CHAPTER FIVE

WELFARE ECONOMICS

Economic Analysis and Social Objectives

5-1 THE ROLE OF WELFARE ECONOMICS Welfare economics is the science of determining how available resources may be best used to promote human welfare. The study is not entered with bias toward any specific social legislation, proposal for government ownership, or other welfare state program which might be proposed to solve specific social problems. Welfare economics seeks rather to develop better procedures (without prejudice toward either the public or the private sector) for allocating the total resource base (labor, capital, land, etc.) among potential uses and users to meet individual and group needs. Individuals need material resources to improve their economic well-being, a healthy environment to maintain their physical well-being, and psychologically satisfying experiences to maintain their mental well-being. Furthermore, man is a social being. He is affected as he observes the welfare of others. Human needs are met as individuals become better satisfied with their own lives and what they see of the lives of their neighbors.

Welfare economics is *normative* or *prescriptive* in character in the sense that it seeks the resource allocation best achieving consensus values or satisfaction of needs fulfilled. However, it is not prescriptive in the sense of recommending what these values should be. Welfare economics can be contrasted with *positive* or *descriptive* economics, which is concerned with understanding the functioning of economic systems. Descriptive economics provides the tools by which the consequence of alternative courses of action may be predicted. Welfare economics uses these predictions to

decide the relative merit of the alternative. It determines and aggregates the values individuals hold, to provide counsel on finding the course of action best promoting overall welfare.

5-2 THE SOCIAL WELFARE FUNCTION Resource development seeks to meet human needs. Some needs are readily met through water resources development. Relief from a periodic flood damage bill frees individuals to concentrate on other economic needs. Waste-water treatment and mosquito control meet man's physical need for improved health. Increased recreation opportunity may provide just the experience required to fulfill the need for mental relaxation. A project may provide jobs for the unemployed and thereby satisfy a group need for a more healthy community. Other kinds of needs cannot be satisfied through water resources development. The satisfactions realized through listening to good music or an inspiring sermon are not achieved through better resources management.

As a planning ideal, water resources development must be evaluated in terms of consequent effects (good and bad) on all human needs. As a practical matter, only certain needs can be satisfied through water-related projects. Other needs might be satisfied through water resources development but can be satisfied at less cost in some other way. Failure to incorporate goals related to either of these two types of needs into water resources planning models is not to say such needs are not worthwhile. The point is that many needs can only or at least can better be met by other means.

The goal of human activity is to meet human needs. Each specific need presents a specific goal. The ideal resource allocation would be achieved by the public policy maximizing a unanimously accepted index of total human welfare. Such an index would be computed by a mathematical formula called a *social welfare function* and incorporating all human goals. For example,

$$I = a_1G_1 + a_2G_2 + \cdots + a_nG_n \qquad \sum_{i=1}^{n} a_i = 1.0 \tag{5-1}$$

The index I must be a scalar value to rank alternatives unambiguously. The units used to measure progress toward each goal G and the weighting factors a must be defined so that society will become progressively more happy and contented with increasing value of I. Each goal must be defined in units permitting quantitative expression of the degree of fulfillment achieved by alternative proposals. Each weighting factor must indicate the relative influence of the goal in determining human happiness. Con-

struction of a social welfare function requires a series of value judgments. If the result is not unanimously accepted, its application will not settle any controversy among conflicting values.

5-3 FIRST-ORDER (SOCIAL) EFFICIENCY In applying Eq. (5-1) to select the best alternatives, one would evaluate the contribution of implementing each alternative toward accomplishing each goal and substitute the resulting values in the social welfare function to calculate I. Values of G for a given alternative may be either positive or negative. Project selection may then be based on the procedures developed previously by using I in place of present worth in the present-worth discounting technique (Sec. 2-9) or by using Eq. (5-1) as the objective function in optimality studies (Sec. 4-3).

However, one need only review the social goals related to water resource development listed below and the diversity of opinion on their relative desirability to realize that an ideal social welfare function will never be available to guide planning decisions.

1 *Maximum national income.* People with higher incomes have more resources for providing themselves with a better life. The model of pure competition achieves economic efficiency in that it maximizes national income. However, none can deny that there are many contented poor and miserable rich. Money is far from the total answer to human happiness. What is?

2 *Ideal income distribution.* Collective happiness is not maximized if the maximum national income is achieved by giving the national wealth to an elite group while everyone else lives in abject poverty. A guaranteed equal income for everyone would weaken the incentives of the ambitious. How should income be distributed?

3 *Environmental quality.*[1] Everyone has scenic spots, historical landmarks, and wildlife forms which he would like to see preserved and is disturbed by destructive pollution. Society agrees with respect to Yosemite Valley, Independence Hall, redwood trees, or obnoxious air and water pollution. But all progress would be halted by the preservation of every childhood home that brings back nostalgic memories. Where can the line be drawn?

4 *Institutional stability.* Continuing rapid social change promotes uncertainty and insecurity. A completely static society departs progressively further from achieving social justice with changing times. What is the optimum rate of change?

[1] Maynard M. Hufschmidt, Environmental Aspects of River Basin Planning, *Proc. ASCE*, vol. 93, no. HY 6 (November, 1967), pp. 323–352.

5 *Public health.* Freedom from disease and accidental injury and the preservation of life involve values that transcend expression in income units. A wealthy man may spend all he has and go into debt to preserve his life or regain his health. Is public health a goal to be preserved at all economic cost? Most would agree that society as a whole is not willing to live in poverty to preserve good health. Accidental death and injury would be substantially reduced by outlawing the automobile, but people would be unwilling to bear the inconvenience. Public health does not completely override all other considerations. How much should be spent to preserve health and life?

6 *Regional development.* A more even geographical distribution of economic development reduces congestion in more highly developed areas, presents the challenge of making wasteland productive, and aids national defense. It improves the income and morale of isolated areas, or even nations, which might otherwise be bypassed by economic growth. Should such areas be developed at a net sacrifice in total income?

