

Assessing and Attributing the Benefits from Varietal Improvement Research in Brazil

Philip G. Pardey
Julian M. Alston
Connie Chan-Kang
Eduardo C. Magalhães
Stephen A. Vosti

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Lídia Pacheco Yokoyama, 1956–2002

To our friend and colleague, Lídia, who exemplified all the best of an economist working for the public good.

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International Food Policy Research Institute
2033 K Street, NW
Washington, DC 20006-1002 USA
Telephone +1-202-862-5600
www.ifpri.org

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Acronyms and Abbreviations

AES	Agricultural Experimental Station
BA	Bahia
CAC	Cooperativa Agrícola de Cotia (Agricultural Cooperative of Cotia)
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza (Tropical Agricultural Research and Higher Education Center)
CEFET-PR	Centro Federal de Educação Tecnológica do Paraná (Federal Center for Technical Education of the State of Paraná)
CENARGEN	Centro Nacional de Pesquisa de Recursos Genéticos e Biotecnologia (National Center for Research on Genetic Resources and Biotechnology)
CEP	Centro de Experimentação e Pesquisa (Research and Experimentation Center)
CEPEC	Centro de Pesquisa do Cacao (Research Center for Cacao)
CGIAR	Consultative Group on International Agricultural Research
CIA	Centro de Investigaciones Agronómicas (Agronomic Research Center)
CIAT	Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture)
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement (International Cooperation Center of Agronomic Research for Development)
CNEPA	Centro Internacional de Ensino e Pesquisas Agronómicas (National Center of Agricultural Training and Research)
CNPAF	Centro Nacional de Pesquisa de Arroz e Feijão (National Center for Research on Rice and Beans)
CNPSo	Centro Nacional de Pesquisa de Soja (National Center for Research on Soybean)
CNPT	Centro Nacional de Pesquisa de Trigo (National Center for Research on Wheat)
COMTRADE	Commodity Trade Statistics Database
CONAB	Companhia Nacional de Abastecimento (National Food Supply Company)
COODETEC	Cooperativa Central Agropecuária de Desenvolvimento Tecnológico e Econômico (Central Agricultural Cooperative for Technology Development and Economics)
COOPADAP	Cooperativa Agropecuária do Alto Paranaíba (Agricultural Cooperative of Alto Paranaíba)
CPAC	Centro de Pesquisa Agropecuária dos Cerrados (Center for Agricultural Research on the Savannas)
CPAO	Centro de Pesquisa Agropecuária do Oeste (Center for Agricultural Research of the West)
DF	Distrito Federal (Federal District)

DNPEA	Departamento Nacional de Pesquisa Agropecuario (National Agricultural Research Department)
DPEA	Departamento de Pesquisas e Experimentação Agropecuária (Department of Agricultural Research and Experimentation)
EAP	Escuela Agrícola Panamerica (PanAmerican Agricultural School)
EEA	Estación Experimental Agrícola (Agricultural Experimental Station)
EEP	Estación Experimental de Patos (Experimental Station of Patos)
Embrapa	Empresa Brasileira de Pesquisa Agropecuária (Brazilian Agricultural Research Corporation)
EMGOPA	Empresa Goiana de Pesquisa Agropecuária (Agricultural Research Corporation of the State of Goiás)
EMPAER	Empresa de Pesquisa Agropecuária, Assistência Técnica e Extensão Rural (Corporation for Agricultural Research, Technical Assistance, and Rural Extension)
EPABA	Empresa de Pesquisa Agropecuária de Bahia (Agricultural Research Corporation of the State of Bahia)
EPAMIG	Empresa de Pesquisa Agropecuária de Minas Gerais (Agricultural and Livestock Research Corporation of the State of Minas Gerais)
EPE	Escritório de Pesquisa e Experimentação (Research and Experimental Office)
ESAL	Escola Superior de Agricultura Lavras (Higher Education School of Agriculture of Lavras)
EUA	Estados Unidos da América (United States of America)
FECOTRIGO	Federação das Cooperativas de Trigo do Rio Grande do Sul (Federation of Wheat Cooperatives of the State Rio Grande do Sul)
FEPAGRO	Fundação Estadual de Pesquisa Agropecuária (State Agricultural Research Foundation)
FLAR	Fondo Latinoamericano para Arroz de Riego (the Latin American Fund for Irrigated Rice)
FT	FT Pesquisa e Sementes (FT Research and Seeds)
FTE	Full-time equivalent
GO	Goiás
IAC	Instituto Agronômico de Campinas (Agronomic Institute of Campinas)
IBGE	Instituto Brasileiro de Geografia Estatística (Brazilian Institute of Geography and Statistics)
ICA	Instituto Colombiano Agropecuario (Colombian Institute for Agriculture and Livestock)
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
INDUSEM	Indústria e Comércio de Sementes Ltda (Industry and Commerce of Seeds)
INIA	Instituto Nacional de Investigaciones Agropecuarias (National Agricultural Research Institute)
IPA	Instituto de Pesquisa Agropecuária de Pernambuco (Agricultural Research Institute for the State of Pernambuco)
IPEA	Instituto de Pesquisa e Experimentação Agropecuária (Agricultural Research Institute)
IPEACO	Instituto de Pesquisa e Experimentação Agropecuária do Centro Oeste (Agricultural Research Institute for the Center West Brazil)

