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THE ECONOMIC EVALUATION OF RESEARCH IN THE AGRICULTURAL SCIENCES AND OF EXTENSION WORK

Mededelingen en Overdrukken
No. 57

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XIV International Conference of Agricultural Economists
Minsk, September 1970

The nature of economic evaluation

Economic evaluation of research and extension means evaluation from the viewpoint of scarcity. It involves a balancing of in puts of scarce goods withdrawn from alternative uses against the outputs in the form of creation and diffusion of new knowledge, technology and information.

Economic evaluation is not necessarily restricted to the effect on satisfaction of material needs or to goods and services traded on markets. It is, however, restricted to values which can be expressed in exchangeables. We cannot count the costs without counting (Boulding (2)) neither the benefits. This counting requires a common value denominator.

This does not have to prevent us however from taking into account effects of research and extension of which the value is not reflected by market prices or cannot be calculated objectively from market prices, but which nevertheless can be appraised in terms of money f.e. on basis of revealed preferences.

In practice however we tend to concentrate heavily on exchange. The conventional yardstick for measuring the increase of human welfare over time is the increase of real income pro head. This is the sum of the deflated market values of produced goods after deduction of the sum of deflated market values of produced goods sacrified in intermediate stages of production. In most studies economic evaluation of research and extension is derived from their effect on this or an in its scope similar concept of human welfare.

Before further discussion of the scope of economic evaluation we shall pay attention to the problems around evaluation of the output of research and extension from the viewpoint of real income and related wellfare concepts.

Outputs of research and extension are social goods

Particularly in agriculture output of most research is a social good which spreads through society without having to pass market barriers. The homogeneity of agricultural products and the nature of inventions make it difficult for individual persons of firms to capture the benefits of their research. Only rarely it is possible to recover the costs of research from the market on basis of patent licences or devices like product registration, brand marks, isolation of genetic parent stock and service industries. And even then the market will not reflect completely the economic value of the research output from the viewpoint of society.

Extension is in about the same position. Nearly all farms are too small not only to support their own specialized research, but also to maintain a staff of specialists or to engage external advisory firms to provide them with all specialized know how and information needed for rational farm planning and efficient performance.

Although an increasing amount of highly specialized extension work is performed by private or cooperative industries in conjunction with buying and selling, often in the framework of vertical integration, there is still a big field, which can be covered only by extension work on a collective basis by the government or other non-profit organizations. The output of this extension work like most research output can be considered as a social good which works not only in the interest of the farmer but also, or even more, in the interest of the general consumer.

Problems of output determination

The primary products of research and extension consequently cannot be evaluated directly on basis of their market price. The benefits arise from the application of knowledge, technology and information created by research and/or diffused by extension. These benefits take the form of a reduction of resources needed tot produce a given output of goods and services or an expansion of total demand for the total product of available resources as a consequence f.e. of quality improvements in consumers goods or introduction of new consumption goods.

Approximations tot measuring these social benefits can be based on the consumer/producer surplus which under certain premises can be taken to measure the aggregate benefit arising from a given market situation as an excess of total utility over resource costs 1). The increase of consumer/producer surplus which can be attributed to research or extension on basis of their effect on demand-supply relations is in this concept a measure for their social benefits.
The most straightforward method is to determine the increase of consumer/producer surplus due to a particular research project (f.e. Griliches (6) for hybrid corn).

Direct observation of the increase of consumer/producer surplus due to a specific research project is however practically impossible. The effect of technological change arises from a multitude of innovations in various stages of adoption which moreover are often complementary. Estimation of the effect of a single innovation therefore will have to be based on technical assumptions concerning its effect on imput output relations and data about the time pattern of its adoption. Practical opportunities for case studies on benefits of terminated research projects are scarce and as must be feared restricted to success stories of conspicuous innovations with a marked influence on imput output relations and a good record of the adoption process.

Approximation of benefits arising from demand expansion is even more difficult. Due to income and substitution effects these estimates cannot be based on demand supply relations for single products but should be based on shifts in aggregate demand.

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1) Consumer/producer surplus is the graphical area between supply and demand curves to the left of the equilibrium intersection.