If all of the above questions could be resolved, the planner could use the resulting social welfare function to devote available resources to endeavors most efficiently contributing to human welfare. Social, or first-order, efficiency would be achieved. But because no one can precisely measure degrees of accomplishment of all social objectives nor assign relative weights to alternative goals, a universal social welfare function can never be developed for general use. The best that can be hoped for is an approximate, or second-order approach.

5-4 THE QUESTION OF SOVEREIGNTY The first step in developing an approximate approach must be resolution of the question of sovereignty. Supporters of individual sovereignty say that each man is and should be the best judge of his own best interest. A man should have the right to spend his money, order his activities, and divide his time according to his own desires. The level of human aspiration will increase indefinitely, always remaining just a little higher than the means for fulfillment can provide.[1] No matter what his income, man's wants can never be entirely satisfied, a condition of perpetual scarcity. Certain wants are expressed by the exercise of consumer sovereignty in the marketplace. Others are expressed by the exercise of individual sovereignty in the voting booth. The market and the ballot box aggregate individual wants to determine collective need according to the prevailing values of the community.

[1] Support for this position is found in Richard S. Weckstein, Welfare Criteria and Changing Tastes, *Am. Econ. Rev.*, vol. 52 (March, 1962).

As long as adequate safeguards are available to make sure that the activities of one man do not infringe on the rights of others, social welfare is maximized by maximizing the sum of the satisfaction brought to each individual.

The second school of thought, which has come to be called *abundancy economics,* attacks the question, "What should man want?" instead of being satisfied with determining prevailing community values.[1] It substitutes value judgments on general welfare by a planning elite for empirical measurement of what the people themselves prefer. It argues that as men become more wealthy, all their reasonable wants are satisfied and they dissipate their excess money. It scorns the idea that a free market dependent on consumer sovereignty can maximize human welfare, with the illustration that $1 million used in cancer research must inherently be more valuable to society than $1 million spent on chewing gum. The rich are spending their money on trivial frivolities while great social needs go begging. It believes market deficiencies to be so vast that no allocation made by the market system can have normative significance. Market theory based on scarcity is not relevant when all reasonable demands for market goods are more than abundantly satisfied. One advocate of this position has stated:

> The assumptions . . . about the efficiency of the private sector achieved through free competition are so removed from reality that I fail completely to understand why they (the advocates of the first position) were led to advance, seriously, criticisms of water-resource development policy built upon such a flimsy foundation.[2]

However, instead of offering a specific social welfare function, this school of thought usually proposes use of political or hierarchical control without defining precise criteria.

Planning and resource allocation through the political process requires people to express their preferences for social action by the ballot box rather than by money votes. The method is based on the assumptions that voting alternatives can be structured in a manner permitting meaningful planning choices, that the voters will make decisions in harmony with a consistent value system, and that voters will base their decisions on overall social welfare rather than their own self-interest. The method is beset with difficulties. Voting motivated by self-interest can produce im-

[1] John Kenneth Galbraith, "The Affluent Society" (Boston: Houghton Mifflin Company, 1958).
[2] Morris E. Garnsey, Welfare Economic and Resource Development, "Western Resource Conference Land and Water Planning for Economic Growth, 1961" (Boulder: University of Colorado Press, 1962), p. 197.

provement only through a more equitable distribution of voting power.[1] Some have hypothesized that voting is based on higher motives than market purchases,[2] but there is no conclusive evidence one way or the other. The voter is faced with broad alternatives, each mixing features which he likes with those he dislikes. The ballot box offers no way to express depth of feeling and thus permits a minority who feel intensely on an issue to be outvoted by a majority who really do not care very much. The outcome of the election can be influenced by the structuring of the alternatives.[3] Political decision making may be used to reach major policy decisions, but is impractical for making the countless little decisions required in resource allocation.

Those who believe man cannot know his own best interest or cannot express it in either the marketplace or the ballot box advocate hierarchal or administrative planning. The leadership should determine the best interest of the people, and experts should organize society in order to achieve that best interest. However, this method has difficulties too. Freedom is lost as leadership decides what is good for the people and molds public opinion to the desired ends. Experts can never be entirely objective or completely free from the same jealousies, ambitions, and desires which influence the thinking of the rest of mankind. The cost of maintaining the organization required to analyze all the available social alternatives and guide the nation in the desired direction is very great. So is the danger of disastrous decisions caused by errors or oversights in using a planning machinery with no self-correcting features. But overwhelming all the other difficulties is the shear impossibility of building the required all-encompassing mathematical model. It is well said:

> Indeed, the best medicine for well meaning central planners is perhaps a stiff dose of down-to-earth operations research on complex problems of the federal government; such an experience would lay bare, more vividly than does meditation alone, the awesome difficulties that would be encountered (and the grim mistakes and concentration of power that would surely occur) in detailed central direction of the economy.[4]

Once the planner overcomes his arrogance enough to realize that the

[1] James M. Buchanan, Politics, Policy, and the Pigovian Margins, *Economics*, vol. 29 (February, 1962), p. 17.

[2] Stephen A. Marglin, Economic Factors Affecting System Design, in Arthur Maass et al., "Design of Water-resource Systems" (Cambridge, Mass.: Harvard University Press, 1962), p. 197 ff. Richard A. Musgrave, "The Theory of Public Finance" (New York: McGraw-Hill Book Company, 1959), p. 87 ff.

[3] Duncan Black, On the Rationale of Group Decision Making, *J. Political Econ.*, vol. 56 (February, 1958), p. 23.

[4] Roland N. McKean, "Efficiency in Government through Systems Analysis" (New York: John Wiley & Sons, Inc., 1958), p. 8.

hierarchical approach to resource allocation is incapable of producing socially acceptable and practically workable results, he has little alternative but to accept individual sovereignty, seek the answer to the question, "What does man want?" and plan to fulfill his desires. The individual may not know his own best interest in an absolute sense, but he probably knows it better than anyone else.

