

THE IMPORTANCE OF IMPACT ASSESSMENT STUDIES FOR THE BRAZILIAN AGRICULTURAL RESEARCH SYSTEM¹

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1.- INTRODUCTION

During the last three decades, a large number of impact assessment studies have been developed in the world showing the contributions of agricultural research to the improvement of productivity, profitability and sustainability of the agribusiness. Brazil is one of the countries where this kind of study frequently appears, particularly at Embrapa - a government research company which is responsible for the most of the agricultural research conducted in the country (Avila & Ayres, 1987; Alston, 2000; Avila, 2001). The question that has been frequently posed regarding these studies is related to their usefulness to strengthen the agricultural research institutions and their funding.

The main objective of this paper is to present clear evidences that the development of impact assessment studies in Embrapa has been fundamental to the strengthening of this institution. These studies started in the beginning of the 80's, when profitability of the big investments made in agricultural research through Embrapa was, for the first time, demanded by the Brazilian society.

Embrapa was created in April 1973 linked to the Ministry of Agriculture. Embrapa embraced research institutes, experimental stations and existing projects of the National Agricultural Research Department (DNPEA), the former federal institution in charge of agricultural research activities.

The importance of Embrapa's role in the technological development of the agricultural sector in Brazil has been systematically shown through a diversified set of impact assessment studies developed not only by Embrapa economists but also by specialists from others Brazilian research institutions and universities, including internationally known specialists.

The development of impact assessment studies at Embrapa, undertaken with the collaboration of foreign universities and research organizations (Yale University, International Food Policy Research Institute and University of California-Davis, for example), using diversified methodological approaches, has been decisive to support the Embrapa's accountability reports and improving its public image.

During the first period of its creation (1973-79), Embrapa's board focused on areas of national priority, namely applied research, carried out by commodity and regional centers throughout the country. During this period, the funds available for Embrapa's activities increased markedly, allowing the institution to achieve important

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results and to implement a comprehensive training program. The steady show of money support to Embrapa was funded by the Brazilian government, the World Bank and IDB (Beintema, Avila & Pardey, 2001).

The amount of resources allocated to Embrapa increased from an average of US\$245 millions, during the 1976-80 period to more than US\$450 millions, during the 90's, in 1993 dollars (Beintema, Avila & Pardey, 2001). Figure 1 shows the evolution of Embrapa's expenditures during the last eight years, confirming that the institution continues to receive a strong support from the Brazilian government, despite of the economic crisis and constraints occurred in the 90's. The annual company expenditures has been relatively stable, except in 1996 where a voluntary retirement plan was enforced.

