of group*	*Urban population*	*% of Age group*	*Rural population*	*% of Age group*	*Total male*	*Total female*
0– 4	13,811	14.8	6,811	13.0	7,000	17.0	6,969	6,841
5– 9	13,460	14.4	6,959	13.3	6,500	15.8	6,799	6,659
10–14	11,859	12.7	6,377	12.2	5,482	13.4	5,974	5,874
15–19	10,253	11.0	5,761	11.1	4,491	10.9	4,928	5,325
20–24	8,286	8.9	4,840	9.3	3,445	8.4	4,037	4,249
25–29	6,504	7.0	3,820	7.3	2,684	6.5	3,173	3,331
30–34	5,664	6.1	3,409	6.5	2,255	5.5	2,560	2,894
35–39	5,089	5.5	3,075	5.9	2,013	4.9	2,502	2,587
40–44	4,535	5.9	2,754	5.3	1,781	4.3	2,288	2,247
45–49	3,546	3.8	2,138	4.1	1,407	3.4	1,795	1,751
50–54	2,940	3.2	1,746	3.4	1,193	2.9	1,486	1,455
55–59	2,288	2.4	1,385	2.7	903	2.2	1,160	1,128
60–64	1,791	1.9	1,079	2.1	711	1.7	903	887
65–70	1,216	1.3	759	0.1	456	1.1	604	611
Over 70	1,708	1.8	1,053	2.0	654	1.6	787	920
Age ignored	184	0.2	110	0.2	73	0.2	93	91
TOTAL	93,139	100	52,085	100	41,054	100	46,331	46,807

SOURCE: Fundação IBGE.[15]

If one defines this group as the labour force, it makes up about 23 percent of the total population. Stretching the definition to cover males in their fifties,

the labour force comes to about 24,236,600 people, representing about 26 percent of the total population.

From these figures one sees that about a fourth of the population has to work for the whole population. This exaggerates the non-working component of the population, since women and men over 60 and under 15, are also part of the labour force. Women represent about 20 percent of the Brazilian labour force, and people under 15 and above 60 add up to about 7.5 percent (Table 8).

TABLE 8. AGE COMPOSITION OF THE LABOUR FORCE (1960 and 1970 census)

Age group		*Participation in the labour force*	
		1960	*1970*
10–14		1.98	2.37
15–19		10.47	11.88
20–24		14.86	15.81
25–29		14.21	13.71
30–39		24.22	23.03
40–49		17.39	17.18
50–59		10.29	10.05
60–69		4.92	4.49
		1.66	1.30
Sex	Male	83.22	79.52
	Female	16.78	20.48

It should be noted that the younger groups (up to 25) that make up the labour force have increased their participation. The others have decreased.

Considering the whole population, the combination of data in Tables 7 and 8 shows that about 53 percent of the population (aged 15 to 60) hold 92 percent of the labour force. The non-active components of the population weigh very heavily in the population composition.

Another special characteristic of the Brazilian population which concerns the country's government, is its educational structure, especially that of the labour force. Table 9 shows the educational composition of the labour force components.

In 1970, about 30 percent of the labour force was illiterate. Over half (54 percent) had only an elementary education. Only about 15 percent had studied beyond primary school. Comparison of the 1960 figures with those of 1970 indicates some change in the right direction, although a lot of improve-

TABLE 9. EDUCATIONAL STRUCTURE OF THE LABOUR FORCE

Level of education	*Labour force composition*	
	1960	*1970*
Illiterate	39.05	29.75
Elementary	51.71	54.47
Jr. High School	5.16	8.02
Sr. High School	2.67	5.24
College	1.40	2.51

SOURCE: Langoni.[34a]

ment is required yet. This is undoubtedly a serious problem faced by the Brazilian government. A more specific picture can be offered by the differentiation of the rural and urban labour forces (Table 10).

TABLE 10. EDUCATION LEVELS OF THE RURAL AND URBAN LABOUR FORCES (1970 Census)

Education level	*Rural sector*	*Urban sector*
Illiterate	53.34	13.99
Elementary School	45.56	60.41
Jr. High School	0.79	12.87
Sr. High School	0.19	8.61
College	0.10	4.12

SOURCE: Langoni.[34b]

The urban component of the labour force is in a better educational situation, especially regarding the percentage of illiterates.

Historically, the rural population of Brazil has been moving to the urban sector. With the kind of education that the rural population has always had, those migrating to the urban sector were not prepared to be absorbed by the industrial sector of the economy. As a consequence, the level of unemployment in the urban sector increased considerably, forcing the absorption of part of the unemployed by the service sector, a process well-described by Schuh and Alves,[37b] relating to the situation of the fifties.

The importance of education in such a situation can hardly be over-emphasized. Especially for the rural sector, education programmes would prepare the out-migrating component of the population to enter the industrial market. Those who stay in the rural sector would be better equipped for the technological innovations which might be adopted.

The recent emphasis on literacy programmes and other kinds of adult education shows the government's sensitivity to this basic problem. The health care and hygiene programmes can be seen as a way to increase the life expectancy of the Brazilian population, thus increasing the average age of the country's labour force.

Internal Migration

A very detailed descriptive study of the internal migration process in Brazil, and its association with the country's growth and development has been made recently.[14] The study covers the period 1872–1970. Attention here will be concentrated on those parts of the study which show the pattern of convergence and divergence among states or groups of states, over the period 1940–68.

The states are classified into two groups. The upper group (Group 2) contains states with a high per capita income. They belong to the Central

TABLE 11. MEASURE OF THE DIFFERENCE BETWEEN THE INCOME AND POPULATION SHARES*

Group of states	1940	1950	1960	1968
	Sum of absolute differences	Sum of absolute differences	Sum of absolute differences	Sum of absolute differences
All States Between Upper and Lower	55.72	57.80	50.98	49.18
States each Treated as Groups				
Upper Group Treated Separately	38.32	43.58	36.52	35.00
Lower Group	46.49	45.85	41.09	40.92
Treated Separately	20.67	17.19	16.88	16.20

* First the difference between the share of the state in total population and total income is calculated. The sum of the differences, ignoring sign, weighted by each state's share of the total population is a measure of relative income inequality per capita. See Graham.[15]

SOURCE: Graham and Filho,[16] Table IV-1. Population data are from demographic censuses with 1968 population data based on interpolation between 1960 and 1970 demographic censuses

West, Southeast and South regions. The lower group (Group 1)—the low income group, includes the states of the Northeast and the North. Table 11 summarizes part of the data for the period 1940–68. These numbers indicate that

1. In the decade 1940-50, there was increasing divergence in income per capita among the states of Brazil, associated with a strong divergent growth between low-income and the high-income states.

2. The decade 1950-60 and the period 1960–68 showed a slight convergence in income per capita among states, and also a marked convergent growth between the high-income and low-income groups of states.

These results suggest a migration pattern that deserves investigation. Table 12 is an adaptation of a table in the original study. It is important to

[14] Net internal migration for each state was calculated by the formula $M=P_t-P_0$, $M=P_{t+n}-nR_nP_t$ where P_{t+n} is the Brazilian native-born population living in the state at the end of the intercensal period, who were already born at the beginning of the intercensal period. P_t is the Brazilian native-born population living in the state at the beginning of the intercensal period. R_n for each period were calculated by dividing the number of native-born Brazilians in the country at the end of the intercensal period who were living at the beginning of the intercensal period. For more details see: Graham and Filho.[16]

TABLE 12. NET INTERNAL MIGRATION OF NATIVE-BORN BRAZILIANS BY STATES AND GROUP OF STATES 1940–50; 1950–60; 1960–70

States	*1940–50*		*1950–60*		*1960–70*	
	Migration no. of inhabitants	*% of 1940 population*	*Migration no. of inhabitants*	*% of 1950 population*	*Migration no. of inhabitants*	*% of 1960 population*
Group 1						
Acre	—6,344	—8.03	—2,758	—2.41	—3,687	—2.30
Amazonas	—23,862	—5.55	1,261	0.24	—17,983	—2.40
Pará	31,255	+3.35	8,638	0.74	89,410	5.52
Maranhão	5,100	0.41	—212,231	13.40	220,542	+8.85
Piauí	—25,120	—3.07	—157,655	—15.05	—18,858	—1.49
Ceará	—36,813	—1.76	—330,739	—12.27	—82,859	—2.48
Rio Grande do Norte	—16,037	—2.09	—133,723	—13.82	—26,171	—2.85
Paraíba	—81,174	—5.71	—256,418	—14.97	—204,418	—10.13
Pernambuco	—14,322	—0.53	—372,565	—10.97	—203,231	—4.91
Alagoas	—98,070	—10.32	—182,636	—16.71	—92,917	—7.31
Sergipe	—40,163	—7.41	—90,123	—15.35	—88,313	—11.62
Bahia	—135,512	—3.47	—501,163	—10.47	—356,763	—6.12
Immigration	+11,444	+0.07	+222,130	+1.12	+115,591	+0.46
Out-migration	—302,358	—3.16	—2,041,782	—10.32	—1,299,571	—5.21
Immigration and out-migration	513,802	3.23	2,263,912	11.44	1,415,152	5.67

Group 2						
Minas Gerais	—681,788	—8.96	—593,386	—7.62	—1,273,746	—12.79
Espírito Santo	—46,230	—5.94	44,612	4.66	—227,833	—16.06
Rio de Janeiro	— 19,122	—1.06	195,542	8.53	201,315	5.92
Guanabara	345,352	22.60	372,816	15.68	372,181	11.25
São Paulo	362,270	5.70	712,706	7.80	993,428	7.66
Paraná	362,263	29.28	912,855	43.58	790,169	18.39
Santa Catarina	4,087	0.36	—63,431	—4.07	—49,237	—2.29
Rio Grande do Sul	13,515	0.42	—167,532	—3.90	—339,909	—6.24
Goiás	91,831	11.15	259,310	21.34	448,076	21.42
Mato Grosso	— 2,251	—0.55	131,568	23.59	268,517	27.38
Immigration	+1,159,320	+4.84	+2,620,090	+8.18	+3,074,686	+6.68
Out-migration	—669,391	—2.80	—819,359	—2.55	—1,890,725	—4.11
Immigration and out-migration	1,828,711	7.64	3,449,359	10.73	4,965,411	10.78
Brazil						
Immigration	+1,170,761	+2.94	+2,852,130	+5.51	+3,190,267	+4.49
Out-migration	—1,171,709	—2.94	—2,861,141	—5.51	—3,190,296	—4.49
Immigration and out-migration	2,342,513	5.88	5,713,271	11.02	6,380,563	8.98

Sources: Graham and Filho[8], Table III-A-1, p. 98. The results for the territories of Roraima, Amapá, Rondônia and Fernando de Noronha were included with those of the states of Amazonas, Pará, Mato Grosso and Pernambuco respectively in 1970, 1960 and 1970.

mention that it neither accounts for the migration within states nor the cases in which a person moves from one state to another, but returns to the original state before the beginning of the census interviews.

The states are classified in two groups as before. The estimates indicate that

1. A sizable part of the native-born population changed residence in the decades 1950–60 (5.7 million people, 13 percent of the 1950 population) and 1960–70 (6.4 million people, 9.0 percent of the 1960 population). The amount of the 1960–70 decade is relatively slightly smaller but confirms the observation that the Brazilian population is rather mobile.

2. The low-income group of states, in the 1960–70 decade, continued to be a net exporter of population, with the exceptions of Pará and Rio Grande do Norte.

3. In the high-income group, Minas Gerais continued to lose its population to other states at a very high rate. Rio Grande do Sul also continued as a net exporter of population, and at a somewhat higher rate than in the previous decade. The inflow of population to Paraná and Goias continued at a high rate. The flow of migrants for Mato Grosso and Maranhão also continued to be large.

4. The data also show the large-scale push into the frontier areas of first, Paraná and later, Goias, Mato Grosso and Pará, and a slowdown of the out-migration from the Northeast, especially in the decade 1960–70. In the areas of the Northeast, Goias, Mato Grosso and Pará, the large-scale investments of the federal government, especially in the last decade, are playing an important role in slowing down the rate of migration (in the case of the Northeast) and directing the migratory movements to rural areas in regions in the process of settlement (Mato Grosso, Goias and Pará).

An Econometric Approach to the Migration Problem.

A different approach and different combination of data, characterizes an econometric examination of the overall internal migration in Brazil, using data from the 1970 census.

A perusal of the literature related to migration leads to the differentiation of three basic approaches to the problem of explaining why people migrate. In a historical perspective one finds the "laws of migration" proposed by Ravenstein,[32 33] when he characterizes the push and pull factors which basically relate to the structure of the agricultural process, and the lure of city life, respectively.

Simon Kusnets[35] with his works on population and economic growth of the United States has led the so-called "Harvard School" approach.[34] Here people's attitudes towards risk act as the argument of selectivity that explains why some migrate and some do not.

The third approach is based on the neoclassical theory of investment. It is supposed to have appeared with the works of Sjaastad[43] and Schultz[39] and for this reason is associated with the "Chicago School."

Sahota,[34] in a study of migration, has neatly contrasted these three approaches. After Sahota's paper came out, the migration process, with special

emphasis on developing countries, was studied with a more accurate definition of the income variable. The expected income of the migrant was supposed to be influenced by the income of the unemployed. The leading writer here is Michael Todaro.[47 48]

Looking at what could be considered the theoretical background of the approaches, one would see that migration flows could be induced by the following variables: income differentials, distance, education, urbanization, industrialization, and level of employment.

Empirical studies of the migration process have also tried to relate migration to the sex and age of the migrants.

In the present section it is aimed to associate the migratory flows within Brazilian regions with some of the above variables. An attempt is made to indicate the ones with better chances of explaining Brazilian migratory movements.

For the purpose of this chapter the overall migration phenomenon is important as it affects the agricultural labour force. Within the overall migration process, one should view the rural-urban migration flows. This will be dealt with in the next section.

The Migration Model and Data.

A single equation migration model is used. A power function, linear in logs, is estimated, with out-migration as the dependent variable.

Income levels—measured by the average income, of the rural and urban sector in 1970.

Income changes—measured by per capita income growth in the period 1950–68.

Income distribution measured by a Gini (the bigger, the more uneven) index averaged in the rural and urban sectors.

Education—measured by the percentage of literates aged five or more, to the total population.

Urbanization—measured by the proportion of the population living in cities of 5,000 inhabitants or more.

Population density—taken as the number of people per square kilometer.

Out-migration, the dependent variable, was measured as the ratio of migrants to the total population in the region.

The data come from several sources, though, basically, from the 1970 census. The unit of observation is a region. For migration studies Brazil has been divided into ten regions. From each region we considered the out-migration to the other nine. There are, then, 90 observations. In the exercises performed to fit the equation, the same explanatory variables were considered both at the origin region as well as at the destination.

The levels of significance of the estimated coefficients and the explanatory power of the fitted equations consistently indicated that the explanatory variables taken at the origin were the more important ones. After a few runs the following estimate was selected. See Table 13.

TABLE 13. INTERREGIONAL MIGRATION, 1970

Variable	*Coefficient*	*Student*
Constant	11.740	—
Income level at origin	-3.552	7.599
Income level at destination	0.199	1.413
Income growth origin/destination	0.268	3.027
Income dispersion at origin	30.93	13.641
Education at origin	8.776	10.465
Urbanization at origin	-2.181	6.580
Density at origin	0.175	3.014
R^2	0.84	

SOURCE: Data on migration: Muta;[24] on income levels, growth and dispersion: Langoni;[17] all others: IBGE.[10 11]

Interpreting the migration phenomenon in Brazil from the estimated equation leads to the following inference: income levels and urbanization at the region of origin prevent people from moving out. Taking now the variables positively associated with out-migration, it seems that income inequality and the education factor both taken at the origin are the two most important. Income level at the destination, demographic density at the origin and the ratio between income growth at origin over the destination tend to affect migration with equivalent intensities. Income growth at the destination, according to the estimation of the model, would tend to discourage out-migration. This is somewhat unexpected. Usually one would reason that people migrate, attracted by the opportunities at their destination. If this is the case, the ratio of income growth at the origin to that at the destination should be positively related to migration, but the obtained result does not agree with such logic. To lend credibility to this finding, this kind of relationship was consistently found in other specifications of the model.

Exploring the meaning of the estimates, it can be said: as the income level of people increases, they tend to migrate; income inequality at the origin induces people to migrate out; income growth at the origin favours migration; income levels at the destination also are positively associated with migration; with the appearance of large cities in their own regions they do not go to other regions; if they migrate, they stay in their regions, moving to these larger towns. Demographic density at the origin favours out-migration.

As more people are educated, out-migration increases.

Rural–Urban Changes

The focus concerning the rural-urban population compositions in Brazil, is on the loss of importance of the rural sector. In 1950, the rural sector of the country held almost two-thirds of its population. The 1970 census shows the rural sector with a population of slightly less than 45 percent of the total. In absolute numbers, the figures are as in Table 14.

TABLE 14. POPULATION CHANGES IN BRAZIL (1950–70 Censuses)

	1950	1970	Total	Rate of change % per year
Rural population	33,162	41,604	25.4	1.2
Urban population	18,783	52,904	181.7	9.0
TOTAL	51,945	94,508	81.9	4.1

If one assumes the rate of growth for the total population to be the same for both the rural and urban sectors, the following situation would be expected for 1970, if no migration had taken place:

Rural population—60,334;

Urban population—34,174.

These two values, compared with the figures found in the 1970 census, show a migration flow from the rural to the urban sector equivalent to about 18 million people.

In fact, such an exercise gives a figure above the number registered in the last census, which shows a number of rural–urban migrants smaller than eight million people. The main reason for such a difference is that the census shows only the last move that people made. It is likely that in the span of 20 years some migrants change places more than once. Another very important reason is the appearance of new towns in places previously considered rural areas. Finally, it is only fair to assume the same rate of growth to apply to the rural as well as to the urban sector.

In terms of intra-regional migration, the exits from the rural sector, net of the entries, show the following situation (Table 15).

TABLE 15. RURAL–URBAN MIGRATION, THE INTRA-REGIONAL MOVEMENTS, BRAZIL (1970 Census)

Region	States	Exits minus entries rural sector	Percentage of rural population
I	Amazonas, Pará, Rondonia, Acre Roraima	46,957	2.4
II	Maranhão, Piauí	20,792	0.6
III	Ceará, Rio Grande do Norte, Paraiba, Pernambuco, Alagoas	446,437	5.5
IV	Sergipe, Bahia	77,252	1.6
V	Minas Gerais, Espirito Santo	467,162	7.4
VI	Rio de Janeiro, Guanabara	234,844	21.5
VII	São Paulo	651,759	18.6
VIII	Paraná	202,620	4.6
IX	Santa Catarina, Rio Grande do Sul	360,313	7.5
X	Mato Grosso, Goiás, Distrito Federal	61,392	2.3
	TOTAL	2,569,528	6.3

SOURCE: Tabulaçoes Especiais do Censo Demográfico de 1970. FIBGE/IBI.

The total shown on Table 15 is considerably smaller than the number of rural-urban migrations in the country. The intra-regional movements are just a portion of the total rural-urban flow of population.

It is important to consider the intra-regional movements of people. The stepwise process, which has been shown to be the one adopted by migrants from the rural to the urban sector,[24 26 14] leaves an important role to be played by intra-regional migration.

Above all, the first step of the migration process is the one in which the effects of the movements are felt in the agricultural labour force. This characteristic makes the intra-regional movements of special interest.

Considering these elements, an attempt was made to determine the variables interfering with intra-regional migration. The information of Table 15 was then associated with data concerning the following variables, by a simple regression equation:

Transportation availability measured by:

Total roads available in the region;

Total roads available in the region as a percentage of the total roads in the country;

Roads available in the region per square kilometer;

Income levels measured by per capita income in the rural sector;

Per capita income in the urban sector;

Income distribution measured by

(a) Gini coefficient for the urban sector

(b) Gini coefficient for the rural sector

Of the equations fitted, the following were selected:

$$M = -0.241 + 0.631\ x_3$$
$$tb_3 = 3.140\ R^2 = 0.55$$
$$M = -3.534 + 1.940\ x_4$$
$$tb_4 = 1.869\ R^2 = 0.30$$
$$M = -7.143 + 3.113\ x_5$$
$$tb_5 = 3.773\ R^2 = 0.64$$
$$M = -3.011 + 5.804\ x_6$$
$$tb_6 = 3.156\ R^2 = 0.55$$

x_3 = road extension per square kilometer

x_4 = per capita income in the rural sector

x_5 = per capita income in the urban sector

x_6 = income distribution—Gini index (the bigger the more uneven) for the rural section

M = migration, exits from rural areas, net of entries.

Among all the misgivings about the use of single explanatory variable models, the possibility of having an independent variable associated with other effects is an important one in the present situation. When models with more explanatory variables were tried, x_3 (road extension), lost its apparent importance as a migration inducer.

