EFFECTS OF RESEARCH AND EXTENSION ON AGRICULTURAL GROWTH AND EQUITY IN BRAZIL

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Since the 1950s, much research effort has been devoted to identifying and measuring the contribution of technical progress to agricultural growth. More recently, attention has also been focussed on the distributional impacts of technological change in agriculture. As a reflection of this worldwide tendency, reinforced by the problems faced by the economy in recent years, research and extension resource allocation began to generate increasing interest in Brazil. This paper contributes to this research. Specifically, the effects of investment in research and extension on total agricultural production and on production of individual crops will be studied. Some distributional effects will be briefly discussed. Due to the lack of data, the first part of the analysis will be restricted to the State of São Paulo, and the second part will cover the entire country.

Aggregate Productivity in Agriculture: Sao Paulo, 1956-1980

The total factor productivity approach was selected for this analysis. Total factor productivity is a measure of the shift in a production function, which would be impossible to measure with partial productivity measures (yield, output per unit of labour, etc.). Total factor productivity implies an aggregate index of total output per unit of total input, the formulae of the individual indexes used being of extreme importance. As stressed by Evenson and Jha, an appropriate productivity measure is obtained from chain linked weighted indexes of outputs and inputs.

For this study, chain linked Fisher's indexes were constructed. The aggregate output index includes 22 vegetable and animal products and the input index aggregates land, labour, draught power, tractors, fertilizers, perennial crops, pastures, and cattle. The average annual growth rates of these indexes and of the resulting total factor productivity index are reported in table 1. To mitigate the effects of weather fluctuations, these rates were calculated using 3-year averages of the indexes.

Table 1. Average Annual Growth Rates

Period	1956-1958 to 1967-1969	1967-1969 to 1978-1980	1956-1958 to 1978-1980
Aggregate output	2.7	3.7	3.2
Aggregate input	0.7	1.0	0.8
Total factor productivity	2.0	2.7	2.4

It is interesting to compare these numbers with those of other regions. The total factor productivity increase of 2.7 percent per year in the period 1967-1969 to 1978-1980 is superior to the performance presented by the developed countries of the European Community during the period 1967-1976, calculated by Behrens and Haen. On the other hand, with respect to developing countries, the productivity gains achieved in São Paulo can be favourably compared to those of many Indian states, but are inferior to the performance of the most dynamic states of that country during the period 1963-1965 to 1969-1971, according to the calculations of Evenson and Jha.

Now, let us turn to the determinants of the total factor productivity increases reported. It was postulated that our conventional (not adjusted for factor quality changes) productivity measure (TFP) is the result of the effects of current and especially past public investments in research (R) and in extension (E) activities. The effects of weather conditions, namely frost in the previous year (F) and water deficiency (H), were also considered. A polynomial distributed lag structure was used to take into account the time spent in the generation of new techniques and their adoption by the producers. Restrictions were imposed on the values of the polynomials, due to the expected effects of research and extension on technological change and productivity behaviour. So, in the model formalized below, $\alpha_r = 0$ if $r = 0$ and $\beta_r = 0$ if $r = 1$.

$$TFP = \sum_{r=0}^{k} \alpha r \; R_{t-r} + \sum_{r=0}^{1} \beta r \; E_{t-r} + \gamma F + \delta H$$

Only the more reasonable results and the best estimates in terms of statistical quality are presented in table 2. In all the equations, the coefficients of research investment, frost, and water deficiency have the expected signs, and the "t" test indicates that they are significant at the 1 to 2 percent level of probability. The coefficients of extension expenditures also have consistent signs, but they are not significantly different from zero at any level of probability. The coefficient of determination is about 85 percent. However, these results must be considered with some care, for multicollinearity between research and extension seems to be in force, which may be preventing a better estimation of the equations.