The more research and production are aggregated the less we have to bother about these difficulties. Most studies on economic evaluation of research and extension are based on an aggregate approach relating aggregate research imputs to aggregate supply and demand of agriculture or agricultural sectors. Such an aggregate approach, of course, is not of much help for economic evaluation of alternative research programs or research projects as a basis for decision making.

It will only provide a general view on the benefits of past research as a basis for comparing its rate of return or benefit cost ratio with other investment opportunities or with a social interest rate.
Aggregate approaches based on estimation of the increase of consumer/producer surplus of agriculture or of an agricultural sector (f.e. poultry; Peterson (10)) have to deal with the problem which part of the increase can be rightfully inputed. to research. The assertion that the whole increase is to be attributed to research is rather impertinent but a basis for allocation to research and other sources will generally have to be arbitrary.

In an other line of approach this difficulty is overcome by taking research as an imput in an aggregate production function in order to establish by means of regression analysis which part of the growth of aggregate product may be attributed to research (Evenson (4); Griliches (7)).

A general problem in aggregate approaches are the various timelags between research and the ultimate application in production. Disregarding these timelags and relating research imputs to technological changes occurring in the same period of course does not expose the true relationships and will result generally in an underestimation of the benefits.

An estimation of the mean time lag may be based on a distributed lag model (c.f. Evenson (4)). For separate sectors or geographical areas this will however be difficult to perform because of lack of data.

Studies on the basis of aggregate production functions are generally based on a cross section of nations or otherwise defined geographical areas. The main premise for this is that there is a relationship between the research undertaken inside an area and the effect of research on production in the same area. This seems in contradiction to the general experience that the flow of research results by publications and personal contacts or embodied in new capital items is not much hampered by frontiers or geographical distances. The contribution of research does not consist only, however, of new knowledge or technology which is readily applicable under all conditions of physical (climate, soil) economic and social environment. A considerable part of research is devoted to further development of general principles involving adaptation to local production circumstances.

The presence of own research institutes moreover will involve probably a better communication with research centres in other parts of the world and a faster diffusion of new knowledge and technology.

Nevertheless we may expect a considerable spill over. Latimer and Paarlberg (9) concluded from their investigation on basis of a cross section in the USA that a single state could curtail its outlay for research and education without substantial injury to the level of farm income in that state provided that the other states and the federal government would continue their research programs. This did not prevent Evenson (4) and Griliches (7) from estimating an important research effect also on basis of a cross section of states in the USA. This will however probably not reflect the whole contribution of research to social welfare.

A question may further be raised about the nature and direction of the relationships between imputs for research and extension at national or regional levels and technological development. In a study on allocation of research, teaching and extension personnel in the USA Peterson (11) found that state income, both farm and non-farm, was the important variable for explaining experiment station support, non-farm income becoming more important in the latter years. It looks like imputs for research and extension depending heavily on non-farm income which may be suspected to have itself a considerable influence on agricultural development. It must be feared therefore that the production function approach is liable to single equation bias and that the correlation between research expenditures and agricultural productivity does not rest only on the effect of research on agricultural imput output relations.

The relations between extension and technological change are still more complicated and vague than for research.

Its contribution of course lies partly in a speeding up of the adoption of innovations. Research after all does not produce innovations but only inventions and information. Its effect on production comes from the practical application at which extension often plays a role. Extension personnel acts as change agents attempting to influence adoption decisions in a direction they feel desirable. Their contribution seems to be more important in the latter stages of adoption where practical application of new ideas, which are already known, is considered and tried (Rogers (12)).

Their efforts may as well be directed to promotion of recommended innovations as to the prevention of non recommended innovations and they may be more effective in prevention than in promotion (c.f. Rogers (12) p.p. 254/255).

Extension, at least if non commercial, is not much specialized and it is therefore difficult to associate extension with specific innovations or parricular products or fields of technology. Economic evaluation therefore will only be possible on an aggregate basis, whereas it is hardly possible to trace the seperate effects of extension on technological change. In studies on basis of aggregate production functions a distinct contribution of extension however did not come out clearly until now (c.f. Evenson (4)).

