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 Policy Analysis Matrix introduced in this lecture has been described and applied widely in the literature on agricultural development. A concise summary can be found in Eric A. Monke and Scott R. Pearson, The Policy Analysis Matrix for Agricultural Development (hereafter PAM), 1989, Chapter 13, pp. 261-265. The PAM book also addresses each dimension of the approach in detail in earlier chapters. The PAM approach was first developed in 1981 by researchers at the University of Arizona and Stanford University to study changes in agricultural policies in Portugal. The seminal book applying this analytical approach is Scott R. Pearson et al., Portuguese Agriculture in Transition, 1987. An empirical application of this framework to rice in Indonesia is found in Scott Pearson et al., Rice Policy in Indonesia (hereafter RPI), 1991, Chapter 7, pp. 114-120, 131-137.
The Policy Analysis Matrix methodology provides information to help policy makers address three central issues of agricultural policy analysis (PAM, Chapter 2, pp. 17-18).

One issue is whether agricultural systems are competitive under existing technologies and prices – that is, whether farmers, traders, and processors earn profits facing actual market prices. Prospective price policies would change the value of output or the costs of inputs and thus the private profitability of the system. A comparison of private profitability before and after the policy change measures the impact of the policy change on competitiveness.

A second issue is the impact of new public investment in infrastructure on the efficiency of agricultural systems. Efficiency is measured by social profitability, the valuation of profits in efficiency prices. Successful public investment (in irrigation or transportation) would raise the value of output or lower the costs of inputs. A comparison of social profits before and after the new public investment measures the increase in social profits.

A third issue is the impact of new public investment in agricultural research or technology on the efficiency of agricultural systems. Successful public investment in new seeds, farming techniques, or processing technologies would enhance farming or processing yields and thus increase revenues or decrease costs. A comparison of social profits before and after the investment in research measures the gain in social profitability.
The three principal purposes of the Policy Analysis Matrix (PAM) methodology are to provide information and analysis to assist policy makers in these three central areas of agricultural policy (PAM, pp. 30-31).

The construction of a PAM for an agricultural system allows one to calculate private profitability – a measure of the competitiveness of the system at actual market prices. Similar analyses of other systems permit a ranking of the competitiveness of agricultural systems at market prices. The calculation of private profitability or competitiveness is carried out in the first (top) row of the PAM matrix.

A second purpose of the PAM approach is to estimate the agricultural system’s social profitability – the result if products produced and inputs used are valued in efficiency prices (social opportunity costs). Complementary analyses of other systems allow a ranking of the efficiency of agricultural systems. The calculation of social profitability is carried out in the second (middle) row of the PAM matrix.

The third purpose of PAM analysis is to measure the transfer effects of policies. By contrasting revenues and costs before and after the imposition of a policy, one can determine the impact of that policy. The PAM method captures the effects of policies influencing both products and factors of production (land, labor, and capital). The measurement of the transfer effects of policies is carried out in the third (bottom) row of the PAM matrix.
A matrix is an array of numbers (or symbols) that follows two rules of accounting – one defining relationships across the columns of the matrix and the other defining relationships down the rows of the matrix. These accounting relationships are termed the identities of the matrix because they are true by definition (*PAM*, pp. 18-19).

The **profitability identity** in PAM is the accounting relationship across the columns of the matrix. Profits are defined as revenues less costs. All entries in the PAM matrix under the column defined “profits” thus are identically equal to the difference between the columns containing “revenues” and those containing “costs” (including both costs of tradable inputs and costs of domestic factors).

The **divergences identity** in PAM is the relationship down the rows of the matrix. Divergences cause private prices to differ from their social counterparts. A divergence arises either because a distorting policy intervenes to cause a private market price to diverge from an efficient price or because underlying market forces have failed to provide an efficient price. All entries in the PAM matrix under the third row, defined as “effects of divergences,” thus are identically equal to the difference between entries in the first row, measured in “private prices,” and those in the second row, measured in “social prices.”
Private Profits in the Policy Analysis Matrix

- Revenues
- Input Costs
- Factor Costs
- Profits
- Private (observed market) Prices
- A
- B
- C
- D

This slide shows only the entries for the first row of a PAM, which contains measures of prices in private prices (the observed market prices). The symbol A measures revenues in private prices, the symbol B stands for tradable input costs in private prices, the symbol C represents domestic factor costs in private prices, and the symbol D is private profit.