The level of income in the rural as well as in the urban sector was positively associated with migration. From the urban sector viewpoint it is natural that the higher the levels of income the more people will be attracted to it. Concerning the rural sector, one could reason that a certain income level is required before people will migrate. The need to cover the migration costs could explain the positive association between rural income level and rural-urban migration.

Income distribution was also positively associated with migration. The way it is measured, the larger its values, the more unevenly the income is distributed. All that the estimated coefficient implies is that people migrate out as the rural income distribution worsens. This result is consistent with the similar one noted earlier.

An additional statistical exploration of the data was also tried. The reduced number of degrees of freedom would impose severe limitations on the number of explanatory variables in the estimated equations. Due to this, variables combining information from the origin and from the destination were proposed. The definition of the dependent variable, "Exits net of Entries," contains the same type of combination.

From the estimated models, the following was selected:

$$M = 0.500 + 2.571\ x_{54} - 5.500\ x_{76}$$
$$t_{54} = 1.927\ t_{76} = -3.719\ R^2 = 0.70$$

x_{54} = urban/rural income ratio

x_{76} = urban/rural income distribution ratio.

Again, the present findings are consistent with the earlier ones. The higher the ratio of urban to rural incomes, the more people will migrate.

The effect of the income distribution ratio on migration is negative. Taking one element of the ratio at a time, other things being equal, one can see that the more uneven the income distribution in the urban sector (urban/rural ratio larger), the fewer people migrate. The more uneven the income distribution in the rural areas, the smaller the ratio and the smaller the negative effect on migration. People tend to migrate from places where the income distribution is uneven. They migrate in the hope of having a more equalitarian income distribution.

FOOD-NUTRITION: THE PERFORMANCE OF THE AGRICULTURAL SECTOR - - FUTURE PROSPECTS

Food Demand

With the rates of growth of income and population in Brazil, pressure is to be expected on the agricultural sector. In poverty areas it is known that malnutrition prevails in many parts of the country.

Food demand in Brazil grew at the rate of 4.0 to 4.2 per cent a year in the fifties, Delfim Netto.[10] In the following decade this rate rose to about 4.6 percent a year. With the assumption of fixed-produce price ratios, fixed distribution

patterns and fixed consumers' preferences, considering P = the rate of population growth; N = the income elasticity of the food demand; R = the per capita income growth

The total growth in demand, D, could be defined as:

$$D = P + NR$$

Making the proportion of the rural population in the total population, one could write

$D = h\,Dr + (1 - h)\,Du$; Dr = growth of demand of rural population; Du = growth of demand of urban population.

Using data from the 1960 and 1970 census for population, Langoni's[24] data for income and income elasticities from Vargas Foundation studies, one can see components of the growth of internal demand for food in Brazil in Table 16.

TABLE 16. ANNUAL RATE OF GROWTH OF FOOD DEMAND, 1960–70

Region	Rural sector					Urban sector					Total demand
	h	P	R	N	Dr	$(1-h)$	P	R	N	Du	
North	0.55	2.1	–0.2	0.44	2.0	0.45	5.3	2.2	0.62	6.7	4.1
Northeast	0.58	1.3	1.1	0.44	1.8	0.42	4.6	1.9	0.62	5.8	3.5
Southeast	0.27	–1.8	2.4	0.38	–0.9	0.73	5.1	4.4	0.56	7.6	5.3
MC	0.55	2.2	0.5	0.36	2.4	0.45	5.2	3.9	0.50	7.1	4.5
MW	0.52	3.1	–0.2	0.40	3.0	0.48	9.0	2.2	0.58	10.3	6.5
BRAZIL	0.44	0.7	1.4	0.40	1.3	0.56	5.2	3.7	0.55	7.2	4.6

Without making any attempt to evaluate the quality of information used, one could call attention to the following:

Total demand for food grew in the sixties at rates which differ from region to region.

Income elasticities for food in the urban areas are higher than in the rural sector. Another component of the growth of demand is to be expected from the migration of people from the rural to the urban sector. This is an indication that the rates shown are an underestimation of the demand growth rate.

The breakdown of the growth of demand for food into population and income components is seen in Table 17.

TABLE 17. POPULATION AND INCOME COMPONENTS OF THE GROWTH IN DEMAND FOR FOOD

Region	Population %	Income %
North	86	14
Northeast	78	22
Southeast	61	39
South	78	22
Midwest	91	9
BRAZIL	70	30

The major component of the increase in the demand for food is the rate of population growth. In perspective, the rate of growth in demand is expected to be influenced by both the population and the income components.

With the same procedure, and assuming a rate of growth of per capita income of 7.5 percent a year, the same income elasticities and the same population growth, the following rates of growth of the demand for the specific food commodities can be seen in Table 18.

TABLE 18. ANNUAL RATE OF GROWTH OF DOMESTIC DEMAND FOR SIX FOOD COMMODITIES

Commodities	*Per capita income growth*	*Regions*					
		North	*North-east*	*South-east*	*South*	*Mid-west*	*Brazil*
Rice	4.5	6.0	4.3	4.9	4.3	7.0	4.5
	7.5	6.0	5.4	5.8	4.8	7.5	5.3
Potato	4.5	7.0	6.8	6.8	5.4	7.7	5.7
	7.5	9.5	9.6	8.9	6.6	9.2	7.3
Bean	4.5	3.9	3.1	3.9	3.6	6.5	3.7
	7.5	4.2	3.2	4.0	3.6	6.6	3.8
Wheat	4.5	7.5	7.6	7.7	5.0	8.4	5.7
	7.5	10.7	11.0	10.5	5.9	9.7	7.2
Corn	4.5	4.7	3.8	2.4	3.5	4.2	3.2
	3.5	5.4	4.5	1.6	3.4	5.5	3.0
Manioc	4.5	4.8	4.7	6.0	4.7	7.4	5.0
(Cassava)	7.5	5.6	5.1	7.6	5.4	8.1	6.1

Departing from the rates of growth of Table 18 and considering the quantities of the commodities consumed in 1970 (a centred mean of the years 1969–71), the quantities demanded of the commodities can be projected, as in Table 19.

TABLE 19. PROJECTIONS OF QUANTITIES DEMANDED OF SIX FOOD COMMODITIES IN BRAZIL

Commodities	*Per capita income growth*	*Regions*					
		North	*North-east*	*South-east*	*South*	*Mid-west*	*Brazil*
Rice	4.5	122	1.459	5.140	1.293	791	8.855
	7.5	189	1.616	5.578	1.352	825	9.560
Potato	4.5	32	171	1.208	528	48	1.987
	7.5	40	222	1.457	593	55	2.377
Bean	4.5	48	786	1.186	425	210	2.655
	7.5	49	796	1.202	425	212	2.684
Wheat	4.5	127	1.148	3.680	1.145	139	6.239
	7.5	180	1.644	5.012	1.319	166	8.321
Corn	4.5	566	4.361	4.843	4.646	2.009	16.425
	7.5	603	4.646	4.464	4.610	2.274	16.597
Manioc	4.5	1.930	14.524	6.719	9.094	3.110	35.505
(Cassava)	7.5	1.977	14.724	6.863	9.492	3.113	36.169

The South and Southeast regions would use over two-thirds of all the six commodities considered. The situation with cassava could change considerably if the extraction of alcohol from cassava should increase.

Comparing projections of production with demand, we can examine how the projections tend to match.

The Vargas Foundation has recently published a preliminary version of a group of supply and demand projections of agricultural goods.[13] To project production a simple and straightforward one-equation model was used, taking time as the one independent variable. This means extrapolation production patterns observed over time.

The projections for the country as a whole are in Table 20.

TABLE 20. PROJECTIONS OF PRODUCTION AND DEMAND OF SIX FOOD CROPS (1000 tons)

Commodities	*Quantity produced*	*Quantity demanded**
Rice	12,254	9,560
Potato	2,380	2,377
Bean	3,883	2,684
Corn	23,947	16,597
Manioc	50,144	36,169
Wheat	n.a	8,321

*Proposed rate of income change = 7.5% a year.

If the trends prevail, there should not be major problems in meeting demand. Regarding quantities, production will outrun domestic demand.

Nutritional Needs

The Vargas Foundation published a thorough study of the nutritional situation of Brazilian families in 1970.[14] The study used data from a survey of 8,600 households. It shows that about 38 percent of Brazil's population had a daily intake of less than 2,450 calories. Over half of the country's urban population and over a third of its rural people had a caloric intake of less than 2,450. Over 7 percent of the urban population and almost 6 percent of the rural population fell below the daily reference standard of 55 grams of protein and 40 grams of fat.

The comments in the present section will come basically from the Vargas Foundation study. Regional or local studies based on more recent surveys are available. They tend to confirm the results of the Foundation's survey. For example, a study done at Montes Claros,[15] a county in the Minas Gerais in the Eastern region, showed an average caloric intake of 2,774. The Foundation's study showed for the whole Eastern Region a caloric intake of 2,575. Between the two numbers the difference is smaller than 8 percent of the lower value.

Table 21 gives a more detailed picture of the regional differences, and associated caloric intake with income classification. The country's average

TABLE 21. DAILY PER CAPITA CALORIE INTAKE, 1960

*Annual Family Income Clan**	*Northeast*			*East*			*South*			*Brazil*		
	Urban	*Rural*	*Total*	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*	*Urban*	*Rural*	*Total*
I	1237	1502	1407	1184	1425	1321	1485	2383	1928	1315	1755	1551
II	1497	1812	1687	1531	2104	1829	1735	2894	2308	1639	2241	1952
III	1997	2135	2100	1876	2212	2050	1967	2498	2248	1937	2291	2115
IV	2322	1820	2002	2091	2721	2418	2048	2862	2437	2134	2505	2317
V	2415	2282	2349	2225	2674	2457	2361	2975	2703	2319	2650	2492
VI	2863	2453	2531	2630	2921	2788	2473	2998	2747	2704	2751	2699
VII	3310	3382	3309	2824	3058	2929	2782	3777	3283	2955	3537	3278
VIII	4040	2866	3287	3273	3042	3157	3085	4128	3601	3383	3331	3359
IX	4288	2900	3548	3750	4103	3891	3168	4773	4024	3754	4014	3854
TOTAL	2309	2145	2207	2399	2769	2575	2498	3058	2771	2428	2640	2565

*Income increases from I to IX.
SOURCE: Fundacão Getúlio Vargas.[14]

TABLE 22. DAILY PER CAPITA PROTEIN INTAKE, 1960

*Annual Family Income Clan**	*Northeast*									*East*									*South*									*Brazil*								
	Urban			*Rural*			*Total*			*Urban*			*Rural*			*Total*			*Urban*			*Rural*			*Total*			*Urban*			*Rural*			*Total*		
	V	*A*	*T*	*V*	*A*	*T*	*V*	*A*	*T*	*V*	*A*	*T*	*V*	*A*	*T*	*V*	*A*	*T*	*V*	*A*	*T*	*V*	*A*	*T*	*V*	*A*	*T*	*V*	*A*	*T*	*V*	*A*	*T*	*V*	*A*	*T*
I	25	11	36	34	17	51	32	15	47	22	10	32	27	8	35	24	9	33	28	9	37	49	16	65	38	12	50	25	10	35	37	13	50	32	12	44
II	30	16	46	34	21	55	32	20	52	29	11	40	41	16	57	35	14	49	34	10	44	55	26	81	45	18	63	31	12	43	42	21	63	38	17	55
III	38	26	64	42	26	68	41	26	67	34	19	53	41	17	58	37	18	55	38	13	51	49	23	72	44	19	63	36	18	54	44	22	66	40	20	60
IV	44	37	81	34	24	58	37	29	66	38	24	62	53	18	71	46	21	67	38	16	54	55	31	86	46	23	69	40	23	63	46	24	70	45	24	69
V	48	35	83	48	32	80	48	33	81	40	27	67	44	23	67	42	26	68	43	23	66	55	43	98	49	32	81	43	28	71	49	32	81	46	30	76
VI	51	47	98	45	36	81	47	40	87	46	38	84	56	23	79	51	31	82	45	24	69	56	39	95	50	32	82	60	35	95	52	33	85	50	34	84
VII	61	53	114	62	51	113	62	52	114	47	45	92	52	28	80	50	36	86	48	36	84	67	55	122	50	46	96	51	45	96	61	45	106	56	45	101
VIII	64	87	151	54	46	100	57	61	118	52	57	109	50	31	81	51	43	94	51	43	94	70	56	126	52	49	101	54	58	112	58	44	102	56	51	107
IX	64	84	148	45	43	88	51	57	108	59	77	136	87	40	127	72	57	129	47	57	104	83	84	167	57	70	127	55	72	127	70	60	130	64	66	130
TOTAL	43	34	77	42	29	71	43	31	74	42	33	75	51	22	73	45	28	73	45	27	72	57	38	95	51	32	83	43	31	74	50	30	80	47	30	77

*Income increases from I to IX. *V*=vegetable, *A*=animal, *T*=total.
SOURCE: Fundação Getúlio Vargas[14].

caloric intake is 2,565 with a high of 2,771 in the South and a low of 2,207 in the Northeast. The minimum caloric intake is 2,450 calories.

The protein intake situation is shown in Table 22. Beyond the regional and rural urban differentiation the source of protein is also pointed out by V (Vegetable), A (Animal) and T (Total). Groups with a protein intake of less than the recommended minimum of 55 grams are found only at the lower-income levels.

For protein consumption, the country's daily per capita average is 77 grams. A regional low, found in the East and the Northeast, was 73 grams daily. The high level was 83 grams, found in the South. Despite the favourable averages, it is known that considerable sections of the population suffer from protein shortage, especially in the Northeast.

TABLE 23. DAILY PER CAPITA FAT INTAKE OF BRAZILIAN POPULATION

Annual Family Income	*Northeast*			*East*			*South*			*Brazil*		
	V	*R*	*T*	*V*	*R*	*T*	*V*	*R*	*T*	*V*	*R*	*T*
I	21	22	21	28	30	29	38	41	40	30	30	32
II	25	28	21	35	47	41	46	62	54	39	45	41
III	37	35	37	48	50	49	52	61	57	46	49	46
IV	44	31	36	52	59	56	57	63	59	52	57	51
V	47	48	49	57	64	60	67	77	75	56	64	60
VI	62	43	49	68	69	69	72	78	75	72	64	65
VII	71	70	71	78	71	74	85	94	90	81	94	88
VIII	110	64	81	94	84	90	93	124	108	96	91	89
IX	131	58	82	107	107	102	110	140	133	114	112	113
TOTAL	46	38	41	63	65	67	71	76	75	63	60	63

SOURCE: Adapted from Fundação Getúlio Vargas.[14]

The average national consumption of fats (Table 23) was 63 grams daily, per capita. The lowest consumption was again in the Northeast, with 41 grams, the highest in the South with 75 grams. Again, the averages seem to be satisfactory. In the groups below average, one will find several groups with shortage of fats in their diets.

Cereals furnish about half the average daily caloric intake per person in the country. Rice, beans and bread supply two-thirds of the caloric intake from cereals.[24p] When cornmeal is added as the fourth commodity, one takes account of 77 percent of the cereal caloric intake in the South, 88 percent in East and 92 percent in the Northeast.

Fats and oils form the second important calorie group.

Sugar-cane is responsible for about 12 percent of the nation's caloric intake and the meat commodity group ranged from 10 to seven percent of the caloric intake.

In all three tables, the Northeast is the region with greatest nutritional deficits. In all the regions of the country the urban sector also shows higher deficiencies.

The Performance of the Agricultural Sector—Food Supply

Several studies have independently argued and shown that the agricultural sector of Brazil has played its role quite satisfactorily. Schuh[39] makes a general argument in favour of the primary sector of the Brazilian economy. Pastore[30] has studied the price elasticity of the supply of agricultural products. Mendonça Barros[28] has examined the generation of foreign reserves from trade of agricultural products, Fishlow[12] analyzed the capital transfer from agriculture via the exchange mechanism. In all these studies the conclusions indicate that the agricultural sector has performed reasonably well.

It has also been argued and it can be shown that the performance of the sector is not to be measured by increases of the land productivity levels. Pastore et al.[31] have considered this particular characteristic in a historical perspective. Their conclusion is that even this characteristic was guided by rational actions which tended to use the abundant factor first, land in this case.

A definition to promote yield increase, at the same time that new land is brought into the production process, has been made by the Brazilian Government. Investments in research, technical and financial assistance are the means to be used to promote the technological changes that will raise the productivity levels in agriculture.

Even without considering any special action to raise the productivity levels of the resources used in agriculture, the projections in Table 20 were shown to outrun the domestic demand expansion. That was the first evidence that as long as the solution of the Brazilian food problem depends upon quantities produced, the agricultural sector of the economy will solve it.

An exercise was performed in extrapolating both the land area and the land productivity trend, to obtain estimates of production of the six commodities considered earlier on a regional basis. Table 24 shows the conclusions:

TABLE 24. SUPPLY PROJECTIONS OF SIX FOOD COMMODITIES, 1979
(1000 tons)

Commodities	*Regions*					
	North	*North-east*	*South-east*	*South*	*Mid-west*	*Brazil*
Rice	156	1953	1843	2997	4218	11167
Potato	—	41	590	719	2	1352
Beans	14	1108	436	1297	310	3165
Wheat	—	—	22	2579	7	2608
Corn	88	2396	5648	9200	1931	19263
Manioc	1980	14907	6297	11648	2529	37361

For the country as a whole, potatoes and wheat projected a deficit at the end of the present decade.

Comparing the values in Table 24 with those of Table 19 will show the regional projected balances (Table 25).

The approach for Table 25 was simple. The supply side is very conservative. Specifically for wheat, the supply projection does not reflect the decision that was made by the Brazilian Government to reach self-sufficiency as early as 1977.

TABLE 25. BALANCE OF SUPPLY AND DEMAND PROJECTIONS, 1979
(1000 tons)

Commodities	*Regional Balance*					
	North	*North-east*	*South-east*	*South*	*Mid-west*	*Brazil*
Rice	—33	337	—3735	1645	3397	1607
Potato	—40	—181	—877	126	—53	—1025
Bean	—35	312	—766	872	98	481
Wheat	—180	1644	—4990	1260	159	—5713
Corn	—515	2250	1884	4590	—343	2666
Cassava	3	183	—566	2156	—584	1192

Demand projections assumed an income growth at the rate of 7.5% per year.

In terms of regional figures, the outcomes for the North are not unexpected. The country has decided to colonize the region, but not within a five-year period. In this light, the deficit shown for the North is not a major problem.

The Southeast is the other region with a consistent deficit for all six commodities. It is a region in which technological changes will have to be made if its food commodities are not to be imported. Cassava and beans are the two commodities which may easily change the balance. This region has been settled and almost all of its tillable lands have been incorporated into the production process. Whatever is left is more likely to be converted into pasture land. The cerrado area remains, which probably will not be "tamed" before the end of the present decade.

A closer look into the supply side can be taken with a different approach. Dividing agricultural products into industrial raw material, export goods, and food, one sees the following situation over the period 1950–68 (Table 26).

In Table 26, attention is called to the two extreme groups of commodities. The food group is the one with the smallest growth in yields; the fastest-growing yields are of the export crops. The rates of growth would be even greater in this group if the table were to show the six crop years after 1968. The soybean boom came in the seventies.

What Table 26 shows is the trend of the export goods that had already started to grow in the early sixties. Apart from the differences in the rates of growth, it can be seen that all three groups of commodities show increasing yields. With the new policies that government has decided to implement for the agricultural sector, yields can be expected to increase more rapidly.

Yield growth is just one component of the total production changes. Total production growth can be broken down into the following components:

TABLE 26. AVERAGE RATES OF GROWTH IN YIELD
(kg/ha)

Time period	*Industrial raw material**	*Export goods †*	*Food products††*
1940–45	—3.72	—0.89	1.34
1945–50	1.72	0.31	0.97
1950–55	4.48	—2.37	—0.45
1955–60	1.32	5.07	2.07
1960–65	4.05	3.33	1.32
1965–68	0.44	8.94	1.08

*cotton, peanuts, sugar-cane, tobacco, soybeans, wheat.
†cocoa, castor beans, agave, coffee.
††rice, sweet potatoes, onions, beans, manioc, corn, bananas, oranges, pineapples, coconuts, tomatoes, potatoes, grapes.
SOURCE: Mendonça Barros.[28]

$$\frac{\Delta P}{P} = \frac{\Delta(P/A)}{P/A} + \frac{\Delta(A/N)}{A/N} + \frac{\Delta N}{N}$$

This decomposition was proposed by Delfim Netto,[10] later by Pastore, and Alves and Rizzieri[31] have also used it. Griliches[20] and Hayami and Ruttan[21] point out that it allows identification of the source of production growth. Table 27 shows each of the components for Brazil of agricultural production, for the same period 1940–68.

