PN-ABT-288

The Use of Rate of Return Analysis for Agricultural Research Priority Setting: Examples from Uganda.

By: Rita Laker-Ojok[1]

ABSTRACT

Benefit-cost analysis was used to analyze the rate of return (ROR) to agricultural research on maize and oilseeds in Uganda. Because the new varieties of maize, soybeans and sunflower have only been released in 1991 and those of groundnuts and sesame are still in the pipeline, this calculation of the ROR was essentially an ex-ante analysis. The study compared the known cost of research in recent years with projected future benefits. This required prediction of farmers' adoption response, market conditions, and institutional support for technology transfer.

The results of the ROR analysis are summarized. The returns to maize research ranged from 27.3 to 50.6%. The estimated ROR for sunflower varies most widely, ranging from 10.3 to 65.8% depending on the assumptions of the scenario. The returns to soybeans are the lowest. They are estimated to be in the range of -6 to 9.6%. Sesame has a ROR ranging from 15.3 to 49%. The returns to groundnut research range from 23.1 to 44.4%.

The primary conclusion of the ROR study was that the potential returns to agricultural research are excellent, even in Uganda with its history of political instability. This holds true despite the high costs of physical rehabilitation, training, and extension.

The Uganda case emphasizes the importance of a subsector perspective in evaluating the impact of agricultural research and identifying key constraints and intervention points. Factors highlighted by the subsector perspective include: the importance of regional export demand for maize; the manner in which the limited demand for soybeans as livestock feed constrained the expansion of processing for edible oils; the fragility of recent sunflower production expansion and importance of increasing sunflower yields to ensure an improved supply of raw materials to processors; and the substantial benefits from development of a white strain of sesame acceptable to the more lucrative market in the Far East.

ROR analysis can make an important contribution to the process of research priority setting. ROR analysis helps to reveal which factors have the greatest impact on the returns to research. Hopefully this study will stimulate greater efforts to collect the data necessary for future analyses. A reasonably reliable set of priority setting principles should then begin to emerge.

---

[1]Paper prepared for the International Crop Science Symposium, Makerere University, Kampala, Uganda, June 1993. Mrs. Rita Laker-Ojok is a Specialist with the Department of Agricultural Economics, Michigan State University. Funding for this research was provided by USAID under the terms of the Agricultural Research Impact Assessment add-on to the MSU Food Security in Africa Cooperative Agreement, #DAN 1190-1-00-4090-00. The research design, data collection and analysis are the result of a joint effort between the author and three Ugandan consultants: Mr. Bernard Bashaasha, Ms. Elizabeth Balirwa, and Mr. Godfrey Turiho-Habwe who participated in the data collection phase.

INTRODUCTION

The importance of the agricultural sector to economic development has long been recognized. Surplus production for sale is the engine of capital accumulation and frees up labor for non-agricultural activities (Shultz, 1953). Agricultural research can lead to the discovery and diffusion of cost saving technology which not only enhances this process but shapes the very direction that development will take. The nature of the technological change determines whether a network of consumption, production and fiscal linkages between the agricultural and non-agricultural sectors will emerge to contribute to overall development.

When new technology is adopted, the increased productivity of the agricultural sector benefits the society as a whole. Producers benefit from lower production costs and increased returns to limiting factors of production (land, labor or capital)[2]. Consumers (including farm households) benefit from increased product availability, improved quality, and lower prices. The nation benefits from the improved health and productivity of its citizens as well as broader economic linkages to the industrial sector. If agricultural research were only conducted by private firms, research investment would be limited to those technologies for which the firm expected to be able to capture sufficient returns to generate a profit on its investment resulting in a sub-optimal level of investment.