We must be aware however that increases in technological knowledge not only involve research activity, but also production experience (learning by doing).

The extension service not only contributes to technological change by diffusion of innovations but also by gathering and diffusing production experience.

In production function approach the attention is also focused on neutral shifts of the production function. As pointed out recently by Atkinson and Stiglitz (1) the different points of a production curve may represent different processes of production, as we know from linear programming. Movements along the production function f.e. as induced by changes in price relations as a consequence of over all economic growth, generally require complex and drastic changes in farm outfit, farm scales and farming methods and reallocation of resources. In aggregate analysis by which changes in imput output relations are measured at constant prices, the economic significance of these adaptations is only partly brought forward.

The contribution of extension work in a developing economy lies particularly in creating an understanding of the necessity of adaptation, in the support of the adaptation process and in the gathering and diffusion of production experience for the new production processes introduced.

Economic evaluation of extension to my opinion therefore has to start with a renewed reflection on the nature of technological change and the implications of economic development for agriculture. The role of the extension service and its contribution to social welfare have to be placed in this context.

Some problems of economic evaluation

Real income pro head of the population, factor productivity or consumer/producer surplus as basis for the measurement of human welfare and social benefits implie a narrow concept of value which disregards many aspects of human wellbeing and preferences. Not all utilities or disutilities are adequately expressed by the market price or, if so, are captured bij the concepts and methods used in actual measurement of social product.

Increase of spare time, lighter and more pleasant work f.e. are not or only partially taken into account by these measures. Damages to natural environment and resources, changes in personal and regional income distribution, hard consequences of reallocation of human resources necessitated by technological change and economic growth are ignored, although they affect human wellbeing and costly actions are taken to redress unfavourable consequences.

If these external economies and diseconomies can be related to technological change produced by research or extension, they could and should be taken into account. An objective measurement on basis of the synthesis of individual preferences presented by the market is however not possible. Their economic value has to be approximated by estimation of the costs which have to be made or would be acceptable in order to prevent these external diseconomies or produce the internal economies.

There are some further implications along this line. The major part of the costs of agricultural research and extension is carried by government public bodies or other non-profit organizations, which have to take decisions concerning the allocation of scare resources to research and extension and among the various disciplines and research projects.

Adaptation of calculation prices to marginal values would infer a relatively lower evaluation of technological change involving saving or substitution of land and agricultural imputs and relatively higher evaluation of saving or substitution of labour and industrial imputs.

If on this basis higher priorities would be given to research projects in the latter categorie this would certainly be in the national interest. at least in the short run.

Systems for economic evaluation of research projects

Planning of research is a problem of choice involving establishment of the total amount of resources dedicated to research and allocation of these resources to various disciplines and projects.

As a consequence of growing complexity and specialization and of increase of interdisciplinary approaches, scientists and research directors become less able to overlook the consequences of different research alternatives and to establish priorities. There is consequently a growing need of economic evaluation of research projects as a guidance for decision making.

In the economic evaluation of research alternatives the following factors have to be taken into account:

- costs of research
- benefits to be expected from the application of new knowledge and technology resulting in case of success
- realization time: elapse of time before benefits will be realized
- deterioration: replacement by new knowledge and technology not built on the same line of research
- probability of success

Economic evaluation requires a sound administration of the costs of different research projects in the first place. Furtheron there is a need of economic classification schemes which can be used as a tool for research managers and decision makers for establishing priorities. In the U.S. Department of Agriculture a scheme for research evaluation has been developed (Fedkiw and Hjort (5)).

In the Netherlands a scheme has been proposed, of which some charactaristics will be exposed 1).
The scheme is based on logarithmic scales for each of the factors mentioned above. In the proposed form it is a benefit/cost approach, flow of income being transposed to present value on basis of a predetermined interest rate (6 2/3%).

1) The principles of this scheme have been developed by A. Eriks and G. Hamming of the Agricultural Economics Research Institute in the Netherlands.