Since 1955, though yield increase has been an important component of the growth in agricultural production, it is not the most important one. Increase in the rural labour force has also played an important role in the total growth of agricultural production.

In the years to come, increase in production per area will definitely play a major role. The investments in production of new technology will guarantee better yields for the land. The rural/urban migration process will decrease the rural labour force and, as a consequence, increase the land/man ratio.

TABLE 27. COMPONENTS OF THE RATE OF GROWTH OF AGRICULTURAL PRODUCTION, 1940–68

Components		*1940–45*	*1945–50*	*1950–55*	*1955–60*	*1960–65*	*1965–68*
Increase in production per area (%)	$\frac{\Delta P/A}{P/A}$	0.58	0.48	0.18	2.99	2.14	2.36
Increase in the land-man Ratio (%)	$\frac{\Delta A/N}{A/N}$	0.59	1.46	0.80	0.46	2.48	0.79
Increase in the rural labour Force (%)	$\Delta N/N$	1.55	1.55	3.53	3.53	1.36	1.36
Production growth (%) rate	$\Delta P/P$	3.11	3.49	4.51	6.98	5.98	4.51

SOURCE: Pastore, Alves and Rizzieri.[31]

With the emphasis that is being put on research and technical assistance, increases in productivity and in the total production can be expected.

Historically, the decisive agricultural policies have been adopted under the critical pressures of the demand for food, mainly imposed by the large industrial centres, São Paulo and Rio de Janeiro, Smith.[44] The situation is not different today. The pressure from the large urban centres apart from São Paulo and Rio de Janeiro is considerable but these two centres exert today a stronger pressure than ever before.

Brazil is developing a tradition as exporter of a few agricultural foods. This new venture is another strong source of demand pressure. The need for foreign currency and the problems of the balance of payments both require larger surpluses to be exported. The country has realized that with a strong agricultural sector it will be able to cope with these pressures, and it has been decided to make the sector as strong as possible. Brazilians know that their country will be of the size of its agriculture.

Future Prospects—Towards a More Aggressive Agricultural Policy

The data examined in the last section contain just the initial effects of the new policies for the agricultural sector. The changes in policies were quite important and will be considered here. More recent data were not available.

With a model based on import substitution industrialization, low food prices, reduction of the utilization of capital in the agricultural sector, an implicit intensification of the use of the abundant factors, land and labour, the agricultural sector of Brazil would not be able to respond to the intense demand pressures exerted on it since the mid-sixties. The high rates of growth regained by the economy and the clear option to fight for external markets for agricultural products, began to require increases of the supply of agricultural products beyond what could be obtained from the expansion of the agricultural frontier.

The Brazilian Government soon understood that the strategy of agricultural policy had to be changed. The new orientation should favour the incorporation of new lands, but at the same time technological modernization would be necessary. The new agricultural policies have now two objectives: expansion of the agricultural frontier and increase in the productivities of land and labour.

The food demand crises continue to play an important role in the reformulation of the country's agricultural policies.

Some specific aspects of the new policy are discussed at this point. The major guidelines are:

1. The central objective is to promote production.
2. The increase in production on the needed scale cannot be obtained only in function of the use of more land. It is necessary to have a self-sustained increase in productivity.
3. The modernization of agriculture associated with improvements of the labour and capital markets will bring about better standards of living for the rural population without having to depend upon fundamental reforms.

4. Productivity increases can be obtained through the use of instruments such as minimum prices, rural credit, and research and technical assistance programmes.

5. In regions where the land tenure structure would impede modernization, a limited agrarian reform would be established, with the central objective of increasing productivity.

The instruments to be used are:

(1) The incorporation of the Amazon and of the cerrado area. Two specific programmes were defined here: the *Polamazonia* and the *Polocentro*. The programmes seek to expand the agricultural frontier in the direction of the abundant fertile lands of the two regions. They intend also to stimulate a migratory flow northeast to these two regions.

The main points of the agricultural side of the programmes are, for the *Polamazonia*:[5] agricultural and livestock research, technical assistance, regularization of the land tenure process and colonization, marketing, natural renewable resources, fisheries. Other components of the programme that are related to the agricultural sector are: construction of the transportation infrastructure, construction of the electrical energy infrastructure, development of the mining industry, health care programmes, educational programmes. About 295 million dollars have been allocated to the *Polamazonia* programme, to be used from 1975 to 1979.

For the *Polocentro*[6] the major lines of action are: agricultural and livestock research (to be promoted through EMBRAPA's units and the state research organization, universities, and other organizations in the area); promotion of agricultural extension; stimulus to forestation and re-forestation with the help of fiscal incentives; road construction (*estradas vicinais*); rural electrification; implementation of a system to process, store and transport agricultural products; stimulate the regional production and marketing of lime and other inputs; regularization of the land process. About 250 million dollars have been allocated to be used in the *Polocentro* in the 1975–77 period. With other possible resources allocated to the region, it is believed that about one billion additional dollars may be added to the programme budget for the same period.[6]

Similar regional programmes have been devised and are in the process of implementation. Among these, is the Pantanal Programme of Mato Grosso, and the programme for the geo-economic region of Brasilia. For the latter about US$ 185 million have been allocated to be used from 1975 to 1977.[7] The *Polonordeste* programme will apply 850 million dollars in the period 1975–79.[8]

(2) Minimum price policy. The objectives of this policy are manifold. Traditionally it has been used in other countries as a means to stabilizing farmers' product prices and farmers' incomes. In the Brazilian case it would also have the objective of accelerating the growth of production.

It would also induce increases in the production of those commodities with favourable markets while it discriminates against those with an unfavourable

market situation.

It also serves the purpose of channelling more production into the markets. Subsistence crops have a substantial part, consumed within the producing unit.

As a risk-reducing device, minimum price policy should pave the way to modernization of agriculture. It should also induce the expansion of land utilization.

Considerable amounts of money have been used to support the minimum price programme (Table 28). About 25 commodities are covered by it. Corn, cotton, soybean, rice, bean and groundnut are some of the most important.

TABLE 28. AMOUNTS OF MONEY PUT INTO THE PRICE SUPPORT PROGRAMME (US$, Equivalent)

Year	*US$ (1000)*
1970	91,897
1971	98,754
1972	174,535
1973	141,853
1974	423,958

(3) Agricultural credit and technical assistance. The credit market, left to itself, has tended to discriminate against the agricultural sector. If nothing else, the industrialization mood would lead to such discrimination. Agricultural subsidized credit is seen as a correction to such imperfection. It facilitates the better use of land and agricultural labour, contributing to the use of more land, a basic objective of the whole set of policies. At the same time, credit subsidies lower prices of modern inputs, making them more attractive to farmers. Once farmers have learned to use them they continue to do so even if the subsidy is cut off; Smith[11] has found evidence of this in Brazil with fertilizers. In this case another objective of the credit programme is to facilitate the modernization of agriculture.

Three factors were mentioned by Smith that would influence the success of the credit policy: the demand elasticity of the subsidized input: the excess of the social marginal productivity over the social cost: the size of the demand shift caused by the knowledge acquired and the experience accumulated by the farmers. In this way agricultural credit will facilitate the modernization of agriculture.

Another component of the problem here is that a great majority of farmers do not know of modern inputs, or cannot use them correctly. Technical assistance is required.

The Brazilian experiment has consisted of combining, in a single programme, agricultural credit and technical assistance. This experiment has been working in Brazil since the late forties. Of the several adaptations it has gone through.

the one made in the name of the new policy has been implemented since 1964. With the emphasis on production as the main focus of the agricultural policy, the extension system, together with the Central Bank, decided to assist the big farmers in an attempt to obtain faster and more sizable responses.

This programme has been responsible for the accelerated use of fertilizers. From 1967 to 1972 the fertilizer application in the country rose from 445,000 tons to 1,746,000 tons. About 70 percent of these fertilizers are imported.

Table 29 shows the amounts of money in the agricultural credit programmes after 1970. The figures are in US dollars at the November 1975 exchange rate.

TABLE 29. AMOUNTS OF AGRICULTURAL CREDIT

Year	*Amount (US$ 1000)*	*Year*	*Amount (US$ 1000)*
1970	2,140	1972	3,333
1971	2,615	1973	4,908
		1974	7,824

SOURCE: Banco Central.[4]

(4) Reformulation of the federal institution for agricultural and livestock research. Historically, the agricultural research capacity of the federal government has been deficient both quantitatively and qualitatively. With the overall change in agricultural policy it has been possible to make the reform that created EMPRAPA (The Brazilian Company for Agricultural and Livestock Research). It is attached to the Ministry of Agriculture and yet enjoys the flexibility of private companies.

The main characteristics of EMBRAPA are:[46]

Major decisions of resource allocation with a commodity orientation.

Concentration of research resources in the problems related to fewer products.

Selection of priority problems with the use of the systems approach.

Resource allocation oriented by well-defined programming process.

Aggressive human resource policy. Here one finds at least three distinct lines of action:

1. Graduate training of the research staff leading to formal degrees (MS and PhD)
2. On-the-job training programmes for some research workers, but basically for supporting personnel
3. An aggressive wage policy that has converted the research job option into one which competes for the researcher's talent in the job market

Foreign technology transfer is also adopted in the EMBRAPA's model. Three basic methods are exercised here:

1. Training researchers abroad

2. Importing a few equipment items and other materials which embody new technologies
3. Hiring research workers in the international market.

The private sector acts as a source of problems to be researched and also as demander and consumer of the research results.

The agricultural research system works well, articulated with the National Systems for Science and Technology.

The agricultural and livestock research system is well connected with the agricultural extension institutions.

Administrative flexibility allows searching for financial resources in different directions. The management of the financial resources of EMBRAPA can be made according to its own priority definitions.

EMBRAPA was created in 1972. It has been in charge of agricultural research in Brazil since 1974. Table 30 gives an idea of the kind of budgetary impact the organization has had on resources allocated to research.

TABLE 30. FEDERAL RESOURCES ALLOCATED TO AGRICULTURAL AND LIVESTOCK RESEARCH

Year	*US$ (1000)*	*Year*	*US$ (1000)*
1970	10.600	1973	14.000
1971	9.500	1974*	26.470
1972	8.800	1975†	80.000
		1976†	91.294

*EMBRAPA started to respond for the agricultural research in the country.

†Proposed budget.

(5) Export corridor. This programme covers the majority of states in the centre-south region. It intends to:

1. Build and equip harbours to lower the cost of embarking agricultural goods
2. Build roads for transporting agricultural produce
3. Build silos and other storage facilities
4. Provide technical assistance to stimulate production of specific commodities such as corn, cotton, beef, wood and cassava.

Since the centre-south region has better conditions for competing in the international market it has been the main focus of the policies. The money allocated to this programme is distributed among others already mentioned. On the consumer's side, government policies related to agricultural products deal basically with the marketing process.

CIBRAZEM, the Brazilian Company for Grain Storage, and COBAL, the Brazilian Company for Food Supply, enter the marketing process to avoid oscillation in food quantities available to the population. Agricultural producers also benefit from their activities.

SUNAB, the National Superintendency of Food Supply, as an overall supervisor of commodity prices, also watches prices of agricultural products, both at the wholesale and retail levels.

These are the benchmarks of the new agricultural policy of Brazil. The authors refrain from adding other items to the list.

The main focus is on promotion of production through enlarging the agricultural frontier with increases in productivity. It is foreseeable that considerable demand for labour should be created in the rural sector. Capital is also subsidized with negative interest rates.

The policy certainly will not be distributionally neutral on its benefits. Larger farmers will benefit from the majority of the incentives. Meanwhile social security and other programmes are being conceived and implemented to favour agricultural workers.

Summary

From 1950 to 1974, the Brazilian economy has had one of the highest growth rates in the world. Despite the perverse effects of some economic policies adopted during this period, it averaged a growth rate of 7.1 percent per year.

The Brazilian labour force has been mobile; in spite of this, sizable wage and productivity differences persist; both interregionally for the same sector and intersectorally for the same region.

A specific labour market study has suggested a strong link between the industrial and the agricultural labour markets. This link explains the interaction between the two sectors which reflects in the well-being of rural people, the failures of the industrial employment process.

Educational effects tend to suggest that education will tend to lower the supply of labour to the agricultural sector (an ambiguous result).

Minimum wage policy has been responsible for the reduction of employment (in the state of São Paulo). There is high substitution ability between labour and capital because of the high wage elasticity in the demand equation.

In the subsistence sector of the agricultural labour market, family labour is used to the limit of its capacity. There seems to be little room for improvement of the income of subsistence farmers through programmes with the goal of increasing production through more intensive use of family labour.

The Brazilian population was, in 1970, near one hundred million. Its rate of growth was high in the fifties, higher in the sixties, reaching about 3.0 percent per year.

The population is not evenly distributed but there is considerable mobility interregionally.

Despite its fast-growing trend and its concentration in regions such as the Northeast not adequately arrayed for the population it holds, the real population problem faced by the government is related to two other characteristics: the age composition of the population and its level of education. These two characteristics of the population are carried to the labour force and have

their adverse effects on the performance of the whole economy. Fifty-three percent of the population, aged 15 to 60, make up 92 percent of the labour force. About 30 percent of the labour force is illiterate. This group and those with elementary schooling add up to about 55 percent of the labour force. Only 2.5 percent of the workers have college education. For the rural sector the situation is even worse. Ninety-nine percent of the rural labour force is illiterate or has only elementary school education.

Rural-urban migration is intensive. With the kind of education the rural population has, urban unemployment increases.

The population problems in Brazil are tackled indirectly through hygiene, health care and education programmes.

The Brazilian population is rather mobile; convergence analyses of the trend of the population movement show the poor states losing population. Two rich states (Minas Gerais and Rio Grande do Sul) are net exporters of population.

Paraná, Goiás, Mato Grosso and Maranhão are the net importers. The Northeastern states are the ones that lose most population. About ten percent of the population migrates within a decade. With migration, it seems that the income differences between the population of the state tend to diminish. This seems to be true when all the states are taken together, when the high- and the low-income states are taken as separate groups, and also when one looks at each group separately.

An econometric analysis of the migration process indicated that people tend to migrate, or not to migrate, in response to their own region's characteristics.

High-income levels and urbanization of a region tend to prevent people from emigration. Inequality of income distribution and education tend to be positively associated with out-migration from a region. Income growth and demographic density at the origin favour migration as do high-income levels at the destination. Concerning rural-urban migration, the distinguishing fact is that the 1970 census has shown the rural sector of the country with less than half of its population.

By means of regression equations, efforts were made to explain the rural-urban migration process.

Within the simple regression models, the variables showing significant effect on migration were: road extension per km,^{2} per capita income in the rural sector, per capita income in the urban sector and income inequality in the rural sector.

The nature and the effects of the explanatory variables prevailed when a multiple regression model was used. The most important directional effect indicated that the higher the rural-urban income ratio, the more people will migrate from the rural sector.

Income and population growth will necessarily represent demand pressure upon the food-producing sector. Between the two, the population component would be responsible for about two-thirds or three-quarters of the increase

in the demand for food. The policy changes in the agricultural sector have made Brazil an exporter of commodities produced by its primary sector.

Extrapolation of the country's production capacity shows that the country will continue to build up its exportable surpluses. The mere extrapolation of the production capacity is a rather conservative outlook. The country's potential as an agricultural producer will allow for more than just the historical growth path that it has shown.

As far as the nutritional situation is concerned, the country is reported to have serious deficiencies in specified sectors of its population. The most notorious deficits concern the caloric intake. Over a third of the country's population is reported to have daily caloric intake of less than 2,450 calories.

In terms of the computed averages, the country is reported to have more than the required minimum of per capita consumption of protein and fats. Partially obscured by the averages, however, is the fact that for significant parts of the population, protein and fat intakes are below the required minimum. The cereals are the major group of foodstuffs to furnish the Brazilian population with calories.

Projections leave the country in a rather comfortable situation as far as cereal production is concerned, but wheat is the exception. But wheat is also a crop in which increases in production in the future should be faster than the historical trend. To change the historical pattern of production, the Brazilian government has decided to implement policies that will change the picture drastically. Agricultural research and technical assistance will be two very important tools in this process.

Agricultural credit will also be highly subsidized. Marketing infrastructure will also be improved considerably. More than just satisfying its domestic demand, Brazil has realized its potential as an exporter of food commodities. The country is now preparing to explore its potential.

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IMPORT SUBSTITUTION AND IMPLICIT TAXATION OF AGRICULTURE IN BRAZIL*

by

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Import Substitution and Implicit Taxation of Agriculture in Brazil

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The industrialization that Brazil experienced prior to World War II was not induced by the government. It had its origin in the relative profitability of the agricultural and industrial sectors, which favored a shift in resources to the industrial sector. During the period from the end of World War II until the early sixties, a deliberate import-substitution policy was pursued. The factors that gave rise to that policy were the difficulty that the country encountered in foreign trade during the Depression and the two world wars, the influence of the Prebish thesis, and the dominance of two-sector models (Rannis and Fei, and Jorgenson) as the basis for development policies.

Brazilian industrialization policy was based upon three principles: protection against international competition, easy access to capital, and stable wages. This constituted a policy to transfer resources generated in agriculture to industry, thus penalizing the primary sector.

The period after World War II witnessed an industrial growth never before seen in Brazilian history. Industrialization generated strong pressures for urbanization, with the result that, by 1970, 56% of the population was urban. This created pressures on the supply of food and fibers.

This paper attempts to review some effects of industrialization on agriculture. It concentrates on economic and trade policies that resulted in the implicit or explicit taxation of agriculture.

Brazilian Trade Policies, 1946–77

This section draws heavily upon studies by Martin, Melo, and Veiga, where a detailed description of the various trade policies may be found. The import policies were designed to stimulate industrialization by protecting the industrial sector against foreign competition and by reducing the cost of capital. These policies also aimed at controlling imports to solve the problem of recurrent trade deficits.

Export policy was based on an "exportable surplus" model (Leff). Trade policy in the period that extended from the end of World War II to 1964 was characterized by a strong bias against exports, thereby discriminating heavily against agriculture. After 1964 most export controls were eliminated and discrimination against exports was reduced substantially in respect to industrial products. In 1968 export promotion policies were established to stimulate the exports of industrial products. The benefits of such policies for agricultural products were small. Moreover, in the case of some agricultural products, outright export prohibition continued when government authorities believed agricultural prices were rising "too rapidly" and/or that "scarcity" could occur in the domestic market.

Trade policies during this period provided strong protection to industry. Bergsman and Candal indicate that effective protection was 190% for consumption goods, 50% for intermediate goods, and 15% for capital goods. The effective protection for agriculture, on the other hand, was negative. Moreover, in the period 1954–59 the effective exchange rate for imports varied from 2.4 to 4.0 times the effective exchange rate for exports.

The result of these policies was the transferance of a substantial amount of resources from agriculture to industry. Fishlow estimates the amount transferred from agriculture to vary from 2.1% to 7.3% of industrial gross national product (GNP) in the period 1955–57, and to range from 11.6% to 19.1% in the period 1958–60.

Trade policy was modified several times in the period 1946–64. Quantitative controls to restrict imports prevailed from 1947 to 1954. Multiple exchange rates for exports were established in the period 1953–57. Ad valorem

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tariffs were introduced in 1957, and substantially increased the protection provided industry. For the general category of imports these tariffs could reach 80% of the value of the good. For the specific category they could be as high as 150%, with further increases permitted by an exchange rate charge that varied from 100% to 200%.

In the period 1964–67, an effort was made to simplify the trade regulations and to open the economy to international markets. The external debt was refinanced, the government tried to keep imports to a minimum, it started to encourage exports, and it began efforts to fight the serious domestic inflation. Means of encouraging exports consisted of not only more frequent devaluation of the cruzeiro but also some reductions in the "contribution quotas" made by coffee and cocoa exporters. However, in January 1965, a 30% "contribution quota" was placed on beef exports. Ad valorem tariffs on some export commodities were reduced however.

Policies initiated in the previous period were carried over into the 1967–73 period. Continued efforts were made to reduce trade distortions. Tariffs were reduced, exchange rates were further unified, and the multiple exchange rates were eliminated.

The major new policy innovation was the introduction of the floating peg exchange rate system. This consisted of frequent "minidevaluations" that occurred seven to eight times per year. These were at first made at regular intervals, but later they were randomized to discourage exchange market speculation. The basic rule followed was to devalue the cruzeiro at a rate approximately equal to the difference between Brazil's internal inflation and the average inflation of Brazil's major trading partners, predominantly the United States, Western Europe, and Japan.

Most export controls were eliminated, although some controls were maintained on coffee and cocoa. Various fiscal, credit, and exchange rate policies were used to provide incentives to export, although these were directed more to the industrial sector than to the agricultural sector. The government provided special incentives to stimulate exports by private firms, such as exemption from excise taxes on all exports, exemption from sales taxes on certain products used in production for export, exemption of export earnings from income tax or reduction of such tax, credit to finance export sales and export promotion at overseas trade exhibitions.

