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Techniques of Project Appraisal

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In this paper, I attempt to bring into focus what I believe to be some of the important practical issues that face development planners in the field of project appraisal. I shall try, insofar as possible, to recognize the handicaps under which planners operate, most importantly the handicaps imposed by imperfect foresight and by the virtual necessity of decentralized decision-making. To elaborate briefly on these handicaps, I think we must take it for granted that our estimates of future costs and benefits (particularly the latter) are inevitably subject to a fairly wide margin of error, in the face of which it makes little sense to focus on subtleties aimed at discriminating accurately between investments that might have an expected yield of 10½ per cent and those that would yield only 10 per cent per annum. As the first order of business we want to be able to distinguish the 10 per cent investments from those yielding 5 or 15 per cent, while looking forward hopefully to the day when we have so well solved the many problems of project evaluation that we can seriously face up to trying to distinguish 10 per cent yields from those of 9 or 11 per cent.

Moreover, in what follows, I shall try to bear in mind the virtual necessity of decentralized decision-making. Rules and procedures can be imposed which assure a certain rough harmony among the decisions taken in such vastly different areas as roads, irrigation projects, and educational investments, but one cannot realistically expect all investment decisions to be funneled through a single office or authority that exercises more than a general supervisory power. Most of the real work connected with project appraisal must, I believe, be done "close to the ground"; this fact alone limits the range of workable procedures to those in which a substantial amount of power can in fact be delegated to decentralized bodies.

Within this general framework the focus of the paper is mainly on

the fact that the relevant prices may change through time. The first section discusses the problem of real wage changes. The second section discusses the problem of future changes in the discount rate; the third section, the choice of a time path for the discount rate; the fourth section, the choice of the level of the discount rate. The fifth section discusses shadow prices for labor and capital, again coming to rest on the problem of selecting time paths. Finally, the sixth section discusses time paths of other prices and of demand functions.

The Problem of Real Wage Changes

Most discussions of project evaluation note that expected price changes should be taken into account, but little more than lip service is paid to this idea when working procedures are outlined. Insofar as the relative prices of commodities are concerned, this neglect of expected changes is understandable. "On the average," our best guess is likely to be that relative prices will remain as they are; cases where we have good reason to believe they will change can probably be regarded as somewhat exceptional, and project analysts can perhaps be presumed to deal with these exceptional cases as they arise.

When, however, we come to the price of labor, the story is very different. A rise in the real wage rate is one of the essential features of economic development, and this means a rise in the price of labor relative to the general price level of the economy. If we normalize on the general price level, we can therefore say that the typical investment is likely to be one in which the price of the product to be produced is expected to remain constant while the wages paid to labor rise. If a private entrepreneur leaves out of account the expected rise in wages (relative to the general price level), he does so at his peril, for this fact can readily turn a potentially profitable project into an unprofitable one.

Consider a case in which the price and volume of the output of a project and the prices and volumes of material inputs are expected to remain constant into the indefinite future, yielding an amount of value added, gross of depreciation, that is expected to be constant at R_0 per year. Assume wages are also constant, amounting to L_0 per year. Then the present value of the income stream acruing to the capital invested in the project will be $(R_0 - L_0)/r$, where r is the rate of discount used. If we assume that the capital cost is equal to this present value, it is a barely acceptable project when evaluated at r per cent. But now suppose that the wage rate is expected to rise at λ per cent per year, while

the product price and materials prices are expected to remain constant. Then, in the first place, the project life ceases to be infinite, as the value of direct costs $L_0(1 + \lambda)^t$ will at some time come to exceed R_0, and the operation will not be worth continuing. Defining the life of the project, N, by $L_0(1 + \lambda)^N = R_0$, we have as the present value of the income stream accruing to the capital invested in the project

$$\left[\frac{R_0}{r} - \frac{L_0}{r - \lambda}\right]\left[1 - \frac{1}{(1 + r)^N}\right]$$

This falls short of the present value obtained in the previous case by

$$\frac{\lambda L_0}{r(r - \lambda)} + \left(\frac{R_0}{r} - \frac{L_0}{r - \lambda}\right)\left(\frac{1}{1 + r}\right)^N$$

This can more conveniently be expressed as

$$\frac{L_0}{r}\left[\frac{\lambda}{(r - \lambda)} - \frac{r}{(r - \lambda)(1 + r)^N} + \frac{R_0}{L_0(1 + r)^N}\right]$$

To guess at the importance of this element, we must evaluate the term in square brackets for alternative plausible values of its parameters. Let us assume a rate of increase (λ) of real wages equal to 3 per cent per annum. The result then will depend only on the ratio R_0/L_0, from which N can be derived, and on the rate of discount, r. Table 1 presents some results that illustrate how important the "wage-increase adjust-

TABLE 1

Reductions in Present Value (ΔPV) Assuming a 3 Per Cent Annual Increase in Wages as Against a Zero Rate of Increase, Expressed as a Fraction of the Present Value (L_0/r) of Wages Bill Assuming a Zero Rate of Increase of Wages