IPEAME	Instituto de Pesquisas Agropecuarias Meridional (Agricultural Research Institute for Southern Brazil)
IPEAS	Instituto de Pesquisas Agropecuarias do Sul (Agricultural Research Institute for South Brazil)
IRAT	Institut de Recherche en Agronomie Tropicale (Tropical Agronomic Research Institute)
IRGA	Instituto Rio-Grandense do Arroz (Rio Grande Rice Research Institute)
IRRI	International Rice Research Institute
MA	Maranhão
MG	Minas Gerais
MT	Mato Grosso
NAPE	Nickerson American Plant Breeders
OCEPAR	Organização das Cooperativas do Estado do Paraná (Organization of the Cooperatives of Paraná)
PA	Pará
PI	Piauí
PR	Paraná
R&D	Research and Development
RS	Rio Grande do Sul
RO	Rondônia
SC	Santa Catarina
SEA	Secretaria de Administração Estratégica (Secretariat for Strategic-Management)
SITC	Standard Industrial Trade Classification
SP	São Paulo
TO	Tocantins
UEPAE	Unidade de Execução de Pesquisa de Âmbito Estadual (State Level Research Unit)
UFLA	Universidade Federal de Lavras (Federal University of Lavras)
UFV	Universidade Federal de Viçosa (Federal University of Viçosa)
UNESP	Universidade Estadual Paulista (State University of Sao Paulo)
UNSD	United Nations Statistics Division
UREMG/ESA	Universidade Rural do Estado de Minas Gerais/ Escola Superior de Agricultura (Rural University of the State of Minas Gerais/Higher Education School of Agriculture)
USDA	United States Department of Agriculture

Foreword

As the number and variety of interconnected sources of agricultural innovations have continued to grow and evolve, so too have the demands for meaningful evidence of both the total payoff and the specific impacts of individual research providers. Important policy and practical funding decisions require a clear understanding of the shares of the overall benefits from investments in R&D attributable to domestic versus foreign and public versus private agencies, or even to individual agencies, as well as the total benefits accruing from innovation.

This report provides a detailed economic assessment of the magnitude and sources of the economic benefits to Brazil since the early 1980s from varietal improvements in upland rice, edible beans, and soybeans—crops that span a range of interests from domestic (or even more localized) food security concerns, as with rice grown in typically rainfed, upland production systems, to crops with important international trade implications such as soybeans.

The authors of this study pay particular attention to isolating the benefits from genetic improvement, distinct from other factors that change grain yield or quality. They use detailed information of the genetic and breeding histories of each crop and the institutional arrangements for more contemporary crop-improvement research in Brazil to attribute parts of the overall benefits to the research done by various agencies within Brazil, in particular the Brazilian Agricultural Research Corporation (Embrapa, Empresa Brasileira de Pesquisa Agropecuária).