Bacha and colleagues estimate that the cruzeiro was overvalued from 20% to 25% in the early to mid-1960s. Pastore and colleagues (1976b) estimated that the exchange rate that would bring equilibrium to the balance of commerce was close to the observed rate for the period 1970–73. This suggests the elimination of part of the trade distortions brought about by changes in trade policies in the period 1964–73.

Oil prices increased fourfold in October 1973. After six years of positive results for the balance of payment, with a surplus of US$1.6 billion in 1973, a substantial deficit of US$938 million occurred in 1974. The choice made by the government to curb the crisis in the balance of commerce was to reintroduce import controls. The ad valorem tariffs were raised, and outright prohibition to import and other measures to reduce imports were imposed. The cruzeiro became overvalued again and preliminary estimates reported by Rosa place the rate of overvaluation between 25% and 35%. The rate of inflation rose to 40%, and price controls on agricultural products became frequent again. The export policy for industrial products was carried over, with minor modifications, into the period 1973–77.

Trade Policies and the Distribution of Income

One consequence of the trade policies was to reduce the cost of capital to industry. At the same time, wage policy raised the private cost of labor well above its social cost (Bacha et al.). The combination of cheap capital and high-cost labor caused the industrial sector to have a low absorptive capacity for labor. In 1964, the industrial sector accounted for 35% of GNP while the share in employment was only about 8%. This was far below the comparative share in other countries with a similar degree of industrialization (Bergsman and Candal).

The low capacity of the industrial sector to absorb labor caused labor to be dammed up in agriculture, with the result that a large flow of rural–urban migrants was channeled into the low productivity service sector or accumulated as urban unemployed. The average productivity of labor in industry, which in 1950 was 6.4 times greater than the average produc-

tivity of labor in agriculture, increased to 11.6 times in 1970. In a sense this indicates a worsening in the distribution of income between the two sectors.

The link between trade strategies and employment is complex. According to Krueger, "it involves not only trade strategies themselves and the structure of the labor market but also entails examination of various factors which contribute to distorting goods and factor markets" (p. 270). Three linkages which hold simultaneously can be identified. First, there is the effect of the trade strategy on the overall rate of growth and in turn on the rate of growth of employment opportunities. In the case of Brazil, Valderrama has studied the impact of the export subsidies for industrial products on the growth of the economy and the growth of exports. His results do not support the idea that the subsidies for industrial products fostered either the growth of the economy or the growth of exports.

A second linkage is the effect on the demand for labor via the influence of the trade strategy on the composition of output. If a trade strategy results in a higher proportion of GNP originating in labor-intensive industries, the selection of the strategy will result unequivocally in a higher demand for labor (at a given real wage) than will the selection of the alternative. The third linkage is the effect that the trade regime has on factor prices. To the extent that trade policy results in incentives for the use of capital-intensive techniques, it affects the demand for labor.

The trade strategies of 1946–73 discriminated severely against agriculture. To the extent that agriculture is more labor-intensive than industry, trade policy reduced the overall demand for labor, other things being equal. Data provided by Mendonca de Barros (1973) suggest that the export promotion strategies benefited relatively more those industries with a high capital-output ratio and which also require labor with a high level of training and specialization. This led to an increase in the demand for a type of labor that was in short supply, and hence contributed to a worsening in the distribution of income (Langoni).

The overvalued exchange rate and selected export subsidies also distorted internal prices. Pastore and colleagues (1967) conclude that elimination of these distortions would raise the relative price of products consumed by the poor. At the same time, the price of products consumed by the rich would decline. Hence, correction of the distortions would aggravate the distribution of income problem, at least in the short run.

A similar point has been made by Schuh (1977) in respect to agricultural products. If export restrictions were eliminated the short-run effect would be an increase in agricultural prices, to the detriment of low income groups. The effect on the rich would be weaker since the consumption of food is a small share of their total consumption.

Trade policy also had a number of effects that were detrimental to regions outside of the industrial Southeast. First, these regions were forced to pay higher prices for those consumption and capital goods produced behind the protective tariff wall than they would have paid if they had been able to import them at nondistorted prices. Second, capital which could have been invested in their own development was transferred out of these regions by means of trade policy. The loss of capital meant that the capital-supplying regions could not provide additional employment for their population, nor finance needed improvements in their basic infrastructure such as education, roads, or agricultural research and extension activities. From about 1950 until 1961 the Northeast experienced an average annual transfer of capital to São Paulo of about US$25 million. For the entire country outside of the State of São Paulo the transfer to this state was about US$31 million (Martin, p. 3[illegible]).

Starting in 1962, the resource flow a[illegible] regions through the terms of trade reve[illegible] The factors affecting this reverse flow included the trade reforms starting in 1964, the rise in international commodity prices (in 1969), and government programs designed to help the Northeast.

Trade Policies and Productivity Growth in Agriculture

Trade policy had a positive effect on agriculture by means of the large urban-industrial complexes that arose as a consequence of import-substituting industrialization. Agriculture benefited from the expansion of the nonfarm labor market which increased the number and kinds of jobs available to prospective migrants. This speeded up the migration process, and as the opportunity cost of labor increased, a reorganization of agriculture was induced. The market for agricultural commodities be-

came large and predominantly located at a few growth poles. Agriculture located close to these poles could operate at lower average cost—either because of increased specialization or because of the realization of economies of scale. With the concentration of production, more social-overhead capital was provided. This included roads, which lowered transportation costs, and improved educational facilities, which increased labor mobility and raised labor productivity (Schuh, 1969).

Recent literature stresses the role of periodic food supply crises on policy making (Smith). The urban-industrial complexes were very sensitive to food shortages and hence were an instrument of pressure on the government to shape an agriculture policy that would increase the production of agricultural commodities at a lower cost. In the short run, the signs of crisis were frequently misinterpreted. Price and export controls were established for agricultural products to lower or to restrain the increase of the prices. But the crises eventually brought about a change in policy, with greater emphasis on increasing agricultural productivity.

The negative effects of trade policies are related to the participation of agriculture in international trade. This participation could have been larger if it were not for the restrictions that stemmed from an overvalued currency and in certain cases from outright prohibitions against the exports of agricultural products. The negative effects also are related to the fact that agriculture could have had access to lower-priced inputs if it were not for the protection given to the industrial sector. The increase in price for modern inputs was a severe restriction to the modernization of agriculture.

Mendonca de Barros and Graham recently constructed aggregate indices for production and productivity of Brazilian agriculture. They considered two regions and compared them with the State of São Paulo. The results were also aggregated for all of Brazil. One region was the poverty-stricken and densely populated Northeast, while the second region included all other states except São Paulo, the Northeast, and the North region (the Center-South). The two regions and the State of São Paulo combined account for about 90% of the agricultural output of the country.

Two classes of products were considered: one included products for the domestic market and the other products for foreign markets. At the aggregate level the annual rate of increase of production for domestic products was 4.4% for the period 1932–76, 4.0% for the period 1962–76, and 3.3% for the period 1968–76. On the other hand, if one excludes coffee from the export products, the annual rates of increase of production for this class of products were 5.3% for the period 1932–76, 7.2% for the period 1962–76, and 9.8% for the period 1968–76. When coffee was included among the export products, the annual rates of growth for this class of products declined to 4.4% for the period 1932–76, 4.0% for the period 1962–76, and, finally, to 3.3% for the period 1968–76.

Given that population was growing at a rate of 2.7% per year, per capita income was increasing at a rate of 6.0% per year, and assuming an income elasticity of demand of 0.5, it appears that domestic demand was increasing at a rate of 6.0% per year. Hence, although the aggregate rates of growth of production were greater than the rate of increase of population, they were not keeping pace with the increase in demand. This was reflected in an upward trend in agricultural prices in recent times. Moreover, products for the domestic markets were being replaced at the production level by export products. This probably aggravated the nutritional problems of the low income classes. Turning to the productivity of land, in São Paulo the productivity for export products (with coffee) increased at a rate of 8.1% per year for the period 1962–76 and 12.6% for the period 1968–76. If coffee is excluded from the export products, there was no increase in land productivity in the period 1968–76, but the increase was at an annual rate of 5.0% in the period 1962–76. Productivity of land for domestic products increased at a rate of 5.3% and 8.0%, respectively, for the periods 1962–76 and 1968–76.

Coffee is not an important product in the Northeast region. The rates of growth of productivity for the export products were 2.5% in the period 1962–76 and 4.0% in the period 1968–76. There was no increase in the productivity of land for domestic products in the period 1962–76, while for the 1968–76 period there was actually a decline in productivity (at a rate of 4.5% per year).

In the Center-South region there was no change in the productivity of land dedicated to export products for either period. If coffee is excluded from the index, the productivity of land for export products increased at an an-

nual rate of 3.4% for the period 1962–76, but there was no increase for the 1968–76 period. The rate of increase of productivity for domestic products for the period 1962–76 was 1.6%. Again, no increase was observed for the 1968–76 period.

For purposes of analysis two questions can be posed: Why were the observed rates of increase of productivity higher in São Paulo than in other regions, and why was the performance of agriculture in general relatively modest? The answers can be found in de Janvry's socioeconomic model of induced innovation, which puts the emphasis on stress, synonymous with falling profits. This idea can be used to further clarify the role of the urban industrial complexes in the modernization of agriculture. But in the case of Brazil, stress is a consequence of increases in the price of food for the urban sector and of the need to expand exports so as to pay for a growing demand for imports brought about by industrialization. The urban population is very sensitive to food shortages and has considerable capacity to influence government to modify agricultural policy so as to increase the supply of food.

To respond to the first question, it is clear that the agriculture located closer to urban industrial complexes can obtain more benefits from them than the agriculture which is farther away. The benefits would come as a consequence of agglomeration, and of agricultural policy on the part of both the federal and state governments that is better designed to avoid a shortage of food and to foster the production of export products. To exemplify, it is well known that São Paulo has invested much more in research and extension than the other states (Smith).

The distortions created by the trade policies also helped São Paulo to develop its extension and research institutions because the state benefited from a substantial resource flow from the rest of the country. The agriculture of the State of São Paulo also benefited from the fact that its urban industrial complexes were developed earlier than in the other states. Martin has shown that the level of urban industrial development plays an important role in explaining why some states invested more than others in these activities.

Martin drew on previous works by Thompson to calculate the internal rate of return that would be realized if the states taken together were to invest in research and extension in the same proportion as São Paulo. Two experiments were performed. The first one maintained for the rest of Brazil (the aggregate of the other states) the same ratio of technicians per 10,000 rural workers as for São Paulo. This would have required that the other states taken together would have had to employ 31,675 technicians. They were in fact employing only 8,189 technicians in 1970, as compared to São Paulo's 2,978 technicians. The other experiment maintained for the rest of the country the same ratio of technicians per Cr$10,000 of value of agricultural production. In this case the other states taken together would have employed 11,133 technicians. The internal rate of return was 18% for the first experiment and 28% for the second, both of which compare well with the 20% rate of return found for the State of São Paulo.

The second question is addressed to the rather modest performance of the agricultural sector. The literature on this subject is extensive. But it can be reduced to three lines of thought. The first was popular in the early 1960s and gave a great deal of emphasis to the size distribution of land. The basic proposition that stems from it is agrarian reform (Cline). The second line of thought is in the neoclassical tradition and considers the industrialization policies—trade distortions, price and export controls, etc. as negatively affecting the modernization of agriculture (Schuh 1974). The Hayami and Ruttan book inspired the third line of thought. The abundance of land and labor that prevailed in a long period of Brazilian history acted as a brake for the modernization of agriculture, leading to agricultural policies strongly biased toward an increase of cultivated area as opposed to an increase of productivity (Pastore, Alves, Rizzieri; Schuh 1974).

The overvaluation of the currency is an implicit tax on the agricultural sector. The predicted effects of this tax indicate a reduction in the use of land, labor, and capital, and a transfer of resources to the urban sectors. These negative effects were aggravated by the fact the industrialization policies increased the prices of modern inputs. Hence the trade policies subjected agriculture to a double squeeze, decreasing the price of agricultural products and increasing the costs of production. There were some compensating measures through subsidies in the form of cheap credit, but these measures led to still further distortions.

Lopes has evaluated the consequences of an overvalued currency on the agricultural sec-

tor. He examined the effects of a decrease of 10% in the price of agricultural products. This shift in the internal terms of trade would reduce the use of labor in agriculture by approximately 18%, release about 27% of the mobile capital in agriculture for investment in the nonfarm sector, and reduce land use by about 10%.

He also found that the value marginal product of labor in agriculture would decline by approximately 15%. When this is combined with the overvaluation of labor in the industrial sector due to the protection of that sector, one begins to understand the large income differential that has emerged between the industrial and agricultural sector in Brazil. The reduction in land also explains the underutilization of land that is common in Brazil. This finding also helps to explain why there were no strong incentives for farmers to use land-saving technology. Hence, in a real sense, trade policies were detrimental to the modernization of agriculture.

Conclusion

The rapid industrialization of Brazil succeeded in changing its product mix in a short period of time. An urban-industrial complex was created, which in 1975 already accounted for 89.5% of national income. Moreover, 62% of the population was living in the cities (IBGE). Growth rates were very high in the 1965–76 period, with GNP per capita growing 6.2% per year and total GNP increasing at a rate of 9.2% per year (*Conjuntura Economica*).

There is growing concern on the part of commercial partners of Brazil in relation to her present trade policies. This concern will probably induce changes that will benefit the exports of products originating in agriculture and those that have high labor content. However, increased per capita income, a high rate of population growth and urbanization, and the need to export more every year will result in accelerating demand for food and fiber from Brazil's agricultural sector. A food crisis will emerge unless production shows a major increase, and the results reported herein suggest that the supply of food and fibers is probably lagging behind the growth of demand.

Brazil in the past could count on an agricultural frontier with favorable ecological conditions. The remaining frontier has continental size, but is far removed from population centers and requires huge capital investments in infrastructure. It also needs large investments in research and development of new agricultural technology which up to now were not produced in other countries or other areas of Brazil.

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3. REFORMING THE BRAZILIAN AGRICULTURAL RESEARCH SYSTEM (*)

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Brazil is presently experimenting with a new model for organizing agricultural research activities: the public corporation model. The primary objective of experiment is to increase the quantity and quality of scientific knowledge relevant to agricultural development. Its main characteristic is that the whole research system is more sensitive to the demand for technology. At the same time, the model is based on a type of organization which is extremely responsive to the change required by the agricultural production sector.

The main organizational agency of the new system is EMBRAPA – the Brazilian Public Corporation for Agricultural Research. This agency operates like any public enterprise, being open to all types of financial and human resources, and at the same time, ready to "sell" its service to all kinds of clients. The Corporation's principal product, of course, is agricultural technology and its primary client, the Government. Both federal and state governments establish their priorities in terms of products for export and domestic consumption. An increase in agricultural productivity is the basic need to be met by the research, extension and credit complex, with research being the responsibility of EMBRAPA. The initial task of EMBRAPA is to transform the general production goals of the government into research programs geared to increase the productivity of land and labor. Its second task is to organize and improve the human cadres who execute the research programs. EMBRAPA is not subject to civil service personnel hiring restrictions. In other words, it is free to hire whatever individuals are considered qualified for its programs at the national and international labor market prices. In order to maximize resources, EMBRAPA is directing its main research programs through national centers. This effort to concentrate financial and human resources in a few, but relevant products is just beginning. Three national centers have been installed to date: wheat, rice and dairy.

This paper first offers a brief overview of the trends in Brazilian agricultural development. Second, it shows the role of research in agricultural development in Brazil by providing a more historical view. Third, the basic principles behind EMBRAPA are described and, finally, the main accomplishments to date are presented.

3.1. Trends in Brazilian Agricultural Development

The model of induced innovation (Hayami and Ruttan 1971) basically states that government and private research agencies tend to concentrate their effort in order to generate the type of technology which saves the scarce and hence expensive factors of production. In this sense, the main lines of scientific and research policies really reflect the relative prices of land and labor in the case of agricultu . Institutional reform, on the other hand, is made possible and stimulated by the new opportunities opened up by changes in the relative prices of land and labor and by the increase in the demand for food.

Land has been an abundant factor in Brazil since its discovery, while labor could have been a scarce fa.. tor if slavery had not been established early in Brazilian history. The occupation of space in Brazil has been directed in such way as to minimize investments in roads and other infrastructure items. As a consequence, agriculture developed along the coast, from the Northeast to the South. Penetration into the central plateau and the northern or Amazon region is an extremely recent phehomenon. The basic policy to increase agricultural production in Brazil has been, during many centuries, expansion of cultivated areas. Although pressures to expand the agricultural frontier and bring new land into cultivation continue to be present today, high quality land is becoming scarce.

The agricultural frontier, however, is not infinite even in a continental nation such as Brazil. In fact, in some regions growth through expansion was effected very early. This was the case of the Southern states, especially, São Paulo and Rio Grande do Sul and, to some extent, the eastern state of Minas Gerais.

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Indeed, São Paulo was the first state to organize a research network directed at increasing the productivity of both land and labor.

Ayer and Schuh (1972) found that São Paulo alone invested more in cotton research than the entire United States did in hybrid corn research. They estimated a rate of return of over 90% on this research, which is higher than the rates reported for hybrid corn (Griliches 1958), poultry (Peterson 1967), and the extension service (Evenson 1967) in the United States.

Pastore, Alves and Rizzieri (1974) have recently studied the trends of the Brazilian agriculture. Their work indicates that during the 1950/60 period, growth of agricultural production was due mainly to an expansion of cultivated area. Indeed, 70% of the increase in production was due to land expansion and only 30% could be explained by an increase in yields or land productivity. With respect to labor, the increase in the agricultural labor force explains 60% of the agricultural growth, while 40% seems to have been due to increases in labor productivity.

The data show some remarkable differences. In the state of São Paulo the increase of agricultural output was practically entirely due to the increase in land productivity which also influenced to a large extent the increase in labor productivity. In the southern region the phenomenon was essentially the same, although less pronounced. In the Northeast, on the other hand, output increase was almost entirely due to an expansion of the quantity of land and labor used.

In the last decade (1960/1970) the situation has changed. An increase in land productivity has been observed over the entire country, with exception of the Northeast. At the same time, the rate of labor absorption has declined significantly (it is negative in São Paulo). The importance of the land/ labor ratio becomes clear in its contribution to agricultural growth.

Comparing these findings with similar data for other countries, one finds that the increase of production per unit of labor is very similar in *developed, intermediate* and *less developed* countries. The Table summarizes this comparison and points out the fact that São Paulo shows a very dynamic growth pattern.

The change in trends of agricultural development that became clear in the last decade (1960-1970) was a consequence of many factors. Favorable conditions in the international market and growth of domestic demand suddenly started pressing for a large increase in agricultural production which exceeded the possibility of growth by expansion of the cultivated area. The availability of good and cheap land for agriculture diminished considerably. These new forces (international and domestic demand for food and fibers) produced a new dialogue between official authorities on the one hand, and the farmers, industrialists and, especially technicians on the other. The result was re-

TABLE

ANNUAL RATES OF GROWTH OF AGRICULTURAL PRODUCTIVITY

Group of countries (*)	Labor ** Y/N	Labor ** Y/A
Developed countries	4.7	2.1
Intermediate countries	4.4	2.0
Less developed countries	1.4	2.1
Brazil	4.0	2.0
Central-South	4.1	2.1
São Paulo	5.4	4.8
Northeast	3.8	0.6

(*) Data on three first types of countries are from Hayami and Ruttan (1971)

(**) Y/N = output per unit of labor and Y/A output per unit of land

direction of the basic agricultural policy. Growth through expansion was maintained. However, increases in land and labor productivity were explicitly introduced as a new, additional goal during the late 1960's and the beginning of the present decade.

Initially, the key move was the attempt to difuse the existing technological knowledge from the research institutions to the farmers. The heavy emphasis on agricultural extension services during the 60's can be understood within this framework. This circumstance also explains the righ priority allocated to development of especial lines of credit for purchase of modern inputs as well as the emphasis on minimun price policies to stimulate production *and* productivity.

An internal crisis for food in the domestic market became an additional and powerful factor for redirecting agricultural policies, especially in the middle 60's. The feeding of the large urban centers suddenly became a crucial ecnomic and political goal. Government became aware that inflation plus food shortages were the ingredients for social convulsions and radical political changes which, obviously, were undesirable at that time.

In short, the increasing of agricultural production at lower production cost entered the picture of Brazilian development in a very explicit way in the beginning of the 70's.

This was crucial to meet the stated objectives as well as to combat inflation and to gain sizable slices of the international markets. These themes were discussed particularly at the federal level where, obviously, the link between agriculture and the general process of economic development was in focus. This is probably the reason why the initial step toward the modernization of the agricultural research system was taken at the federal level or, more explicitly, within the Ministry of Agriculture, which was under

increasing pressure to raise the productivity of the sector.