5-5 THE QUESTION OF GOALS Acceptance of individual sovereignty still leaves the problem of aggregating individual choices into a social welfare function. Market processes provide the most effective mechanism of aggregating the countless individual choices reflecting varying degrees of preference and affecting small groups of people. If the market is perfectly competitive, it will allocate resources so as to maximize national income. Of course, actual markets are not perfect. Market failures require administrative agencies to evaluate their consequences, act to remedy resulting allocation deficiencies, and determine normative shadow prices for use in planning. Specific problems are described in subsequent sections on public wants (Sec. 5-9), external effects (Sec. 5-10), and natural monopoly (Sec. 5-11).

However, optimum resource allocation is influenced as individuals seek goals other than maximization of income. Each alternative needs to be evaluated to determine its consequences for each such goal. The evaluations consider what have traditionally been called intangible values in engineering economy studies (Sec. 1-6). Effects concerning conflicting goals must be tabulated and incorporated into the decision-making process. However, the final resolution should, according to the principle of individual sovereignty, be based on some community consensus and not on the necessarily arbitrary decision of a planning elite. Where market processes cannot work, political choices provide the next best method for defining the relative importance people attach to various goals. For ex-

TABLE 5-1 Comparing Alternatives Achieving Multiple Goals

Alternative goal	Economic benefits	Regional income	Environmental quality*
A	$1,000	$400	50
B	900	400	75
C	900	600	50

* Measured in a unit increasing with a higher-quality environment.

ample, politically determined income tax schedules provide a starting point for establishing the relative importance of income redistribution (Sec. 5-13).

Two approaches are available for mechanically handling multiple goals. One is to predetermine the weighting factors [Eq. (5-1)] and use the resulting social welfare function in systematically comparing alternatives. The second approach is to develop a decision matrix based on alternatives as rows and goals as columns. For example, a particular study may produce the information shown in Table 5-1. With this information at hand, one would have to decide whether an extra 25 units of environmental quality are worth achieving at a sacrifice of $100 in economic benefits. He would have to decide whether $200 of additional benefits to the region were worth a $100 loss in national income. Through answering a series of such questions and trying various design modifications, the planner could eventually produce an optimum or at least an acceptable design. The alternative finally selected from the decision matrix will imply a full set of weighting factors which can be calculated from observed marginal trade-offs.

Several difficulties in designing to achieve multiple objectives are pinpointed by Table 5-1. It is very difficult to express achievement of certain goals (environmental quality, for example) in numerical units. Furthermore, the best project for achieving one goal is seldom the best for achieving other goals. One cannot escape the value judgments required in the trade-offs necessary to resolve conflicting goals. Therefore, an explicit statement of the required value trade-offs so that they can be publicly discussed is one of the major advantages of the matrix approach.

5-6 BASIC OPTIMALITY CRITERIA[1] The early contributions to welfare economics were based on the premise of individual sovereignty with each individual subjectively evaluating his own goals to maximize his welfare. The first criterion of welfare economics, known as the *Pareto criterion* after the Italian Vilfredo Pareto, who about 1899 first proposed it, is:

> Any change which harms no one and which makes some people better off (in their own estimation) must be considered to be an improvement.[2]

By including the words "in their own estimation," individual sovereignty is explicitly accepted. In order to avoid the severe restriction of being

[1] For discussion in greater detail, see William J. Baumol, "Economic Theory and Operations Analysis" (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1961), pp. 262–275.

[2] As quoted in *ibid.*, p. 267.

unable to make a choice which harms anyone at all, Kaldor proposed the more widely applicable criterion:

> A change is an improvement if those who gain evaluate their gains at a higher figure than the value which the losers set upon their losses.[1]

From the point of view of the general economic welfare, it is irrelevant whether the losers are actually compensated by the gainers. Such an exchange would represent a transfer of money among individuals and not a net increase in national welfare. The exchange represents an income redistribution and must be evaluated with respect to that goal.

5-7 SECOND-ORDER (ECONOMIC) EFFICIENCY If one uses income as the sole index of individual and social welfare, $I = G$ [Eq. (5-1)], where $G = B - C$. The resulting approximation says social welfare improves as the aggregate national income increases. The optimum project is the one most effective in increasing national income. The criterion for resource allocation is economic efficiency.

The goal of maximizing national income (net benefits) was used in Chap. 4 to derive the conditions characteristic of the optimum production process. Later in the chapter, a review of the pure-competition model showed that an ideal market would automatically achieve these optimum conditions. At this point, we can also show that under the approximation of economic efficiency the same set of rules also satisfies the Kaldor criterion.[2]

RULE 1 *The Optimum Allocation of Goods.* Each consumer maximizes his satisfaction by ordering his consumption so that the marginal rate of substitution between any two goods is equal to the ratio of their prices. Each pair of consumers must have the same marginal rate of substitution or a trade of goods would effect a mutual gain. According to Kaldor's criterion, an improvement would have been registered. An improvement would mean the initial conditions were not optimum in that they did not maximize collective welfare. Pure competition achieves equal marginal rates of substitution by making the price of any good constant throughout the economy and hence making all price ratios uniform.

RULE 2 *The Optimum Degree of Specialization.* Each firm maximizes its profit by making its marginal rate of transformation between any two outputs produced equal to the ratio of their prices. Each firm must have

[1] As quoted in *ibid.*, p. 269.

[2] For detailed derivations, see Syed F. Hasan, "Introduction to Welfare Economics" (New York: Asia Publishing House, 1963), chap. 4.

the same marginal rate of transformation to keep a trade of outputs from effecting a mutual gain. Pure competition achieves this goal by making the price ratio between any two outputs constant throughout the economy.

RULE 3 *The Optimum Relationship between Input and Output.* Each firm maximizes its profit by equating the marginal physical product of input in producing output with the ratio of their prices. If this ratio were not constant for any given input-output pair within the economy, a given input shifted to a firm having a higher ratio would achieve a net social gain. The optimal condition of maximum welfare could not have initially existed. Pure competition also satisfies this rule by achieving uniform price ratios.

RULE 4 *The Optimum Allocation of Inputs.* Each firm maximizes its profit by making its marginal rate of substitution between any two inputs used in production equal to the ratio of their prices. Ratio variation among industries would mean trade could improve overall welfare, and pure competition would maintain a uniform ratio.

