COST-BENEFIT ANALYSIS APPLIED TO TECHNOLOGY

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Introduction

Broadly defined, "technology" can be used to describe technological and scientific know-how, engineering expertise, management practices, organizational know-how, marketing, financial, control techniques, and so on.

Although some researchers in the field of international production have advocated the need for a higher degree of adjustment of technology in developing countries, and some case studies have been added to the literature in the field, no formal attempt has yet been made to find an answer to whether technology should be adjusted or not.(1)

Given that the technology market is not a unified, perfectly competitive market for all products and processes, but is often likely to be monopolistic or oligopolistic, in order to know the alternatives available for acquiring the technology, it will be necessary to have at least some qualitative idea of the motives of different foreign investors in making direct investments in the host country, as this will in turn influence the terms on which the technology can be acquired.

It is unlikely that it will be possible to get anything more that qualitative evidence to form judgements about the reasons for particular direct investments. But it will be necessary to document those, together with any other information (quantitative if possible) on the alternative choices which might have been available to the host country to acquire the necessary technology. This information relates to the costs (direct and indirect) of acquiring the same or similar technology from alternative sources, if they exist.(2)

The objective of this chapter is to show how the technological factor can give rise to differential costs/benefits for different mixes of private foreign investment and to suggest some tools which may help determine the social net benefit of a particular technology.

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Of course, a clear formulation of the alternatives is an essential prerequisite to the proper appraisal of the value of foreign technology. The important point for analysis and policy is to envisage the various alternatives, against which any operational assessment has to be made and to assess the benefits and the costs of each, measuring what is measurable and judging what is not.(3)

Selection of Technology Transfer Projects

Methods of social cost-benefit analysis have been developed to help countries in making decisions regarding the choice of projects. In making such decisions countries have a number of objectives i.e. to increase income or employment, possibly to reduce dependence, to reduce income inequalities between people and regions, and others. By means of a cost-benefit analysis it becomes possible to take such objectives into account in a systematic and consistent way, in the sense that if employment is given a particular weight in one decision it is given a similar weight in another. This in a sense reflects the limitation of the cost-benefit approach, inasmuch as the technique is useful only for decision-making in the light of a wide range of considerations, some of them of a political or social character.

Thus, the purpose of cost-benefit evaluation is to assess projects in the light of social objectives. It enumerates all the relevant costs and benefits and draws attention to the close links between them.(4)

For a firm, profitability analysis is really a private cost-benefit analysis, i. e. the difference between the value of receipts and costs, measured at market prices. The market evaluation of economic activity is inadequate for a social evaluation of needs and may differ from social evaluation because some items which have an effect on social welfare may not be given any value of price at all by the market; and items which have no market price would be valued differently by the government. In evaluating an industrial project involving a transfer of technology some objectives such as the creation of employment, the development or inhibition of local technological capability including skill formation, may either not be included or given only inadequate weight in the market evaluation.

One criterion for determining the value to the economy of a project involving the transfer of technology could be the present value of net social benefits, arising from the project. This is the difference between

the stream of benefits and costs (measured in social values) flowing from the project during its life time, discounted to the present day. Due to the fact that any project involves costs and benefits over many years, and that benefits that are received in the future are not so valuable as those received today, future values should be reduced by a certain proportion to estimate how much they would be worth in terms of today's values. What the socially correct proportionate reduction (i.e. discount rate) should be is important and difficult to determine. This is the task of central decision-makers involved in aggregate planning. If shadow prices (social prices) are chosen corectly, all projects with a positive net present social value should be chosen, and all those with a negative net present social value should be rejected. In other words, we have to project the benefits of the project to the society as a whole, and compare these to the costs imposed by the project. We seek to determine whether a project's (discounted) benefits (B) exceed its (discounted) costs (C). If so, then its present social value (PSV) is greater than zero at the appropriate discount rate. It also follows that if the benefits exceed costs, then the benefit-cost ratio is greater than one. In other words, if (B C, then B/C I.

As mentioned before, the net present value criterion is based on the difference between benefits and costs, both discounted at the appropriate interest rate. In the ideal situation the investing unit, whether a private investor or government, should have (1) several potential projects from which to choose; (2) a capital budget that determines the amount to the invested; and (3) a discount rate that reflects the cost of capital to the particular investor or to the economy as a whole. Each project should be analyzed and the net present values calculated at the chosen discount rate.