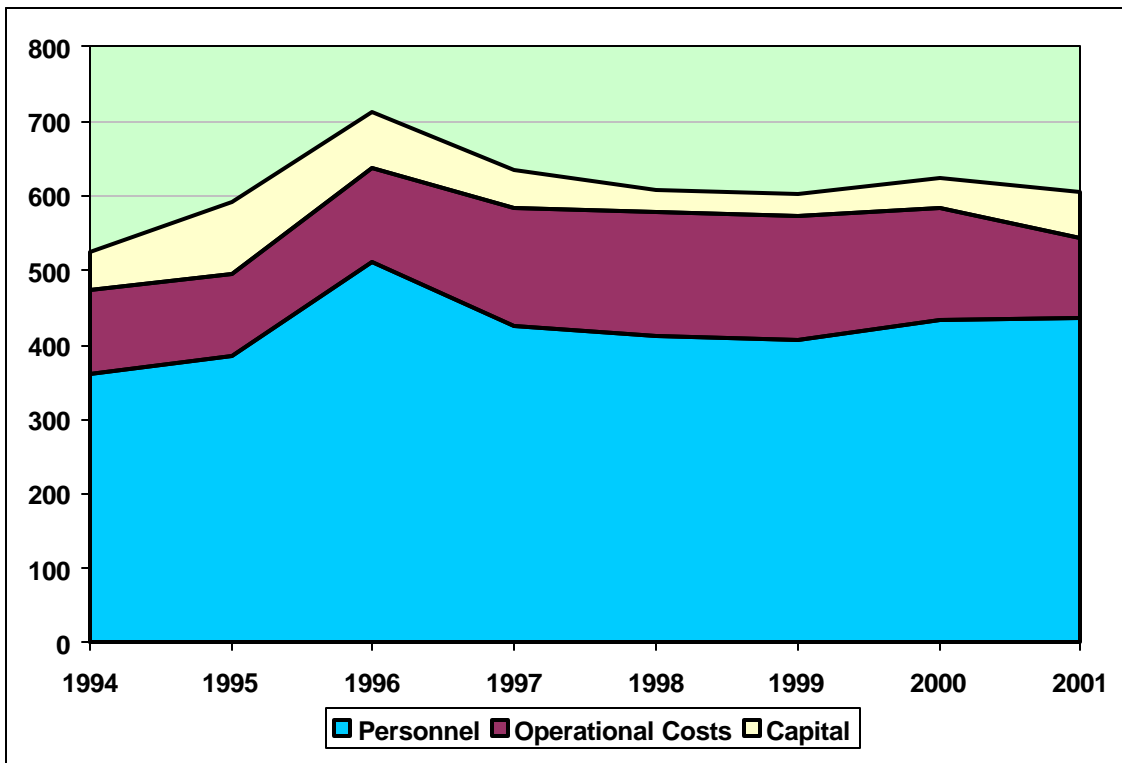


Figure 1 - Evolution of the Embrapa Expenditures: Period 1994-2002
(Source: Embrapa/DAF- December 2000 INPC Prices).

Is important to emphasize that the Brazilian government continuously invested in Embrapa allowing the institution to consolidate a modern infrastructure of agricultural research nationwide and to change the human capital profile dedicated to research activities.

The improvement in qualification of the Embrapa's research staff is shown in Figure 2. In 1974 only 17% of the researchers had MSc and PhD degrees. In less than 10 years this figure changed to 75% and, actually, this number is around 97%. In 2001 only 3% of Embrapa's staff lacked postgraduate training. This effort continues, specially in regard PhD and post-doctoral training. Embrapa supports, annually, more than 200 researchers in training programs at Brazilian universities and abroad.

Another evidence of public support to Embrapa is the fact that during the nineties, although there was a strong reduction in personnel due to budget restrictions imposed by the economic crisis (9861 to 8421), the number of researchers was maintained at practically the same number of the beginning of the decade.

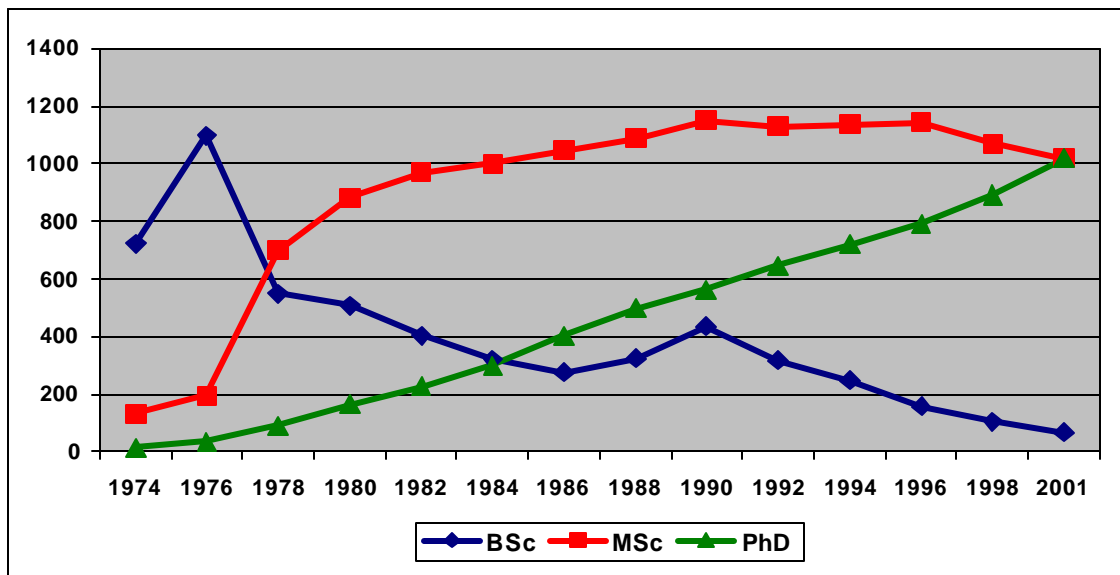


Figure 2 - Evolution of the Academic Degree of the Embrapa Researchers Staff (Source: Embrapa/DAP).

It's important to notice here that the institution even increased the number of researchers in the middle of the 90's and actually is hiring more than 200 to renew its staff. The company is also hiring research support staff.