RULE 5 *The Optimum Direction of Production.* Overall welfare is maximized if the marginal rate of transformation in the production process between any two outputs is the same as the marginal rate of substitution between the same two goods on the part of the consumers. Otherwise, welfare would be increased by shifting production to goods placed in relatively higher value by consumers. The uniform prices of pure competition would also achieve this goal.

RULE 6 *The Optimum Allocation of an Individual's Time.* Optimum welfare also requires that the marginal rate of substitution between leisure and wages for each person must be the same as the marginal physical product between the work done and the resulting output for each firm. An individual maximizes his satisfaction if he equates his marginal rate of substitution between money and leisure with the wage rate he receives for labor. Similarly, a firm maximizes its profits if it equates its marginal physical product between a unit of labor and a unit of output with the ratio of their prices. Under pure competition, all firms sell the identical output for the same price, and all firms must pay the same wage rates for all workers with the same skills.

RULE 7 *The Optimum Allocation of Assets over Time.* An individual maximizes satisfaction by equating his marginal rate of substitution between present consumption and future consumption with the rate of interest he can earn in the market. In the same way a firm equates its marginal rate of substitution between present and future assets with the rate of interest it must pay for borrowed funds. Pure competition equates these two marginal values by making the lending rate equal the borrowing rate.

Conclusions The achievement of the optimum allocation of goods according to the Kaldor criterion by the purely competitive model means that under ideal conditions the market automatically achieves economic efficiency. Government economic planning could not improve the efficiency of an ideal economy. The ideal market provides the needed community consensus on resolving conflicting economic preference (Sec. 5-5) and thus a basic framework for planning. Project evaluation can begin by determining marketplace values for benefits and costs. However, such values cannot be used indiscriminately. Adjustments are needed for market imperfections. Adjustments are needed to consider other goals. Each is discussed below.

Adjustments Required by Imperfect Markets

A primary role of government in a free economy is to compensate for failures of real markets to organize production as efficiently as the purely competitive model. Such failures are most frequently caused by limitations on the ability of the market to respond to certain types of demand, the effects of market transactions on third parties, and the possibility of creating a natural monopoly by economies of scale.

5-8 ADJUSTMENT PROCEDURE The complexity of the adjustment analysis required to correct market prices to normative ones for use in project evaluation depends on the degree of market distortion. A partial equilibrium analysis can be used where it is only necessary to adjust a few values inadequately handled by the market. Price corrections and project input and output are assumed to be too small to produce major market disruptions. For example, a typical project would not be large enough to use so much steel as to upset steel prices and thus the production function of other steel users throughout the country. Where major distortions or disruptions exist, a general equilibrium analysis is needed to evaluate the economic ripples. Such an analysis is usually based on an input-output model (Sec. 9-3). It is more likely to be required in a small country or a developing economy.

In conclusion, the following steps can be used to obtain the normative value of an input or output:

1 Determine the market price.
2 Determine whether one of the conditions described below (Secs. 5-9 to 5-11) exists. If so, adjust the price as required.

3 Determine the extent of the effect the project is likely to have on market transactions throughout the economy. If the effect is negligible, adjusted prices can be used directly. If the effect is confined to a few items' changing price, the value for project analysis can be approximated as the mean of the before and after prices as estimated from supply and demand curves. If the project will produce major economic disruptions, general equilibrium analysis is required to estimate subsequent prices.

5-9 PUBLIC WANTS Public wants comprise human desires which cannot be satisfied or at least cannot be satisfied to an acceptable degree by market processes.[1] Social wants cannot be satisfied at all because they demand goods or services which must be consumed collectively. Clean air must be provided to the entire community if it is provided to anyone. It is not technologically possible to clean only the air breathed by those paying a fee and leave dirty air for those not paying. Such goods or services must be enjoyed by all or none. Other examples are street lighting, national defense, flood protection, and natural environment.

Merit wants can be satisfied to some extent by market processes, but they represent wants where political consensus shows the market provision to be inadequate. The associated goods and services cannot neatly be classed as either a market or a collective good. They lie in the fringe area. For example, public education, health services, outdoor recreation opportunities, and historic landmarks may be provided by private enterprise but not in sufficient quantities because the market can only collect from a small portion of those who benefit. Firearms or liquor may be overprovided by private enterprise because the market cannot register the objections of those who are harmed. The preservation of natural resources represents a special type of merit want where the market is unable to express the wishes of future generations (Sec. 9-5).

Even though the goods and services fulfilling public wants cannot themselves be exchanged in the market, the principles of market analysis can still be applied to establish values. Individual demand curves may be implicitly derived from costs which would occur if the good were not provided (flood control) or from costs borne to obtain the good (recreation). The individual-demand curves are added vertically because each person receives the same level of service and the total value realized by the group is the sum of the values individually realized. This contrasts with the horizontal addition for market goods (Sec. 3-12) where individuals pay the same price but receive different levels of service.

[1] Richard A. Musgrave, "The Theory of Public Finance" (New York: McGraw-Hill Book Company, 1959), chap. 1.

Aggregate-demand curves for collective goods can be used for project optimization in the same way as aggregate-demand curves for market goods are used (Sec. 4-16). For merit wants, the aggregate-demand curve may be developed by vertically adding appropriate values from derived demand curves representing the social or collective aspects of the demand.

5-10 EXTERNAL EFFECTS

Nature of Effects External effects may be either external economies or external diseconomies. External economies refer to favorable consequences or benefits which consumption or production by one party has on others. External diseconomies refer to harmful consequences or costs which occur in the same way. An external economy exists when provision of a good or service to one group makes it possible for another group to receive the same or another good or service without paying for the benefit it has received. On the other hand, an external diseconomy exists when provision of a good or service for one group causes increased costs for another group and the second group is not compensated for its loss.