Because social benefits are not equal to private benefits, benefit-cost analysis is often employed to evaluate decisions regarding the appropriate level and distribution of public sector investments in agricultural research. The rate of return (ROR) is the measure of project worth most commonly used in this evaluation. The ROR is a single number which summarizes the time pattern and the relative sizes of the cost and the benefit streams resulting from the research[3]. The ROR is comparable to the rate of bank interest which the investment would have to earn to achieve the same net returns as the research project. Once the ROR has been calculated, it can be compared to the prevailing interest rate or some other measure of the opportunity cost of capital to determine the relative attractiveness of the investment. If the

---

[2] Returns to factors of production will increases as long as adequate market outlets for surplus production exist. In the absence of adequate demand, however, it is possible for the decline in prices to completely offset the reduction in production costs. In such a case, benefits accrue only to consumers.

[3]The advantages and disadvantages of various alternative measures of project worth are discussed in detail by Gittinger (1982).

ROR exceeds the cost of capital then the research project is considered economically successful (Schwartz et al. 1990, Daniels et al. 1990).

In recent years many experts have been urging national agricultural research systems in developing countries to adopt more formal priority setting methods in order to help them improve the relevance and pay-off of their research (Norton and Pardy, 1987; Bottomley and Contant, 1988; Raman, 1989; Javier, 1989). A variety of tools to assist in this process have been designed. These range in complexity from simple checklists and tests of congruence to complex mathematical programming models. Each has its own comparative advantage. The selection of what tool or combination of tools to use should depend on the adequacy of the data; the finances, manpower and time available; and the economic importance of the decision. The two most widely used methods are weighted criteria scoring methods and benefit-costs analysis. The weighted scoring method gives no specific attention to either the timing or the cost of the research while the ROR is a dynamic analysis which emphasizes both of these factors. The ROR explicitly compares the time valued estimate of the net returns from the adoption of research results with the time valued costs of the research itself. The balance between the time value of costs and benefits is tested, using sensitivity analysis, to identify those factors which have the greatest impact on the ROR.

METHODOLOGY

A number of different methods have been used to calculate the ROR to agricultural research. These include the index number approach, the benefit-cost approach, the production function method, mathematical programming and simulation studies. Given the limited availability of data in developing countries, however, the benefit-cost approach is the one most frequently used for project appraisal. This approach was selected for a recent study of the ROR to agricultural research on maize and oilseeds in Uganda. Because the new varieties of maize, soybeans and sunflower have only been released in 1991 and those of groundnuts and sesame are still in the pipeline, this calculation of the ROR was essentially an ex-ante analysis. The study compared the known cost of research in recent years with projected future benefits. This required prediction of farmers' adoption response, market conditions, and institutional support for technology transfer. The uncertainty of the resulting ROR, highlights the importance of sensitivity analysis. The usefulness of the ROR estimates lies primarily in the issues they raise regarding the factors necessary to achieve a reasonable payoff to research investment.

The Uganda study was based on information from a wide variety of sources. In addition to compiling secondary data including on-farm trial results, primary data collection was carried out in the districts of Masindi, Mityana, Luwero, Kasese, Tororo, Palissa, Lira and Apach. Surveys were conducted with 168 on-farm trial participants and 281 non-participating farmers regarding maize, soy and sunflower production. One hundred and twelve extension agents, including 29 on-farm trial agents and 83 other extension staff, were also interviewed regarding maize and oilseeds production. Data was collected on research investments made by USAID; Makerere University; the Ministry of Agriculture, Animal Industries and Fisheries and the World Bank on maize, soybeans, sunflower, sesame and ground-nuts.

THE UGANDAN CONTEXT

As a result of the macro-economic policies and political climate of the 1972-86 period, Uganda underwent a dramatic reversal of the agricultural and structural transformation process achieved in the 1960's. The decline of the Amin years was exacerbated by the poor macro-policies and internal unrest of the early 80s. By 1986 Uganda had suffered a nearly total breakdown of agricultural research, seed multiplication, output markets, input distribution networks, and extension services.