Profitability Identity – Private Profits

- private profit: \( D = (A-B-C) \)
- competitiveness of agricultural systems
- private benefit-cost ratio:
  \( (PBCR) = A/(B + C) \)

In empirical PAM analysis, the revenue and cost categories in private prices (entries A, B, and C) are based on data from farm and processing budgets. The symbol D, profits in private prices, is found by applying the profitability identity. According to that accounting principle, D is identically equal to A - (B + C). Private profits in PAM thus are a residual discovered by subtracting private costs from private revenues (\(PAM\), pp. 19-20).
The calculation of private profits, from data in farm and processing budgets, measures the competitiveness of agricultural systems. One key result for agricultural policy thus is obtained from the first row of the PAM matrix.

To compare results from agricultural systems that produce unlike outputs, analysts compute ratios (PAM, pp. 25-26). The computation of ratios thus avoids having to compare profits per kilogram of rice, for example, with profits per kilogram of soybeans. The comparison of competitiveness of unlike systems is facilitated by computing the private benefit-cost ratio (PBCR) for each system and then comparing these ratios across all the systems. The PBCR is equal to the ratio of private revenues to private costs, or PBCR = A/(B + C).

Slide 7

Social Profits in the Policy Analysis Matrix

- Revenues, Input Costs, Factor Costs, Profits

Social (efficiency) Prices
- E, F, G, H

This slide shows only the entries for the second row of a PAM, which contains measures of prices in social prices (prices that would result in the best allocation of resources and thus the highest generation of income). The symbol E measures revenues in social prices, the symbol F stands for tradable input costs in social prices, the symbol G represents domestic factor costs in social prices, and the symbol H is social profit. Countries achieve rapid economic growth by promoting activities that generate high social profits (large positive H).
In empirical PAM analysis, the revenue and cost categories in social prices (entries E, F, and G) are based on estimates of the social opportunity costs of commodities produced and inputs used in production. These estimated social (or efficiency) prices then are applied to the original quantities of outputs and inputs (those used in the calculation of private profits in the top row of PAM). The symbol H, profits in social prices, is found by applying the profitability identity. According to that accounting principle, H is identically equal to E - (F + G). **Social profits in PAM thus are a residual discovered by subtracting social costs from social revenues** (*PAM*, pp. 20-22).

The calculation of social profits, from estimates of social prices applied to input-output data in farm and processing budgets, measures the efficiency of agricultural systems. A second key result for agricultural policy thus is obtained from the second row of the PAM matrix.

The *social (efficiency) prices for tradable outputs and inputs are the comparable world prices* – import prices for commodities that are partly imported (importable) or export prices for commodities that are partly exported (exportable). The value (social opportunity cost) of producing an additional ton of an importable commodity (e.g., rice in Indonesia) is the amount of foreign exchange saved by replacing a ton of imports – given by the import price. Similarly, the social opportunity cost of producing an additional ton of an exportable commodity (e.g., palm oil in Indonesia) is the amount of foreign exchange earned by increasing exports by a ton – given by the export price.

The *social (efficiency) prices for domestic factors of production (land, labor, and capital) are estimated also by application of the social opportunity cost principle*. **Because domestic factors are not tradable internationally and thus do not have world prices, their social opportunity costs are estimated through observations of rural factor markets.** The intent is to find how much output and income are foregone because the factor is used to produce the commodity under analysis (e.g., rice) rather than the next best alternative commodity (e.g., sugarcane).
To compare social results from agricultural systems that produce unlike outputs, analysts again compute ratios. Comparison of the efficiency of unlike systems is done by computing the social benefit-cost ratio (SBCR) for each system and then comparing these ratios across all the systems. The SBCR is equal to the ratio of social revenues to social costs, or $SBCR = \frac{E}{F + G}$.

**Slide 9**

### Divergences Identity in the Policy Analysis Matrix

<table>
<thead>
<tr>
<th>Revenues</th>
<th>Input Costs</th>
<th>Factor Costs</th>
<th>Profits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private</td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Social</td>
<td>E</td>
<td>F</td>
<td>G</td>
</tr>
<tr>
<td>Divergences</td>
<td>I</td>
<td>J</td>
<td>K</td>
</tr>
</tbody>
</table>

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 (slide 3), **divergences arise from either distorting policies or market failures; either source of divergence causes observed market prices to differ from their counterpart efficiency prices** (*PAM*, pp. 22-25). 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).

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 (slide 3), **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 $(D - H)$. 
Divergences Identity

- market failures – monopolies/monopsonies, externalities, factor market imperfections
- efficient policy – corrects market failures
- distorting policy – creates divergences
- most efficient outcome – offset market failure, remove distorting policy

One source of divergence is the existence of a market failure. A market fails if it does not generate competitive prices that reflect social opportunity cost and lead to an efficient allocation of products or factors. Three basic types of market failures create divergences. The first is monopoly (seller control over market prices) or monopsony (buyer control over market prices). The second are negative externalities (costs for which the imposer cannot be charged) or positive externalities (benefits for which the provider cannot receive compensation). The third are factor market imperfections (inadequate development of institutions to provide competitive services and full information).