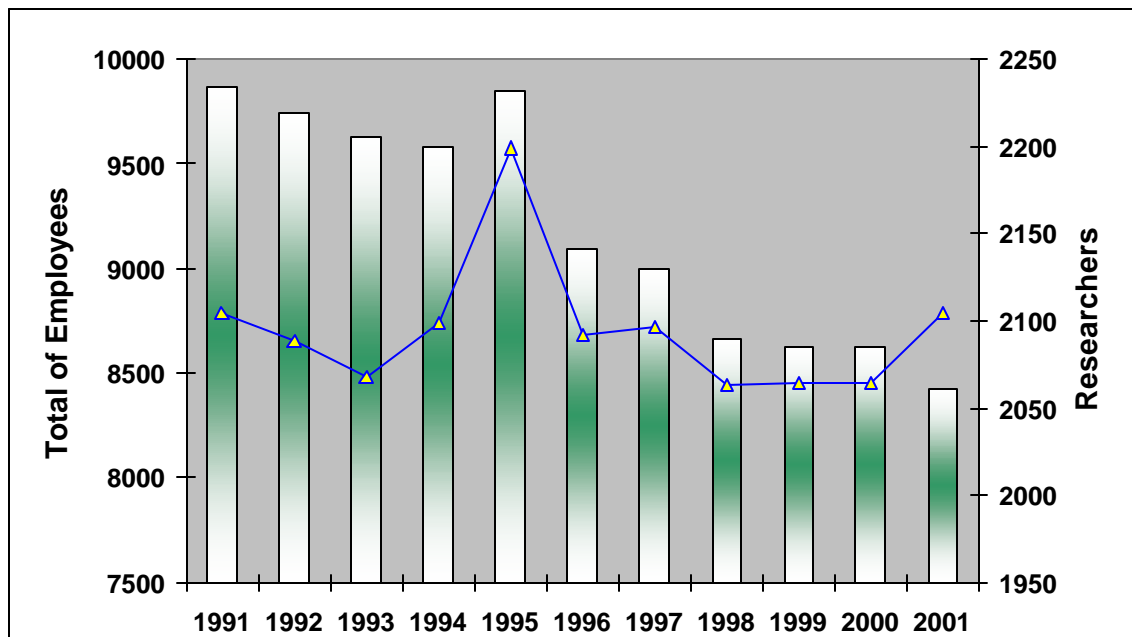


Figure 3 - Evolution of the Embrapa Research and Personnel Staff: 1991-2001 (Source: Embrapa/DAP).

Continuous public support has allowed Embrapa to maintain a well-trained research staff with competitive salaries and good conditions to develop their research activities. This context is fundamental for the institution to maintain a continuous flow of technological results that has been progressively introduced in the Brazilian agribusiness.

An example that Embrapa has maintained competitive salaries is the comparison between the actual salaries of Embrapa researchers and teachers of the University of Brasilia at the senior level. The Embrapa salaries are higher than those paid by the public universities, where the University of Brasília used as a basis (Figure 4).

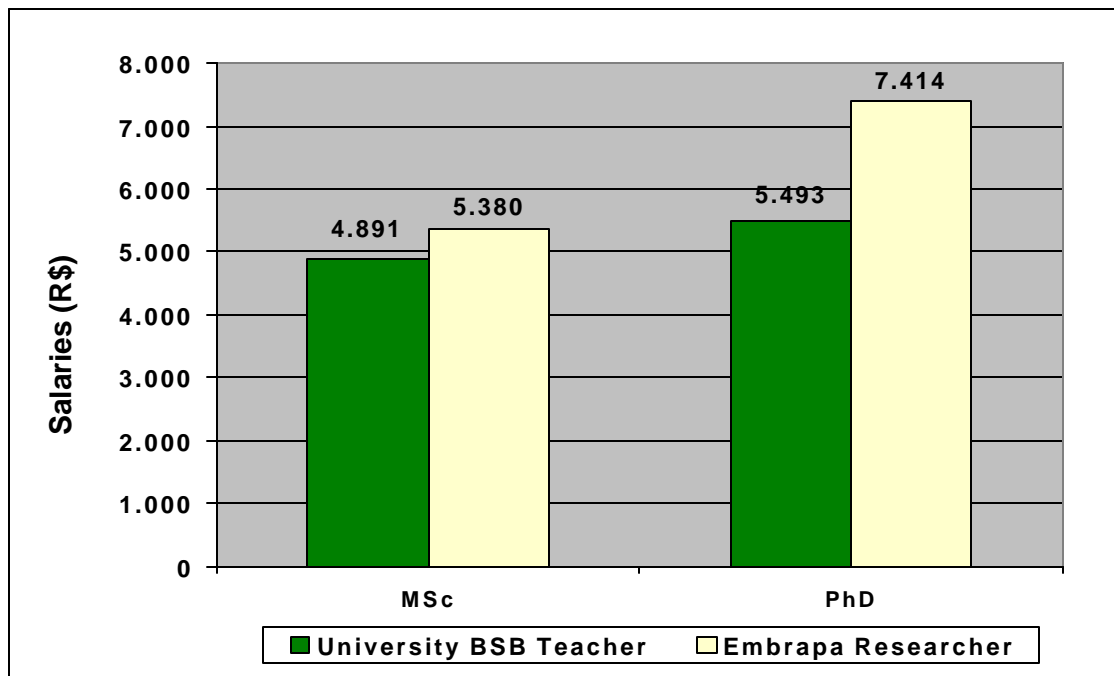


Figure 4 - Salaries comparison - University of Brasília and Embrapa: Senior level