R_0/L_0	1.159	1.344	1.558	1.806	2.094	2.427
Implied value of N (years)	5	10	15	20	25	30
$r\,\Delta PV/L_0$ assuming $r = .06$	.369	.634	.816	.941	1.021	1.074
$r\,\Delta PV/L_0$ assuming $r = .10$	.264	.384	.457	.482	.485	.484
$r\,\Delta PV/L_0$ assuming $r = .15$	.206	.272	.284	.274	.268	.261

ment" is in different cases. As can be seen there, for the cases examined, the adjustment ranges from 20 per cent to over 100 per cent of L_0/r, the present value that would be computed for wage outlays if the wage rate were assumed not to change. For what I consider to be the most relevant part of the table—$r = .10$ and R_0/L_0 ranging between 1.5 and 2.5—the adjustment is consistently between 45 per cent and 50 per cent of the present value of wages estimated, assuming the wage rate to be constant. Clearly this is not a negligible factor; I think the conclusion is obvious that the anticipated growth of real wages should be built into project analyses as a matter of normal operating procedure.[1]

Future Changes in the Discount Rate

The discount rate used in cost-benefit analysis should reflect the marginal productivity of capital in the economy as a whole. Obviously, a fully optimal situation would require that the marginal productivity of capital be the same in *all* applications within the economy, and problems are created when, because of capital market imperfections, differential rates of taxation among activities, or other reasons, rates of marginal productivity vary from sector to sector. Let us waive these difficulties for the moment, however, so as to be able to concentrate on variations in the discount rate over time. Thus, in this section we will be assuming a well-functioning capital market without significant imperfections.

The key element that enables us to take account of variations in the relative scarcity of investible funds is a discount rate that changes as we move through time. If funds are particularly scarce this year, but are expected to be relatively abundant in subsequent years, this fact might appropriately be reflected in, say, a 12 per cent rate of discount applying to this year's flows of benefits and costs, and a more modest 8 per cent

[1] The example above assumes that the amount of labor required to produce a given output from the project in question remains constant through time, and is not reduced as a consequence of improvements in "productivity." This is the case for many types of projects, in which labor and materials requirements are established by the initial design of the project and its associated capital equipment. However, it is certainly possible that for some projects one might reasonably forecast a gradual improvement in labor productivity; in such cases the labor requirements should be projected independently, and the wage rate should, as in the example above, reflect the expected trend of real wages for the relevant categories of labor. Even where productivity on the project is expected to rise through time, there are no grounds for assuming that, project by project, the increase in productivity will just offset the anticipated rise in real wages.

rate applying to future flows. The present value of a project (PV) would then be found by the formula

$$PV = \sum \frac{N_t}{\prod_{i=1}^{t} (1 + r_i)}$$

where N_t represents the estimated excess of benefits over outlays in year t, and r_i is the rate of discount applicable to flows accruing during the year i.

This formulation also brings out clearly the method of analyzing the benefits or costs associated with the postponement of a project. Assume the project costs \$1 million and yields a stream of benefits (net of current costs) of \$100,000 per year in perpetuity starting in two years. Let the discount rate for all years from next year onward be 8 per cent, and let the discount rate appropriate to this year be 20 per cent. Then the present value of net benefits, evaluated as of next year, will be \$1.25 million, and brought back to this year will be \$1.04 million. Benefits thus exceed costs, if the project is undertaken this year, in the amount of \$40,000.

But suppose it would also cost \$1 million to do the project next year, and that in that event benefits would begin to accrue three years from now. In this case the present value of net benefits evaluated two years from now would again be \$1.25 million, but brought one year from now they would be \$1.16 million. From this sum we must deduct the project cost of \$1 million, and discount the difference of \$160,000 back to this year at 20 per cent in order to obtain the present value of the project if undertaken next year. This yields a present value of \$133,000—clearly higher than is obtained under the option of doing the project this year, and it thus pays to postpone the project for one year. It does not pay to postpone the project for two years, however, for in this case the net present value of the project must be discounted for an additional year at 8 per cent, yielding a value of \$123,000.

Actual problems of project postponement are likely to be more complicated than that above, for postponement is likely to alter the size and time shape of the stream of net benefits, and also the capital costs of the project, rather than just displacing both benefits and costs through time. But the principle of evaluating benefits and costs under alternative assumed timing patterns remains valid when these complications are taken into account.

The Choice of a Time Path for the Rate of Discount

I should like to begin the discussion of this problem from a different starting point than is usually taken. What should be r_{10}, r_{11}, r_{12}, . . . , r_{20}, etc.? That is, what should be the one-year discount rate applicable to flows 10, 11, 12, . . . , 20, etc., years in the future? One answer is surely clear: We have very little specific information on which to base such a judgment. But it is worthwhile to add a second statement: The limited information we have is very unlikely to lead us to judge that r_{10} should be .08, r_{11} should be .14, r_{12} should be .10, etc. Even though we know that there will be cyclical and other short-term variations in the relevant rate of discount in the future, we do not know when they will occur, so our best guess as to the relevant rate for year 11 will not be very different from our best guess as to the relevant rate for year 10, etc. Thus we can conclude that the relevant rate for years in the far-distant future will move, if at all, only as the result of the operation of basic secular forces.