Efficient policy is a government intervention to correct a market failure and thus offset a divergence. For example, successful regulation of a monopoly would reduce seller prices, cause private and social prices to become equal, and increase income.

The second source of divergence is distorting government policy. Distorting policy prevents an efficient allocation of resources to further non-efficiency objectives (equity or security) and thus creates divergences. A tariff on rice imports, for example, could be imposed to raise farmer incomes (equity objective) and increase domestic rice production (security objective), but it would create efficiency losses if the replaced rice imports were cheaper than the costs of domestic resources used to produce the additional rice (as explained in the fifth lecture in this series). Hence, a trade-off would arise, and policy makers would need to assign weights to these conflicting objectives to decide whether to introduce the tariff.

The most efficient outcome could be achieved, in principle, if the government were able to enact efficient policies that offset market failures and if the government were to decide to override non-efficiency objectives and remove distorting policies. If these actions – the introduction of efficient policies and the removal of distorting policies – could be carried out, divergences would be offset and the effects of divergences (measured in the bottom row of
PAM) would be zero. In this idealized example, all entries in the bottom row of the PAM matrix – I, J, K, and L – would be zero and the entries in the top row would be identical to those in the second row, i.e., private revenues, costs, and profits would be the same as social revenues, costs, and profits (A = E, B = F, C = G, and D = H).

**Slide 11**

### Research Inputs for Efficiency and Policy Analysis

- identities, research inputs, and research results
- research inputs – from budgets for systems
  - private revenues (A)
  - private tradable input costs (B)
  - private domestic factor costs (C)
  - social revenues (E)
  - social tradable input costs (F)
  - factor divergences (K)

Of the twelve entries in the PAM matrix, only six need to be data or research inputs. The remaining six entries then can be found as research results by applying the profitability or divergences identities.

Most of the data for the six research inputs are obtained from the activity budgets (farming, marketing, and processing) for each agricultural system. The data for private revenues (A) and costs (B, C) typically come directly from these budgets. These budgets usually are based on both secondary data (gathered by other researchers) and primary data (obtained by the field research team).

The entries for social revenues (E) and social tradable input costs (F) come partly from the system budgets and partly from government documents or industry sources. Information on input-output relationships (quantities of inputs needed per hectare or per ton of output) typically are assumed to be the same in both private and social analysis and thus are obtained from the system budgets (and then from the first row of PAM). However, social prices differ from their private counterparts if distorting policy or market failures cause divergences. The social prices for tradable outputs and inputs are comparable import or export prices, found in government or industry documentation.

The entries for social valuation of domestic factor costs (G) cannot be observed directly in the field or taken from government or industry documents (because comparable world prices do not exist for factors). Instead, field researchers study rural factor markets to search for the presence or absence of divergences in each factor market – effective distorting policies or significant
market failures. Hence, the **entry for factor divergences (K) becomes a research input, which is then used to estimate social factor prices from observed private factor prices.** This empirical procedure is described in the lecture on factor markets.

**Slide 12**

![Research Inputs in the Policy Analysis Matrix](image)

The six categories of **research inputs in empirical PAM analysis (A, B, C, E, F, and K)** are **underlined in the PAM matrix** shown on this slide.

**Slide 13**

![Research Results from Efficiency and Policy Analysis](image)

Research results in the PAM approach flow directly from application of either the profitability identity or the divergences identity. Since these accounting principles govern the relationships in the PAM matrix, the key results are obtained from straightforward subtraction among entries of research inputs.
The first two results – private profits (D) and social profits (H) – are obtained from application of the profitability identity (revenues less costs equal profits). Private profits (D), a measure of competitiveness, equal private revenues (A) less private costs (tradable input costs (B) and domestic factor costs (C)). Similarly, social profits (H), a measure of efficiency, equal social revenues (E) less social costs (tradable input costs (F) and domestic factor costs (G)). The calculation of social profits (H), however, must await the estimation of social factor prices (G), itself a research result.

The next two results – output transfers (I) and tradable input transfers (J) – are obtained from application of the divergences identity (entries in private prices less entries in social prices equal the effects of divergences). Output transfers (I), a measure of the implicit tax or subsidy on outputs, equal private revenues (A) less social revenues (E). In turn, tradable input transfers (J), a measure of the implicit tax or subsidy on tradable inputs, equal private tradable input costs (B) less social tradable input costs (F).