Another evidence that Embrapa has received a differentiated support from the Government support is the growth rate of its salaries. During the period 1995/2001 the staff personnel of Embrapa received an increase of 55% in salaries, distributed annually. The inflation rate in the period was 66%. In the same period, the personnel working directly for the Federal Government received in the period, in average, less than 20%.

2.- ECONOMIC IMPACT STUDIES

After of its first ten years, when Embrapa enjoyed a generous amount of public funds supported by international loans to create its infra-structure and for training of its human capital, in the mid 1980s, the government suffered a series of financial crises. As a result of this crisis most public institutes experienced severe budget cuts to the point of threatening their ability to operate.

In this scenario, the performance of Embrapa was also beginning to be questioned since the corporation had received substantial public funding over the years, and returns on these investments to the Brazilian economy were hard to pinpoint. As a

reaction to the questioning, the institution begin a program of economic impact studies to demonstrate the benefits of investments in agricultural research. This program counted on the participation of Embrapa researchers and also experts from Brazilian and foreign universities.

The initial studies in the eighties were oriented to show that the resources from the national treasury and international loans (IDB and World Bank), invested in infrastructure and human capital in the Embrapa's research centers, indeed generated high returns. The economic studies develop during the eighties is shown in the Table 1.

Table 1 – The Experience of Embrapa on Impact Evaluation during the Eighties

Authors	Specification Area or Region	Period	IRR (%)
Cruz, Palma & Avila (1982)	EMBRAPA research: Aggregate	1974/92	22-43
Cruz & Avila (1983)	World Bank Project I	1977/82 1977/91	20 38
Avila, Borges-Andrade, Irias & Quirino(1984)	Human Capital: Training	1974/96	22-30
Roessing (1984)	Soybeans Research Center	1975/82	45-62
Ambrosi & Cruz (1984)	Wheat Research Center	1974/82	59-74
Avila, Irias & Veloso (1985)	IDB Project I: EMBRAPA research South research System	1977/96 1974/96	27 38
Barbosa, Cruz & Avila (1988)	EMBRAPA research: aggregate	1974/96	34-41
Kitamura et al. (1989)	EMBRAPA research: North Region	1974/96	24
Santos et al. (1989)	EMBRAPA research: Northeast Region	1974/96	25
Teixeira et al. (1989)	EMBRAPA research: Center-West Region	1974/96	43
Lanzer et al. (1989)	EMBRAPA research: South Region	1974/96	45
Barbosa, Avila & Motta (1988)	World Bank Project II	1982/87	43
Santos & Barros (1989)	Cotton Res. Center: Aggregate	1975/86	24-37

Source: Avila (2001).

The institution was continually demanded to show evidence that the high investments in its activities were worthwhile and new impact studies were then developed. The new studies of economic impact evaluations most developed during the 90's, in general, are a consequence of the postgraduate training program, international loans demand and isolate initiatives of Embrapa's researchers rather than an institutional nationwide effort as was the case during the eighties (Table 2).

During the 90's the number of economic impact studies developed at Embrapa was smaller than during the 80's. The theoretical basis adopted in these studies relies on methods other than the economic surplus approach (econometric methods) and results cover not only the profitability of the investments in agricultural research but the factors

affecting the adoption of Embrapa technologies and the impact of improved varieties on productivity as well.

Table 2 – The Experience of Embrapa on Impact Evaluation during the Nineties

Authors	Specification Area or Region	Period	IRR (%)
Kahn & Souza (1991)	Cassava & Fruit Research Center: cassava and cow-pea crop system	1974/90	29-46
Barbosa & Cruz (1993)	IDB Project II	1985/90	43
Dossa & Contini (1994)	Soybeans Research Center: a reevaluation	1987/93	65
Avila & Evenson (1995)	Embrapa research (TFP): national programs regional centers	1970/85	56 46
Evenson & Avila (1995)	Embrapa Grain Research: soybeans maize rice wheat	1978/92	40 58 37 40
Oliveira & Santos (1997)	Goat Research Center	1984-93	24
Vilela, Morelli & Makishima (1997)	Vegetables Research Center: carrots research	1977-96	36
Pereira & Santos (1998)	Cotton Research Center	1975/96	15
Almeida, Avila & Wetzel (2000)	Embrapa Research: soybeans varieties improvement	1980/97	69
Ambrosi (2000)	Wheat Research Center	1986/97	88-143
Almeida & Yokoyama (2001)	Embrapa Research: upland rice varieties improvement	1977/95	93-115

Source: Avila (2001)

Table 3 shows independent studies (not related of Embrapa's institutional program) on the impact assessment of agricultural research, in general, that add to Embrapa's experience (Table 3).

