The Economic Journal, **98** (*September* 1988), 801–807
Printed in Great Britain

INDIRECT DISTRIBUTIONAL EFFECTS IN BENEFIT–COST ANALYSIS OF SMALL PROJECTS

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It is well recognised that public policies – such as building of roads, imposition of taxes and tariffs, or provision of defence – generally disturb the equilibrium prices of both goods and factors. Virtually all works on benefit–cost analysis would recommend that the distributional consequences of these price changes be taken into account in policy evaluation, provided that the distribution of income is deemed relevant for policy. (See, for example, Dasgupta *et al.* (1971), Little and Mirrlees (1974), Squire and van der Tak (1975), Harberger (1978), or for a recent review, