

A METHOD FOR ANALYSING SECONDARY ECONOMIC EFFECTS
GENERATED BY BIG RESEARCH CENTRES.

by

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1. INTRODUCTION.

Research activities in the natural sciences, and especially those in the field of pure research work as opposed to applied research, are being financially supported for various reasons, probably the least of which is the hope for a quick economic return. It has, nevertheless, been realised for a number of years that benefits of one sort or another may appear in various and sometimes unexpected ways, where these benefits are not the direct consequence of the application of a research result. They are rather to be compared with the well-known "spin-off" effects obtained while pursuing the research work. An example may help to illustrate what is meant.

Instruments and materials used in research institutions often need to be of the most advanced type and even then they are not always satisfactory. A research worker may therefore develop, for example, an improved instrument or a new method for better or more precise measurements of a desired quantity and may then approach a manufacturer. The manufacturer builds the instrument, perhaps even with the help of the researcher and then sells the desired quantity to the research institution. This line of approach is very frequent, especially in research institutes where facilities for the manufacture of larger quantities of instruments or other pieces of hardware do not always exist. If subsequently the industrial manufacturer sells this new instrument on the market, a new situation arises: he will probably increase his sales fig-

ures because he is alone in offering this instrument, he may have lowered the production cost by learning some new techniques in making the instrument, and he may even have increased his turnover for other products he manufactures by using the "X-Institution", for which he worked, as a reference. As may be seen from this somewhat simplified example, it can happen during a number of research activities that industrial partners profit in some way from the collaboration with the research institution even if nobody takes out any patents, and quite apart from the results of the research activity of the institution concerned.

This phenomenon is certainly not new as such; efforts to obtain some precise figures however are not numerous. This may be partly due to the fact that an economic model has to be used which works on data which are available from industry, and partly due to the effort involved in carrying out such an undertaking and in convincing the participants that such an evaluation is at all possible.

For government-financed research centres, such as the European Laboratory for Particle Physics (CERN) and the European Space Agency (ESA), it was nevertheless important to obtain some more precise information on the economic advantages a number of industrial manufacturers may have obtained, and thus to understand better what eventually happens to the tax-payer's money.

2. ECONOMIC UTILITY.

It will now be assumed that the collaboration of an industrial manufacturer with a research institution may be of some economic usefulness for this manufacturer, and it will be shown how this usefulness may be quantified.

To illustrate the argument, the example of CERN will be described. This is also interesting for historical reasons, as it was there that the above considerations led for the first time to some conclusions. As far as the method described is concerned, any other research centre may take the place of CERN.

Consider a firm which at the end of the financial year shows some gain,¹ G. If this firm had an order from CERN during the year, it will probably be possible for the firm's management to evaluate what the hypothetical gain, G_{hyp} , would have been, had there been no order from CERN. The real gain, G_{real} , in this year however contains the influence of the order from CERN, and this influence may in a simplified way consist of a larger sales figure than the one in the hypothetical situation without the CERN order, and also some savings the firm was able to realise due to working in collaboration with CERN.

Let the difference between the real and the hypothetical gain be called the economic utility, U_t :

$$U_t = G_{real} - G_{hyp} \quad (1)$$

This definition serves as the conceptual basis for the utility quantification formula given in the subsequent section.

It has been said that this definition is based on simplified assumptions. What is meant by this remark is the following: in a general case it must be assumed that an order, especially a large one, may not only influence the sales figures and cause some cost savings, but that it can also influence the price of products sold, the purchase price of semi-finished products, the depreciation of installations, the remuneration paid to employees, etc. It has, however, turned out that the above definition, even if it is based on a simplification, appears to give a reasonable approximation to the actual situation, and that it has the further advantage of using only data which are easily accessible, whereas the consideration of all factors being influenced will often be impossible and thus may cause unpredictable errors. A more detailed discussion of this point may be found in the literature (1).

The utility, U_t , as defined in equation (1), was the object of a first study carried out at CERN from 1973 to 1975, where a total of 199 cases concerning

¹ "Gain" is used in this paper to denote all financial benefits arising from turnover, cost savings, etc.

127 industrial firms were investigated. The results have been published (2), and were encouraging enough to stimulate further studies. This first study, which covered the period from 1955 to 1978 (i.e. the firms were asked to make a forecast for a maximum of 5 years), already showed that the 127 firms investigated had an overall utility of 3.7 monetary units $\pm 20\%$ for every monetary unit CERN had spent on orders with these firms. This ratio varied widely over the different fields of activity, the extremes extending from 1.4 (electric equipments) to 29 (precision mechanics).

Two further studies followed, concerned with the utility created by contracts from ESA, and the results of these have been published (3-4). A second study of utility created by CERN started at the end of 1982 which, for the first time, will reveal, amongst other things, how much the forecasts up to 1978 made by the industry during the first study deviate from the reality arising from an economic slowdown.

The firms to be interviewed are selected on a statistical basis, and the first interviews have already been held. Preliminary results should become available by the end of 1983.

3. THE QUANTIFICATION FORMULA.

For this second CERN study, it is again the definition of utility, U_t , of equation (1) which is being used. However the model has been somewhat improved, mainly by including, in a more formal way, weighting factors which can be made available by industrial manufacturers, as experience with the earlier studies has shown. It may be useful to discuss a number of the quantities which enter into the quantification formula before looking at the formula itself.