The first group of studies shown in the Table 3, the authors, based on Marshall's concept of economic surplus, computed the benefits of the agricultural research developed in each one of the products under evaluation. This kind of approach to evaluate the agricultural research is also known as "input-accounting", because the benefits are measured accountably, not econometrically.

A different approach for the evaluation of agricultural research impact is presented in the same table. Some authors used aggregate production functions (Silva, 1984; Pinazza, 1984; and Ayres, 1985), while others use decomposition methods (Evenson, 1982; Evenson & Cruz, 1989) to compute the benefits and evaluate the return of agricultural research investments in Brazil.

The PROCISUR's study of the economic impact evaluation of wheat, maize and soybeans research on agricultural productivity, in Table 3, includes other south Americans countries (Argentina, Uruguay, Chile, Paraguay and Bolivia). The results obtained on this regional study however can be used as a partial evaluation of the Brazilian agricultural research impact, the Brazil is considered the principal donating country in this program.

Table 3 - Brazilian Agricultural Research Evaluation: Other Ex-post Studies

Authors	Area/Region	Product	Period	IRR (%)
Ayer & Schuh (1972)	São Paulo	Cotton	1924/67	77
Monteiro (1975)	Brazil	Cocoa	1923/75	16-18
Fonseca (1976)	Brazil	Coffee	1933/95	23-26
Moricochi (1980)	São Paulo	Citrus	1933/85	28-78
Avila (1981)	Rio Grande do Sul	Rice	1959/78	87-119
Ribeiro (1982)	Minas Gerais	Rice Cotton Soybeans	1974/81	69 48 36
Monteiro (1985)	Minas Gerais & Espírito Santo	Cocoa	1958/85	61-79
Gonçalves, Souza & Rezende (1989)	São Paulo	Rice	1876/88	85-95
Cançado Júnior, Lima & Rufino (2000)	Minas Gerais	State research: EPAMIG	1874/97	32
Authors	Area/Region	Product	Period	MIRR (*)
Evenson (1982)	Brazil	Aggregated	1966/79	69
Silva (1984)	Brazil	Aggregated	1970/80	60
Pinazza et al. (1984)	Variety NA5679: São Paulo	Sugarcane	1972/82	35
Ayres (1985)	Brazil Paraná São Paulo Santa Catarina Rio Grande Sul	Soybeans	1955/83	46 51 23 31 53
Evenson & Cruz (1989a)	Brazil	Wheat Maize Soybeans	1966/88	39 30 50
Evenson & Cruz (1989b)	PROCISUR Region	Wheat Maize Soybeans	1969/88	110 191 179
Evenson (1990a)	Brazil	Field Crops	1970/75/80	41-141
Evenson (1990b)	Brazil: Center-South	Field Crops Perennial Crops	1970/75/80	68-75 71-78

(*) - Marginal internal rate of return (%).

Finally, it's important to notice the set of impact studies developed by Embrapa researchers with the Economic Growth Center team, from the Yale University, using the productivity decomposition method, based on agricultural census data. These studies, initially covered the Census years 1970, 1975 and 1980 (Evenson 1990a,b). Later these studies were updated in the context of a collaboration effort between the institutions during the nineties showed in Table 2 (Avila & Evenson, 1995; Evenson & Avila, 1995).

The values of the rates of return reported in Tables 1-3, estimated in each one of these 53 Brazilian agricultural research impact studies (excluding Procisur), indicated a very high profitability of the investments in agricultural research activities in Brazil. In general, in the economic impact literature, a real internal rate of return over 25 or 30 percent would be considered an excellent return on investment, a limit that is inferior to almost all evaluations reported in the Brazilian studies. Median rates of return are shown in Figure 5 for various world regions, including Brazil.