The economic forces that entered the picture in the last decade have created in the beginning of the 70's a favorable atmosphere for a profound change in the Brazilian research system. This system has undergone several changes, but none of them succeeded in providing Brazil with a research institution capable of facing up to agricultural problems. It is our contention that lack of incentives in the economic system have been responsible to a great extent for the failure of the reforms that have been tried. The next section will provide the reader with some historical perspective of the Brazilian agricultural research system.

3.2. Historical background

The great changes of XVIII and XIX centuries occurring in agrarian sciences in Europe had some mainifestations in Brazil. Actually, the first Brazilian agricultural research units were created within the atmosphere of European liberalism which generated a *diffuse model* of research activity. The main feature of this type of model is that each research unit tries to diversify its activities, researching many different products and attempting to generate a wide array of technologies. The role of making the proper choice of tecnology as well as determining optimun system is left completely to the farmer.

The diffuse model represents an adequate system for organizing research in an environment with special characteristics. Among these characteristics are:

a) Abundant resources are available for research. The abundance of resources destined for research indicates that the society has already recognized the importance of research in the modernization of agriculture. Furthermore, mechanisms have been developed to provide agricultural research with sufficiently generous and flexible budgets to meet its needs.

b) Predominance of a liberal philosophy which accepts the behavior of the scientists as individuals and provides an atmosphere of liberty in the choice of research projects.

c) Existence of a critical mass of farmers sufficiently organized to interact with researchers and administrators and make the problems they face explicit. From this dialetic interaction, pressure develops that results in adequate resources being allocated to research and, at the same time, prevents the scientist from becoming alienated from reality and concerned only with problems of his particular preference.

The pressure from farmers, together with the individual orientation of the scientists, results in a research system which seeks to generate information of a diversified nature covering a vast gamut of subjects and large numbers of crop and animal enterprises. There will be many lines of research, some seeking to economize on land and/or labor. However, no attempt is made to direct the types of knowledge generated by appying the criteria of relative change of prices.

The tendecy is to develop, given the limitations of time and money, what is possible in a broad range of areas. The individual interests of the scientists are satisfied because they have a wide range of choice in their respective areas of research. At the same time, this system guarantees that the desires of the majority of farmers, particularly those in position to influence the research institutions, will be satisfied. When an individual farmer seeking information to improve the efficiency of his farm comes in contact with the universe of knowledge generated, it is highly likely that he will encounter the information he desires especially adopted to his financial situation and psychological nature.

It is natural that the dialetic process which develops between the farmer and researcher in an environment of abundant resources for research and researcher freedom will lead to the diffuse research model. In this sense, it is considered adequate and, additionally, given the diverse nature of knowledge generated, will permit the development of a large number of production systems which can be adjusted to widely varied conditions.

The freedoom of choice of the researcher also guarantees that the research projects developed will not be concerned merely with short-run necessities. The gamut of research results generated will include some which have no immediate application, but which may be of great value if the socio-economic conditions change. This occurs because some researchers with great intuition anticipate change, and because of luck in other cases.

The diffuse model generates a large amount of information with a low probability of crystalizing into a new technology. For this reason the diffuse model is extremely expensive and possible only in rich societies which can invest large quantities of resources in research.

In the developing countries, two of the essential ingredients are lacking for the diffuse model to function. Resources destined for research are scarce, and further, the low cultural level of farmers, together with the difficulties of transportation and communication, make establishment of the dialetic mechanism difficult. On the other hand, researchers have cultivated the individualistic tradition inherited from the developed countries through training abroad and the scientific literature. Conditions exist that alienate research from the current agricultural situation and lead to a dispersion of research among many crop and animal enterprises. Since human and financial resources are limited, this dipersion of effort reduces the efficiency of research. In other words, the stock of knowledge being generated does not maximize the number of systems of production that could be developed. The farmer finds only limited and incomplete information available which does not permit the elaboration of a production system.

Presumably then, in an environment of scarce resources, the diffuse model of research has undesirable characteristics. It is necessary to modify it in such a way that the knowledge generated meets certain defined guidelines. Otherwise the knowledge generated does not allow for the efficient development of large numbers of production systems.

With the exception of São Paulo and Rio Grande do Sul, financial and human resources were extremely limited practically everywhere in the country. In addition, a critical mass of influential farmers does not exist to promote the necessary dialectic mechanism and to sensitize Brazilian authorities to the sector's needs. As a consequence, the imported diffuse model – wich is in practice not only in Europe but also in the United States and, lately, in Japan – can not really have the same impact in Brazil.

The Brazilian agricultural research system little by little developed an extremely individualistic orientation; research topics and methodology were viewed as being the exclusive property of the investigators themselves even though research was completely financed by public money. Research priorities were viewed as "sacred" themes and the directing of science and technology toward solution of the entrepreneurs problems was considered "heretic" thinking.

Scarce resources tended to be allocated to a wide variety of research topics defined by the researchers who, not rarely, were more eager to duplicate an investigation recently published abroad than to solve the farmer's problem. The lack of pressures that accrue from scarcities in land and/or labor actually contributed to this exagerated individualistic pattern. Researchers felt themselves unprotected and, at the same time, very independent and risk-averted. Their whole style of working was defined as the "one-man venture" type: research tended to be designed in such a way that research teams were completely dispensable. As a consequence, no emphasis was placed on training and preparation of new research generations. Few people went abroad for training and those who returned rapidly started defending the "uncommitted" type of research and reinforcing the diffuse model based on the individual pattern. The eventual long-run impact of research activity was used as the main argument for future investments in parellel projects. In fact, the government's research investments were mainly an "act of good faith" rather than a goal directed effort. This type of social background pervaded both the agriculture colleges as well as the more applied research units, namely, the agricultural experimental stations and institutes.

In short, the Brazilian agriculture research structure seems to have been negatively affected by two types of forces. On one hand, due to the relative abundance of land and labor, there was little pressure for research to develop technology which conomized on these factors. On the other hand, there was the prevailance of extremely individualistic research patterns imported from developed countries within which positive benefits could be derived from the diffuse model of agricultural research. Changing forces entered the picture at the beginning of the 1970's in the form of pressure to enlarge agricultural production in order to meet the new economic forces; namely, the increase of domestic and international demand for food and fibers as well as the political need for feeding the urban population. These forces have created a new atmosphere for shifting from a diffuse and completely subsidiary model to one in which concentrated research efforts predominate. To these forces, one could probably add the emergence of concentrated model elsewhere, particularly the international research institutes which are concentrating massive financial and human resources on the researching of a very limited number of products.

The role of science and technology in increasing agricultural productivity became one of the central concerns of the Minister of Agriculture, Dr. Luis Fernando Cirne Lima, in late 1971. A decisive move was made by him in early 1972, when he called a meeting of all State Secretaries of Agricultre and Agricultural experiment station directors to present the clear desire of the central government to modernize the research system in order to accomplish the newly defined national goals. Simultaneously, the Minister nominated a special committee to present an appraisal and some lines of action to remove the main weaknesses of the Brazilian agricultre research sector.

The report of this committee pointed out the basic positive and negative aspects of the federal research units. The positive aspects can be summarized as follows:

(1) a geographically dispersed network of reserarch units was available to the federal government and covered practically the whole nation;
(2) equipment and basic infrastructure were considered reasonably adequate for most of the units, with a total investment in land, building, laboratories and other facilities totaling about $ 300 million;
(3) sixteen techinical journals were available for publishing the eventual results of agricultural research;
(4) a small, but well qualified group of researchers could be better used by the units if their administrative load would be assumed by some other professionals;
(5) a relatively well-defined consciousness of the need for an integrated research policy for the agricultural sector was present in most of those above mentioned researchers.

The negative aspects, unfortunately, were overwhelming:

(1) the basic national needs of agriculture were unknown to most of the research personnel;
(2) lack of a general policy and interaction between research personnel and farmers were dominant;

(3) the existing administrative structure inhibited the recruitment, training, and promotion of well qualified personnel;
(4) a complete lack of internal communication among units and individual researchers was evidenced by large numbers of parallel projects on unimportant products;
(5) the lack of suitable programming and evaluation mechanisms permitted researchers, to undertake individual activities with doubtful research output and valua;
(6) of 1,902 individuals considered formal researchers, only 10% could be considered as professionals with some kind of graduate training in research;
(7) a lack of salary policy which permitted competition in the professional labor market as well as quick admission and promotion of qualified personnel and demotion of the unqualified ones;
(8) predominance of a personnel policy in which better salaries could be obtained only if an administrative position was held, thereby inducing a process of rapid shortening of the technical life of the better researchers;
(9) inadequate mechanisms for obtaining and managing financial resources which were limited to the direct subsidiary budgets coming from federal government;
(10) underutilization of all the existing facilities.

The committee also examined a variety of institutional arrangements that, according to Brazilian Law, could be chosen to implement research activities. A public corporation was considered the most adequate one. The Congress, in December 7, 1972, approved the creation of EMBRAPA as a public corporation to coordinate and to administer at the federal level research in the area of agriculture and animal husbandry. EMBRAPA started operating on the 26th of April, 1973. The basic principles of the model are presented in the next section.

3.3 The Basic Principles of the Present Brazilian Model

The years of 1971-1972 have marked the history of Brazilian agriculture as a period for the creation of a more flexible and sensitive mechanism for agriculture research. The basic tenant of this model is that the applied side of agricultural research, the one which is closer to technology and to the needs of the farmers, should be directed by the concrete needs of the national society. In other words, agriculture research institutions should be developed to meet the country's demand needs. Two demand components were visualized: the present demand and the potential demand. The present demand is visible through government policies and the concerns of industrialists, extension personnel, and farmers in general. The potential demand can be surmised by looking at longrun government plans and the trends of particulr scientific endeavors in Brazil and abroad and through researchers' intuition. In this respect, the execution of applied research directed toward present demand is visualized as a proper activity of the technological research institutes, whereas the more fundamental type of investigation should encounter its more appropriate habitat in the universities. This is not a rigid division of labor between the two types of research instituions; it is just the idea of using their comparative advantages for two types of research.

The components of the research system of the Ministry of Agriculture can be generally placed in the first category. Therefore, their main thrust should be directed toward the present demand for technology, which means generating the types of knowledge that can be readily incorporated into the production sector, thereby reducing costs and increasing product quality. Also, this general strategy implies that technologies should not be pursued separately. Rather, the development of the agricultural sector in other nations has shown the importance of working toward the creation of technological packages that achieve technical and economic efficiency.

In additon to these general principles, six other ideas have been used as guidelines in reforming the existing research apparatus. First, the transfer of foreign technology to the agricultural sector is considered as a valid means of improvement, but of limited importance in many instances. The transfer of materails and of certain packages (i.e., pultry technology) is loked upon as an opportunity to capitalize on some other contry's investiments. Among the types of technological transfer, training abroad and imports of personnel are defined as being most applicable to the Brazilian situation.

Second, given the scaricity of financial and human resources for research activities, the idea arose of concentrating efforts on regional projects. The main research programs reflect the basic national needs as well as regional demand. This principle should overcome the difficulties of transferring technology among different ecological and economic regions through the country. All programs and projects are designed with the closest possible involvement of the private sector, including financial participation in some cases.

Third, the private sector should operate as the originator and the controller of most of the research projects. At the same time, agricultural research should be closely articulated with the nation's overall science and technology system. Agricultural research, in short, should be closely related to the private sector, the university system, and the other science and technology units.

Fourth, the agricultural research system should be redirected in order to gain more administrative flexibility to include:
(a) the possibility of obtaining additional resources through contracts and agreements; (b) the possibility

of paying wage of researchers on a market basis; (c) the possibility of developing an aggressive policy of human resource development, including basic training and graduate work.

Fifth, a closer relationship should be developed with the extension services and the agricultural input industries in order to speed knowledge dissemination throughout the country.

Sixth, knowledge from the international institutes and from other foreign research centers should be adapted and diffused in the country. The technological packages should be adapted by the research system to a great extent in order to decrease the farmer's risk. This means that an economic component should be systematically included in the agronomic investigations.

The concentrated model was chosen as the research model that requires investment of massive financial and human resources, but on a very limited number of products. The challenge that this model brings about is to define the criteria for orienting the generation of knowledge. One alternative would be to follow an orientation similar to an automobile company. First, two prototypes of production systems need to be defined. One, consists of modifications which improve the production systems already in use by farmers. This is what an automobile company does when it makes minor changes in a model well accepted by the public. The second prototype deals with production systems that one imagines will be appropriate for conditions some 5 to 10 or more years in the future. Its desing depends largely on futurology. However, some orientation is provided by information existing in the factor and product markets, nationally and internationally.

Once the prototypes have been desingned, researchers must select a group of research projects that will result in the systems of production designed. This provides the research system with a definite orientation from which the maximum number of production systems can be developed.

This type of orientation leads to a number of problems. Among the most important are:

a) Problems of methodological nature occur, such as definition of the general lines of research and the specific projects. to be undertaken.

b) Since resources are scarce, it is necessary to limit the number of production system prototypes developed and the number of commodities researched. Hence priorities must be established.

c) Selectivity with respect to enterprises to be studied implies some groups of farmes will not receive the benefits of research. National agricultural policy provides some orientation in this respect.

d) For development of future production system prototypes, problems of foresight exist.

e) There are problems of allocation of resources between research with immediate applicability and that with applicability in the longrun.

f) For small farmers who combine various enterprises in their operations, the concentrated research model may have difficulty developing systems of production which are adequate for them.

g) The concentration of effort requires an appropriate institutional system. It is unlikely that research institutes which work on a large number of commodities and are organized on the basis of disciplinary departments such as soils, plant improvement etc. will have a high degree of sucess in developing production systems. In this type of environment, given the individualistic tradition to which researchers are accustomed, pressures will develop that cause departure from the priorities and areas of concentration established. These pressures arise from the departments which seek to develop a i area of specialization, as is common in the developed countries, and from researchers that have dedicated their lives to commodities not considered to be of national priority. It should be noted that the organization of research in institutes of this type is a consequence of the requirements of the diffuse model. In rejecting this model, it is also necessary to modify the institutional arrangements which made it possible.

3.4 Agricultural Research under EMBRAPA

The process of generating new knowledge seems to present two related levels of activity. The first one includes all research activity aimed at advancing sciences and experimental techniques, including hypothesis testing procedures and theory construction (Type I). The other level involves experimental work using existing scientific knowledge and is aimed at the generation of alternative technologies (Type II), whick may improve the agricultural productivity. The gray area, obviously, is large.

On the basis of this distinction, one can organize the research agencies, recognizing their comparative advantage in one or the other of knowledge generation process. As a general rule of thumb, one can say that the first level of knowledge generation can be better performed by the universities or colleges of agriculture. The second type of research activity can be allocated to other research units. Depending on resources and time, the universities may allocate some of their personnel to the Type II research; conversely,

some people from technological institutes may devote some time to Type I research.

In addition to this type of specialization, Brazil, as a continental country, faces the problem of space specialization. In other words, EMBRAPA can be defined as an agency mainly concentrated on the Type II research for agricultural development and at the same time as an agency leading a system of state units dedicated to regionalized experiments. It has been recognized that it is not EMBRAPA's responsability to perform all agricultural reserarch in the 25 Brazilian states. As a consequence, two important roles have been defined for EMBRAPA. On one hand, it has the responsibility of creating and/or supporting the state research systems. On the other hand, it is responsible for creating and implementating commodity-oriented National Research Centers.

(1) Supporting the State Systems

Agricultural research at the state level is very heterogeneous in Brazil. The southern states, a it was pointed out, possess relatively mature research systems. EMBRAPA expects to continue supporting their activities. At the same time; it expects them to adopt more flexible administrative units (corporation type agencies) in order to facilitate the state-EMBRAPA articulation.

There are many other states, however, wich have no research tradition whatsoever, although many ot them have been receiving research funds from the central government. In these states, EMBRAPA is helping the state governments create their own capabilities. The main support up to now has been in terms of training massive groups of research personnel as well as aiding the state secretaries of agriculture in organizing their own state corporations.

(2) The National Centers

These centers are defined in terms of other basic national needs for the agricultural sector. The main strategy is to concentrate funds and talents in a few and relevant products and specific phisiogeographic regions. Wheat, sugar cane, corn, cane, corn beans, soybeans, rice, coffee, rubber, livestock and dairy have been defined as the crucial agricultural products for the country. Among the key resource areas to be developed through national centers, EMBRAPA has included "cerrado", semi-arid agriculture, and humid-tropical agriculture.

State agencies can articulate themselves directly with the national research centers, particulary when they are located in a nearby state or in the state itself wherein a given center is located.

In this framework, there are two levels of research priorities guiding EMBRAPA's activities. The first on refers to those prjects which can be performed by the state with EMBRAPA's support and guided by regional priorities. The second refers to those projects which will be performed directly by EMBRAPA through the national centers and by integration with the state units when it is necessary. This combines national priorities with region specialization in order to assure transferability of research results.

The most important results obtained in the 1973-74 period ate the following:

(1) EMBRAPA replaced the National Department for Agricultural Research of the Ministry of Agriculture. The year of 1973 was a transitional year. The corporation indeed assumed the operation of research activities in 1974.

(2) The realized budget of the old system in 1973 amounted to US$ 14,000,000 (exchange rate of December, 1973). In 1974, EMBRAPA expended about US$ 25,000,000 in research activities (exchange rate of December 1974). The Planned budget for 1975 was estimated at US$ 65,000,000 (exchange rate of December 1974).

(3) The old system was overcrowded with bureaucratic personnel. The Corporation was, by law, allowed to select the personnel best suited for its work. It selected 3422 (data of January 1975) out of 6705 employees of the old system.

(4) The trainig of personnel is one of the most important part of this program. It is creating conditions for 1000 researchers to acquire M.S. and Ph.D. degrees in Brazilian and foreign universities. It is financed by Brazilian and foreign fund. In this respect, USAID, through a loan to Brazilian Government, is an important source of funds for a program with U. S. universities. At the present, 500 researchers are in universities obtaining M.S. or Ph.D. degrees. The aim of the program is to have at least 80% of EMBRAPA's researchers with Master's or Doctor's degrees. In the old system this percentage amounted to 10%.

(5) National Centers for the most significant products of the Brazilian agriculture will be in operation by the end of this year. Nowadays, the National Centers for dairy cattle, rice and wheat are in iperation. Three National Centers for the development of natural resources will be in operation this year. One in the area of the cerrado, another one for the semi-arid region of Northeast, and a third one in Center for Tropical Agriculture in the Amazonas region.

(6) EMBRAPA is strengthening institutional linkages with Brazilian and foreign universities, with the International Research Centers, and with development banks to obtain technical and financial support for the program.

(7) Three states have already reformulated their research systems according to the federal

model. Their research projects are supported to some extent by EMBRAPA funds. In other states an institutional arrangement has been established with the purpose of setreng-thening their research capability and creating conditions for the corporation model.

(8) Brazil has accumulated a stock of knowledge that is useful to its agriculture. Farmers are drawing from this stock of knowledge to organize their production systems with the help of the Extension Service. The stock of knowledge is however insufficient to attend to Brazil's needs. It was generated according to the analytical tradition without paying attention to the idea of production systems. However, experience has demonstrated that it is possible to generate some technological packages out of this stock of knowledge. EMBRAPA organized several meetings for this purpose in 1974. The meetings covered the most important products and regions. Extension people, farmers and researchers met, on an informal basis, with the objective of organizing available knowledge into technological packages for different classes of farmers (classified according to size of land holding, type of land ownership, etc.). Each meeting covered jus one product and generated technological packages for a region where the available knowledge is known to be applicable. EMBRAPA will expand the program in 1975. It will invest US$ 1,300,000 in these activities compared with US$ 360.00 that invested in 1974.

(9) A system of planning has been worked out in detail. The priority criteria established will allow a detailed evaluation of the research projects of the Old System. Those projects that did not satisfy the priority criteria were either eliminated or reformulated.

The experimental stations are being reorganized. We seek to equip them in a more adequate fashion and to increase their sizes. For this reason some of the experimental stations will be closed and others will go through a substantial enhancement of their research programs.

EMBRAPA has created conditions for young and competent researchers to assume leadership in their research areas. There were, consequently, profound changes in the power structure. These were deemed necessary for the implantation of the new research system.

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DEVELOPING AND MANAGING STAFF ON AN AGRICULTURAL RESEARCH INSTITUTION *

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DEVELOPING AND MANAGING STAFF OF AN AGRICULTURAL RESEARCH INSTITUTION

Eliseu Roberto de Andrade Alves*

INTRODUCTION

In recent years an increasing awareness of the problems related to development and management of agricultural research and their importance has become apparent. The spiralling of research costs and the need to develop agricultural research systems in developing countries have lent a special urgency to find the optimum form.

It is the objective of this paper to present some ideas to help in understanding the problems of developing and managing a national agricultural research program that has its own specific characteristics and therefore sometimes requires unique adaptations of basic management principles.