Technological external effects result from physical interaction between the activities of two or more parties. For example, a dam constructed for the purpose of producing hydropower also produces downstream benefits in mitigating both flood and low flows. A private power company will not consider these effects in plant design because it is not reimbursed for them. By the same token, a private firm which discharges untreated wastes directly into a stream causes those downstream to suffer uncompensated loss. The market does not allocate resources efficiently in the presence of external effects because no market transactions are involved. Firms which are not rewarded for their external economies will produce less than is optimum, while those which are not penalized for their external diseconomies will produce more than is optimum. The private power company will normally build a dam that is too small. The firm discharging waste will normally discharge too much.

A separable technological effect influences the variable cost and thus shifts the marginal-cost curves of other production units. A firm benefitting from an external economy will tend to overproduce. A firm subjected to an external diseconomy will tend to underproduce. An inseparable technological effect only influences the fixed cost of other production units. It will not affect the optimum output unless an external economy is large enough to put other firms into business or an external diseconomy is large enough to cause them to withdraw.

Pecuniary external effects result from shifts in the supply and demand curves caused by one firm and altering the production decisions

of another. An expanding production unit may bid up prices for the goods and services it uses as inputs (a pecuniary external economy to the supplier of the input and diseconomy to other users), force down the price of substitute products (economy to user and diseconomy to supplier), induce an increase in the price of complementary products (economy to supplier and diseconomy to user), or lower the price of its output (economy to consumer and diseconomy to competitive supplier). Since each pecuniary external effect is a gain to one party offset by a loss to another party, economic efficiency is not affected, but income distribution is. The evaluation of pecuniary external effects is in the scope of first- but not second-order efficiency.

Market external economies are a special type of pecuniary economy which results from the creation of a large new production unit such as a water resources project. They result from the fuller utilization of existing transportation and other public facilities and more efficient operation of processing firms. Many of these economies have come to be known as *secondary benefits.*

Psychological external effects occur when the consumption by one party alters the satisfaction received by other parties. One may not desire a particular type of consumption until he sees another enjoying it, or he may receive satisfaction from seeing others enjoy consumption of a type of which they were previously deprived. Demand analysis assumes the wants of various parties are independent, and economic efficiency criteria can not be used for optimization if this assumption is untenable.

Methods of Dealing with Effects The technological spillovers should be directly evaluated in project formulation because they physically alter the production functions, and the goal of planning is to pick the optimum production process. This is best done by an analysis of the production function of the second party with and without the external effect caused by the first. Damages from poor water quality can be estimated both with and without the low-flow augmentation provided for navigation. The difference in damage is the value of the technological external economy.

The effect of pecuniary spillovers can best be explained through supply and demand curves. If a commodity characterized by the demand curve of Fig. 5-1 were to reach equilibrium at price P_1 and demand Q_1, it would have an aggregate value in use equal to the sum of areas A, B, and C and a consumer's surplus equal to area A. If the advent of a new low-cost producer (a pecuniary externality) were to cause the price to drop to P_2 and sales to increase to Q_2, the original producers would lose the income represented by area B, but consumers would benefit by an amount represented by the sum of areas B and D. Thus the pecuniary spillover has two

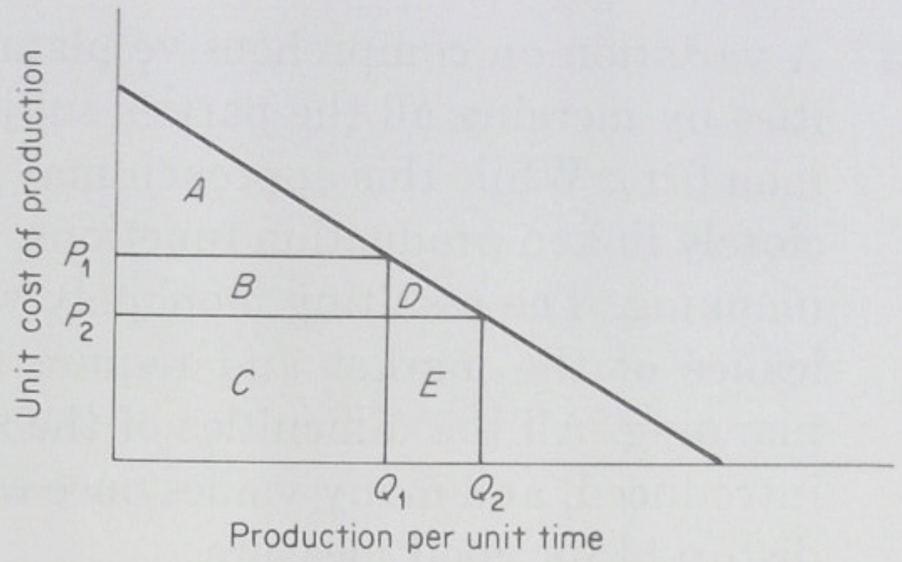

FIGURE 5-1 Effect of pecuniary spillovers.

types of effects. The value of area D is a net gain to consumers. The value of area B is transferred from the producers to the consumers. The transfer has no influence on economic efficiency. It is instead related to income distribution. As a result it does not enter into the economic feasibility of a project, but it is closely tied to the political, social, and institutional factors which help determine whether or not a project is built (Sec. 8-1). Area D is a net benefit when price decreases owing to increased output or reduced demand and a net loss when price increases owing to decreased output or increased demand. In either case, the value of area D should be incorporated into project evaluation just as technological spillovers are.[1]

The water resources planner might deal with external effects in one of a number of ways:

1 He may ignore them. Because the inability of the market to handle external effects efficiently is a major argument for government planning, it is hardly proper for government planners to ignore them. The same results could be achieved by market forces without the planning cost of the government bureaucracy. In fact, this approach is only mentioned because of the number of times it has actually been applied. Irrigation projects have been planned and built while ignoring downstream salinity. Surface-water supplies have been developed with no thought to their influence on ground-water users. Reservoirs have been built with no prior analysis of the effect of reduced sediment flow on downstream channel stability. Planners must do better.

2 The second possibility is to catalogue and evaluate every externality in a truly comprehensive plan. However, the conceptual problems which would be encountered and the magnitude of the task in such a colossal undertaking make the comprehensive approach impractical if not impossible. Even if a good job could be done, the planning cost would quite likely exceed the marginal benefit of the improved results.