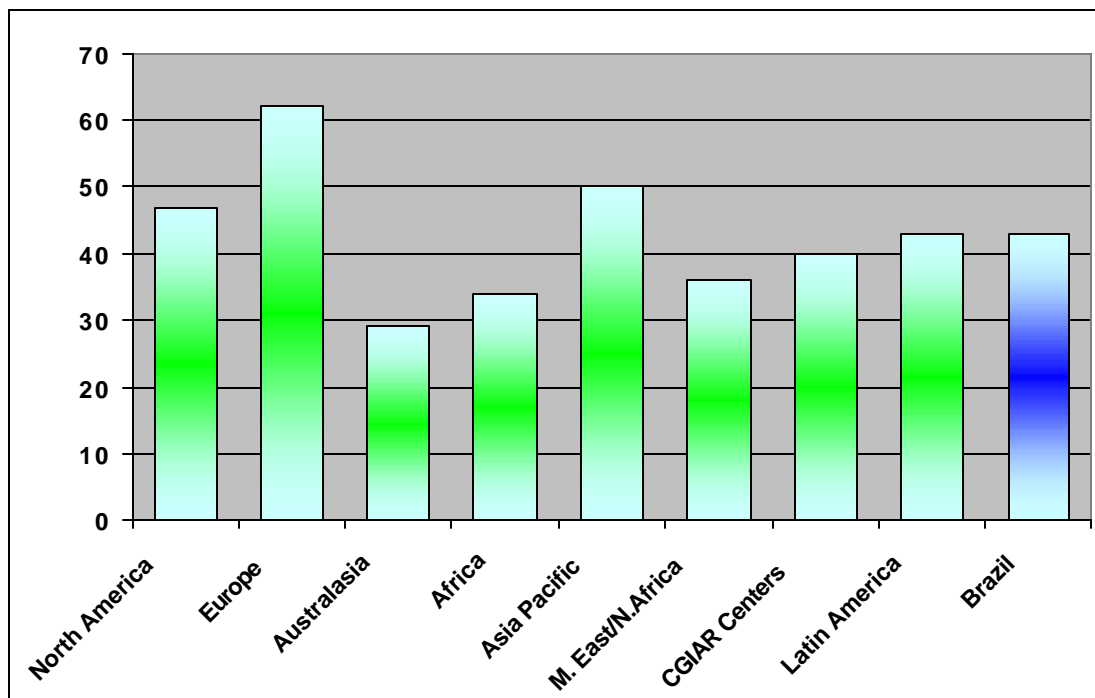


Figure 5 - Median Rates of Return on Agricultural Research and Extension by World Regions (Source: World regions - World Bank, 2001; Brazil - Avila, 2001).

3.- ECONOMIC EFFICIENCY STUDIES

Another Embrapa's policy that is making a difference in public support is the adoption of an integrated evaluation and award system based on results (Portugal et al., 1999). All research centers have been evaluated annually, since 1996, based on a set of performance indexes measures of economic efficiency, accomplishment of goals, research funding grants concessions, institutional image, technological impact and productivity. The best teams and employees are annually awarded. As this award is not incorporated to salary and it varies according to performance, this policy has stimulated a general increase in the institutional production and an improvement in the effectiveness of the research centers in the production of their output.

Probably the most strong feature of Embrapa's evaluation system is the use of measures of economic efficiency in the assessment research production (Souza et al., 1999). The technique used is Data Envelopment Analysis (DEA) which explores Farrell (1957) concepts of economic efficiency through the use of linear programming. Using single measures of production efficiency Embrapa monitors 34 output and 3 input variables in its research (production) system.

The outputs variables are classified into four categories: "Scientific Production", "Production of Technical Publications", "Development of Technologies, Products and Processes" and "Diffusion of Technologies and Image".

a) The category of Scientific Production includes the publication of book chapters, articles published in refereed journals and articles and summaries published in proceedings of congresses and technical meetings.

b) The category of Production of Technical Publications groups all sorts of publications produced by research centers aiming, primarily, agricultural businesses and agricultural production. Typical of this category are technical circular, research bulletins and instructions and technical recommendations which are publications written in simple language aimed at extensionists and farmers containing technical recommendations regarding agricultural production systems.

c) The category of Development of Technologies, Products and Processes groups variables related to the effort made a research unit to make its production available to society in the form of a final product. Typical of this category is the production of improved crop varieties and new practices, inputs or agricultural methods.

d) The category of Diffusion of Technologies and Image includes variables related to Embrapa's effort to make its products known to the public and to market its image. Typical of this category is the organization of field days and demonstration units. The objective of the former is the diffusion of knowledge, technologies and innovations to farmers and of the later is to demonstrate research results already in the form of a final product.

The input variables used in the economic efficiency model adopted by Embrapa are personnel expenditures, operational costs (research inputs, transportation costs, consultant services, per diems, etc.) and capital costs (depreciation).

Input oriented DEA measures of technical and allocative efficiency are computed for research units similar in size. The process allows the detection of units with relatively low levels of production and indicates directions to be followed to increase production, reduce costs and improve efficiency. Contrary to the idea that such system may introduce an unhealthy competition, Embrapa has found, statistically, that partnership has a real positive correlation with economic efficiency.