MANAGING STAFF

Managing the staff is managing the institution. The following assumptions were made in the process of developing various ideas presented in this paper:

1) The institution has an over all responsability for agricultural research at the national level.

2) This responsability is limited to research only and excludes both extension and education.

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3) It is dedicated mainly to applied research aimed at solving farmers problems. Organization and classification of knowledge and development of theory, do not constitute major functions of this institution.

4) The political setting is a federal system where importance is given to cooperative aspects between federal and state systems in a joint effort to put agriculture on a scientific basis.

5) There is a social environment favorable to the development of science due to the following forces:

   a) Understanding that science is an important source of national power;

   b) The urban population which is dominating the political process is putting pressure on government to find solutions to growing food prices with the government realizing that the solution could only be found through the support of research institutions;

   c) Additional support to agricultural research comes from the producers, who see their production cost grow rapidly.

   Depending on political organization, the national aspiration level and the level of industrialization and urbanization, one of these three forces will predominate over the other two. The research administrator should be able to predict correctly where the potential demand for the research is, so as to be able to adjust accordingly the development of the institutional system.

6) The institution has two major outputs: results of research and well trained research workers. It is the function of the administrator to make decisions that guarantee and facilitate the increasing flow of these two outputs. The first of these, results of research, is essential in obtaining an increasing support of the society. The second means that the institution is continuously increasing its capacity to produce research results, therefore, to become increasingly more useful to the society it is part of.

7) The institution is organized so as to create a climate that stimulates creativity, recognizes talent and encourages the members to make farm problem solving the major form of professional satisfaction. An attempt should be made to single out factors which facilitate institutuional development so as to create standards to guide short term decision making.

Oganizational Factors

A research institution is aimed to have a rather long life span. Many people confused this with the idea that research institutions need a long time span to obtain valuable results. In reality, every research institution produces some results every year. Still, a research institution is like a dam that takes years to be built. But, once built, it provides a steady supply of energy. This confusion has resulted in the fact that agricultural policy makers do not give enough importance to research because they want short term results.

The long life of a research institution creates special needs for a continuous renovation process to avoid becoming obsolete. To avoid obsolescence research institutions should be allowed the following:

1) A legal organization that permits freedom to capture financial resources, management of its budget, a personnel policy appropriate for a research institution, close relationship with: the university system, the private sector and foreign research institutions. It must also have the freedom for formulation of its own research program.

2) It is essential to divide adequately the responsibilities between the federal and the state governments. Depending on the political development stage of the country, a major responsability can rest with federal government as long as there are mechanisms that assure continuous descentralization in favor of the state or regional governing bodies. One must not forget that research is always site specific, making it difficult for the federal government to be responsible for solution of the problems that are specific only to certain states or regions. On the other hand, the local political power will hardly support research programs and institutions without being directly involved in its administration and financing.

3) The research stations should be located in a region that either comercially produces the commodities of interest or has resources required by the research. This will assure that the research workers will be in continuous contact with producers. These contacts will inspire the research workers to concentrate their efforts on relevant problems and encourage them to continuously strive for professional achievement based on solving the farmers problems. The research units should specialize on a rather limited number of products or problems to avoid diffusion and dispersion of their efforts and keep their size to a controlable number of researchers, estimated between 30 and 100.

4) The traditional organization of research institutions is in the form of specialized departments set up by disciplines. The main function of these departments was to gather a group of scientists, create pressure on the budgeting process so as to benefit the discipline and allow scientific development and growth of a given field of specialization. This organization may create difficulties for problem solving research aimed at producers and demanding formation of interdisciplinary groups.These difficulties can be solved with a certain ability and patience so as not to compromise the professional interest involved. On the positive side, this organization has the advantage of being able to avoid that the research institutions dedicate themselves only to the solution of immediate short term problems that,as the experience has shown, does not produce the highest returns in the long run.

The other form of organization is to create multidisciplinary teams for solution of specific production oriented problems. This organization guarantees a better perfomance, in terms of the solution of given problems and facilitates collaboration and administration of research workers. It is also more responsive and relevant as far as farm interests are concerned. Still, it may have the disadvantage of reducing creativity of scientists that have different interests than those of the dominating group, and may result in rather superficial research work, if certain precautions are not taken. The organization tends to benefit from group action in detriment to individual actions that are necessary to obtain the research results. It is however an appropriate model for applied research as long as the individual work of each scientists is protected. The definition of the problem is made by the whole team and the work is divided so that each scientists has his own project.

Frequent meetings have the purpose of following the development of the projects, avoiding major deviation from established objectives, making proper changes when needed and evaluating the results. Here, the most important factor is the capability of the team leader.

It is possible to combine the two forms of organization, that is, the traditional disciplinary department organization with the multidisciplinary team organization. The Departments will be restricted to basic disciplines or to the service areas like laboratories, administration and others.

5) The resources allocated to research are usually limited. As a result, programming aimed at optimum efficiency becomes very important. Still the experience shows that a strong programming-planning system of research has a high cost in practice. A rigidly programmed research institution does not induce private initiative or participation of university systems. It does not follow basic procedures of scientific methodology, but tends to be rather general as opposed to specific, and over demanding in terms of time to be dedicated to paper work by the individual research workers which constitute the most valuable resource of any research institution. It tends to be more bureaucratic and centralized, is an excellent producer of paper but inhibits good ideas. Thus, all programming functions should be permanently subject to critique by research workers so they can be adapted and improved continuously to the convenience of the research workers concerned. In other words the programming system must be as dynamic as possible.

The research program must be well balanced in terms of short term and long term projects. Giving needed priority to produce immediate results, that are easily adapted by the farmers, is indispensable for survival and growth of the institution. At the same time the projects of greater impact or productivity, that need longer time for execution, can not be sacrificed. The program must also include those that have high risk since these are the ones that give much higher returns once successful. The program should take into consideration actual production practices of various farmer groups, the interest and potential of small and low income producers, export crops and other special interests. Finally, it is very important to avoid dispersion of efforts through establisment of a set of research priorities.

6) The nature of research activities requires a rather steady budget and can not afford wide fluctuation of the financial resources. Still, in practice, it should not provide excessive financial security in terms of research money to all scientists. At least a part of the resources should be given in a

competitive process where research workers will submit projects for financing by private institutions or foundations and try to finance part of their on going work through the selling of produced technology and patent rights. This search for financial resources, even though time consuming and sometimes frustrating, has the advantage to create a permanent interest on behalf of the institution in societal problems and develop the ability to relate and communicate with existing political and economic power structure that otherwise would be negleted. Commercial production using idle resources and newly developed technology produced by experiment stations constitutes an excellent opportunity to test certain innovations before their diffusion among the producers. Commercial activity of research units should not interfere with the major function of research and its administrative set up, if possible, should be separated.

7) The institution of applied research oriented towards obtaining short term results based on fast decision making has a tendency of being vertically structured with a strong hierarchy instead of being a democratic and participatory organization as in some more traditional research institutions. A vertical power structure in regional experiment stations is not necessarily antidemocratic. Still, it does have potential of a totalitarian system that may stagnate the institution. Various alternatives have been tried to solve this problem. One is an elective process for choosing executive personnel. This results in that the leadership becomes over committed to the private interest of their electorate. In terms of the general objective of the system this is not always productive. Another alternative is to create working groups and committees of research workers that sometimes include producers and consumers that participate in administration or a least in setting up the general policy of the research institution. The optimum solution should be worked out for every case. The major consideration is to find an equilibrium between lack of flexibility of a vertical structure and need for fast decision making that is not common with any descentralized democratic organization.

Descentralization of power could be achieved through giving certain autonomy to descentralized units without destroying over all power structure of the institution. Local autonomy, even though healthy from an organizational point of view, may not give a needed voice for research workers and thus has to be completed by other systems that gives direct representation to research workers, to producers, to consumers and to the extension personnel.

8) The relationship with the outside world could be given only limited space in this paper mentioning only the following items which are considered of major importance:

   a) It is vital to assure intensive and direct relationship with rural producers and private enterprise related to the agricultural sector. This relationship promotes the interest of research workers in relevant problems and creates an interest in research on the part of various groups that have power to influence the allocation of needed public and private resources for the research. To see and to hear are two different things. The researcher has to see in order to understand. He will hardly undertand well a problem seen and reported by others. Certain details, sometimes crucial, escape the observation of a non-trained person;

   b) The process of creating knowledge is a continuum that starts with identification of a problem and only finishes when the producer incorporates into his production system the technology resulting from the research aimed at the solution of his problem. During this process there are various functions It is common to differentiate two of them: The research and the extension. The first creates a body of knowledge. The second adds to the research results the information needed to make the research results adaptable by the producers. "The former creates the product, the latter sells it". These two functions could be located in the same institution or could be separated. In both cases the problems of integration are present due to the fact that the work of researcher and extension workers do not coincide, even though they may have the same objective, that is, to increase the productivity of agriculture and well being of the producers. The integration between extension and research lies, in the first place, in showing that the interest of two groups coincide and that one can not survive

without the other. Second, a way must be found through which each group participates actively in the work of the other, both at the level of contact with producer and the initial or continuous training programs. One finally should recognize that a certain amount of competition and even professional jealousy is healthy and productive in spite of what many people think..

c) A good relationship with the mass media is indispensable for communication between research workers, consumers, government and the private sector. The mass media coverage should be aimed at local and national levels. It should be handled in a professional way using specially trained personnel. To build up a good public image and favorable public opinion is a task that needs a major effort and can not be neglected.

d) University systems have high level trained personnel. The areas of potential colaboration are the following:

- Education: Training agricultural research technicians at advanced level, both short & long term, and specialized non degree courses.
- Consulting: Providing technical services related to special problems identified by research.
- Exchange of personnel: This means the University personnel will work in research institutions, occupying administrative and executive position when needed and vice-versa.
- M.S. & Ph.D. Dissertations: Use of graduate students to prepare dissertations dealing with problems identified by research.

e) Agricultural technology is site specific. Rarely can it be transferred from advanced countries without a major adaptive effort. Still there are great benefits in contacts with other countries & international organizations.

The major areas are as follows:

- The science and scientific methodologys that generate technology have universal application. Advanced training of technicians at universities and other institutions and use of foreign specialists for short term and long term assignments help in skipping or accelerating institutional development stages leading young research workers to the frontier of knowledge.
- As a product of many years work advanced countries have been able to gather and develop germoplasm collections and a genetic base for plants and animals aimed at increased productivity. These collections have a great potential to contribute to any plant and animal breeding program in any part of the world.

HUMAN RESOURCE DEVELOPMENT

In research there is no substitute for the quality of human resources involved. This is why the principal task of administration is to help to create an environment that stimulates high level performance based on creatitivy and protects these talents. The first part of this paper dealt with the organizational aspects of research institutions. The second part will treat various aspects directly related to development of human resources.

1 - Human Capital

The formation of human resources represents institutional investment in human capital. One can not forget that human capital has depreciation rates that can be very high in an environment that does not stimulate a continuous search for knowledge and that affects the health and creates irritating internal frictions and alienation of individual technicians within the institution.

To avoid depreciation of human capital the administrator should try to give incentives to individual research workers by continuous investment of time and money in their education. This is due to the fact that the capacity of each research unit to achieve given objectives are, to a major extent, a function of the quality of the technical staff, rather than their number.

There are research institutions that still have elements that induce high level human capital depreciation. The leading contributors of this are: lack of wage differentials among those who produce and those who do not, lack of healthy professional competition, small numbers of research workers with advanced training, extensive bureaucracy, shortage of support personnel able to increase efficiency and output of individual researchers, and the lack of tradition in terms of administrative research leadership. This type of institutional setting contains some of the factors that puts a heavy risk on investment made in human resource development.

The effort to learn more is made as a response to lack of equilibrium between what one knows and what one could learn.

Factors that make for perception of this lack of equilibrium and that tend to perpetuate this perception resulting in permanent state of des-equilibrium, as far as the individual's knowledge of his topic is concerned, should be maintained so as to motivate a desire among research workers to continuously increase and widen their knowledge. Differential salary possibilities for post-graduate training, evaluation systems based on merit and talent are policies that, to a certain extent, tend to perpetuate a state of lack of equilibrium. The lack of competition among high level research personnel, the tendency to be intolerant with colegues that question the experimental design and other research procedures, the lack of students that stimulate their teachers to search for new knowledge, the difficulty in travel and contact with research workers of other institutions and other countries, the absence of a well organized technical publication service, are, among other things, the factors that make research workers stay happy with what they know and diminish the pressure between what he could learn and what he already knows.

It is important to emphasize that depreciation of human capital has two dimensions: one absolute, the other relative. The absolute level refers to the loss of knowledge due to time and lack of usage. The relative dimension refers to not keeping abreast in relation to progress made in scientific fields that are developing at a rather fast rate. In this case the research scientist, instead of trying to diminish the difference between his knowledge and the frontier of

his field of science, lets this gap grow and is left behind more and more every day.

Special care must be taken so as to avoid that the learning curve mantains the form presented in the following page. This graph show that substantial increase in knowledge are achieved strictly during graduate study and in the rest of professional life no increase in knowledge is shown.

2 - The Spirit of Competition

A healthy competitive spirit must be maintained among various private and public research units as well as among individual scientists. It is the function of the evaluation system to stimulate competition to the extent that it promotes the most competent workers. A system of recognition of achievements through prizes and honors that create competitive spirit among scientists must become an integral part of the research organization.

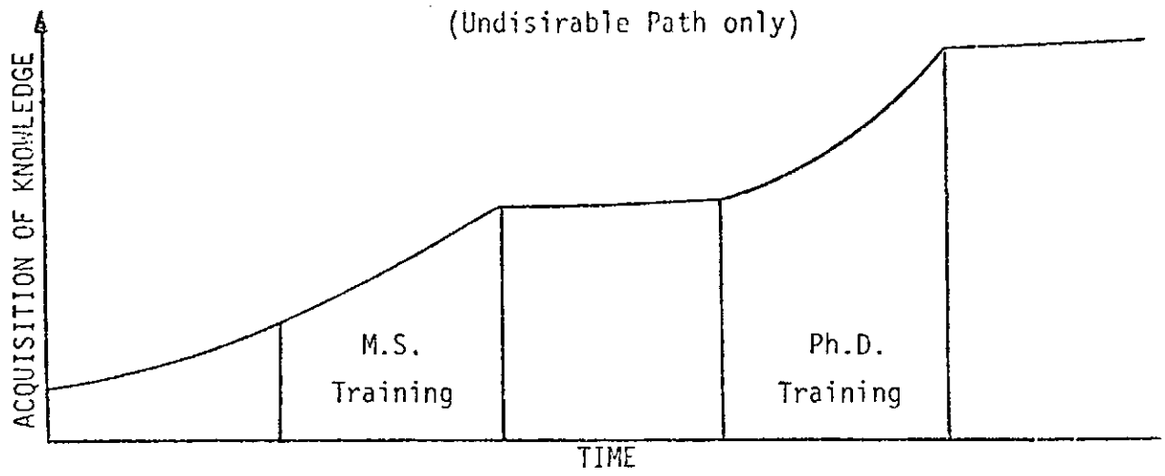
Cut throat competition must be avoided. The function of the administrator in this context is to warm up the institutional environment when it is apathetic and without motivation, and cool it down when rivalry starts creating a risk for institutional unity and inter-institutional relationships.

3 - Salary Scale

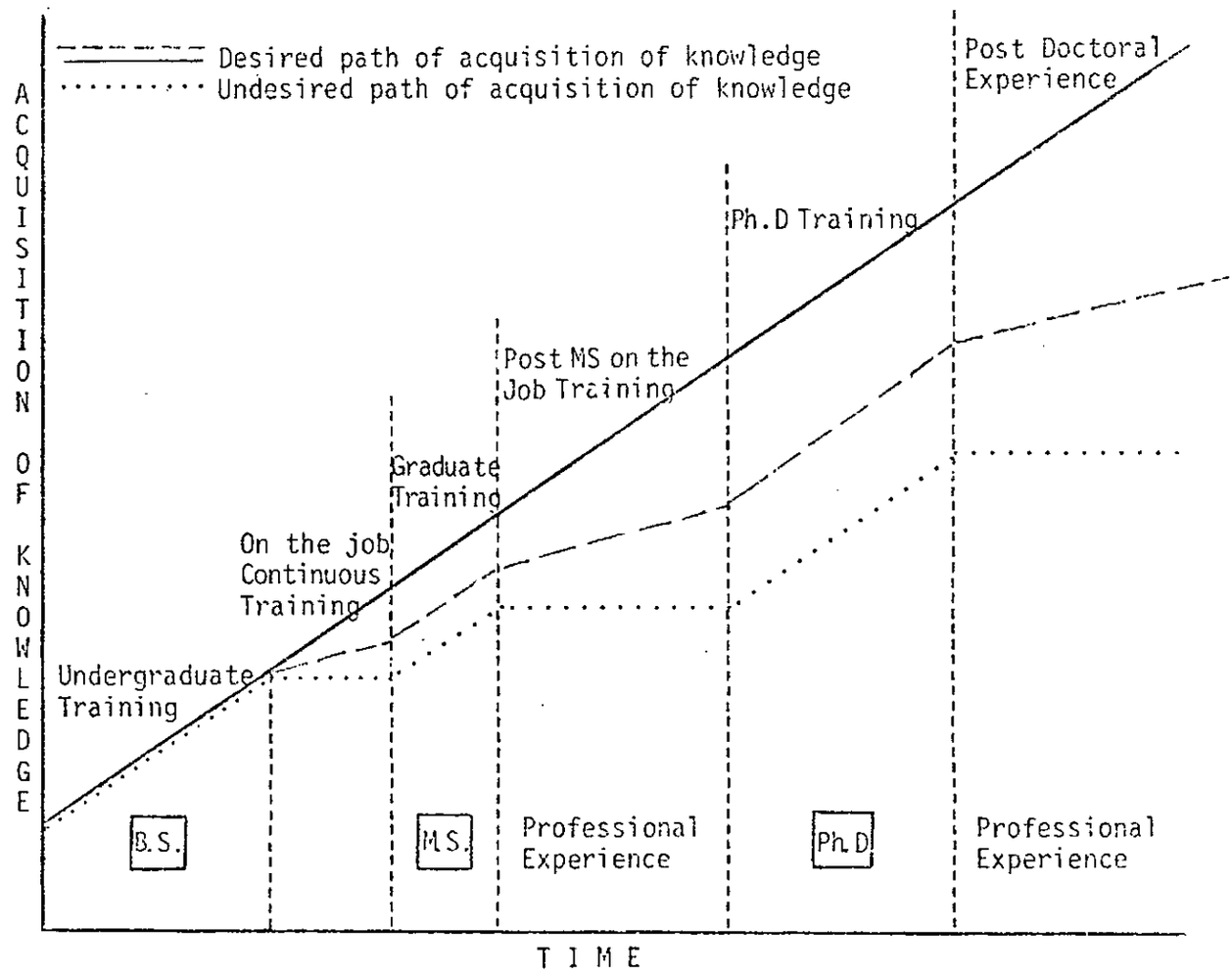
The salary scale should avoid the seniority system and tendencies to equate salaries. The basic principle must be to give due merit to work and achievement. It must recognize that research workers that question established norms and procedures can be creative and as such, the progress of research needs their contribution. The administration of salary scale needs a system of evaluation and promotion. Since the use of this system is difficult, it is common to neglect it in practice. This constitutes a major error. The ideal solution is to have in the organization specialized personnel that continuously revise and adapt the evaluation and promotion criteria to needs and realities of the institution. Still this is an area where very little has been done and a great deal of progress and work is needed.

ACQUISITION OF KNOWLEDGE DURING THE PROFESSIONAL LIFE OF A RESEARCH WORKER

(Undisirable Path only)



(Disirable and Undisirable Paths Compared)



4 - Publication of Results

Every research institution must participate in founding and supporting scientific periodicals.

It must encourage the research scientists to publish their results. This applies to publishing in national and international journals or other technical publications. It must also encourage publishing of non-technical work in local press to reach local people. The participation in radio and television programs is also of upmost importance.

5 - Training of Research Executives

Managerial control and administration of research centers need special skills that can only be developed through appropriate training. It is recognized that a good administrator has the capacity of keeping a coherent team of scientists dedicated to the achievement of all objectives of the institution. The power to destroy an established research institution and research team by a poor administrator is even greater. This is why the selection, training and evaluation of research executive-administrators is the major factor of the success of any research program.

There are those that advocate that a research administrator does not have to be research scientist. The experience is not clear in this respect, still it tends to favor an opposite hypothesis. It is prefered to have and administrator with some experience as a researcher even though he does not need to have a distinguished career as a research scientist. It would be desirable for him to have had a versatile experience, where he has been exposed to the various aspects of research, extension and public relation, in order for him to deal with these areas as a research administrator. He also must have proven leadership ability and lust for power.