Table 2. Regression Results[1]

Variable/Statistic	15 years	20 years
Research[2]	0.3306	0.4435
	(3.5989)	(3.8573)
Extension[2]	0.0108	0.0125
	(0.4185)	(0.5210)
Frost	-11.3553	-11.6006
	(-2.6312)	(-2.6988)
Water deficiency	-0.1471	-0.1462
	(-3.2208)	(-3.2388)
Constant	119.799	109.983
	(11.8208)	(10.0634)
R^2	0.8530	0.8598
DW	2.2703	2.2648

[1]Equations estimated using the Cochrane-Orcutt technique with observations from 1956 to 1980; "t" values in parentheses.

[2]Sum of lag coefficients.

What are the economic implications of these estimates? The marginal contribution of research to agricultural productivity would be Cr$75 to Cr$101 per additional invested cruzeiro. Let us compare our findings with those obtained for other countries. The marginal product of research estimated for São Paulo is about double that calculated for agriculture by Evenson--US$40 per additional dollar. Such magnitudes and discrepancy suggest some comments. First, it is probable that both are upward biased for several reasons, but even with maximum adjustments for overestimation, the implied returns to research investments would still be very high. Secondly, it seems natural to expect higher returns in developing areas when compared with developed areas for two reasons: (1) in the latter, a greater proportion of investments is allocated to maintenance research; and (2) the former are in better position to import technology and basic scientific knowledge. The marginal product of research estimated by Evenson and Jha for Indian agriculture of approximately 9-14 rupees per additional rupee is much lower than that estimated for Sao Paulo agriculture. In this case one can think that the comparison would be quite different if only Punjab, Haryana, or Rajasthan (states of exceptional performance in India, like São Paulo in Brazil) were considered.

Turning from research to extension, our estimates suggest that extension activity has no (or negligible) effect on production. Although this conclusion cannot be considered firm due to the above mentioned multicollinearity problem, there are several reasons that could explain this unexpected finding. The education level of the labour force and of the decisionmakers has rapidly increased in the long run, and other information channels were simultaneously improved. Both factors are expected to reduce the role of public rural extension. Another force operating in the same direction is the increasing share of medium and large farms in agricultural production, for it is probable that the importance of extension decreases with farm size. Besides these factors, it should also be recalled that the nature of the extension effort has changed over time, possibly impairing its efficiency. Additionally, extension expenditures have increased much faster than research investments, which suggests an over-development of extension activities in relation to the flux of innovations generated by research. Finally, it is interesting to note that in general the returns to extension are low--in India, for example, Evenson and Jha estimated a return to extension of only one-hundredth that of research. In any event, the effect of expenditure on extension must be further investigated.

Land Productivity in Crop Production: Brazil, 1930-1979

In this section, the agricultural research effort is examined in relation to the behaviour of crop yields in the entire country. It must be recalled at this point that although yield is an imperfect indicator of technical progress, it seemed reasonable to use it in this analysis due to the lack of data for a more appropriate approach. For this reason, the investigation is restricted to the biological subprocess which together with the mechanical subprocess forms the whole agricultural production process. It must also be remembered that due to the omission of other inputs into the biological subprocess, the yield gains reflect the total effect of research, including the indirect contribution through those inputs.

To examine the research effort we will utilize a survey of the results of agricultural research in Brazil over 50 years. In that study by Silva, Fonseca, and Martin, the number of scientific publications was used as indicator, following the procedure of Evenson and Kislev. Our first finding was that the State of São Paulo accounts for about 62 percent of the total number of research publications in Brazil during the period 1927-1977. The research effort outside São Paulo became important (with a few exceptions) only in the period 1970-1977. It was only in that recent period that more than 60 percent of the

computed number of research publications were outside São Paulo. Additionally, great discrepancies in the research effort among the other regions were also detected. Another interesting finding of that same study is that the research paths were quite different in São Paulo and the other regions of the country. Although research related to export products dominated in São Paulo up to the 1950s, a greater emphasis was put on production for domestic consumption in the last two decades. An inverse trend was observed in the other regions, where the research directed to export products was intensified in the period 1970-1977. Furthermore, the changes in these research patterns are interpreted by Silva, Fonseca, and Martin as a response to emerging problems in the food sector in the case of São Paulo; and also as a response to problems arising from the recent effort to open the economy to foreign trade of agricultural commodities in the case of the rest of Brazil.