Notably, the balance of local versus international spillin contributions to the improvement of each crop is sensitive to the particular crop and time period under consideration. Moreover, the estimated returns to research are especially sensitive to approaches taken to account for the multiplicity of past and present research providers involved in Brazilian crop improvements. Ignoring the efforts of others results in markedly upward-biased estimates of the returns to Embrapa research. Importantly though, even after attributing the overall benefits among the myriad of research providers, the returns to investments in Embrapa research on the three study crops are still substantive.

As well as providing new and important evidence on Embrapa's crop-improvement programs and their payoffs, this report provides more general insight into the importance of addressing attribution questions in evaluating public research investments, develops some methods for doing so, and illustrates how to apply them.

Joachim von Braun
Director General, IFPRI

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Summary

We estimate that Brazil received \$16 of benefit from every dollar invested by Embrapa in improving upland rice, edible beans, and soybean varieties. The total research benefits over the period 1981–2003 amounted to \$14.8 billion in present value (1999 prices) terms—or 6.1 percent of the corresponding value of crop output—of which \$3.1 billion were attributed to the efforts of Embrapa. These benefits to Brazil came from either maintaining yields in the face of pressures that would otherwise cause them to fall, or improving the yield performance over time relative to base-year yields. They represent the gains from varietal improvement research alone, abstracting from other factors that can affect yields. The upland rice program has also substantially emphasized the need to improve the quality of the grain. We estimated the benefits arising from this aspect of that research amounted to \$233 million, in addition to the \$1.68 billion attributable to the yield-enhancing aspects of the rice research.

Embrapa's varietal improvement research investments have been profitable overall, primarily because of a very high benefit–cost ratio for soybean research. Although the quantitative details may change, the qualitative pattern was preserved when we investigated the sensitivity of the estimates to changes in the interest rate used to discount the benefit and cost streams (4 versus 10 percent), and the length of the benefit stream (benefits truncated in year 1998 versus 2003). These benefit–cost ratios are backward looking: they reflect the benefits accruing to the past investments, specifically the investments made between 1976 and 1998. Nonetheless, to the extent that the future can be expected to be like the past, they provide an indication that crop improvement research by Embrapa, especially research on developing improved soybean varieties, would be a very profitable investment of public funds in the future. As such, the results here provide strong support for claims to sustain and even increase funding for all three programs of research, especially varietal improvement research on soybeans.

Although the benefits attributable to Embrapa are large absolutely and relative to the size of the costs of research, the results indicate that sources other than Embrapa contributed significantly to the benefits. In addition, the share of total benefits attributable to Embrapa versus other agencies varied among the different crops and periods considered. The evidence indicates that CNPSO (the Embrapa soybean center) accounted for a sizable and increasing, but not dominant, share of the benefits from improved soybean varieties since 1981—using a geometric attribution rule to apportion the contributions of past breeders to each improved variety of commercial consequence, 9 percent of the benefits for 1981–85 and 28 percent for 1993–98. The genetic material underpinning all these gains drew heavily on material from non-Embrapa sources (significantly, the United States). The non-Embrapa content of upland rice varieties was much more reliant on domestic sources compared with soybeans, whereas edible bean varieties drew more heavily than either rice or soybeans on foreign sources—CIAT, Colombia has been a major source of the pedigree material used by CNPAF (the Embrapa rice and bean center)—and other local breeders, and a nontrivial amount of foreign-sourced edible bean varieties were used directly by Brazilian farmers.

Some are skeptical about the often high reported rates of return to agricultural research, and we were mindful of the issue in developing our own estimates. Our results indicate that some of these high reported rates of return may arise from mismatching the benefits from research and development (R&D) and the costs that brought them about. In this study, if all of the varietal improvement benefits accruing to Brazil were attributed to Embrapa, a public research corporation accounting for more than half Brazil's agricultural R&D spending, the benefit–cost ratio would be 78:1. When a geometric attribution rule based on genetic histories is used in conjunction with quantitative evidence on the extent of research collaborations to account for the innovative effort of others, the ratio drops substantially to 16:1, or an internal rate of return of 38.7 percent per annum. Notably, the social returns to the Embrapa R&D being evaluated are substantial, even after considerable care was taken both to isolate the effects of research from other factors that would cause crop yields to rise and to account explicitly for the contributions of many public, private, and international agencies besides Embrapa in the development of improved crop varieties.