The training of administrators must give them a general view particularly relevant to science policy and economics. Is must also cover leadership development and basic administration principles. Still one always must remember that the basic idea is to train an administrator and not a scientist trained in administration.

6 - Short Courses and Seminars

There is evidence that research workers that do not go through a regular graduate program or who do not participate in academic life after graduation tend to depreciate rapidly in terms of human capital. These research workers feel discouraged to acquire systematic knowledge and overestimate what is conventionally known as "practical experience" so popular among farmers and politicians.

It is possible to partially create what universities offer in terms of basic training through specialized courses and seminars within the research units. This is aimed at interchange of practical knowledge among experienced researchers and training the new ones.

It is even possible to arrange credit courses jointly with universities and count these courses offered, within the research system, for graduate credit toward a degree. In addition special courses should be organized by research units for extension agents and farm leaders.

7 - Training of Support Personnel

Increased productivity by support personnel means increased productivity of the whole research system and thus of the individual research workers. This training should cover not only technical aspects but also be of a general nature to include objectives of the institution and specific functions of the unit.

Well trained and trustful support personnel proportionately increases the capacity of research workers in term of the projects and experiments he can undertake. Still this must not substitute for the necessity of continuous follow up and close supervision of experimental plots or laboratory experiments. Without this continuous close supervision of work in progress the research worker will not be able to develop his observational capacity to the full extent as demanded by the nature of research work.

8 - Contact with Current Issues

Due importance must be given so that research workers will participate in seminars and public debates where national problems are discussed. They must be able to travel outside and particularly inside the country. This will provide for the over all maturity of individual scientists that is very important for applied research.

9 - The Spirit of Organization

It is very important to create what the French call "Esprit du Corp" among all members of the research organization. They must feel as being an integral part of the organization.

They must be proud in helping to build a scientific base for national agriculture and feel that their work is important for overall national development and growth.

A special program should be organized to create this spirit among all level of employees. This program will include lectures and public events with participation of national and local leaders. Even though research scientists normally will be responsible for these activities, the creation of a cast system should be avoided so that all members of the establishment feel they are part of the mission undertaken by the research institution.

GRADUATE TRAINING (M.S. & Ph. D. LEVEL)

This training is mostly aimed at preparing technicians to systematize their knowledge and test theories. The level of systematization aimed at varies depending on the capacity of scientists and the development of a particular field of knowledge. The same applies to the complexity of the hypothesis to be tested. During the graduate work there is a stage where the student has to learn special techniques, that are important to solve some problems; however, this has to be understood as a teaching devise that helps the student in the process of mastering theoretical knowledge. Is is said that a graduate student is more interested in "why" rather than "how". As a result of this training the technicians must acquire a capacity to identify problems to be solved and more than anything else learn being critical.

Need for Graduate Training

Graduate training is necessary for many reasons among which the following deserve special attention:

a) Since agricultural technology is site specific, each country needs technicians with capacity not only to imitate but also to understand. Otherwise the technology generated will be irrelevant or potential progress rather small.

b) There is a large stock of knowledge that can be utilized in development of technology. Advanced training gives one access to this knowledge using a critical approach.

c) Foreign technical assistance could never be effectively used without the presence of well trained national personnel who have the capacity to absorb and adapt the experience of foreign technicians.

Some Problems of Graduate Training

Even though badly needed, the experience has shown many problems related to graduate training, Some of them are mentioned below:

High Expectation Followed by Disappointment - Developing countries, initially, have great confidence and expect too much from their first M.S. and Ph.D. holders. Since they are not able to perform miracles the result is frustration and disappointment of local authorities followed by a decrease in the financing of graduate training that, even though expensive, has a high return in the long run.

Resentement by Collegues & Occasional High Level Appointments - In many cases the institutional structure is not prepared to receive the returning technicians. The salary scale is not appropriate. Since they are few among a multitude of technicians with no graduate training they are faced with a general boycott. The graduate training curricula does not teach them how to overcome these barriers. On the other hand, at certain stages of development, returning graduates with M.S. or Ph.D. degrees without any appropriate experience or leadership training are given high administrative positions. Thus, it will be important for students from developing countries to receive, together with their specialized training, courses in leadership and how to overcome the resistance of a hostile environment.

Selection of Candidates & Training Facilities

One shoud have in mind that a large proportion of applied scientists are interested in applying knowledge rather than expanding scientific frontiers. This group should be trained in departments oriented towards application and not so vigorous in pure science. This group can also be sent for training in specialized subjects and within conventional graduate study systems where they do not need to go beyond M.S. training.

The Ph.D. candidates should be seen in a different perspective. They must have ability and interest to learn theory. They should have distinguished themselves during the first two years of undergraduate work, mainly in the basic courses. Preferably they should be younger and able to be motivated toward emphasizing theoretical types of knowledge in their studies.

There is a great discrepancy in academic programs in different countries, both at graduate and undergraduate levels. It is possible that in some cases the undergraduate program in one country corresponds to the M.S. program of another. If an undergraduate candidate comes from a developing country he may require additional time to be trained up to the standards of a developed country, before starting his graduate program. This fact tends to prolong the training period of candidates, and this situation is not usually acceptable by the authorities of developing countries. However if no especial precautions are taken, then there is a tendency for high rates of failures among students attempting to obtain a M.S. or Ph.D. degrees in developed countries. These failures create a negative impact on both the students and the organization which financed the training program.

In case of M.S. programs and non-degree specialized training, it is desirable to have this training given under ecological conditions comparable to the country of origin of trainees. For Ph.D. program this requirement is not all that important. The quality of the Ph.D. training should be the major consideration in this case.

There is a natural sequence that, as a rule, must be observed so as to facilitate a better understanding of the potential for individual technicians. candidates for graduate training.

The technicians should be hired soon after he finished undergraduate training.

He should work at least two years within a research institution. If he shows exceptional capability he should be sent to a Ph.D. program at the end of this period. Otherwise, he should be sent for an M.S. course preferably in his own country or to non-degree specialized training wherever it is available.

After finishing the M.S. training the technician should put in at least four years of work. From this group that has M.S. degree, a group will be selected to do further graduate work for Ph.D. degree.

Here, care must be taken to match capabilities of individual candidates to the requirements of the course and academic department.

The total number of Ph.D. and M.S. research technicians will depend on availability of financial resources and cultural or development stage of each country.

The Law of Large Numbers in Selection

The training of scientists can be regarded as the selection from a population of technicians, the career of researcher being offered to those selected.

The selection techniques are more efficient when the population and the sample are large.

In this respect the situation of developing countries is difficult. They have few technicians available and from this, only a small number is chosen to follow the research career. In that way there in a low propability that technicians with the best qualifications and a proper research aptitude be chosen.

That is why the selection process must be much more careful, starting with observations of potential candidates during the undergraduate studies. At the same time, the salaries should be made atractive to recruit the most gifted students.

Nevertheless, the best choice is to enlarge the population and the sample of technicians chosen for the research career. In the first stages of economic development, when this enlargement is impossible, the role of foreign technical assistance is enhanced, as well as the process of human resources development, so as to reduce the negative influence of the existing small number of technicians.

SUMMARY OF RECOMMENDATIONS AND CONCLUSIONS

The framework for staff management and human resources development discussed in this paper leads to the following recommendations and conclusions:

1. The available evidence strongly supports the inference that organized agricultural research has been one of the most profitable national and international investments.
2. Managing the staff, which is equivalent to managing the research institution, together with an appropriate human resource development program are the two major items in building research capability.
3. Flexibility must be built into every management decision.
4. Every research institution should produce some short term results.
5. To avoid obsolescence a research institution should have freedom of action to:
   a) Capture resources.
   b) Maintain a close relationship with university systems, the private sector and foreign research instituions.
   c) Formulate its research policy.
6. The responsibilities between federal and state government as far as agriculture research is concerned should be well defined.
7. The research units dedicated to particular crops and resources should be located in the appropriate production areas. However, the research work should be distributed all over the country given the fact that research results are always site specific.
8. The professional staff of an agricultural research unit must be large enough to permit intense in depth study of significant problems, application of different disciplines of knowledge, and diversity in approaches. On the basis of relevant experience a full-time staff of 30 to 100 qualified multidisciplinary professionals represent the proper size for the staff of an agricultural research unit.
9. Even though financial stability is needed so as to avoid over confidence and potential apathy, researchers should be encouraged to finance some of their projects through contracts and patent rights and use idle resources of the institution for commercial production.

10. The process of creating knowledge is a continuum that starts with identification of a problem and is not finished until the producer incorporates into his production system the technology resulting from the research.

11. A research institution should not neglect the university system where the major area of potential colaboration are: graduate training including M.S. and Ph.D., dissertations dealing with problems identified by research, use of consulting services and exchange of personnel.

12. The formation of human resources represents the major and highest paying investment of any research institution.

13. Research institutions must create an environment in which all technicians are undergoing continuous training and professional improvement.

14. The spirit of a healthy professional competition should be maintained without damage to the institutional unity and inter-institutional relationships.

15. Salary scale should mainly reflect work and achievement and not seniority.

16. Emphasis should be given to training of administrators that, in addition to some basic management principles, will include science policy and economics.

17. It must be remembered that the idea is to train an administrator and not to make the administrator a scientist trained in administration.

18. Training should also be given to the support personnel. This includes presentation of objectives of the institution as well as each research unit.

19. Research workers should be given a chance to travel inside and outside the country, participate in public debates and professional seminars and thus achieve over-all professional maturity.

20. It is very important to create "Esprit du Corp" and "Institutional Pride" and make every one feel as being an integral part of the organization and its mission.

21. In selection of candidates for graduate training the following sequence is suggested:

    a) Hire the young technicians upon graduation.
    b) Have them work for at least two years.

c) Select the most promising and send them for combined M.S./Ph.D. programs.

d) Those selected only for M.S. programs preferably should study in their native country or when possible ina country with similar ecological conditions.

e) New M.S. graduate technicians should work at least 4 years before being sent to Ph.D. programs.

22. In selecting of the country and the university and for Ph.D. training, the major consideration should be given to the quality of Ph.D. training and matching of capabilities of individual candidates with the requirements of the course. This will avoid failures and resulting individual and institutional frustrations.

23. In the early development stage, since only small populations of graduates are available for selection as research scientists, it should be made during the last two years of undergraduate training. Use of expatriates to get the institution going at the beginning may be the only form to compensate for the lack of qualified local candidates.

The three major recommendations of this paper are that the key to success of every research institution must be the involvement of the research workers in a continuous contact and dialogue with their main clients the farmers, for the creation of new technology must not be a one-way street. The objective of agricultural research is not to displace all traditional practices with new technology, rather it is to achieve a synthesis between agricultural knowledge available in the traditional method in a dialectical sence. And finally every research institution should identify the political force that will give highest support to agricultural research and adjust its program accordingly.

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MAKING EFFECTIVE USE OF EXPATRIATE PERSONNEL*

by Eliseu Roberto de Andrade Alves
Levon Yeganiantz

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MAKING EFFECTIVE USE OF EXPATRIATE PERSONNEL

Eliseu Roberto de Andrade Alves*
Levon Yeganiantz**

Existence of Knowledge & Technology Backlog

The purpose of this paper is to identify and discuss the application of principles for effective use of expatriate personnel.

The most fundamental factor conditioning structural transformation in contemporary underdeveloped countries is the existence of a large stock of proven technical innovations in the more-developed countries. The existence of this technology backlog, much of which is transferable, creates the possibility for late-developing countries to bypass the vast investment of time and resources that the accumulation of this knowledge involved.

The results of modern research in agriculture are among the greatest assets available to the developing countries today. The potential for agricultural development of such scientific innovations as the correct use of irrigation, fertilizers, and improved seeds is perhaps even greater in these countries than in the more advanced ones, since most of them are located in tropical or subtropical regions, where climatic conditions are especially suitable for the use of biological and chemical techniques designed to increase production.

As developing countries try to increase their agricultural productivity today, they benefit from the availability of existing agricultural technology. Advances that have taken years of research and development, and a sizable investment by one nation or research center, are available for potential use and adaptation. Still, today only the skills that have been developed in the expansion of temperate-country agriculture can be directly transferred to others without risk. Hence there is a need to "customize technology" to allow for the great diversity of agricultural conditions even within areas in close proximity to each other.

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Research workers have to be constantly alert to the opportunities provided by new information resulting from basic research carried out elsewhere and new technological breakthroughs. It would amount to professional negligence not to take advantage of every step forward made in agricultural knowledge in any part of world. As a result of increasing specialization usually only workers engaged in research in a given field are able to keep abreast of developments and correctly evaluate the potential importance and applicability of the results of basic research carried out elsewhere.

Difficulties of Technology Transfer

Several specific problems have limited the progress in generating the flow of innovations that is crucial to agricultural progress. Lack of continuity in research programs and failure to make research relevant to actual conditions at the farm level stand out as the two major factors that have compounded the difficulties stemming from limited financial support and lack of trained manpower. Furthermore, technical assistance programs which enable developing countries to employ expatriate scientists with broad experience and demonstrated capacity for productive research do much more then simply overcome a quantitative deficiency. Academic training of high quality is a necessary but not a sufficient condition for successful perfomance as a research worker, and effective leadership in the planning and execution of programs of research is a rare talent that is best nurtured through a "learning-by-doing" involvement in successful programs.

Although the value and need of expatriate scientists is clear, it has entailed important disadvantages. It is almost inevitable that a foreign scientist will lack a deep understanding of existing farming systems and the constraints that condition the ability and willingness of local farmers to accept innovations. In fact, the educational backgroung of many developing country agricultural scientists is such that not infrequently they also are lacking in understanding of actual conditions at the farm level.

Closely related to the foregoing problem is the lack of continuity in research personnel and programs that has so frequently had adverse effects on the results achieved. It needs to be recognized that an individual with a specialized competence can often make a notable contribution in a short period of time, provided the existing staff are able to convey their experience and understanding of problems to the new staff member and in turn profit from his special knowledge and skills. But all too often the core staff to provide that continuity and fruitful interaction has been lacking. These problems are of course exacerbated when recruitment procedures, the incentives offered, and the conditions of work fail to attract scientists of high caliber.

Ruttan and Hayami divide the technology transfer into three phases: (1) material transfer; (2) design transfer and (3) capacity transfer or institution building.[1/]

The problem of facilitating international technology transfer as an instrument of agricultural development is, therefore, how to institutionalize a system of adaptive research and development which is responsive to the opportunities of technology transfer that exist in each developing country.

This system once institutionalized will be able to use problem solving capacity and know-how existing at international level to solve local problems.

In general, as far as effective use of expatriate personnel is concerned, one must separate two major activities: the institution building and problem solving; and define these two functions and the type of foreign technicians accordingly. Greatest care should be taken not to use these two groups interchangibly.

1/ Vernon W. Ruttan and Yujiro Hayami, "Technology Transfer and Agricultural Development", Technology and Culture, 14:2, pt.1. (April 1973), 124-125.

Expatriates Institution Building Specialists

The major contribution of this group will be what Hayami and Ruttan defined as "Capacity Transfer" (1). They will build in a host country a capacity that with time will enable the production of locally adaptable technology following the prototype which exists abroad or might even create completely new prototypes together with local research technicians and supporting institutions.

They will create the capacity in their host country to select the proper plant and animal varieties and breed them locally to adapt them to local ecological conditions. They will show how to modify imported machinery designs in order to meet climatic and social requirements and factor endownments of the economy. By identifing or creating technology that economically makes sense to producers, they will create technology leading to induced innovation. By organizing research and teaching of social sciences applied to agriculture, like agricultural economics and rural sociology and by taking a stand on issues(which local technicians may avoid) these scientists through their publications in international technical literature may cause what Ruttan refers to as "institutional innovation" and identify social problems that hinder progress. They will suggest solutions creating awareness of the problems and a proper environment for social change.

This group of expatriate scientists are difficult to identify and recruit and even with much pratical experience often results in failures. The reasons for these failures are varied but among them one can mention the following:

1) Difficulty in recruiting established scientists for long periods of time and providing them with the necessary support with which they are accustomed in their own country.

2) Creating a good working relationship with local professionals. One reason is that too often the salary scale of local professionals having a similar educational level as expatriate personnel and years of local experience is significantly less. The personal relationship in this situation become rather difficult. The only solution is to have a good salary scale at least for those professionals directly working with expatriates.

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(1) Ibid.

3) The expatriate specialist with long years of experience may have to respond directly to a local executive who is poorly trained professionally and has problems communicating with expatriates.

4) A major problem is that a large number of expatriates usually come on short term assignments and are to often sucessful in proposing solutions for specfic problem without sufficient time for implementation during his term of residence.

5) The expertise gathered during short term problem solving assignments later is considered as valid in order to be selected for long term assignments that include institutional development rather than problem solving proposal formulation.

6) The recruitment of long term expatriate personnel should be based on completely different criteria as comparaed to the problem solving specialist.

Certain professional qualification and other criteria to be considered in the selection of institutional builders, are:

1) Ability to get along and work under unfavorable working conditions. This could be supported by certain experience like military service, working odd jobs (when going to school) and peace corp type of experience, etc.

2) Ability to learn languages. This could be judged by grades in his native tongue during college and the supplementary skills acquired.

3) Athletic record like group sports could be indicative of his ability to work with various types of professionals in a team.

4) Family situation including the wife's attitude and interest should also be considered.

5) In certain cases religions preference and country of origin may also have to be taken into consideration.

In addition, some positive characteristics & attitudes for institution builders are:

1) He should give high priority to activities that strengthen the technical and institutional capacity essential for institution

building of research and related systems.

2) The work should include giving some formal or informal in-service training to his local colleagues as part of his regular activities.

3) His major goal should be creating and adapting of new technology as a way to develop appropriate methodology and capacity needed to produce this technology.

4) In seeking solutions for agricultural problems he should dedicate his efforts to strengthening the research institution so as to build problem solving capacity as opposed to dedicating all his efforts to finding the optimum solution for a particular problem.

5) He will try to use local resources whenever possible as opposed to imported ones.

6) Finally, and more important, he will have to be able to "build" research programs on a national or regional scale. By organizing new research programs within the existing framework he will build a permanent capacity to do problem solving research that will remain and be self perpetuating long after he leaves the institutions.

It is highly desirable that his contract be long term so that he can become completely involved with the problems of the country that he is serving. Therefore it must be established from the beginning that his responsibility and obligations are with the country that he is serving and not with the agency that pays his salary.

This type of specialist, when found in the areas of research administration, should have working experience in an ongoing research institution. He should be proficient in research planning and budgeting human resources improvement and training, program organization, project evaluation and in understanding the mechanisms for the transfer of technology.

The specialist in experimental field station development can also be included here. He must be able to design, budget and construct the buildings and plant required in an experimental station as well as plan and develop the field sites with irrigation and drainage in an efficient manner and train personnel to run the experimental station.

In both cases it is also important that the expatriate personnel take the responsibility of on-going projects and not simply act as an adviser. In addition he should understand that he must train people who later on will replace him.

It is advisable that the national institution who employs the expatriate personnel helps them to feel that they are welcome and useful. They should be part of all meetings, field days, etc., including social events. By clearly specifying what is expected of them and then giving them complete freedom to work the necessary relationship can be achieved. On the other hand, expatriate personnel who come only as advisors and refuse to get involved should be immediately disposed of because they will adversely influence the entire institution.

Expatriate Problem Solvers

Most agricultural research should be highly applied and developmental. The success of this research depends on its close association with the problems it is expected to solve.

The best way to utilize advanced skills of various specialists available for short-term consultancy is first to have local technicians with administrators define a specific research problem. Review the approach and study solutions used in other countries and identify professional who have made important contributions.Then contact, via various technical organizations a particular institution asking for a specific research worker or a suggested substitute. Even though this looks complicated, giving proper emphasis to selection of expatriate personnel and using information systems on research in progress, the proper man for every job can be identified. When a country does not have its own research workers who can follow the work of colleagues in other parts of the world, it can: 1) Define the problem and ask a specialized agency to find a proper specialist; 2) Call a specialist team to define research problems and formulate proper job descriptions for specialized technicians or prepare lists of potential candidates.

Knowledge has no organizational or national bounderies. Given the international character of science, the criteria of selection of problem oriented research personnel should be based on professional qualifications. Host country scientists working in their country or outside should be considered together with foreign nationals. Multinational teams should be encouraged. Professional experience and publicationscould be used as major criteria. In case of younger professionals, degrees university and academic records should be used in the selection process.

The so called "foreign", "overseas" or "international" experience should not be given higher importance than experience in native countries unless it is directly applicable to the problems under consideration. This is due do the fact that what is foreign experience for one technician will be local experience for another.

The selection should not be limited to a rather small group of well established and internationally traveled scientists often available for "short term assignments".

Some expatriate technicians can be selected from the larger population of scientists who may not have the experience, know-how and curriculum vitae of the established professional elite. Out of this larger group a selection could be made among those who show high potential by their academic records including thesis or dissertation work. This group will usually show higher motivation and a greater willingness to work than the already established internationally experienced group.