Indeed it is true that the close monitoring of the production system of its research units has increased the quantum and quality of Embrapa's research output through a healthy internal competition and by allowing the company to assess its performance relative to external benchmarks. A byproduct of this effort in recent years has been the strengthening of Embrapa's image as a highly efficient public institution in Brazil and abroad.

4.- OTHERS IMPACT ASSESSMENT INITIATIVES

Embrapa has used a diversified set of instruments to demonstrate its importance in the modernization of the agribusiness sector. In this direction, is worth to mention a well planned strategy of preparation of annual progress reports where the technologies

generated by each one of its agricultural research centers are presented with its expected impact on Brazilian agribusiness.

Another important initiative was the development of aggregate studies to demonstrate the role of the agricultural research in the technological change of the agricultural sector and to increase exports. Embrapa has invited well-known economists with influence on the Brazilian decision-making process but not linked to Embrapa, to develop three aggregate studies.

The three topics object of analysis and discussed in the seminar that hold in Brasilia, in May 2001, were the following: a) Economic and social long run impacts of the agriculture expansion in Brazil: The invisible revolution and social inclusion; b) Productivity increase and exports; and, c) Agricultural research effects to the consumer.

The results obtained in this seminar, that counted with the presence of politicians, government advisers, specialized journalists and researchers as discussants, indirectly confirmed the importance of Embrapa in the recent progress of the Brazilian agriculture, specially in the generation of economic and social benefits.

Another kind of impact assessment initiative developed by Embrapa is the annual social balance, where the company shows the social activities developed by each of its research centers, specially with poor urban groups, small rural communities, land reform settlements, Indians communities, etc. The annual report on social balance also show evidences that the technological innovations developed by Embrapa are also generating additional economic benefits.

The experience with social balance in Embrapa begin with the 1997 Social Balance. The social balance, originated as an obligation imposed on public institutions by the Federal Government, has been very important to the consolidation of an excellent institutional image of Embrapa with the Brazilian society (Embrapa, 1998-2001).

5.- EMBRAPA VARIETIES ROLE ON THE BRAZILIAN SEED MARKET

Another alternative that has been used by Embrapa to show its impact is to quantify the role of their crop varieties in the seed market. During the 90's, Embrapa with the Ministry of Agriculture and the Brazilian Seed Producers Association (ABRASEM), established a nationwide system of data collection on seed production for the main agricultural commodities (rice, beans, corn, wheat, soybeans, potatoes and cotton). Annually, each Brazilian state collected data of all the seed produced on these commodities and this data is used by Embrapa to show to the Government, Congress and society the role it has in the seed market. Below is presented a synthesis of the Brazilian seed market of these commodities and the role of Embrapa.

The leadership of the public sector in the release of varieties is particularity important for rice and beans, where Embrapa and the state organizations are responsible for a large share of the seed market. In the case of rice (upland and irrigated) the public institutions (Embrapa and state institutes) are responsible for more than 90% of the registered seed produced and adopted in Brazil during the 1991/2000 period. For beans, the varieties developed by the state research institutions are more important than those

of the Embrapa centers. The Embrapa varieties participated in the seed market in 1999/2000 with 39%.

In the case of irrigated rice, Embrapa varieties developed in partnership with the Irrigated Institute for Rice of Rio Grande do Sul state (IRGA) dominated the seed market. At the end of this period the varieties developed only by Embrapa (Embrapa 6 and 7) assumed a more important share in this market and now it is around 34%.

Cotton is another commodity for which the participation of the private sector is close to zero. Until the season 1994/95 the IAC's (São Paulo state) varieties dominated the seed sector, with a small participation of the varieties from the IAPAR institute (Paraná state). After 1995/1996 the number of varieties diversified, specially due the entrance of varieties from Embrapa that in 1999/2000 occupied 43% of the Brazilian cotton seed market.

Wheat is also a commodity where the varieties from the public institutions for agricultural research are the leaders in the seed market. For this commodity, the most important varieties are from Embrapa and state research institutions (IAPAR, IAC and FEPAGRO). Both public and private sectors have an important participation in the seed market for soybeans. The participation of Embrapa varieties has varied during the nineties from 30 to 50%.