The last two results – social factor prices (G) and net transfers (L) – are less straightforward. As noted above (slide 10), social factor prices (G) are found by adjusting private factor prices (C) for observed divergences causing factor price transfers (K). Because the divergences identity requires that (C − G) = K, it is also true that (C − K) = G. The final result, net transfers (L), can be found by applying either the profitability identity (I − (J + K) = L) or the divergences identity (D − H = L). The net transfer (L) thus can be interpreted either as the net effect of all divergences or as the difference between private and social profitability. This single measure thus shows the extent to which distorting policies and market failures implicitly subsidize an agricultural system (by transferring resources into the system) or tax that system (by transferring resources away from the system).

Slide 14

The six categories of research results in empirical PAM analysis (D, G, H, I, J, and L) are underlined in the PAM matrix shown on this slide.
Empirical application of the PAM approach is based on the compilation of data in budgets (PAM, Chapters 9 and 10, pp. 151-187). Four different budgets are put together for each agricultural system – one on farming, a second on marketing (from the farm to the processing center), a third on processing, and a fourth on marketing (from the processing center to the wholesale market). Details on the assembly of data in budget formats are set forth in the first of a two-part set of manuals designed to teach PAM application on micro computers. That first manual is entitled, Volume I: The Policy Analysis Matrix, and can be visited by clicking on the URL given here.

An early issue that PAM researchers confront is how many agricultural systems to study (PAM, Chapter 8, pp. 131-150). This decision depends critically on the nature of the questions addressed in the study. In general, however, researchers need to stratify the population of farmers according to several variables – the commodities of interest, the geographic regions or agro-climatic zones, the seasons of production, the agricultural technologies (differentiated by water control, inter-cropping, high-yielding seeds, modern inputs, and mechanization), and the areas cropped, owned, and rented in or out. By choosing a subset of these stratification variables, researchers can select a workable number of agricultural systems for which to create PAMs.

A number of guidelines assist the compilation of farm budgets. For most PAM analyses, the farm budgets should be based on actual data from a recent time period, not on optimal performance. The budgets are intended to be representative of current average farming behavior, not that of the best and most progressive farmers. The data in the budgets should be measures of average costs and returns; in this important respect, PAM analysis differs from efforts to build supply schedules of agricultural commodities, which are based on marginal (incremental) cost of production. The numeraire (the units used to denominate entries in the PAM) is usually domestic currency units per quantity (ton or kilogram) of output, since only farming budgets
(and not marketing and processing budgets) can be done using domestic currency units per
hectare.

Empirical PAM analysis usually should begin with the **compilation of synthetic budgets based on secondary data collected by other researchers.** These early budgets are synthetic in two senses – they are not the result of original field work and thus are somewhat artificial, and they are syntheses of existing work. The purpose of compiling synthetic budgets is to guide the researcher toward essential missing or conflicting information. Actual field work ideally then can focus on completion, verification, and updating of the synthetic budgets rather than starting from the beginning and building all new budgets.

**Slide 16**

**Fieldwork Principles for PAM**

- field observations – small samples, modal values, expert opinion
- data reliability – check for inconsistencies – yields, conversion factors, qualities
- opportunity costs – private (market choice) vs. social (foregone national income)

In carrying out PAM analyses, most of the time spent by researchers is devoted to interviewing farmers, traders, transporters, and processors in the field. Careful field work is crucial to understanding the farming systems, but it is also expensive in consuming scarce manpower and other project resources. **The budget data needed for PAM entries can be based on relatively small samples of farmers, traders, and processors.** PAM entries are modal values (central tendencies) not econometrically-estimated parameters drawn from statistically valid samples. Field observations and the allocation of researchers’ time in field work take advantage of this property. Researchers are encouraged to seek a wide range of informed and expert opinion about the agricultural systems rather than to meet imposed standards of large sample size.

**PAM researchers carrying out field work need to be aware of ways to cross check the reliability of the data they are collecting.** If private profits are negative, the farmer must be able to explain this result (usually because of unexpected poor weather or interrupted marketing of inputs or outputs). Researchers also need to check for possible inconsistencies in data from various respondents. Variations in yields (output per hectare) need to be consistent with applications of fertilizers and labor. In processing, conversion factors (e.g., quantity of milled rice per quantity of paddy) and qualities of outputs (e.g., percentage of broken kernels in milled rice) need to be analyzed consistently across processing units.
In making estimates of private and social prices, the principle of opportunity costs needs to be applied consistently and widely. Private opportunity costs reflect market choices. The rental value of a certain quality and location of land, for example, depends closely on the productivity of that land in producing various crops. Social opportunity costs reflect foregone national income. The social rental rate for land devoted to producing rice, for example, is given by the social profitability of that land in its best alternative use.