However, analysts and investors are not always in a position to know all the investment possibilities. Investment decisions frequently are made on ad hoc basis, the question being whether or not to proceed with a single project that has been proposed and analyzed. In this situation, the yield from investment cannot be maximized because the decision makers do not have full information. But the net present value technique can be employed to ensure that the investment will be productive enough to pay for the cost of capital and leave some surplus or profit for the investor. The rule is simple : If the discount rate truly represents the cost of capital, then any project whose NPV is positive should be implemented.(5)

Evaluation of Technology

One of the important advantages claimed for private foreign investment is that it enables the domestic firm to keep abreast of technical progress. Different forms of acquiring technology will therefore have different effects in keeping domestic plants economically competitive. In an industry with rapid technical progress, without access to new knowledge, the domestic plant will become uncompetitive sooner than one in an industry where technology is more stable, or where the domestic firm has access to the continuing R & D innovations of foreign firms.

In addition to the various forms of acquiring technology through licensing agreements, technology may be also acquired through franchising agreements and licensing agreements with equity participation and the so-called management contracts. While franchising agreements are relatively simple, equity participation in licensing agreements, particularly when connected with joint venture, is an entirely different matter. Instead of royalties or cash payments for the technology, the licensor - for various reasons - often requests equity participation in the licensee's operations, either in the form of direct participation in profits or by acquiring a certain percentage of shares. It is also possible that if a new company is being established, the licensor may require the share in a joint capital which is represented by the value of technology, know-how and services supplied.(6)

Formally, policy-makers may be considered to be faced by the problem of maximizing a specified social welfare function subject to given resource and transformation constraints.The effects of a technology project will then have to be evaluated in terms of its impact on social welfare, taking into account the opportunity costs of all the domestic resources which will be absorbed by the project. These opportunity costs and relative benefits of the technology acquired will depend upon the alternatives to that investment.

For the evaluation of the "technology" component in a new joint venture project, we have first to identify the special issues that arise mainly in connexion with the evaluation of the costs and benefits specially related to the transfer of technology (presented later). Using the same analytic framework described above, and depending on the net present value (NPV) criterion, we can decide whether or not to accept the technology project suggested. The precise way to evaluate the technology component can be explained in terms of an example. Suppose there are two alternative projects A an B, for producing the same product. A is in

the form of a joint venture which has access to the latest technological advances in the foreign parent firm. B is a domestic firm which wil depend on the technology available in the public domain. The way in which the differential effects of the two kinds of technology can be taken into account in cost benefit studies is through measuring the present value of the benefits and costs of the (foreign) technology used by project A (Tf) as as well as the present value of the benefits of the (domestic) technology used by project B (Td) and if :

PV ' BTf - PV BTd - PV CTf O

this means that benefits exceeds costs and that B/C 1.

It is clear, however, from our example that the joint venture plant wil never become technologically obsolescent, it being assumed that the costs of physical depreciation required to keep the plant physically intact from one year to the next also include any costs that may have to be incurred to incorporate the latest techniques in the existing plant. The costs of this continuing access to the latest technology will appear in the repatriation of dividends and in any direct technical fees that may be paid to the foreign partner. For the domestic company (project B) on the other hand, on our assumption, the plant will become technologically obsolescent after a certain number of years. The benefits to be ascribed to its operations will therefore cease on that date.(7)

However, when the technique of cost-benefit analysis is used in the evaluation of projects involving a transfer of technology or in the choice of alternative mechanisms of transfer, some specific issues arise from the peculiar nature of the transfer itself. It is not the intention here to cover these issues in full detail, only some of the more impotrant are considered, especially those which arise mainly in connexion with the identification and evaluation of the social costs and benefits related to the transfer of technology and employment creation.

Elements of cost-benefit analysis :

1 — Foreign exchange costs

Foreign exchange costs are perhaps the most obvious item in costs, both because foreign exchange is particularly scarce in many developing countries (and this scarcity is not usually fully reflected in the exchange rate) and because the import of technology frequently involves substan-

tial foreign exchange outlays ever a period of time. The foreign firm may be given equity in the local company in return for its technical know-how; it may be paid a fee, for instance, related to sales or output; or it may receive payment through a combination of a fee and local equity. The alternative costs of acquiring the technology could take any of the above forms. These costs will, however, appear directly in the financial inflows and outflows of the firm's balance sheet, and will be taken into account in the same way as any other financial inflows and outflows. The problem is to delineate the relevant alternatives in each case, and to assign values to the expected costs which may often be hypothetical and based on the judgement of experts in the field.(8)

Apart from careful collection of basic statistics on outlays and inflows, attention must be given to two important matters related to the principle of opportunity cost (the principle that the cost of producing an item should be reckoned as the forgone opportunity of producing other items). The first is that it is only expenditures of scarce foreign exchange on one project that could have been used on other projects which impose a social cost. A second aspect of foreign exchange costs is that they may be incurred to a significant extent in indirect ways. One such way is through the use in a project of intermediate goods which are imported or else manufactured domestically by means of processes which involve foreign exchange costs. The purchase of these intermediate inputs will in any case involve a payment which would normally be counted as part of the cost of a project - but if for any reason the prices of these inputs do not fully reflect their social cost, i.e. benefits forgone because of the non-use of these inputs in other projects, adjustments should be made when evaluating any project utilizing these inputs.