The work of expatriate scientists should be done on the basis of cooperation and partnership. The visiting scientists will not be working "for" the host institution and their scientists, rather he will be working "with" them. This concept of assistance is in part due to the recognition of the mutual benefits of joint efforts.

Any publication resulting from the work of a visiting scientist preferably should be a joint publication with his host country collaborators. This will avoid a misconception that visiting scientists mainly want to collect data and information so as to be able to make a contribution to professional literature. In some cases it may be preferable to have him sign an agreement not to use data and information gathered during a given period of time unless authorized by host authorities. This will aid the scientist in concentrating on finding solutions rather than collecting interesting data for professional work.

Sometimes it will be necessary for the host institution to protect the visiting scientists from his own sponsoring institution, if any, in terms of report writing that may not be of interest to the host country as well

as other administrative requirements that may take a considerable amount of his available time. It should also do everything possible to help him with local formalities and see that a major part of his time initially is not spent finding lodging, dealing with customs formalities, purchasing an automobile, transfering money, getting a local driving license, etc.

The potential lanaguage difficulties should be taken into consideration during the planning process. In this regard it is suggested that:

a) In case of a long term assigment, giving too much weight to the knowledge of a given language may lead to the wrong choice in terms of professional qualifications. If knowledge of language is essential either host or sponsoring institution should provide the best available training during the initial part of the assignment.

b) In case of short term assignments it is best that the host country working colleagues be able to speak the language of the expatriate technician or the host should provide a translator when needed. Otherwise the entire effort may be a failure due to communication problems. If the nature of the assignment creates a need for review of local literature this literature should be collected early and put at the disposal of the scientist upon arrival. It should not be restricted to a few reports written by other expatriates on short term assignment. The work of national scientists should be given priority.

The interviews and the other contacts of short term consultants should not concentrate on foreign trained and foreign language speaking high level authorities and university professors but rather on "short sleeve" technicians and active research workers. As a question of principle, even though operationally not needed, a certain number of farm visits or visits to markets, cooperatives or other agricultural institutions should be included in the program to give a visiting scientist a certain contact with the reality of the agricultural sector.

Concluding Remarks

In general we can classify the expatriate personnel into two broad categories:

a) Institutional building specialists;

b) Problem solving specialists.

Greatest care should be taken not to use these two group interchangibly.

It would be a mistake to conclude that foreign expertise should only be limited to trouble shooting of already identified and defined research problems. There are expatriate personnel who, given the shortage of local trained technicians, can be pioneers of new developments, and institution building. They can be thinking ahead of farmers and planners and speareading agricultural progress in any part of the world.

The institution should be understood as a group of people united for a purpose within an organization containing the necessary physical infrastructure needed to carry out this purpose. It is assumed that the institution fulfills certain basic needs of individuals and the society.

The comprehensive aims and scope of the agricultural research institution building concept naturally increases its visibility and the interest taken in it by politicians and numerous constituencies.

Once institutional mechanisms are established to transfer, adapt and create agricultural technology, farmers in developing countries will be able to increase their productivity at a relatively minimal cost and at much faster rates than farmers in countries that had to cope first with the problems of the new technologies.

In the case of the problem solving specialist, the situation is somewhat easier because normally it is a short term contract to solve a specific problem. What is important here is the degree of competence of the individual in relationship with the problem.

EMBRAPA
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(ANNEX)

EMBRAPA - THE BRAZILIAN PUBLIC ENTERPRISE FOR AGRICULTURAL RESEARCH

Brasília, DF - 1980

EMBRAPA- The Brazilian Public Enterprise for Agricultural Research

Background

The development of agricultural research services in Brazil has gone through three periods. The first period ran from the late 19th Century up to the mid-1940s. During this period plantation agriculture was at its peak, even though there was no defined agricultural policy to provide clear research objectives at the federal level. Efforts were largely confined to the major export crops such as coffee, cacao and sugar, and emphasis was clearly on expanding the agricultural frontiers rather than increasing production per unit area. This period ended as industrialization began to play an important role in economic policy. The second period went from the mid-1950s to the mid-1960s when economic expansion of the industrial base was a clear prerrogative and allocation of resources, away from agriculture, resulted in less support for this sector, particularly its research institutions. With the gradual withdrawal of support from various institutions, at both the federal and state levels, several of them went out of existence entirely and research activity of others was severely curtailed. 1/

The third period, which began in the early 1960s and continues to the present, is characterized by a broader understanding of the role of agriculture in economic development. It has been recognized that expansion of the agricultural frontier alone cannot continue to meet demands from both domestic and foreign markets and that higher productivity per unit area must be part of agricultural policy and goals in the future. In 1962, the Ministry of Agriculture was reorganized and rural universities became autonomous. As a result, agricultural education and research were no longer subordinate to a single administration. The old National Center for Research and Agricultural Education (CNEPA) was disbanded and its research function taken over by the Department of Agricultural Research and Experimentation (DPEA). In 1970, tree more institutes were added and the Department moved from Rio to Brazilia. In 1971 it became the National Department for Agricultural Research (DNPEA). This Department had six divisions and nine regional research institutes. 2/

Establishment of EMBRAPA

In 1972, a goverment group was formed to study agricultural policy and propose institutional reforms, and, as a result of its recommendations, the "Empresa Brasileira de Pesquisa Agropecuária" - EMBRAPA, was organized late that same year. It started operations on April 26, 1973.

EMBRAPA is a public sector corporation attached to the Ministry of Agriculture, with financial and administrative autonomy. Its statutes are contained in the Law No. 5 851 of December 7, 1972, which outlines the agency's main functions as follows: (a) to direct, control and execute agricultural research activites for the purpose of producing new

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1/ ALVES, E.R.A., Cronology of Agricultural Research in Brasil at the Federal Level. Brasilia, DF. EMBRAPA, 1974, mimeographed, pp. A-B

2/ Ibid.

technology for the development of national agricultural production; (b) assist the federal executive branch, and its entities, in technical and administrative matters related to the agricultural sector; (c) stimulate and promote the decentralization of research activities to the benefit of state and local interests; (d) provide tecnical coordination of research projects, the execution of which involves the technical-administrative services of other federal agencies, (e) maintain close contact and coordination with the Brazilian Technical Assistance and Rural Extension Corporation (EMBRATER) to effectivelv execute diffusion of research results and technology, and (f) plan, program and budget research activities to reflect the guidelines and policies established by the National Commission for Agricultural Research, Technical Assistance and Rural Extension (COMPATER).

Basically, EMBRAPA's research program aims at implementing government policies as to the development of technology to increase agricultural production and productivity, and per capita income of farmers. This means the expansion of domestic food supply, the increase of commodities exports and therefore the betterment of rural populations. EMBRAPA not only carries out research necessary to fulfill its mandate, but is responsible for coordinating the overall national agricultural research program which involves many public and private sector institutions outside of EMBRAPA.

Based on experience in the 1970s, specific research areas have been identified by EMBRAPA for special attention in the 1980s. These are: evaluation and improved management of natural resources (soils, frontier areas; integrated control of agricultural pests, diseases and weeds; crop and animal improvement; phosphorus as a critical basic nutrients; biological fixation of nitrogen; micronutrients, crops for production of alcohol and fuel oil; agro-industry tecnology; irrigation; rural administration; social sciences; animal health; and conservation of natural resources.

Organization

EMBRAPA, headquartered in Brasilia, is headed by a Board of Directors consisting of the President and three Executive Directors. The officies of the headquarters consist of: the Presidency, the Technical and Administrative Advisory Office (ATA), the Advisory Office for International Cooperation (ACI), and the Legal Advisory Office (AJU). There are nine departments at headquarters:

- Department of Planning Methodology - DDM
- Department of Special Projects - DPE
- Department of Science and Tecnology - DTC
- Department of Diffusion of Tecnology
- Department of Information and Documentation - DID
- Department of Human Resources - DRH
- Department of Quantitative Methods - DMQ
- Department of Finance - DFN
- Department of General Administration - DPA

Research Station Network

EMBRAPA has 11 national commodity-oriented research centers that search for new concepts, planting materials and technologies, aiming at agricultural production systems for a limited number of high priority commodities, for the domestic food and foreign markets. These centers are as follows:

- National Center for Cotton Research at Campina Grande, Paraiba
- National Center for Rice and Beans Research at Goiânia, Goiás
- National Center for Sheep and Goats Research at Sobral, Ceará
- National Center for Beef Cattle Research at Campo Grande, Mato Groso do Sul
- National Center for Dairy Cattle Research at Coronel Pacheco, Minas Gerais
- National Center for Cassava and Fruit Research at Cruz das Almas, Bahia
- National Center for Maize and Sorghum Research at Sete Lagoas, Minas Gerais
- National Center for Rubber Research at Manaus, Amazonas
- National Center for Soybeans Research at Londrina, Paraná
- National Center for Swine and poultry Research at Concordia, Sta. Catarina
- National Center for Wheat Research at Passo Fundo, Rio Grande do Sul.

There are four regional research centers:

- Center of Research for Cerrados, at Planaltina, Brasília, D.F.
- Center of Research for the Semi-Arid Tropics, at Petrolina, Pernambuco
- Center of Research for the Humid Tropics, at Belém, Pará
- The Regional Unit for Forestry Research in the Central-South, at Colombo, Paraná (URPFCS).

The first three centers survey and evaluate natural, economic and social resources over specific ecological regions, in order to improve actual farming systems and develop new and better ones. URPFCS operates under the National Program for Forestry Research. It aims at increasing fields of forest tree crop species, improving the quality of forest products and rational utilization of native forests.

State and territory agricultural experiment stations are run directly by EMBRAPA. They test planting materials and tecnologies developed by the National and or Regional Centers under local conditions. The state stations are referred to as UEPAEs and the correspondingly ones territories are UEPATs. Currently there are 16 UEPAEs and 1 UEPAT.

EMBRAPA also has four centers or services that support or supplement the overall research system. They are:

- CENARGEN: National Center of Genetic Resources
- CTAA: National Center for Food Technology
- SNLCS: National Service of Soil Surveying and Conservation
- SPSB: Service for the Production of Basic Seed

State departments of agriculture have their own research programs that are operated through state companies (corporations). These state systems chiefly carry out on-farm research, testing and adapting to local conditions results and planting materials emanating from the national research centers. There are now 11 state research companies. There are also integrated research programs in the state of São Paulo, Paraná and Rio Grande do Sul.

Interactions With Other Agricultural Services

EMBRAPA considers research as a continuum that starts in a research project seeking and answer to an agricultural problem that originates with a farmer and ends with the farmer, when he puts into practice the results of research in order to increase his productivity and income. Thus EMBRAPA deems it essential that all useful research results be made available to and used by farmers. To this end EMBRAPA must work closely with a number of other organizations that also are concerned with accelerated agricultural development 1/. Included are organizations concerned with extension, inputs, credit, marketing, and area development, and nationalcommodity-oriented production projects.

Extension

EMBRAPA works closely with the Brazilian Corporation for Technical Assistance and Extension (EMBRATER) both at the national and state levels. The National Commission of Agricultural Research and Technical Assistance (COMPATER)has been set up as the coordinating link between EMBRATER and EMBRAPA, and is responsible at the federel level for sinchronizing, reviewing and coordinating the programs of both agencies.

Improved agricultural production systems are a major instrument for facilitating cooperation between EMBRAPA and EMBRATER. The farming systems program forms one of the major direct links in the system of dissemination of information obtained at the research level. Indeed most of the projects carried out under the program have research and extension staff inputs, with the former usually from National Commodity Centers involved, the local research station at the state level (UEPAE) or, on occasion, both will participate in the experimental layout preparation and publications of the results in a technical bulletin, or informative brochure, describing production methods used and results which may be attained under the particular farming system. The main objective of the program is to speed up adoption of new technology at the farm level, and to keep production pratices as current as possible with research results.

EMBRAPA also has extension type programs with producers and various grower's organizations; integrated programs, in São Paulo, Rio Grande do Sul and Paraná States; and multi-institucional programs and projects, such as The National Alcohol Program, National Program of Forestry Research, National Project of Agrometeorology, National Research Program in Animal Health, National Program of Soil Conservation, Integrated Project for the Control of Pastures Spittle Bugs, and Research Project in Drying and Storage.

EMBRAPA, through its Basic Seed Production Service (SPSB), is closely associated with both public and private sector components of the national seed program. Furthermore, its researchers have a direct role in the development of new varieties of all the crops covered by EMBRAPA.

Other National Institutions

In the annual exercises leading to the National Agricultural Research Program (PRONAPA), EMBRAPA involves participants from integrated rural development programs, universities, agricultural credit organizations, private enterprise and other interested entities.

1/ Relatório Anual EMBRAPA 1979

International Links

In the field of international technical and scientific cooperation, EMBRAPA has developed various multilateral and bilateral programs. Among multilateral programs, the activities carried out in cooperation with the Interamerican Institute for Agricultural Science (IICA); United Nations Food and Agricultural Organization(FAO); Internacional Center for the Improvement of Maize and Wheat (CIMMYT, México); International Tropical Agriculture Centers (CIAT, Colombia, and IITA, Nigeria); International Rice Research Institute (IRRI, Philippines); and the International Potato Center (CIP, Peru) are noteworthy. Bilateral cooperation includes agreements with the Federal Republic of Germany, the United States, Japan, and Canada. Other agreements are being prepared with France, Australia, The Netherlands, Great Britain, and Israel. EMBRAPA also gives technical assistance in soil analysis to Guinea Bissau and Cape Verde.

STAFF

In 1980, EMBRAPA had a staff of 7.436 of which 1.530 were researchers and 5.906 were administrative and auxiliary personnel. The staff of the National Agricultural Research System included 14.178 persons, of which 2.808 were researchers and 11.370 were auxiliary and administrative personnel.

Of the total of the 2.808 researchers 66,1% equivalent to 1.856, had since 1974 started graduate courses in both master and Ph.D programs at universities in Brazil and abroad. From this total of 1.856 researchers 54,8%,equivalent to 1.017, have already returned as of august 1980; 481 are still working on their graduate programs, the other 245, or 13,2%, droped the graduate work or after graduation left EMBRAPA.

Budget

One of the measures of the importance that a country gives to agricultural research is the investment made in this activity. Brazil has decided to invest more heavily in agricultural science and research, thus duly acknowledging the vital role played by the deepening of know-how for boosting agriculture productivity. As an instrument of this policy, the Brazilian Enterprise for Agricultural Research (EMBRAPA), which was created in 1973, had in 1974 a budget of 25 million (United States currency exchange rate of December 1974)[1/] and for the year 1980 the budget allocated for the institution amounted to 176 million dollars (exchange rate of US$ 1.00 = Cr$ 46,00).

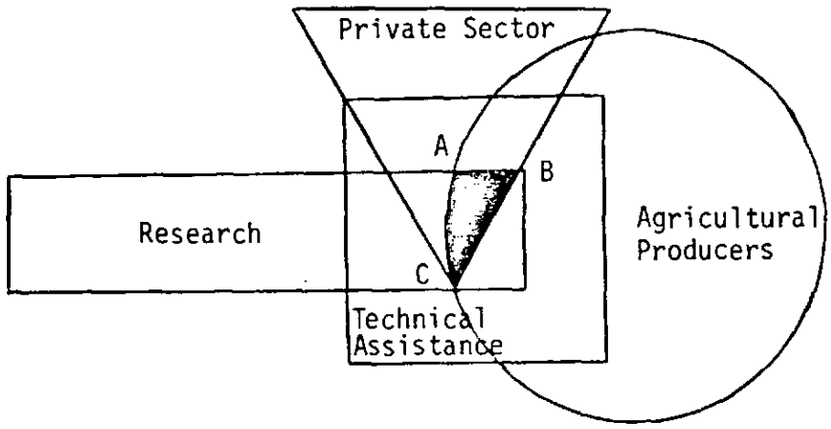
1/ PASTORE, J. & ALVES, E.R.A. Reforming the Brazilian Agricultural Research System, In ARNDT, T.M., DALRYMPLE, D.G. & RUTTAN, V.W. Resource Allocation and Productivity in National and International Agricultural Research. Minneapolis, University of Minnesota Press, 1977. 617p.

The Circular Model of Research

The programming of agricultural research has as its objective the promotion of a better allocation of human and material resources in such a way that permits the generation of knowledge and production systems able to improve the yield, shortening the time between the generation of knowledge and its utilization by the agricultural producers, as well as to increase the generation of knowledge.

To be able to develop an objective programming model of agricultural research it is absolutely necessary to involve the agricultural researchers with all those sectors that in one way or another participate in the production process, such as: (1) agricultural producers, (2) extension service and (3) modern agricultural inputs and processing industries. This process constitute the logic of the so called circular model. The integraction between various sectors and their common interest should constitute the high priority core of agricultural research program.

MODEL OF ARTICULATION FOR RESEARCH PLANNING

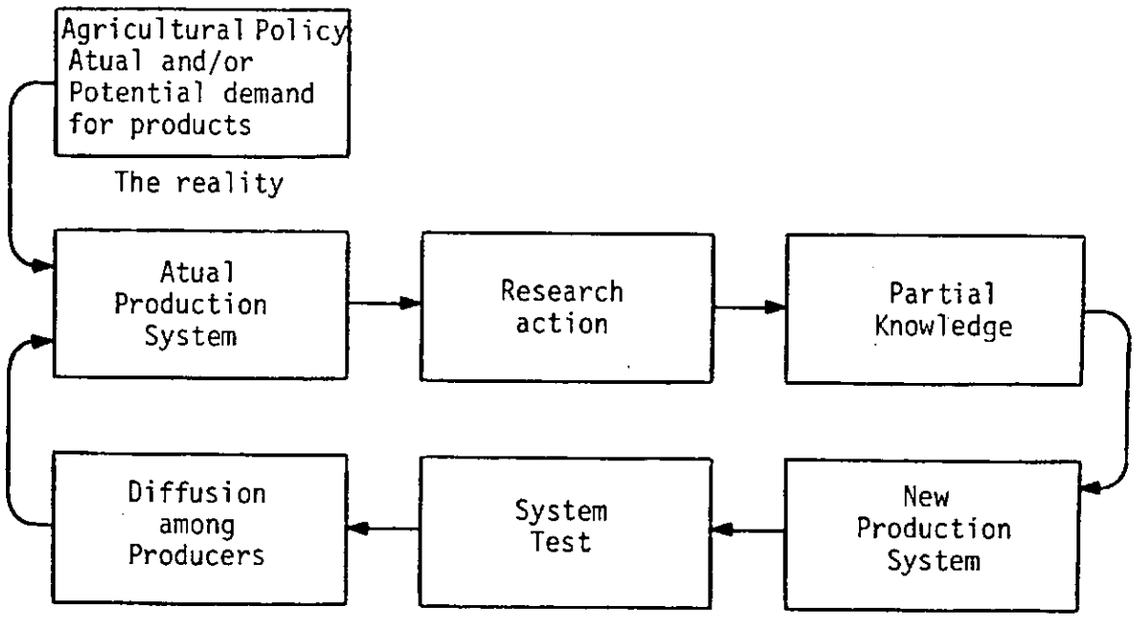


The circular programming of research is based on production systems that traditionally have been used. Its identification and description will show clearly the bottle necks that impede the increase of the yields of these traditional production systems. The elimination of these bottle necks will generate new production systems.

In the above methodology we can see a process of synthesis-analysis-action of research and synthesis, which is better called circular programming of research according to RAMALHO 1/. In the following graph this idea is better explained.

This circular system is characterized by a strong feedback mechanism while in the linear system this mechanism is absent.

CIRCULAR MODEL OF PROGRAMMING OF RESEARCH



1/ RAMALHO, J.P. Considerações sobre a programação da pesquisa agropecuária. Brasilia, D.F., EMBRAPA, 1979.

Taking into consideration the two former models of articulation and circular programming and in accordence with the priorities already fixed by Minister of Agriculture, the Board of Directors of EMBRAPA decide which programs should be accepted as major objectives of the system.

Once the Board of Directors has decided on the National Programs, they will assign the coordination of each individual national program to the appropriate centers of research generally depending on the agricultural product being studied. The national coordinator of each program will then call a meeting of all the centers involved with the specific Research Program and out of these meetings will come the plan for the research projects.

The research programs are executed by EMBRAPA through a network of national and regional research centers, and state and territorial experiment station.

At the present time EMBRAPA has 38 national programs of research on rice, beans, corn, wheat, soybeans, beef cattle, dairy cattle, horticulture, cassava, sheep and goats, swine and poutry, sorghum, cotton, rubber, temperate climate fruit production, citric production, pineapple , banana, mango, wine production, african palm, industrial agriculture, and food technology, genetic resources, soils and basic seed production. Evaluation and improved management and socio-economics studies of cerrado, semi-arid tropics and humid tropics. Forestry, ienergy, fuels, and of agricultural diversification are also included.