Corn is the crop where the private sector has the strongest presence in the market. Research corporations as AGROCERES (a Brazilian company bought by MONSANTO in 1997) and multinationals such as Cargill, Braskalb, Novartis, Pioneer, etc. are dominant in the seed market. Embrapa represents the public research, with a smaller number of varieties and hybrids in the seed market, but with an important volume of seed produced in the period. BR 201 and BR 106, are the more important products of Embrapa in the Brazilian seed market. The actual share of the Embrapa varieties in this market is 21%

Both public and private sectors have an important participation in the seed market for soybeans. The varieties from the state institutes (IAC, EPAMIG, and EMGOPA – the research institution of Goiás State) are also important. COODETEC and FUNDACEP again represent the soybean research of the private sector. Some foreign varieties from USA (Brossier, Coob, Davis, etc.) were important during the early years of the period, but their presence has declined since then. The participation of Embrapa varieties has varied, and in 1999/2000 its share attained 51%.

Finally, the case of the seed market of potatoes. This commodity also included in the nationwide seed production system and has the private sector as dominant in the Brazilian market. Almost all varieties cultivated are from European countries, especially German and Holland. Brazilian varieties from Embrapa and state organization have an inexpressive participation in the market.

The economic impact of the breeding program of Embrapa on soybeans, upland rice and beans was recently evaluated by IFPRI - International Food Policy Research Institute and shows the high returns of the investments in this area (Alston et. al., 2001). The benefit-costs ratios calculated in this study varied between 10 to 74 showing that the investments in this program were very profitable for the Brazilian society.

Avila et. al (2001) show the role of improved varieties on the increase of the Brazilian productivity in wheat, irrigate rice, maize, cotton, beans, soybeans, potatoes and upland rice during the nineties. This work focus the crop genetic improvement research and shows that this program is significant for the agriculture since contributes in roughly to 40 percent of the realized yield gains over the period. Estimates of crop genetic improvement impacts on a crop basis show some variations in the contributions across crops. However, all crops benefited with this research program.

The marketing policy of the company clearly recognizes the role of partnership in the technological development generated by its research activities (Portugal, 2001). The Embrapa has a worldwide network of partners for the generation of technology. It maintains bilateral cooperation agreements with 55 countries, 155 research institutions, developing more than 250 R&D projects. In the multilateral cooperation partnerships it works with 29 countries and several institutions, such as the CGIAR centers and national agricultural research systems.

Embrapa's national partnership are more encompassing and involves almost 200 public institutions for agricultural research and rural extension, 75 universities and research foundations. In the year 2000 the Embrapa research centers had partner activities with more than 300 rural organization and almost one thousand of R&D activities with the private sector. An instance of a profitable partnership involving Embrapa research centers and national and international R&D organizations is the case of CGIAR. According to Embrapa's estimates, 25% of the seed market of wheat, maize, beans and rice is held by varieties improved in Embrapa with use of genetic material from CGIAR centers.

It is relevant to point out that impact assessment studies are still making a difference in Embrapa due to an aggressive policy of communication and marketing carried out by the company. This policy, adopted in the middle 90's, has shown to Congress and the general public the more important Embrapa's results and their economic, social and environmental impacts.

4.- CONCLUSIONS

This paper summarized the diversified set of impact assessment studies developed at Embrapa, by its own researchers and by specialized external economists, all as a part of an institutional strategy for the strengthening of the organization. Since its creation in 1973, and mainly during the eighties, the internal culture was built in a way that all the internal reports would be always oriented to show that the organization is not only generating technologies, but, also to present evidences that these results were being adopted.

The strengthening of Embrapa due the nature and adoption of its research results has increased the participation of the Embrapa researchers in the formulation of public policies as advisers, specially of the ministries of Agriculture and Science and Technology. Embrapa has had in the last years a strong participation in the reform of the law of intellectual property rights (IPR) and in the formulation of the new patent and the cultivar protection laws. Another instance of this kind of involvement is the important role played by Embrapa's researchers in the design of the new innovation law actually in progress in Congress.

The perspective is that impact assessment studies will continue to play an important role at Embrapa and for Brazilian policy makers. This claim is supported by the recent demand of the Administration Board of Embrapa directing to the implementation of a new impact evaluation system in the company covering economic, social and environment aspects. The novelty of this evaluation system is the fact that the impacts are analyzed along the productive chain and not only at producer level, as usual (Avila, 2001).

In this new stage of the development of impact assessment studies at Embrapa all its 37 agricultural research centers are being involved as separate evaluation units. It is expected the participation of more than 150 socioeconomic and environmental researchers in this evaluation effort. To be sure that all research centers get involved in the process the Embrapa Board linked the impact studies to the evaluation and award system, by including as an evaluation performance criteria, the research centers commitments to the study.

In synthesis, if impact assessment studies are being made but aren't making a difference elsewhere very likely one of the three aspects could be the cause: the agricultural research results are really poor, the studies are not being properly understood or the studies have not been well conducted. At Embrapa there are strong evidences that impact assessment studies are really important and are making a real difference, serving the propose to strength Embrapa's institutional image in the context of the Brazilian society.

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