Foreign exchange costs, like all other costs and benefits, are a function of the conditions under which a project involving a transfer of technology is carried out. Regulations governing the remittance of foreign exchange by foreign companies and persons, the debt/equity proportions and size of equity holdings by foreign companies in enterprises in developing countries ,as well as other factors, all influence the size and form which foreign exchange costs may take. The evaluation of foreign exchange costs must attempt to take into account as many of these ways as possible in order to arrive at a reasonably accurate assessment of the social costs.

2 — Technical Efficiency

The different alternative forms of acquiring technology may imply differences in the technical efficiency of the firm. This will appear as a difference in the input-output coefficients of the various alternative technologies for producing the relevant good. Thus though the direct costs of acquiring a technology through route "A" may be less than those through route "B", the technology acquired through A may be relatively inefficient (in the sense that it may require more inputs per unit of output than the alternative) compared with B. Here again if both the alternative sets of input-output coefficients are given, there is no further problem.. The normal procedures of social evaluation will take into account the differential of the two alternatives.

3 — Managerial Efficiency

Differences in efficiency need not be ascribed to purely technological factors, but more importantly may encompass differences in managerial efficiency. The latter is said to account for the advantages of private foreign investment in which the foreign firm has a majority equity holding. The differences in managerial efficiency may show up in a number of ways, for example, smaller working capital requirements, lower wastage rate for inputs and rejection rates for the output, lower rate of breakages, quicker reaction to mechanical and / or administrative faults and bottlenecks.(9) Though it may not be possible in practice to identify and quantify the precise reasons for differences in efficiency of the alternatives, some qualitative information may be available and should wherever possible be obtained. However, if these differences in managerial efficiency exist, even though they cannot be pinpointed by source, they will nevertheless be taken into account in the normal way in the differences in the inputs and outputs of the alternative investments.

So far our analysis has been conducted on the assumption that all the relevant inputs, outputs and prices could be assigned values with certainty, and that we had certain and precise knowledge of the differences in input-output coefficients due to the differential technical efficiency of the various alternatives. In practice, it may not be possible to have this knowledge, and certainly for "ex ante" appraisals it will be impossible to obtain them for all cases. Here there is no escape from intelligent and informed guess work. From past experience in the industry in the host country (if is exists) or in other countries, some idea of the differential

coefficients may be obtained. As this is really an important area of uncertainty, probability weights should ideally be attached to our estimates. Once the various possible outcomes of the relevant variables are known, and probabilities assigned to each outcome, the expected value is obtained by multiplying each possible outcome by its probability of occurence and then summing over all possible outcomes.

4 — Skill Formation

The foreign effects of a technology project are not the only costs and benefits which must be calculated. There are others of particular relevance to projects involving a transfer of technology. One of these arises from the external effects of production. Externalities are costs and benefits which do not acrue directly to the project but indirectly to the rest of the rest of the economy. These are often called "spillovers". A distinction is also often made between technological and pecuniary spillovers; the main consideration should be the technological spillovers.

Projects involving a transfer of technology may contribute to the creation of local skills of various types trained through them. For the purpose of estimating the skill formation effect, various classifications of skills can be devised. The following classification may be a suitable point of departure for evaluation :

a) Scientists and engineers

b) Technicians and draftsmen

c) Other professionals

d) Managers

e) Machinists, electricians, tool and die-makers

f) Other skilled manual workers

g) Clerical, sales and services workers.

h) Semi-skilled and unskilled personnel.

Of course, this classification is not hierarchical : that is to say, there is no suggestion that skills of type A are in some sense of a higher social value than skills of type B. The question of the relative social valuation of the skills is one which can only be answered by reference to social and economic objectives and to the stocks of skills available in the economy.

In other words, there will be a shadow price attached to each of the skill categories.

In evaluating skill formation effects there is one principle which should guide all calculations, viz. that the provision of training not available elsewhere is the ground for imputing skill formation benefits to a project. The application of this principle is general in that it covers the possible depreciation of skills as well as the creation of new skills. Thus if the establishment of a project permits skilled workers to continue to exercise the talents they already possess, whereas in the absence of this project the workers would have been employed in occupations of less value to society where their existing skills would have deteriorated, the maintenance of skills due to the project must be reckoned a favourable factor.

A project involving a transfer of technology can be viewed as an activity which, among other functions ,transforms labor with certain skills into labor with more valuable skills. An increase of skills could be valued in terms of the additional units of future industrial output (measured in units of present consumption) which it makes possible. This method of valuation allows for different types of skill, for various skills may make more or less significant additions to future industrial output.