Obviously, the marginal productivity of capital will be affected by many factors: the rate of capital formation, the rate of labor-force growth, the nature and degree of "neutrality" or "nonneutrality" of technical advance, the nature of changes in the pattern of demand, particularly of relative shifts toward or away from capital-intensive industries, etc. Some of these prices by themselves would work to produce a secularly rising rate of marginal productivity, others to produce a secularly declining rate. One obviously cannot be dogmatic about which set of forces will dominate in the long-term future, but I think that our past experience is relevant here. If we have had steady downward trends in series that we might take as reasonable indicators of the marginal productivity of capital, that would give us some basis for projecting a secular downward trend in the future. But I do not believe that the evidence can be read in this way. Whether one looks at interest rates, at rates of return on corporate capital, or at ratios of the rent of property to its value, no case can be made for a significant downward (or upward) secular tendency. In the face of the historic sluggishness of these series, I believe it is reasonable to project far-future rates of discount, for the purposes of cost-benefit analysis, to be constant and to be somewhere near the historical average of the most directly relevant past series.

This judgment greatly eases the burden on the project evaluator. He has basically three questions to answer: (1) What is the relevant long-term future rate of discount? (2) What is the relevant rate for the

current year? (3) By what path will the relevant rate move from its current to its expected future level? We have already hinted at the answer to the first of these questions, so let us set that aside for a moment and turn to the second and third questions. A general answer is easy: When investible funds are relatively scarce this year and in the near-term future, relative to what is expected for the long-term future, the near-term rates of discount should be above the rate for the far future, and vice versa when investible funds are relatively abundant. Obviously, relative scarcity here incorporates both demand and supply factors, and I think that it should be fairly easy for project evaluators to have a good sense of whether they are in a year of glut or famine in this sense. Where really good capital markets exist, one can get a direct indication of the ease or stringency of the current relative to the expected future situation from the relationships of short-term relative to long-term interest rates. From the yield curve of loans and bonds by term to maturity, one can derive implicit expected one-year rates for each year in the future. This observed pattern can then be compared with the "average" pattern of the past to see what "abnormalities" exist. Where current short-term rates are relatively high, the difference $(r_t - \bar{r}_t)$, where r_t is the expected one-year rate applicable to the year t and $\bar{r}_t$ is the average of past expected rates applicable to times t years in the future, will tend to look like curve A in Figure 1. Where the situation is normal, the difference $(r_t - \bar{r}_t)$ will tend to look like curve B, and when the situation is one of current glut, a curve like C will be likely to apply.

Although, for reasons to be indicated later, the level of interest rates

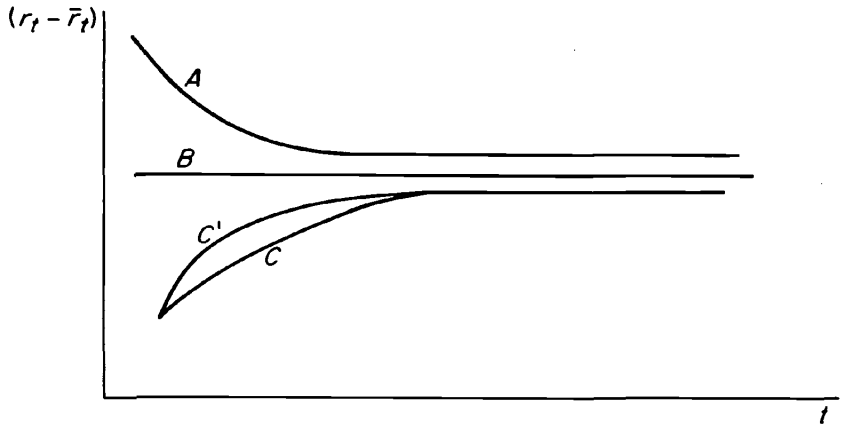

Figure 1

on bonds and loans is likely to be a poor indicator of the level of the relevant discount rate for cost-benefit analysis, the use of bond market information can give us clues as to the intensity of stringency or glut of investible funds in a given year, as to the length of time that the stringency or glut is likely to last (this being the length of time before the curve has effectively leveled out), and as to the expected pace at which the stringency or glut will be eased (compare C and C'). All of this information will be helpful to the planning authority in setting the time path of discount rates for cost-benefit work.

The Choice of the Level of the Rate of Discount

We now return to question (1), above, distinguishing between the time-shape of curves representing the discount rate to be applied to flows in year t and their general level, perhaps best summarized by the common level of longer-term future one-year discount rates. I have already indicated that I believe this level should be set at approximately the average of the relevant rates in the past. But we do not have data on the marginal productivity of capital itself, and it certainly is not equalized across industries. I would choose here the average rate of return to capital for the economy as a whole, at least in cases in which this rate appears to have been relatively constant. In textbooks, when the average rate is constant, the marginal rate must equal the average, but we are dealing here with a considerably more complicated problem than the textbook example from which the above statement was drawn. It is not by any means necessary that the marginal rate of return from capital should have always been equal to the average, just because the average rate has been historically constant, and I must emphasize that the choice of the past average rate entails an element of judgment. What we can be dogmatic about is that one should use the marginal social rate of productivity of capital as the discount rate, that this rate includes taxes paid on the income from capital, as well as any other external effects not perceived by the individual investor, and that largely for the above reasons (principally the inclusion of taxes) the relevant rate is likely to be quite high compared with the observed rates on bonds, mortgages, etc.