Now, however, the potential for agricultural transformation is much brighter. A major structural re-organization is underway which will greatly strengthen the agricultural sector. This re-organization includes market liberalization in both the input and export markets, rehabilitation of the seed multiplication scheme with particular emphasis on making the scheme self- accounting, and the establishment of the National Agricultural Research Organization as an independent parastatal organization capable of offering more competitive incentives to researchers and demanding greater productivity and accountability.

While Uganda's producers have demonstrated a willingness to bring under-utilized resources into production in response to market incentives, future productivity increases will be much more difficult to achieve using existing technology. Production increases will have to come from new technology and capital formation. Research must play a major role in the identification, adaptation and testing of productivity increasing technology appropriate to the farming systems of Uganda.

In 1983 USAID signed an agreement with Uganda to assist with rehabilitation, training and institutional strengthening under the auspices of the Manpower for Agricultural

Development project (MFAD). Maize, sunflower and soybeans were selected as the primary focus of the USAID supported research activities. Since 1988 research at Namulonge Agricultural Research station has been closely linked with on-farm testing. In 1991 new open-pollinated varieties of maize, soybeans and sunflower were released. Multiplication by the Uganda Seed Scheme has been supplemented by donor efforts at seed multiplication and distribution. Additional support to these commodities took the form of rhizobium development and the design and dissemination of manual oil pressing technology[4].

In addition, local currency funding for groundnut and sesame research was provided by the MFAD project from June 1990 to June 1992. In late 1992 the groundnut and sesame research programme began to get funding under the World Bank Funded Headstart for Agricultural Research and Extension project (HARE). The mid-term evaluation of the Manpower for Agricultural Development Project-Phase II (USAID, 1990) reported that small farmer production of soybeans and sunflower was increasing, relevant technology was reaching the farmers, and an increase in food availability and incomes was evident. Questions were raised, however, concerning the process of research priority setting. The potential importance of the more traditional oilseeds was pointed out[5]. The mid-term evaluation, therefore, recommended that this assessment of the ROR to agricultural research for the entire oilseed sector be carried out.

RESULTS

The ROR analysis was conducted on three levels, demonstrating the impact of expanding the definition of "research costs". The first level included only those costs directly associated with the research; 1) government investments in the various commodity programs, 2) local currency donor contributions to on-station research costs 3) hard currency investments in equipment. The second level added the cost of training scientists connected to the commodity

---

[4]For a detailed discussion of these research and promotional activities, see Laker-Ojok 1993a.

[5]Most oilseeds are actually consumed directly, providing calorie-dense high-protein sauces to accompany local staples. The areas planted to groundnut (175,000 ha) and sesame (80,000 ha) far exceed those of soybeans (10,000 ha) and sunflower (2,000 ha) in Uganda. In addition, sesame is increasingly becoming an exportable cash crop alternative to cotton in Northern Uganda.

programs, and the rehabilitation of the research facilities and equipment. The third level of costing included extension services[6]. The results of the ROR studies in Uganda are summarized in Table 1.

The primary conclusion of the ROR study was that the potential returns to agricultural research are excellent, even in Uganda with its history of political instability. This holds true despite the high costs of physical rehabilitation, training, and extension.

The returns to groundnuts, maize and sesame greatly surpass those reported for soybeans and are less uncertain than those of sunflower. A number of factors contribute to this. First, the area planted in maize and the traditional oilseeds far exceeds that in soybeans and sunflower. This increases the potential for large scale national benefits. Secondly, the markets for these commodities are better established. They are highly valued on the domestic market and the export market for sesame has been flourishing in recent years. Neither do these commodities face the kind of downward international price pressure exhibited in sunflower.

The potentially high returns to both sesame and sunflower, which had been ranked as lower priority commodities by the earlier weighted scoring exercise, illustrates the importance of considering not only domestic food production needs, but also market potential and foreign exchange earnings. The instability of these returns, however, highlights the importance of price and marketing policy as well as specific issues directly related to research productivity.