[1] Stephen A. Marglin, Objectives of Water-resource Development, in Maass et al., *op. cit.*, pp. 55–58.

3 A variation on comprehensive planning is to internalize the externalities by merging all the parties subject to external effects into a common firm. While this approach may prove valuable for industries with closely linked production functions, it is no answer for water resources planning. The resulting monopoly would negate the normative significance of the market and require its replacement by mathematical planning. All the difficulties of the second approach would have been introduced, and many values once established by the market would be distorted for good measure.

4 A fourth approach is to attempt, by legal means, to prevent externalities from occurring. This may be done either by the passage and enforcement of legislation or by court action. Numerous laws deal with such subjects as land use on flood plains, water pollution control, and channel encroachments. Court decisions have established precedents in cases on water rights, disposition of drainage water, and other external diseconomies where a single individual can be held directly responsible. However, settlements often depend more on political power and legal persuasiveness than on objective analysis. Laymen can hardly be expected to reach a meaningful decision on technical matters without technical advice.

5 One may wonder what course is left if one cannot successfully handle externalities by ignoring them, comprehensively analyzing them, or preventing them. All spillovers can be tabulated qualitatively. The major ones can be selected and evaluated quantitatively so the values can be incorporated into project optimization. Whether or not an effect should be evaluated depends on whether the nature of the optimal project is sensitive to the effect. In accordance with this rule, major technical spillovers require serious analysis; but the consumers-surplus triangle is normally too small to require detailed analysis of pecuniary spillovers.

5-11 NATURAL MONOPOLY Another deviation from the model of pure competition that serves as a justification for government activity is caused by natural monopoly. Monopoly occurs when the optimum plant size (Sec. 4-15) supplies a large enough portion of total market demand to influence market price. Economic efficiency requires that the market price equal marginal cost. However, to any firm finding its price dependent on its output, marginal revenue is less than price; and to maximize profit, the firm will equate marginal revenue with marginal cost. The consumers will be getting less than optimum level of output at a higher price. In addition, the firm will be receiving monopoly profits. To promote efficient resource

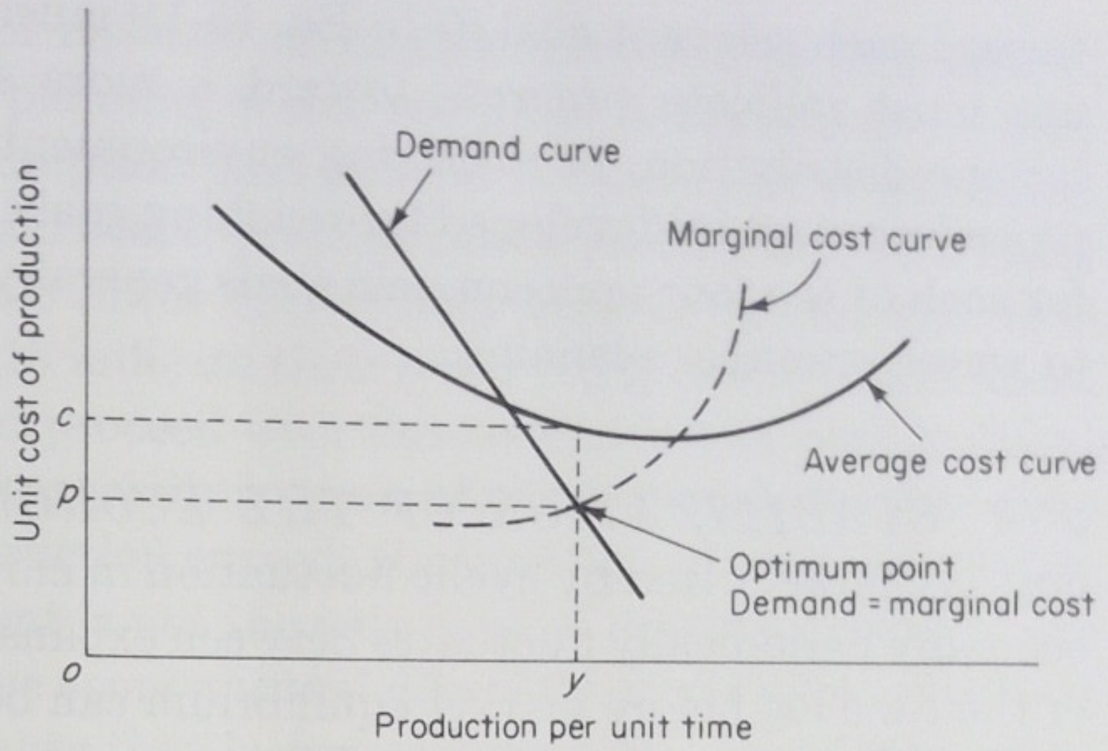

FIGURE 5-2 Decreasing-cost situation.

utilization the monopoly must be regulated or managed by the government so that market price equals marginal cost.

For a natural monopoly, average cost is decreasing at the point of optimal output (i.e., where price equals marginal cost). Where average costs are decreasing because the optimum scale of the plant is large compared with market demand, average costs will always exceed market price. As illustrated by Fig. 5-2, optimum output is y, unit revenue is p, and average unit cost is c. The smallest average cost occurs when the market is cornered by one producer, all other producers are eliminated by the market, and natural monopoly results.

Natural monopoly is characteristic of many utilities as well as water resource development where reservoir sites are limited, large-scale investments are required, and duplicate distribution systems are impractical. A common solution is to allow private enterprise an exclusive market but to regulate charges by the utility to yield only a fair return on its investment. Some utilities may be government owned to serve as a bench mark for regulation of the remaining private utilities. A third possibility is government ownership of the entire utility complex.

Adjustments Required by Multiple Goals

Two steps are required to adjust project planning for economic efficiency to incorporate other social goals. An acceptable measure of progress

toward each relevant goal [G in Eq. (5-1)] must be established. The measure must indicate progress toward a more stable economy, desirable income distribution, or satisfying environment. Secondly, an acceptable procedure must be developed for weighing goals. Specific discussion follows for each of the four noneconomic goals generally considered most relevant to water resources planning.