One must recall that the purpose of the discount rate in cost-benefit analysis is to be a guide to decision-making. Suppose that we took some average of bond rates as the relevant one; virtually automatically, almost any corporate investment would pass the test of yielding a positive present value of benefits minus costs. This would be so because the benefits

counted by corporate investors are net of tax, while the benefits relevant for social decision-making are gross of tax. Thus any corporate investment found privately acceptable at the market rate of interest, for example, would be socially an excellent investment; and many projects rejected by corporations because they fail to yield the market rate of interest net of tax would nonetheless have to be adjudged socially acceptable after including the tax component of benefits. Virtually no privately undertaken project would fail to pass the market-rate test, and many more would be added that would pass the market-rate test once taxes (let alone other social benefits) were included in the analysis. I cannot imagine that funds would be forthcoming from any source (private or public) to finance the volume of investments that would pass the market-rate test once we count social as well as private benefits.

On the other hand, if we use as the social rate of discount the rate including taxes, for example, existing private sector projects would "on the average" pass the test, but some (with less-than-average taxes and normal post-tax yields, for example) would have negative present values while others (with higher-than-average taxes and normal post-tax yields, for example) would have positive present values. The decision rule implied by a tax-inclusive rate of discount would call for shifts in the allocation of investment from low-tax to high-tax fields—as well it should—but it would not normally call for any long-term major alteration in the propensity of the community to save.

Some writers appear to argue for a rate of discount reflecting social time-preference in some sense. Without attempting to argue the case in depth, let me note that such a procedure does not run into practical difficulties if one is able to generate a sufficient volume of savings so as to be able in fact to set in motion all the projects that pass the present-value test using such a rate. But I find it hard to support a policy that would force from the community the savings levels that would be required to do, say, all investments passing a 4 per cent test, and difficult to believe that this would be possible to do even if desirable.

There is an argument for eliciting from the community more savings than it currently undertakes on the ground that, because of taxes and other possible "externalities," the social yield of investment is higher than the private yield. But this argument would not justify extracting (perhaps by taxes) more savings from the community than it would be ready to make voluntarily if faced with a private yield equal to the social marginal productivity of capital—and the available studies of savings behavior do not show any powerful responsiveness of private savings to the private rate of return. Thus some supplementing of private

savings by public savings appears to be justified, but not nearly so much as would be required to pull the typical rate of marginal productivity of capital in the economy down very substantially.

Other arguments that sometimes arise in discussions of this general point are (1) that the market mechanism fails to give a vote to future generations and therefore generates too little savings, (2) that private investors excessively discount the far future on grounds of risk, and (3) that private individuals would like to provide better for future generations than they do, if only this were done collectively, as they know that individually they can have little effect on future generations' standards of life. These arguments are discussed by Robert Strotz in a recent paper.[2] Strotz emphasizes, and I have long agreed, that the integeneration comparison, as a normative problem, arises only if we expect future generations as a whole to be poorer than we are. There is no normative reason for making the present (poor) generation save more than it wants to in order to make future, richer generations still richer. On the risk-premium argument, Strotz notes that there are ample possibilities for risk-pooling, and that yields in industries of differential riskiness do not diverge widely from each other.[3] I would add that yield curves give us an even better way of isolating the relative discounts placed on the far-future as against near-future income, and that they provide no presumption of an excessive discount of the distant future. Consols have not gone begging for a market in this world, nor have 30- or 40-year bonds!

Argument (3), best reflected by Sen and Marglin,[4] smacks of charity. It already rests on a rather weak reed if it is assumed that future generations will in fact be better off than the present one. Such compassion as nonetheless exists for future generations is, however, dissipated because each individual's saving will presumably be reflected in negligibly small increments in the future welfare of many individuals. To avoid this a concerted effort of the present generation is needed, each individual's contribution being contingent upon those of the rest. My reaction to this is simple: Any individual who wants to help others and make sure that his contribution is not dissipated can do so by selecting one or more people of the present generation to help. By so doing he can be sure that the object of his charity is needy, and that all his

[2] Robert H. Strotz, "The Social Rate of Time Discount," mimeo., 1964, pp. 2–6.

[3] Strotz here cites the results reported in George J. Stigler, *Capital and Rates of Return in Manufacturing Industries,* Princeton, N.J., 1963.

[4] See A. K. Sen, "On Optimizing the Rate of Saving," *Economic Journal,* September 1961; and Stephen A. Marglin, "The Social Rate of Discount and the Optimal Rate of Saving," *Quarterly Journal of Economics,* February 1963.

charity will reach the desired object. Moreover, it is clear that by helping the youth of the present generation more fully to reach their productive potential and their human potential as individuals, one is likely to do much more for the generation of the year 2000 than by setting up a generalized trust fund in their favor.

I am thus left with recommending the observed past average social rate of return to capital as the best first approximation of the rate desirable for cost-benefit analysis. This rate should, of course, be modified whenever there are good reasons to expect that in the future the typical rate of social marginal productivity of capital will differ from that observed in the past, and for the present and near-future years should be modified whenever there is evidence of an abnormal scarcity or glut of investible funds.

Shadow Prices for Labor and for Capital

It has come to be generally accepted that when prevailing prices do not reflect the true scarcity value of goods or services, one should substitute for them "shadow prices" that in fact do so. There are many ramifications of this simple statement, and I shall not go into all of them here. For the moment let me focus on the shadow price of labor and on the shadow rate of return to capital.

The shadow price of labor should in some sense reflect the opportunity cost of such labor. When there is a substantial pool of unemployed labor, it is likely that the shadow price of that factor will be below the market price, and it is sometimes sustained that when there is really widespread unemployment in the economy, the shadow price of labor should be at or near zero.