For both sesame and sunflower, the timing of adoption has a major impact on the expected returns. This is reflected in the large difference between the base case scenario and the worst case results. Sunflower returns will be highly dependent on what happens in the marketing and price of the commodity and the resultant adoption by farmers. The ROR to sesame research, on the other hand is most affected by the potential for delay in the release of research results. A two year delay in the release of the improved variety reduces the ROR by nearly two thirds[7].

---

[6]Detailed information about the level of investment in extension services is difficult to obtain. This analysis assumed that extension agents dedicate effort to commodity promotion in proportion to the relative importance of that commodity in the farming system. Based on this assumption, the annual extension cost was apportioned according to the percent of cultivated land area devoted to the commodity.

[7]Bottomley and Contant (1988) recommend that in cases of considerable uncertainty the ROR be specifically calculated using both optimistic and pessimistic assumptions. "If under pessimistic assumptions the results still indicate a high priority, then it would be reasonable to

Table 1. THE RATE OF RETURN TO MAIZE, SOYBEAN AND SUNFLOWER RESEARCH IN UGANDA[a].

SCENARIO ANALYZED	MAIZE	SOY-BEAN	SUN-FLOWER	SESAME	GROUND NUTS
1. Research Costs only.	50.6%	9.6%	65.8%	49.0%	44.4%
2. Including Research, Rehabilitation, Training, and Extension Costs at worst case scenario adoption, price and yield levels.	27.3%	(6.0%)	10.3%	15.3%	23.1%
3. All Costs, Base case scenario for adoption, yields and price.	33.2%	4.8%	38.4%	42.5%	37.1%
4. Ex-Ante Analysis Including All Costs, Assuming Release of Higher-Yielding Variety in 1994.	47.3%	19.9%	51.6%	56.7%[b]	NA

[a] Table is based on results of the ROR studies reported in Rita Laker-Ojok, "The Potential Returns to Oilseeds Research in Uganda: The Case of Groundnuts and Sesame." February, 1993.

[b] For sesame this scenario assumes release of a pure white strain of sesame that meets export requirements for the higher-priced Japanese market.

THE ROLE OF ALTERNATIVE PRIORITY SETTING METHODS

Uganda is in the process of a major reorganization of the entire agricultural research system. As part of this structural re-organization process an extensive priority setting exercise was conducted in 1990 using the Weighted Scoring Approach (Republic of Uganda, 1991). In the weighted scoring method, national agricultural research policy objectives were converted into measurable criteria for priority setting and weighted. These weighted criteria were applied to

---

accord it that, in spite of all the uncertainties" (p. 86.). The case of sesame and sunflower is less clear cut since under the most pessimistic assumptions the ROR falls to low but acceptable levels.

the various commodities to arrive at a numerical score which could be ranked ordinally and then divided into three priority classes; high, medium and low.

Such scoring methods are readily understandable even though they are also fairly subjective. What is important is that priority setting mechanisms be continually strengthened by an ongoing effort to improve our understanding of the relative importance of the different factors underlying the benefits and costs of agricultural research. This is where the investment in more detailed benefit-cost analysis fits in.

Because benefit-cost analyses are frequently used in project appraisals of all sorts, they employ a logic and language with which policy makers are familiar. One problem, however, is that because of their complexity there is a tendency for researchers and policy makers to view them as a black box. A mass of data is fed into one end, and the "correct answer" miraculously pops out at the other end. To achieve its greatest impact, ROR analysis requires a great deal of interaction and dialogue between the analyst and the research community.

Properly conducted, however, benefit-cost analysis has the advantage of compelling the planner to take into account the anticipated sequence of events and their magnitude. The ROR analysis subsumes a large array of variables into a manageable number of indicators[8]. It integrates both scientific and economic variables into the priority setting process in a consistent and systematic manner. These variables include: a) the quantity of specific commodities produced and consumed, b) commodity prices and any distortions due to price policies, c) the price responsiveness of supply and demand, d) the time value of money, e) the cost of research, f) the probability of success of the research program, g) the extent to which the research enhances output or reduces costs over time, and h) the expected rate and spread of technology adoption.