5-12 STABILIZATION OF THE ECONOMY The national economy is characterized by cyclic fluctuation in employment levels. A market economy periodically fluctuates between expansion and retraction because of the time lag before market equilibrium can be reestablished in response to changing demand or supply. When supply exceeds demand, producers reduce output, workers lose their jobs, and spendable income is reduced. As demand is further reduced, the resulting deflation may bring extensive unemployment before conditions stabilize and recovery begins. The most severe cycles may lead to general economic breakdown or what has been called *general* or *Keynsian unemployment*. Such conditions spread throughout the world in the 1930s. When demand exceeds supply, producers increase output, workers become in short supply and can command higher wages, and spendable income is increased. As more money becomes available, increasing price levels produce an inflationary condition which hurts fixed income groups and discourages long-term investment. Such conditions increased prices in Germany by a factor exceeding 10^{10} in the 1920s.

Government uses fiscal and monetary measures to prevent severe fluctuations. Fiscal measures implement government's taxing and expenditure powers. In principle, if inflation prevails, the government can reduce demand by increasing taxes and reducing its expenditures. If depression threatens, the government can increase demand by reducing taxes and increasing expenditures. Monetary measures adjust the money supply. The Federal Reserve Board can reduce the supply of money in time of inflation and increase it in time of depression. It does this by (1) selling or buying government bonds in the open market—selling bonds will reduce the money supply while buying bonds will increase the money supply—; (2) making or restricting loans to Federal Reserve Banks—making loans increases the reserves of the banks and allows them to increase loans to others—; and (3) changing bank reserve requirements—the higher the reserve requirements, the lower the money supply, and vice versa.[1]

The economic analysis of engineering alternatives normally assumes that government fiscal and monetary policy successfully stabilizes the

[1] Paul A. Samuelson, "Economics: An Introductory Analysis," 5th ed. (New York: McGraw-Hill Book Company, 1961), chap. 17.

economy at a high level of resource utilization. It would be inconsistent for government agencies planning water resources development to base their decisions on the assumption that policies for economic stabilization will fail. If depression should occur, projects can be reevaluated with lower interest rates to reflect the lower opportunity cost of capital and with lower prices for resources to indicate their lower input cost. Nevertheless, long-term planning should proceed with the assumption of high employment and price stability, especially in view of the fact that the lead time required for project construction exceeds the duration of economic cycles.

General unemployment is not the only type of unemployment which may be reduced to improve economic stability. Structural unemployment involves groups who, because they lack necessary skills, are unable to find work even when the overall economy is booming. Structural unemployment may result when changing demand patterns (horse-drawn carriages to automobiles) or changing production techniques (hand to machine sewing) eliminate the demand for once valuable skills. Others structurally unemployed may have never acquired any productive skill. Water resources projects are generally planned on the assumption that government educational and training programs are more successful in combatting this problem. However, under some conditions, project design or the construction methods should be modified so as to make greater use of the less skilled. The social cost of using unemployed resources is zero, and equating the marginal rates of substitution among project inputs shows the optimum policy is to increase use of unemployed resources until their marginal physical product becomes negative. However, the unskilled become trained in time, and project planning should not be based on a zero resource cost over the entire project life.

Regional unemployment includes groups which are unemployed because they prefer to live in familiar surroundings and remain unemployed than to move to a new location to find a job. Areas whose basic economy is tied to a declining industry present the most critical problem (New England textile mills or Appalachian coal mines). After people are thrown out of work, it takes time for them to move to find a new job. People who value their homes and neighborhood more highly than a steady income may not move at all, and regional adjustment may require two or three generations. While this problem also is not one which water resources development can solve very effectively alone, projects providing electric power, navigation, flood control, or other services may attract new industry to increase regional employment. Such an approach to stablizing a local economy is closely related to the goal of regional development (Sec. 5-14).

Underemployed resources are not used to their full productive capac-

ity. A highly skilled person may take a job requiring little skill when none other is available. Underemployment may be either structural or regional. Underemployment may be handled in project planning in the same manner as unemployment except that the social cost is the value of the resource in its lower-valued use rather than zero.

While water resources development is not a particularly efficient measure for nationwide economic stabilization, projects can be used to reduce the variability of annual regional income. Water development to broaden an agricultural or provide an industrial base can reduce the income fluctuations characteristic of a single-crop economy. Flood control reduces income fluctuations caused by periodic large damages. A project producing benefits which remain fairly constant from year to year or a project reducing damages into a more uniform annual pattern introduces greater economic stability. A useful index for measuring project effect on economic stability is the change in standard deviation of the annual income of the beneficiaries. A sample calculation for flood control is given in Exs. 10-4 and 10-5. The value judgment used to pick V_α for Eq. (8-7) is essentially the selection of an appropriate weighting factor for combining stabilization with economic benefits.

5-13 INCOME REDISTRIBUTION The distribution of income and wealth within a society is determined by the rules governing property ownership and inheritance, market transactions, and taxation and by the distribution among individuals of educational opportunity, ability, and motivation. Individuals view the resultant distribution with varying degrees of satisfaction. Collective dissatisfaction may through the political process promote action to redistribute income to poorer groups. The process has produced progressive income taxes and transfer payments to veterans, the aged, and the unemployed. Minimum wage legislation, tariff protection, farm subsidies, and fair trade legislation are other forms of income redistribution.

Water resource projects have been proposed as an additional method for redistributing income from richer to poorer groups. Several facts need to be kept in mind. Water resource projects are not particularly efficient in redistributing income because the rich always reap part of the benefit and the poor always pay part of the cost. The magnitude of water project expenditure is such a small part of the national income that a major income redistribution is unlikely to be ever achieved. Failure to incorporate income redistribution explicitly as a project objective does not necessarily mean the objective is not considered worthwhile. It only means the redistribution can be accomplished more effectively in some other way.

Explicit analysis of the income redistribution effects of a specific water resources project requires determination of the incidence of project benefit (and cost) among individuals by income category. The value judgment of weighting-factor selection comes in placing a higher value on benefits to those in one income group than in an other. Income redistribution to the poor is encouraged by using weighting factors inversely related to income. An explicit approach is presented in Sec. 8-10.