Let me begin by attacking what is surely a straw man. Suppose an economy in which we can take it for granted that the shadow price of labor is zero. The wages bill of the nation is then, in effect, not a required payment to labor because of its scarcity-induced productivity, but rather a sort of transfer payment out of the "true" marginal product of capital. If, for example, we have a capital stock of $30 billion and a national income of $10 billion divided equally between labor and capital, the full $10 billion should be counted as representing the social marginal product of capital, and the estimated rate of social productivity of capital should be 33⅓ per cent, not the 16⅔ per cent that we would estimate using the observed return to capital.

The point of this example is to emphasize that to the extent that we set the shadow price of labor below the market wage, we are obliged

also to set the social marginal rate of productivity of capital above that which we would compute by counting all wages paid as true economic costs. As one pushes the shadow wage to zero, one simultaneously pushes the shadow rate of productivity of capital toward the ratio of national income to capital stock in the economy. With this come some rather embarrassing implications: A rate of discount as high as the income-capital ratio is virtually a kiss of death for projects with long gestation periods or long economic lives. Waiting cannot well be afforded at a 33⅓ per cent rate of discount, and far-future incomes are virtually worthless when discounted back to the present at such a rate. Moreover, as one looks at the full equilibrium of an economy with a zero shadow wage, one finds that the appropriate prices for all goods are proportional to their capital-service components; that is, in such a full equilibrium, the ratio of net value added to capital would tend to be equal in all industries and sectors. I shudder at what this means for house rents, electricity prices, road charges, and the prices of the outputs of other similarly capital-intensive activities; and I doubt that any who may momentarily believe that a zero shadow price for labor is truly relevant for any given economy will continue to sustain this view after they follow through its full implications.[5]

In practice, the shadow wage for labor is, I venture to assert, never zero for the entire labor force and rarely zero for any significant part of it. But it certainly may fall below the actual wage for some occupations in many industries and for many occupations in some industries. To the extent that it does, the excess of the actual over shadow wage bill in any industry or sector should be attributed as part of the true economic yield of capital, and should thus tend to produce a discount rate for cost-benefit analysis that is higher than the observed gross-of-tax rate of return to capital.

But—and this is an extremely important point—it is hardly something to be hoped for that the shadow wage should forever remain below the actual wage. Unemployment, underemployment, market imperfections, all the forces that make for a discrepancy between actual and shadow wages, are things that one would hope and expect to be substantially reduced if not eliminated as an economy develops successfully. This has important implications for cost-benefit analysis, which I shall try to bring out in a simple example. For this example, let me assume that we can take, for each year, the ratio of estimated shadow

[5] I have dealt with this subject at some length in "Cost-Benefit Analysis and Economic Growth," *Economic Weekly*, Annual Number, February 1962, pp. 207–21.

income from capital to total capital stock as the relevant shadow rate of return to capital applicable to benefit and cost flows during that year.

Let us start with the prospective total national income stream shown in the last two columns of Table 2, divided between labor and capital according to market prices, and with a ratio of shadow wage to actual wage expected to move from a current level of .70 to a level of .99 in ten years.

TABLE 2

Year	National Income	Labor Share at Market Prices	Capital Share at Market Prices	Shadow Wage as Per Cent of Market Wage	Labor Share at Shadow Wage	Capital Share at Shadow Prices
1	1,000	600	400	70	420	580
2	1,060	640	420	75	480	580
3	1,120	680	440	80	546	574
4	1,180	720	460	84	605	575
5	1,250	760	490	88	669	581
6	1,320	800	520	91	728	592
7	1,400	850	550	93	790	610
8	1,480	900	580	95	855	625
9	1,560	950	610	97	922	638
10	1,650	1,000	650	99	990	660

In Table 2 the returns to labor and capital are evaluated at shadow prices. Now assume the series in Table 3 for the prospective level of capital stock in each year. This series was so selected as to yield a market rate of return (gross of taxes, of course) to capital of 10 per cent in each year.

The re-estimation of the shadow rate of return to capital, year by year, to take account of the expected gradual elimination of the discrepancy between shadow and actual wages obviously has the effect of bringing the shadow rate of return to capital gradually into correspondence with the market rate of return. Moreover, it leads to a decision rule which is much less discriminatory against capital-intensive or long-lived projects than a rule based solely on the initially prevailing shadow wage and the initially prevailing shadow rate of return to capital.

The technique just outlined of obtaining the time path of the shadow

TABLE 3

Year	Capital Stock	Capital Share at Shadow Prices	Market Rate of Return to Capital (per cent)	Shadow Rate of Return to Capital (per cent)
1	4,000	580	10.0	14.5
2	4,200	580	10.0	13.8
3	4,400	574	10.0	13.0
4	4,600	575	10.0	12.5
5	4,900	581	10.0	11.8
6	5,200	592	10.0	11.4
7	5,500	610	10.0	11.1
8	5,800	625	10.0	10.8
9	6,100	638	10.0	10.5
10	6,500	660	10.0	10.2

rate of return to capital is appealing in other ways as well. First, it is consistent with the over-all approach that was recommended above for a situation in which market prices were taken as a guide; in effect the 10 per cent market rate of return to capital could be the observed past average of that rate, or that average adjusted in the light of prospective market developments. Second, it develops the shadow rate of return to capital on the basis of macroeconomic magnitudes of the type likely to be estimated by development planners. And third, it recognizes that the setting of the shadow rate of return to capital as something distinct from the gross-of-tax market rate of return should be based on the discrepancy between the wages bill for the total economy valued at market prices and the wages bill for the total economy valued at shadow prices, rather than on these magnitudes by individual industries.