Even where national data bases are not extensive, ROR analysis can still provide valuable insights as long as expertise is available to make sensible hypotheses. The advantage of conducting even a few ex-ante benefit-cost studies is that, through sensitivity analysis, they help to reveal which factors have the greatest impact on the returns to research. Its application can

---

[8]ROR analysis assumes two agricultural research goals; raising the national income (efficiency) and equity in terms of the distribution of benefits between producers and consumers. A procedure similar to that for soliciting weights for the weighted scoring model can be used to determine the relative emphasis on each. When only the ROR is used to rank research investments, all of the weight is being implicitly placed on the efficiency objective.

then stimulate greater efforts to collect the relevant data for future analyses. When they are later followed up by ex-post ROR analyses, a better understanding of how innovations behave within a given farming system and socio-economic environment develops. A reasonably reliable set of principles which decision makers can take into consideration begins to emerge.

The major disadvantage of relying exclusively on ROR analysis for priority setting, however, is that such analysis biases the research system against subject matter research (including socio-economics) which does not easily lend itself to ex-ante benefit-cost analysis but is clearly essential as a compliment to commodity research. Hence, the need for a blend of priority setting mechanisms used intelligently by experienced researchers and administrators.

CONCLUSIONS AND OUTSTANDING ISSUES

The ROR analyses for maize, soybeans, sunflower, sesame, and groundnuts have pointed out a number of important issues which need to be addressed. One key factor is the need for better data collection in order to document the performance of new technologies under farmer conditions and to map the extent and spread of adoption. Virtually no information currently exists concerning on-farm yields and variety adoption. Better data collection will need to be a key component of future research impact monitoring. This information will then feed into making more realistic estimates for future ex-ante projections.

The analyses also highlight the importance of marketing and technology transfer systems which are external to the research system itself but greatly affect its potential impact. An ROR analysis focussed on the production level may fail to bring out the potential negative impact of constraints at other levels of the subsector. A subsector analysis approach, which takes a broad look at the constraints from production through to consumption, is recommended to identify the key areas for policy consideration. Key issues identified by the subsector perspective include:

1. The importance of regional export demand for maize and the necessity for stable, lucrative, and smoothly functioning markets if benefits from increased maize production are to be achieved.
2. The manner in which the limited Ugandan demand for soybeans as an ingredient in livestock feed constrained the expansion of processing for edible oils as well.
3. The fragility of the recent expansion in sunflower production and importance of rapidly increasing sunflower yields and gross margins to ensure an improved supply of raw materials to processors.

4. The substantial benefits that can be captured if release and multiplication of a pure white strain of sesame allows Uganda to break into the larger, more lucrative market in the Far East.

It is important to note that there are benefits to agricultural research which are not easily captured by the ROR analysis. One benefit which is difficult to quantify is the extent to which research investments have strengthened the human capital base and institutional capacity of the country. Institutional and human capital development are investments which have positive payoffs far into the future and across a broad spectrum of commodities and research efforts. The history of research in Uganda illustrates the impossibility of turning research off and on. It takes only a short lapse in research support to result in massive losses in human and physical capital which will require painful and expensive new investments to overturn.

Decision regarding the prioritization of research efforts between different commodities have long been recognized as having serious regional equity implications. In Ugnada, this is especially true for sesame and sunflower. Farmers in Northern Uganda have shown keen interest in expanding sesame and sunflower production in order to diversify their sources of income. Given the historical concentration of economic activities and development in the southern part of Uganda, efforts to increase incomes in the Northern region are of particular interest. The importance that the Ugandan government places on economic development for this region is demonstrated by the recent efforts to initiate a major reconstruction project for the North, financed by the World Bank. Recent history suggests that economic development of the North could even have important implications for future politicai stability.