The redistribution of income is reduced as beneficiaries are required to pay for project output. Income redistribution effects may be even more important as a tool in financial analysis to determine who should pay than they are in economic analysis.

5-14 REGIONAL DEVELOPMENT The geographical distribution of economic growth within a society is determined by the historical response to topography, climate, trade routes, mineral deposits, soil fertility, international disputes, and a host of lesser physical, economic, and social factors. Collective dissatisfaction with the resultant distribution may spring from a number of causes. Settlement of underdeveloped areas may improve military security, lay the groundwork for a future more broadly based economic expansion, and provide new opportunity for the dissatisfied. The ill effects of extreme population congestion may be mitigated. New industry may be brought into rural areas to alleviate urban migration caused by an increasing economic farm size. A thriving rural community can provide better public services to the benefit of long-time residents.

Water resources projects have been proposed as an element of a public program to encourage economic development in lagging regions. The effectiveness of such a program depends on the degree to which an inadequate supply of the kinds of output water resource projects can produce has served as a bottleneck to regional growth. Water resources development can make a major contribution through providing water to a desert, dry land in a swamp, electricity to those still using kerosene, or transportation for exporting a mineral ore. In other situations, economic growth may be restricted in ways which make water resources projects ineffective.

Explicit analysis of the regional development caused by a specific water resources project requires determination of the incidence of project benefit and cost by geographical location. As benefits tend to concentrate in the area near the project location while costs are spread more evenly throughout the country, project construction implies an economic sacrifice on the part of the rest of the country to develop a local area. If develop-

ment in the local area is judged more important than development elsewhere, a project with a net negative economic benefit can be justified. However, such a decision should reflect a national consenses and not the skill of the few who stand to receive large gains at outmaneuvering the many who have to make a small sacrifice. The legitimate goal of regional development should not be confused with the failure of some project planners to take the national viewpoint. Regional development in the national interest is best encouraged by deriving acceptable weighting factors to apply to cash flows by geographical location.

Project development in a small nation or other limited trade area may find it advantageous to favor locally available to imported inputs. Where the balance of payments requires that imports be limited to what can be financed from exports sold, the available foreign exchange should be used in the manner best promoting national goals. It is seldom possible to import all goods having an economic value exceeding their cost. A shadow price multiplier should be used in project planning to make sure the limited imports are used effectively. The appropriate λ can be estimated by the procedure used in project ranking (Sec. 9-12).

5-15 ENVIRONMENTAL QUALITY Unless explicit safeguards are introduced, planning based on economic criteria may inadvertently destroy the quality of environment required to preserve man's psychological and even long-run physical well-being. Even though individuals differ widely in environmental preference, common consensus is often reached to support unique natural areas and some open countryside and oppose destructive pollution or excessive congestion and resultant blight.

Structural measures for water resources development are widely viewed as having a destructive influence on environmental quality. The conflict can be mitigated by introducing an esthetically more pleasing design or by achieving project objectives through nonstructural measures. Explicit analysis requires both precise definition of what aspect of environmental quality is to be preserved or promoted and development of an index proportional to the quality achieved. Different indices apply in different situations. Sometimes physically measurable quantities such as acres of open land or wildlife populations may be used. Other times more indirect measurement through preference rating based on photographs may be possible. Often environmental quality must itself be handled as a multidimensional goal.

It is very important to remember that planning should seek to maximize the total social welfare function and not just environmental quality alone. The quality of the environment is usually only improved at

would goal G_1 require to favor alternative A_1? How low would the weighting have to drop to favor alternative A_5?

c For the optimum alternative of part *a* and assuming equal weighting for the other two goals, for what range in the weighting factor for goal G_1 would the same alternative be selected? What range for goal G_2? What range for goal G_3?

5-2 List as many arguments as you can in support of the *abundancy* approach to planning. List as many arguments as you can supporting the *efficiency* approach. Evaluate the two approaches according to their ability to provide practical guidance to planning decisions. What other considerations are required in choosing between the two approaches?

a sacrifice in national and regional income and employment. A reasonable compromise can only be reached through specific information quantifying the cost of achieving environments of progressively higher quality.

SELECTED REFERENCES

Arrow, Kenneth J.: "Social Choice and Individual Values" (New York: John Wiley & Sons, Inc., 1951).

Baumol, William J.: "Welfare Economics and the Theory of the State," 2d ed. (Cambridge, Mass.: Harvard University Press, 1967).

Bergson, Abram: "Essays in Normative Economics" (Cambridge Mass.: Harvard University Press, 1966).

Buchanan, James W.: Politics, Policy, and the Pigovian Margins, *Economics*, vol. 29 (February, 1962).

Galbraith, John Kenneth: "The Affluent Society" (Boston: Houghton Mifflin Company, 1958).

Garnsey, Morris E.: Welfare Economic and Resource Development, "Western Resource Conference Land and Water Planning for Economic Growth, 1961" (Boulder: University of Colorado Press, 1962).

Hasan, Syed F.: "Introduction to Welfare Economics" (New York: Asia Publishing House, 1963).

Hufschmidt, Maynard M.: Environmental Aspects of River Basin Planning, *Proc. ASCE*, vol. 93, no. HY6 (November, 1967), pp. 323–352.

Pigou, A. C.: "The Economics of Welfare," 4th ed. (London: Macmillan & Company, Ltd., 1932).

Weckstein, Richard S.: Welfare Criteria and Changing Tastes, *Am. Econ. Rev.*, vol. 52 (March, 1962).

PROBLEMS

5-1 Management has three goals which it desires to attain and considers of equal importance. The available alternatives are mutually exclusive and provide degrees of progress toward the goals as summarized in the following matrix:

	G_1	G_2	G_3
A_1	70	12	9
A_2	40	30	33
A_3	25	60	11
A_4	29	37	38
A_5	15	15	65

a Which alternative is to be preferred?

b If goals G_2 and G_3 were equally important, at least what weighting