To elaborate a bit on the last point, assume that in Sector A the shadow wage is equal to half the market wage, while in Sector B the shadow wage and market wage are the same. Suppose the market rate of return to capital is 10 per cent in both sectors, but that by imputing half the wages bill of Sector A to capital in that sector, we would thereby increase the computed rate of return to capital to 20 per cent in that sector. It makes no sense at all to proceed with project evaluation in this case by using a 20 per cent rate of return for projects in Sector A and a 10 per cent rate of return for projects in Sector B. The same rate

must be used in both sectors, and the above procedure would estimate the approximate rate by, in effect, obtaining a weighted average of the 20 per cent return imputable to capital in Sector A and the 10 per cent return of Sector B. Projects of Sector B would (and should) be burdened by being required to meet the test of a higher rate of return than the 10 per cent market rate, while wages paid in B would be fully counted as costs. On the other hand, projects in Sector A would benefit from being allowed to exclude from costs half of their wages bill and include that amount as imputed income from capital, while being required to meet a 15 (not 20) per cent test of capital yield at shadow prices.

The treatment of capital and labor in the above example is obviously different, and for a good reason. Discrepancies between shadow and market wages vary by skill of labor, by region, and by industry sector, among other things. Shadow prices should discriminate in favor of projects that actually draw into employment workers whose opportunity cost is less than the wages paid them, and should discriminate (at least in a relative sense) against projects that do not do so. This is done by assigning a share of the wages bill to capital in the former class of projects—a share that varies from project to project in accordance with the degree of discrepancy between their shadow and market wage bills. Once this is done, the accounts have been rectified, so to speak, and the projects should be free to compete for available capital funds by being required to meet the same rate-of-return or present-value test.

The main weakness of the procedure used in the tables above is that it requires one to specify—in advance, so to speak—the time path by which the gap between over-all shadow and actual wage bills will be reduced. Obviously, this time sequence cannot be drawn out of thin air or assumed at will; on the contrary, its estimation is a serious responsibility of the macroeconomic planners. Without attempting here to go into detail as to reasonable ways of guessing at this time path, let me just note that the most common alternative procedure also makes such a guess—by assuming that the shadow wage remains constant through time. The procedure advocated here simply makes explicit that a guess is required—and suggests that it be the best guess possible in the face of all available evidence and judgment.

Time Paths of Prices and of Demand

Let me begin this section by focusing on a particularly important price—the exchange rate—to indicate how its role differs from that assigned

to the wage rate in the preceding section. The key point of the preceding section that is relevant here is that a shadow wage below the market wage had a direct implication with respect to the rate of return to capital. The situation is not nearly so clear when we consider a shadow exchange rate (defined as the price in local currency of foreign currency) different from (generally above) the market rate. A rise in the rate of exchange will enhance the profitability of export industries through its effect on their product prices. It may or may not enhance the profitability of import-competing industries, depending on whether imports were previously restricted (e.g., by licensing) to a volume determined by foreign exchange availabilities (in which case the effective internal price of imports might decline as a consequence of the rise in the exchange rate together with a relaxation of restrictions), or whether imports were freely admitted at the pre-existing exchange rate (in which case their price would surely rise). The rise in the exchange rate, on the other hand, would tend to reduce the profitability of investment in industries using imported materials and also in industries using imported capital equipment. The net effect of all these forces is uncertain in that there is no presumption that the introduction of a shadow exchange rate in place of a (lower) market rate will either typically raise or typically lower the shadow rate of return to capital.

The exchange rate differs from the wage rate in another important respect as well. Whereas the labor market imperfections that require the use of shadow as distinct from actual wage rates tend to be rather fundamental phenomena—not possible to eliminate quickly—there is no corresponding excuse for the use of shadow pricing with respect to the exchange rate. A simple act of devaluation can put into effect as the market rate whatever value one would choose to set as the shadow price of foreign currency. I feel that the policy of allowing the exchange rate to reflect the scarcity value of foreign currency is virtually essential for good project evaluation—as well as being good for other reasons. It obviates the need for readjusting a whole set of internal product prices and for revaluing amounts of capital actually invested. Moreover, even if the exchange rate is allowed to reflect the scarcity value of foreign currency, it still presents substantial problems for the project evaluator and the planner whenever it is expected that the rate will have to change through time. As in the case of investible funds, we may face circumstances of abnormal scarcity or glut of foreign currency that would require different expected exchange rates to be applied to different future years. I see no merit at all in compounding these problems by following

exchange rate policies that require a complete reshuffling of the accounts for the present year as well.

Much of what has been said about the exchange rate applies to other prices as well. If the shadow price of a product is different from the actual price, this fact is not likely to have a profound effect upon the shadow rate of return to capital for the economy as a whole. But it does introduce serious problems in that purchasers of the product guide their own decisions by the actual price, while we would like them to guide their decisions by the shadow price. It may take ingenuity to make the actual price reasonably reflect the shadow price in some cases, but as the experts of Electricité de France have shown, the job can be done well even in some very complicated cases.