The numbers in table 3 show that export products were responsible for 45 percent of the number of research publications. They also indicate that among the domestic products, basic foods account for 28 percent while vegetables and fruit account for 16 percent. A fact not reflected in the table should be mentioned--in general the research related to export products began earlier than that oriented to domestic products.

Table 3. Number of Scientific Publications on Agricultural Research, 1927-1977

Product	Number of Publications
Exports:	2,353
Coffee	884
Sugarcane	410
Cotton	326
Oranges	261
Soybeans	236
Groundnuts	102
Cocoa	93
Castorbeans	41
Basic Domestic:	1,462
Maize	321
Rice	303
Wheat	261
Beans	259
Potatoes	232
Cassava	86
Other Domestic:	839
Vegetables	433
Fruit	406
Other:	543
Total	5,197

Source: Silva, Fonseca, and Martin, p. 208.

Now let us compare the research effort briefly described above with the yield behaviour of each selected crop in the main producer states. The numbers in tables 3 and 4 show that coffee, the product with the greatest number of publications, had high yield increases in São Paulo and Minas Gerais. In Paraná, coffee yield has also increased, but has subsequently declined apparently as a result of the cumulated effect of frequent frosts and droughts. Sugarcane occupies the second place in terms of number of publications. The technological changes that took place as a result of this research effort have provoked a continuous increase of sugarcane yield in São Paulo, Pernambuco, and other areas. It remains quite intriguing why Rio de Janeiro has not taken advantage of the new techniques. Cotton is probably the most spectacular case of success in agricultural research in Brazil. The performance of cotton yield in Sao Paulo, Parana, and other nearby states is clearly the result of objective research with herbaceous cotton, reflected in the number of scientific publications. Conversely, the states of the Northeast region of the country, where arboreal cotton is cultivated, have not received research support. For this reason, Ceará and Paraiba experienced great yield decreases. With respect to oranges, a relatively small but sustained yield gain was obtained in São Paulo, the main producer state. Nevertheless, the major contribution of research to this crop has perhaps been the creation of conditions for firm expansion of production, impaired by diseases in the past. Research on soybeans is more recent, but it has positively affected the soybean yield in the main producer states, Rio Grande do Sul, Paraná, and São Paulo. The research effort devoted to peanuts, cocoa, and castorbeans was smaller but it seems to have induced some yield gains.

Among the domestic products, the situation is quite different. As was already emphasized, basic food products have commanded a much smaller effort when compared with export products. Maize, the product of this group with the greatest number of publications, is a case of relative success. A substantial yield gain has been achieved since the 1960s in São Paulo and Paraná, a modest one in Minas Gerais, and almost none in Rio Grande do Sul. In the states of the Northeast region of the country, maize yield evolved poorly. Rice and black beans are the most important foods in Brazil. Rice is the second product in number of published articles. The major research effort devoted to rice was done in Rio Grande do Sul where the crop is irrigated, causing an impressive

Table 4. Yield Changes, 1950-1954 to 1975-1979

Crop	State[1]	Percent Change	State[1]	Percent Change	State[1]	Percent Change	State[1]	Percent Change
Coffee	SP	252	MG	251	PR	2		
Sugarcane	SP	36	PE	33	RJ	2		
Cotton	SP	286	PR	243	CE	-40	PB	-38
Oranges	SP	40	MG	-27	RJ	-14		
Soybeans[2]	RS	37	PR	48	SP	45		
Groundnuts	SP	44	PR	52				
Cocoa	BA	32						
Castorbeans	BA	-38	SP	48	PR	58		
Maize	PR	38	RS	6	MG	12	SP	49
Rice	MT	-37	GO	-44	SP	-28	RS	35
Wheat	RS	-3	PR	13	SP	3		
Beans	PR	-32	MG	-51	SP	-45	CE	-56
Potatoes	RS	38	SP	147	PR	156	MG	101
Cassava	PE	-2	BA	18	MG	-5	RS	2