Another point which deserves attention, is that existing experience with imported technologies may permit more efficient importation and operation of technologies in the future. There are two aspects to this point.

One is that technologies may be more efficient selected in the future, the other is that those selected may be more efficiently used. The valuation of benefits of this sort is equivalent to estimating the present social value of future cost savings in consequence of this development. In the case of the operation of equipment, an estimate might be made by examining the additional costs of current projects, and calculating the expected elimination of such costs in future projects as a result of the greater availability of skills.

Employment creation(10)

Since manpower is a basic input in any production activity, each particular project features a certain level of labor intensity. If its labor intensity is high, the project in question has a relatively high labor-output ratio, and vice versa. If the labor intensity as well as the structure of wages of the project were known, the wage bill could then be calculated.

Such a calculation might be done at different levels of disaggregation in order to reflect the occupational composition of the labor intensity of the project. Such a calculation would represent the first step in manpower cost benefit analysis.

Manpower cost-benefit analysis aims essentially at deriving a set of cost-benefit ratios, each ratio reflecting a particular kind of production technique such as labor-intensive or capital-intensive. These ratios can be compared to find which particular production technique is the most appropriate on social efficiency grounds. Whenever the cost-benefit ratio of a labor intensive technique exceeds that alternative techniques, it should be the one selected for implementation.

PERIOD	EXPENDITURE E_t	$Y_t = E_{t-1}$	$C_t = .5Y_t$	$C_t = (C_t - C_{t-1})$	$1_t = 2L_t$	$C_t + I_t = Y_{t+I}$
t = 0	5	4	2			5
1	3.5	5	2.5	.5	1.0	3.5
2	.25	3.5	1.750	- .75	- 1.5	.25
3	- 3.125	.25	.125	- 1.625	- 3.25	- 3.125
4	- 4.9375	- 3.125	- 1.5625	- 1.6875	- 3.375	- 4.9375
5	- 4.281	- 4.9375	- 2.46875	- .90625	- 1.812	- 4.281
6	- 1.484	- 4.281	- 2.1405	.3285	.657	- 1.4835
7	2.055	- 1.484	- .742	1.3985	2.797	2.055
8	4.566	2.055	1.0275	1.7695	3.539	4.5665
9	4.795	4.566	2.2830	1.2555	2.511	4.794
10	2.626	4.795	2.3975	.1145	.229	2.6265
11	-.856	2.626	1.3130	- 1.0845	- 2.169	- .856
12	——	- .856	- .428	- 1.741	- 3.482	- 3.91(

SOURCE : J. S. Henderson, **National Income, Statics and Dynamics,** (New York, Harper and Row, 1961), p. 264.

FOOTNOTES

(1) Nueno, Pedro, Suggested Approach to the Problem of Adjustment of Technology in Developing Countries, in Herrero, F.h., ed., Papers on Business Education, Pamplona, 1975.

(2) Lal, Deepak, Appraising Foreign Investment in Developing, Countries, London, 1975, p. 67.

(3) Streeten, Paul, Costs and Benefits of Multinational Enterprises in Less-Developed Countries, in Dunning, J., ed., The Multinational Enterprise, Praeger Publishers, George Allen & Unwin, Ltd. 1971, p. 250.

(4) The approach suggested here is based on UNIDO, Guidelines for Project Evaluation, United Nations publication, (E. 72. II. B. 11).

(5) Roemer, M., and Stern, J., The Appraisal of Development Projects, A Practical Guide to Project Analysis with Case Studies and Solutions, Praeger Publishers, 1976.

(6) Selected Aspects of International Licensing, by the Secretariat of UNIDO, Training Workshop on Negotiation and Regulation of Investments, Zambia 1976, United Nations, Department of Economic Affairs, New York.

(7) Ltl, Appraising Foreign Investment in Developing Countries, op. cit., pp. 70-71.

(8) Ibid, p. 68.

(9) Fforde, J. S., An International Trade in Managerial Skills, Oxford, 1957.

(10) For an extended discussion see Mehmet, Ozay, Benefit-Cost Analysis of Alternative Techniques of Production for Employment Creation, International Labor Review, July-August 1971.

تطبيق تحليل التكلفة والفائدة
علـــى التكنولوجيـــا

وهبي غربال

يتناول هذا البحث موضوعا هاما في تقويم جدوى المشروعات بتحليل التكاليف والمنافع ، ومحاولة تطبيق هذا التحليل على التكنولوجيا . ويقوم باستخدام الوسائل المستقرة في هذا التحليل وخاصة اسلوب القيمة الحالية الصافية لتقدير جدوى المشروع .

وقد تضمن البحث افكارا مفيدة ، خاصة فيما يتعلق بكسب الخبرات والقدرة على حسن اختيار المعدات نتيجة الاخذ بأنواع معينة من الاساليب الفنيـــة .