Finally, just as with the exchange rate, even if we do permit market prices to reflect scarcity values on a current basis, we still have the substantial problem of estimating the future path of prices. With respect to this problem, there is one principle which is crucial to good project evaluation. One often hears projects justified, in practice, on the basis that even if they are not profitable today, they will become profitable in the future because of the growth of demand. There can indeed be such a justification for particular projects, but when this is the case it is more subtle than many people think. Almost any investment made today would become profitable with time if no competing investments were made in the future. But that does not say by any means that all such investments should be made today. In the first place, their postponement might result in their having even higher present value, and this should be taken into account in the process of analysis and decision-making. In the second place, and probably much more important, is the fact that the "profitability" of today's investments should be estimated on the assumption that all "profitable" future investments will also be made. This kind of consideration must of necessity enter into investment decision-making in a competitive industry, where one can more or less be sure that someone will undertake those investments that become profitable in the future even if they are inimical to the profitability of one's own investment of today. It is properly reflected, for example, by forecasts of declining prices where rapid technological advance is foreseen. In public-sector decision-making, one cannot rely on the expectation of "someone's" future action to force upon the project analyst a pattern of a declining future price in the face, for example, of a rapidly rising total demand for the good or service in question. Here, of necessity, the project analyst himself has to estimate an expected time path of the price —not on the assumption that his project stands alone, nor on the as-

sumption that future projects will be held up in order to "protect" the profitability of his current project, but on the much more rigorous assumption that future investments will be made on their own merits and without consideration to their effect on the profitability of any past investments. All this can in most cases be summarized in the expected price path of the product through time, but it must be realized that the expected price path here means more than just a guess about future prices—it means rather a guess as to the prices that will be generated in the future by an essentially optimal investment policy or, perhaps better put, by the continuous application in the future of valid investment decision rules.

What has just been said about prices can be translated into corresponding statements about consumers' surplus. For simplicity, I shall represent this problem by a simple supply-and-demand diagram (Figure 2), but it should be borne in mind that the principle involved extends to much more complicated cases. Assume that the demand function for a product shifts, through time, from D_1 to D_2 to D_3, etc. Assume, furthermore, that in each period the installation of new capacity of 1,000 units is expected to be justified, following a valid decision rule.

The benefit stream attributable to the first year's investment will be (1) in the first year, (2) in the second, (3) in the third, (4) in the fourth, etc. It will not be *EFCO* in the second period, *GHCO* in the third, and *IJCO* in the fourth, because in these successive periods additional

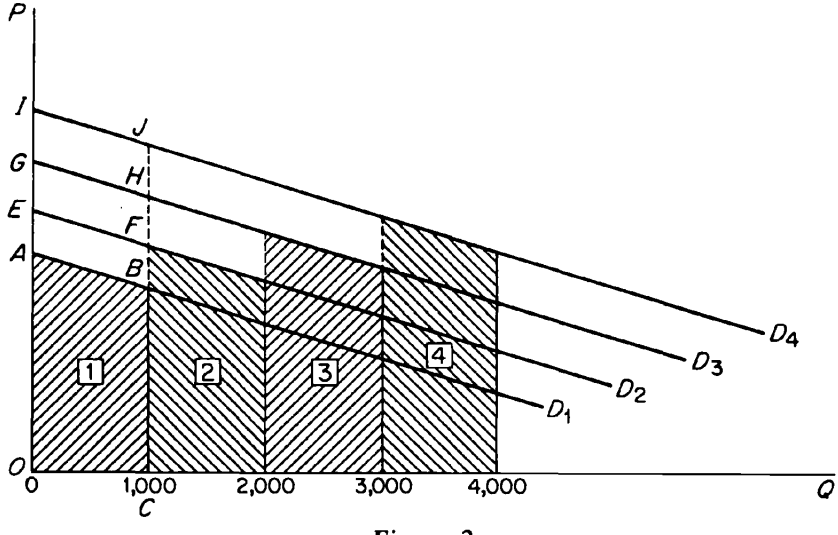

Figure 2

amounts of capacity of 1,000, 2,000, and 3,000 units must be assumed to be installed. Similarly, in evaluating the second year's investment, the benefit stream should be (2), (3), (4), etc.

One can, on occasion, count *ABCO, EFCO, GHCO,* and *IJCO* as the benefit stream from the first investment, but that only occurs if no further acceptable investments will be generated as demand grows through time—a condition that can be presumed to be highly unlikely.

The general principle involved here is that in assessing the contribution of any unit of capacity, it should be considered as the marginal unit in each year of its operation. Inframarginal benefits, which would have accrued in any event as a consequence of subsequent additions to capacity in the absence of, say, the first year's project, should not be attributed to part of the benefits of that project. Indeed, one can go further, for no benefits should be attributed to any given project which are greater in present value than the lowest alternative cost of achieving the same benefits. Following this principle, it is quite possible that the shaded areas in Figure 2 might overstate the benefits properly attributable to the first year's project. We can be sure, however, that they do not understate the relevant benefits.

COMMENT

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In his paper, Professor Harberger has very perceptively chosen to focus attention on the effects of uncertainty (imperfect foresight) on project appraisals. This is a most important topic and one that is rarely recognized or accounted for in practical cases. Typically, a project appraisal treats the information as though it were known with certainty, with the result that the calculations are carried out in great detail. This paper attempts to provide an antidote for that procedure. Under this heading the paper focuses primarily on the implications of changes in one particular price, that is, the level of and changes in the discount rate.