Economic evaluation has to serve as basis for optimal decisions. The objectives of government and other collectivities are however not fully covered by maximization of social product in terms of real income. There will be many additional objectives partly competing with maximization of real income. In the economic field f.e. objectives with regard to income distribution, balance of payments, safeguarding of national food supply, future development etc.

To an increasing extent the government also takes actions and allocates scarce resources to preventing of "social bads" or producing of "social goods" on basis of collective preferences, which are not expressed adequately by the price mechanism.

If economic evaluation of agricultural research and extension is to serve as a basis for optimal decisions, it has to be based on optimalization of the whole set of objectives of the decision maker. This involves of course that the decision maker has to expose his objectives and how they have to be weighed, so that they can be synthesized into an economic value. It might be that the government wishes to direct research partly to objectives of agricultural policy like avoidance of surpluses, income parity etc. (c.f. Cochrane (3) p.p. 130-131), which of course would influence the evaluation of alternative research projects and extension programs.

An increasing part of agricultural research, particularly if we include the social sciences, is moreover oriented to the actions and policies of government concerning agriculture. This research can only be evaluated from the viewpoint of the objectives of the government. In the practice of evaluation of current or future research projects it is therefore useful to distinguish into production research and policy research. Only for production research which is orientated to technological change, economic evaluation on basis of increase of social product taking into account external economies and diseconomies, is an appropriate approach.

An other problem is formed by the prices on which the economic evaluation should be based. Taking into account the time lags, evaluation of current of future research and extension programs should be based on price relations to be expected in the future.

There is still an other issue on prices. The question is to be raised if national pricelevels for agricultural products are a sound basis for evaluation of the impact of technological change on national income. Pricelevels in most countries are regulated in order to achieve a fair remuneration of the immobile factors of production in agriculture. As a consequence they do not reflect the marginal values on basis of prevailing demand supply relations.

Changes in the output of main products of agriculture induce changes in imports or exports or other outlets of agricultural surpluses at prices much below the national pricelevel. Economic evaluation on basis of internal prices therefore leads to an overestimation of the economic value of changes in output from the viewpoint of national income.

Investigations in Japan and the USA indicate that in recent years yield technology (production per acre) and mechanization (acres per man) contributed in nearly equal parts to the raise of labour productivity (Kaneda and Auer (8)).

Scale	Present value (x 1000 guilders)	Annual benefits	Realization after...... years	Deterioration Application during..years	Probability of succes(%)	Total costs of research project (x 1000 guild.)
0			0–7	> 16	60–100	
1	25–40		8–14	9–15	40–60	25–40
2	40–60		> 15	5–8	25–40	40–60
3	60–100			3,4	15–25	60–100
4	100–150			2	10–15	100–150
5	150–250			1	6–10	150–250
6	250–400				4–6	etc.
7	400–600	25–40			< 4	
8	600–1000	40–60				
9	1000–1500	60–100				
10	1500–2500	100–150				
11	2500–4000	150–250				
	etc.	etc.				

The probable net benefits can be approximated by simple deductions of scale coefficients. A project costing 125 000 guilders and estimated annual benefits of 125 000 guilders to be realized after 10 years with an application period of 5–8 years and a probability of 50% is evaluated as 2 (= 10–1–2–1–4).

The scale is constructed by dividing the factor 10 over 5 classes. Because of addition of 5 scales the total rounding up error of this estimate will be about twice ($\sqrt{5}$) as much as that of single scales, which seemed reasonable.

This system can of course be expanded by adding criteria and perfected by taking closer intervals. It can also be adapted quite simply to calculation of benefit cost ratios or internal rates of return.

Benefit/cost ratios can be calculated by dividing the present value of benefits after correction for realization, deterioration and probability by the costs. The internal rate of return can be derived from the distance between the scale coefficient of research costs (in the example (4) and of the corrected benefits (in the example 6 (= 10–1–2–1)).

The scale table is based on an interest rate of 6 2/3%. A difference 1 means an internal rate of return of $\pm$ 10%, 2 means $\pm$ 16%, 3 $\pm$ 25% and 4 $\pm$ 40% as can be derived from the table.

The advantage of this system is that it does not involve complicated calculations.

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