Despite the high potential ROR to investments in oilseeds research, Uganda is still plagued by various constraints that inhibit adoption of new technology and the achievement of significant future research results. Macro-level constraints on the productivity and sustainability of the research system have not yet been fully overcome. The Ugandan government's inability to raise sufficient tax revenues to finance an adequate program of investment in the agricultural sector leaves the fate of agricultural research largely in the unpredictable hands of donors. The uncertainty and lack of control over operating funds is corrosive to research productivity. For example, the Groundnut and Simsim Subproject of the World Bank funded HARE Project received only 8.5 million USH out of the nearly 72 million USH that it was budgeted to receive by the end of 1992. This shortfall in funds is primarily the result of the Ugandan government's inability to advance money for research which can later be submitted for World Bank

reimbursement. In all likelihood this funding has been completely lost and will not be recoverable even if the flow of funds improves in the future under the financial management of NARO. Continuity of funding is absolutely essential to the achievement of the research impact predicted by the ROR analysis.

The final conclusion is that ROR analysis can make an important contribution to the process of research priority setting in Uganda. The ROR analysis subsumes a large array of variables into a manageable number of indicators. It integrates both scientific and economic variables into the priority setting process in a consistent and systematic manner. Even in Uganda where the national data base is not very advanced, ROR analysis helps to reveal which factors have the greatest impact on the returns to research. Hopefully this study will stimulate greater efforts to collect the relevant data for future analyses. If this study is followed up by later ex-post ROR analyses, a reliable set of principles should begin to emerge which can be taken into consideration in the course of future research priority setting. Priority setting is not a once-and-for-all accomplished fact. Continued dialogue and re-assessment are required in order to maximize our understanding of the research system and its impact on the agricultural sector. Only then can an effective mechanism for research planning and management be established which is responsive to the changing physical and economic environment.

SELECTED BIBLIOGRAPHY

Bottomley, Anthony and Rudolf Contant. Methods for Setting Priorities Among Different Lines of Agricultural Research. Staff Notes No. 38-88. The hague: ISNAR. 1988.

Contant, Rudolf and Anthony Bottomley. Priority Setting in Agricultural Research. working Paper No. 10. The Hague: ISNAR. 1988.

Daniels, Lisa et al. "Assessment of Agricultural Research: Ex-post, Ex-ante, and Needed Methodologies". Draft Working Paper. MSU. 1990.

Gittinger, J. Price. Economic Analysis of Agricultural Projects. EDI Series in Economic Development. John Hopkins University Press. Baltimore and London. 1982.

Javier, Emil Q. Priority Setting and Resource Allocation in Agricultural Research: an Overview. Staff Notes 89-70. The Hague: ISNAR. 1989.

Laker-Ojok, Rita. "The Rate of Return to Agricultural Research in Uganda: The Case of Oilseeds and Maize". Consultancy report prepared for USAID. February, 1993a.

_____. "The Potential Returns to Oilseeds Research in Uganda: The Case of Groundnuts and Sesame." Consultancy report prepared for USAID. February, 1993b.

Norton, George W. and Phillip Pardy. Priority Setting Mechanisms for National Agricultural Research Systems: Present Experience and Future Needs. Working Paper No. 7. The Hague: ISNAR. 1987.

Raman, K. V. Systems Thinking in Planning Relevant Research. Staff Notes no. 89-62. The Hague: ISNAR. 1989

The Republic of Uganda. National Agricultural Research Strategy and Plans: Volume I Strategy, Organization and Management, Volume II Priorities and Programs. Prepared by Uganda Working Group 9A - Agricultural Policy Committee with the assistance of ISNAR. 1991.

Schwartz, L. A. et al. Impact Study of the Bean/Cowpea CRSP for Senegal. Michigan State University. 1990.

Shultz, T.W. The Economic Organization of Agriculture. New York: McGraw-Hill. 1953.

USAID. "Mid-term Evaluation: Uganda Manpower for Agricultural Development Project - Phase II." 1990.

[File: ritasem.pap]