The utility, U_t , as well as the quantities on which the evaluation of U_t is based are monetary quantities, M_i , which in the case of CERN are expressed in Swiss francs. Several quantities of this kind enter into the evaluation: the turnover of the firm, M_t , the sales to CERN, M_s , the cost savings, M_c , which could be

realised, the opportunity cost, M_o , which represents additional turnover which would have been possible but which for well understood reasons was not realised, and finally the utility, $M_u = U_t$.

If one wishes to obtain the net influence of CERN to the sales figures, one has to consider only that part of the total turnover, M_t , which has some relevance to the products sold to CERN. An example may help to illustrate this point. Consider a firm making transformers, electric motors and household appliances. Suppose the firm has made electromagnets for CERN which subsequently led to improvements in manufacturing their main products, i.e. transformers and motors, leading to sales increases. No influence of the CERN contract was felt however on the side of the household appliances. The turnover of the firm, M_t , therefore has to be multiplied by a factor $C_t \leq 1$ which gives the percentage part of the total turnover, M_t , which is realised by the parts of the firm making transformers and motors, i.e. those parts being influenced by the CERN contract.

A further correction has to be applied to this reduced CERN-relevant turnover, $C_t * M_t$, which is given by the sales to CERN M_s . The economic utility, U_t , of interest is the net utility the firm has succeeded in creating by dealing with customers other than CERN. The turnover figures with CERN, M_s , have therefore to be deducted from the CERN-relevant turnover, $C_t * M_t$.

The utility, $U_t = M_u$, can be split into the part, M_{us} , of M_u which is caused by increasing sales figures and the part, M_{uc} , which are the cost savings. It then becomes

$$U_t = M_u = M_{us} + M_{uc} \quad (2)$$

A few considerations still enter into the evaluation of U_t . It is easily seen that only that part of the turnover, M_t , must be considered which is given by the added value, i.e. purchases of raw materials, pre-fabricated parts and energy, etc., which appear in the turnover, have to be disregarded.

Two kinds of weighting factors are used, which help in identifying the source of utility.

1. The economic success factors which take into account the percentage influence of the firm's different activities, such as marketing, price competitiveness, quality, research and development, etc., on the turnover on one hand and on the cost savings on the other.
2. The CERN influence factors on the same activities.

The product of corresponding factors gives the influence of CERN in the field of marketing, price, quality, etc., on the turnover of the firm under consideration (see equations 4-7 below).

It is now possible to present the quantification formula in equation (2) with the different quantities which enter into its evaluation. These quantities, denoted by capital letters with indices, are:

- M \equiv monetary quantities, expressed in Swiss francs.
- E \equiv economic success factors, dimensionless.
- C \equiv CERN influence factors, dimensionless.

The indices used are the following:

- t = turnover of the firm.
- s = sales influence.
- c = cost savings.
- o = opportunity cost.
- a = additional cost.
- l = losses.
- u = utility.
- m = marketing.
- n = new products.
- p = price.
- d = decision making process.
- q = quality.
- r = research and development (technology).
- x = any other success factor index.

With these conventions the following quantities may be defined, most of which have already been discussed in the preceding sections:

M_t = turnover of the firm.
 M_s = sales to CERN.
 M_c = cost savings.
 M_o = opportunity cost.
 M_a = additional cost.
 M_l = losses incurred on CERN contracts.
 $M_u = U_t$ = utility.
 M_{us} = utility due to sales increase.
 M_{uc} = utility due to cost savings.

The individual economic success factors E then are designed by two indices, where in E_{ij} the first index indicates the activity (marketing, price, quality, etc.), whereas the second is either s (sales) or c (cost savings), which follows equation (2), where the utility is split into these two parts. In this notation:

E_{ms} = contribution of marketing to sales.
 E_{rc} = contribution of research and development to cost savings.
 etc....

The CERN influence factors, C_{ij} , are defined in analogy, again with the second index being either s or c:

C_{ms} = CERN influence on sales via marketing.
 C_{nc} = CERN influence on cost savings with new products.

Two more quantities which also have been discussed in the preceding sections are:

C_t = percentage factor for CERN relevant turnover.
 k = percentage factor for added value.

For the dimensionless quantities E and C the following constraints are valid:

- a) they are all ≥ 0 and ≤ 1
- b) $\sum_j E_{js} = \sum_j E_{jc} = 1$ for $j = m, n, p, d, q, r, x$ (3)

Equation (3) says that all relevant factors which cause the economic success (sales increase or cost savings) must have been taken into account.

$$(CE)_s = \sum_j C_{js} E_{js} \quad \text{for } j = m, n, p, d, q, r, x \quad (4)$$

then denotes the sum of all factors relating to sales, while

$$(CE)_c = \sum_j C_{jc} E_{jc} \quad \text{for } j = m, n, p, d, q, r, x \quad (5)$$

gives the same sum relating to cost savings.

With these notations the quantification formula in equation (2)

$$U_t = M_u = M_{us} + M_{uc} \quad (2)$$

can now be decomposed into

$$M_{us} = k [(CE)_s (C_t M_t - M_s) - M_o] \quad (6)$$

$$M_{uc} = (CE)_c (M_c - M_a) - M_1 \quad (7)$$

Equations (2), (6) and (7) are the basis of the second study of economic utility created by CERN contracts in industry. As the first interviews with industrial firms indicate, the formulas are based on quantities which are not only available in industry but which firms in general are also willing to communicate. It is therefore thought that this model would also serve to evaluate the economic utility of other research institutions.

4. REFERENCES.

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