One other aspect of project appraisals is briefly mentioned, the "virtual necessity of decentralized decision-making." It is true that in most cases project appraisals are performed by ministries, public corporations, and similar bodies, and there is a need to regularize the procedures that they use. This is particularly true when projects are relatively small in scale; very large projects usually receive a great deal of attention not only from the ministry involved but also from the planning body and from various other interested agencies. But the general point is well taken.

These comments raise certain questions about the development of the topic as presented in the paper, but it is also necessary, it seems to me, to consider whether some of the most critical elements in project appraisal are in fact covered by the paper. Consequently, some brief additional remarks on this point are appended.

Our attention is first directed to the necessity of adjusting for real wage changes in project appraisals and a generalized formulation of the problem is given. But there seems to be some confusion here between changes in the wage rate and in the total wage bill. As development proceeds we expect that the real wage rate will rise, but this does not necessarily mean that the wage bill for any project will also rise. Wage rates rise because of increases in productivity, and at the project level the total labor force may be so adjusted to compensate for this rise that the wage bill stays the same. Alternatively, if the total labor force on the project is maintained, we would expect that total revenues would increase rather than remain constant as is postulated in the example. Consequently, it would appear that the problem is rather more complicated than it is presented in the paper.

The extended discussion of the appropriate choice of rates of discount provides a number of practical suggestions to the analyst. There are only a few minor comments that might be made. First, it is suggested that the information derived from capital markets may be useful in determining an appropriate discount rate. This is certainly true, but as a practical matter most underdeveloped countries have extremely weak or nonexistent capital markets; so they do not provide any satisfactory source of information. As a brief digression I might mention one specific instance in which such information appears to lead to a wrong decision rule. The regulations adopted by the Agency for International Development on this matter make a distinction between local currency costs and dollar costs. In the absence of any other information the regulation states that local currency costs shall be discounted at 6 per cent and dollar costs at 3½ per cent since this approximates the rate on U.S. government bonds. Clearly the decision rule is faulty. The 3½ per cent rate does not reflect the marginal productivity of investment in the United States nor in the underdeveloped country. Moreover, the use of two different rates suggests that there is a difference in the productivity of local currencies and dollars. That may in fact be the case, but if so the evidence is mostly to the effect that the productivity of dollars is higher; so a higher rate (not a lower rate) should be used. This is simply one illustration of the difficulties of obtaining appropriate information from the capital markets.

The paper also comments somewhat unfavorably on the argument that "private investors excessively discount the far future on grounds of risk" and says that there are "ample possibilities for risk-pooling" (citing approvingly a paper by Strotz). On this I am skeptical. Where are the possibilities for risk-pooling in underdeveloped countries, and if they exist why are they not better used? Basically the tendency to discount the future heavily is directly related to the investor's perception of the degree of uncertainty, both political and economic, associated with his investment. This is a "play it safe" strategy which makes a good deal of sense to the individual investor. In the long run the problem is to try to reduce those uncertainties, and in the short run a solution may well require higher public participation.

The necessity of adjusting market prices to reflect the scarcity value of inputs is discussed generally, and an illustration is provided. There can be no quarrel with the desirability of undertaking such corrections. The problem is how to find appropriate measures for the shadow prices and how far to push the process of correction to the inputs. The illustration presents a case where the correction is applied only to labor and not to capital. It must be assumed that the market price and the shadow price are the same for the latter. This leads to some curious conclusions. It must be assumed that the labor input is the same (in quality) in Sector A and Sector B, but in Sector A the shadow wage is only half the market wage whereas in B they are the same. Alternatively, this says that the productivity of labor in Sector A is half that in Sector B, and the capital-labor ratio in A is twice that in B when both are computed at their shadow prices. The paper concludes that "shadow prices should discriminate in favor of projects that actually draw into employment workers whose opportunity cost is less than the wages paid them. . . ." In the context of the example this suggests that increased employment is the criterion, but if that is so the appropriate strategy in this example is to increase projects in Sector B where one unit of capital provides twice the employment that it does in A. In short, omitting consideration of the scarcity of capital involves confusion and probably a wrong decision rule.

If the admonitions and suggestions contained in the paper were followed by project analysts, a substantial improvement in the appraisals would most certainly result, but in many cases the difficulties of choosing an appropriate discount rate are completely swamped by uncertainties with respect to other prices and costs. Gross errors are typically found in the estimates of both the investment and operating costs of projects. These errors can sometimes be greater than 100 per cent. Min-

istries consciously or unconsciously present the most favorable case for projects for which they are responsible. Projections of demand are typically overoptimistic; estimates of labor productivity are too high; delays in project implementation lead to rapid cost increases; and project designs do not adequately reflect investment costs. Perhaps most importantly of all, projects are not systematically compared to alternatives in the same sector. It is not enough to consider the individual merits (including the appropriate rate of discount) of double-tracking a stretch of railway; the question is whether this is the best way to increase capacity or whether some alternative methods (such as block signaling, increased length of trains, etc.) might not be better. This lack of attention to alternative investment opportunities and the absence of any sensible priority system is one of the major defects of project preparation in underdeveloped countries. While the points raised in the paper are obviously significant for project appraisal, major improvements are likely to require some workable solutions to these other problems.