Scott Pearson is Professor of Agricultural Economics at the Food Research Institute, Stanford University. He has participated in projects that combined field research, intensive teaching, and policy analysis in Indonesia, Portugal, Italy, and Kenya. These projects were concerned with studying the impacts of commodity and macroeconomic policies on food and agricultural systems. This effort culminated in a dozen co-authored books. These research endeavors have been part of Pearson’s longstanding interest in understanding better the relationships between a country’s policies affecting its food economy and the underlying efficiency of its agricultural systems.

Pearson received his B.S. in American Institutions (1961) from the University of Wisconsin, his M.A. in International Relations (1965) from Johns Hopkins University, and his Ph.D. in Economics (1969) from Harvard University. He joined the Stanford faculty in 1968.

The framework used in this lecture has been developed in conjunction with Carl Gotsch, the author of the Benefit-Cost computer tutorial included in this series. Materials in the lecture and computer tutorial have benefited from the work of J. Price Gittinger, Economic Analysis of Agricultural Projects. The book is on-line and, where possible, links have been made to it from the lecture and the tutorial. The book provides both a solid theoretical foundation and detailed examples for computing benefit-cost ratios (B-C) and internal rates of return (IRRs).
PAM Basics

- Gather data on technical relationships (I-O table) and private and social prices
- Using the same I-O table, compute private and social profits to determine competitiveness. (Gross revenues minus input and resource costs.)
- Subtract social from private elements (revenues, costs, profits) to determine government policy involvement or market imperfections

The Policy Analysis Matrix (PAM) approach is based on two sets of commodity budgets, one computed using private (market) prices, the second using social (economic) prices. Cells may represent individual commodities or a mix of commodities that reflect a “farming system.”

The PAM analysis is an important step in determining which investments are likely to have a high payoff. For example, investing resources in expanding the production of commodities that are socially unprofitable is generally an unwise strategy.
1. This slide shows all twelve entries for a PAM, given by the letter symbols A through L. It adds a third row termed the Effects of Divergences row. As noted above, divergences arise from either distorting policies or market failures; either source of divergence causes observed market prices to differ from their counterpart efficiency prices.

2. The symbol I measures divergences in revenues (caused by distortions in output prices), the symbol J stands for divergences in tradable input costs (caused by distortions in tradable input prices), the symbol K represents divergences in domestic factor costs (caused by distortions in domestic factor prices), and the symbol L is the net transfer effect (arising from the total impact of all divergences).

3. In empirical PAM analysis, the effects of divergences (in the third, bottom row) are found by applying the divergences identity. According to that accounting principle, all entries in the PAM matrix under the third row (defined as effects of divergences) are identically equal to the difference between entries in the first row (measured in private prices) and entries in the second row (measured in social prices). Therefore, I is identically equal to (A – E), J is identically equal to (B – F), K is identically equal to (C – G), and L is identically equal to (D – H).
### Benefit-Cost Basics

- Using regular PAM methods, compute private (D) and social (H) profitability. Call this the “without project” case.

- Compute a second PAM using an input-output table incorporating the impact of a capital investment. Call this profitability the “with project” case (D', H').

- Compute capital investment costs, e.g., pumps, dams, extension programs, research projects.

- B-C ratio = incremental revenues (with project minus without) divided by investment cost

The data gathered in the course of a benefit-cost analysis is very similar to the data collected in a PAM appraisal. There are two major additions: (1) information on the cost of the project investment whose benefit is being evaluated, and (2) a second input-output table that incorporates the impact of the investment. In the case of an investment in pumps, for example, the second input output table would reflect increases in yields that irrigation makes possible as well as new crops that can be grown with the additional water.

The initial PAM provides the data for the “without project” case. A second PAM, utilizing the information in the new input-output table, provides the profitability in the “with project” case. Subtracting the without project profits from the with project profits yields the incremental benefits of undertaking the investment. These are compared with the cost of the investment to determine if the benefits exceed the costs.

When incremental benefit, the difference between the with and without project profitability, exceeds the cost of investment (B/C > 1), the investment should be undertaken.
A single-period analysis in a matrix format:

There are two PAMs, one reflects the “without project” case, the other the “with project” case. (The example refers to the returns on a single-period investment, e.g., fertilizer. Other inputs such as pesticides would have a similar characteristic, i.e. returns occur in the same period that the investment is made.)
The PAM representing the “without” project case (W/O) gives no evidence of government policy interventions or market failures. (Subtracting social elements from private elements results in zeros.) The “with” project analysis, (W) on the other hand, show subsidies to tradable inputs (reduced costs).

At private prices, the increase in revenues resulting from the private investment –and the subsidies to inputs—is sufficient to generate a B-C ratio greater than one. On the basis of the private analysis, the project should be undertaken. Private producers have the necessary incentives to adopt a new input.

At social prices, however, the increase in revenues resulting from the investment are not sufficient to produce a positive B-C ratio. From the perspective of the economy as a whole, adopting the new input would be inefficient. As the PAM analysis shows, it is the subsidy to inputs, not the increase in productivity, that accounts for the positive private B-C ratio.
1. Project evaluations ordinarily reflect situations that take place over a period time. In the initial years of the project, net benefits are expected to be negative as the costs of implementing the project outweigh any benefits that might be forthcoming.

2. Subsequently, the positive returns outweigh the negative returns. The analyst must determine if the sum of the positive returns, when discounted to reflect the opportunity cost of capital, are greater than the sum of the negative returns, also properly discounted.
Multi-Period B-C Formula

\[
\sum_{t=1}^{t=n} \frac{\Delta D_t}{(1 + i)^t} - \sum_{t=1}^{t=n} \frac{I^P_t}{(1 + i)^t}
\]

where:

\(i\) = interest rate

\(n\) = life of the project in years

The formula shown above yields a discounted benefit-cost ratio. This is the ratio obtained when the present value of the benefit stream is divided by the present value of the cost stream.

The benefit-cost ratio was originally developed to evaluate water resource projects in the U.S. and is still used by such organizations as the U.S. Army Corps of Engineers and the Bureau of Reclamation. However, for technical reasons, it is not widely used in developing countries where discounted cash flow measures such as the internal rate of return (IRR) are more popular.
In the numerical example, the returns to the investment continue for 4 years without the need for further capital infusion. The result is a B-C ratio greater than 1.

2. The individual entries, discounted at 10%, are shown in the example.
The internal rate of return (IRR) is the discount rate that would make the net present value of the benefit stream or the incremental cash flow equal to zero. It is the maximum interest rate that can be paid for investment and operating costs if the project is to break even.

The internal rate of return is an important measure of project worth. It is the measure used by the World Bank for practically all of its economic and financial analyses and the measure used by most other international financing agencies.

3. The formal selection criterion for the IRR measure of a project is to accept all independent projects having an internal rate of return equal to or greater than the opportunity cost of capital. An IRR can only exist if the cash flow has at least one negative element. It can only be used in a crude way to rank projects.
Numerical IRR Analysis

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<th>Profits</th>
<th>I-Cost</th>
<th>Cash</th>
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<td>Inputs</td>
<td>Factors</td>
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<td></td>
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IRR 35%

1. The algorithm used to compute the IRR is one of Excel's financial functions. The project should be accepted if the opportunity cost of capital is less than 35%.