[1]SP - São Paulo, MG - Minas Gerais, PR - Paraná, PE - Pernambuco, RJ - Rio de Janeiro, CE - Ceará, PB - Paraíba, BA - Bahia, MT - Mato Grosso, GO - Goiás.
[2]For soybeans, the period is 1960-1964 to 1975-1979.

yield increase. A smaller amount of research was carried out in São Paulo, where rice is not irrigated. In that state, Mato Grosso, Goiás, and practically all the rest of the country, yields have showed erratic fluctuations or decreasing trends. Except in Rio Grande do Sul, the research has been unable to modify this situation. The research related to beans is very recent, although it has produced about the same number of publications as rice. Therefore it seems natural that a yield decreasing tendency was detected in important producer states and in the entire country. Wheat, an increasingly important food, had almost the same number of publications as beans and the research effort is also recent. Nevertheless, there are records of significant results of research conducted in Rio Grande do Sul. The behaviour of wheat yield in both that state and in Paraná seems to be associated with those results, but up to now research has apparently not created the conditions for a sustained growth of that crop. Potatoes, a food of some importance in the South, is a crop with greater research tradition and has also benefited from imports of improved varieties. The behaviour of potato yield in this and other nearby states seems to be closely related to that research effort. There was little research on cassava, an important food in the Northeast, and there is no evidence of technological developments. The general long run trend of yields has been to decline.

The analysis of the impacts of the agricultural research effort on yields of the main crops in the entire country proves its potential to accelerate agricultural growth, which has been asymmetrically exploited in terms of regions and crops.

Reflection on Some Equity Implications

In the preceding sections, the contribution of agricultural research to agricultural productivity was discussed using two bodies of strong evidence. Finally, we reflect on some equity implications of the path and performance of agricultural research.

It is a well-known fact that the Brazilian economy faces very serious and increasing equity problems. According to Langoni, the average per capita income in the primary sector was about 38 percent and 35 percent of the average incomes in the secondary and tertiary sectors of the economy, respectively. There were also great differences among states; the average income in the Northeast was about a third of the average income in the State of São Paulo. With respect to the personal distribution of income, the Gini indexes indicated a worse situation in the tertiary sector (0.57) and industrial sector (0.50) when compared with the agricultural sector (0.44). In general, the distributional patterns evolved in a disfavourable way between 1960 and 1970, and one can suspect that this tendency remains the same up to now.

Technological change in agriculture can affect income distribution in a number of ways. It is widely accepted that an intensive process of technological change, making possible high productivity gains, is fundamental to the reduction of the rural-urban income disparity. It is also recognized that a faster technological advancement in developing areas, by reducing productivity gaps, would decisively contribute to the reduction of interregional income disparity. Similarly, modernization has to be spread among marginal producers in order to decrease technological duality, thus mitigating intrarural income disparity. On the other hand, an appropriate rate of technological advance in food crops is a necessary condition to avoid negative distributional effects on the low income classes of the population due to the behaviour of food prices.

Assuming those dimensions of the equity problem as the most important ones related to the process of technological change in agriculture, a relevant question emerges to be answered: What role has indeed been played by research in this respect? The possibility cannot be rejected that the research policy put into practice in the past has at least reinforced those equity problems. Further detailed investigation is needed to answer this question appropriately, but the

evidence provided in the previous section suggests that the contribution of research to mitigating income disparities could have been much larger with a more ambitious and balanced research policy.

Note

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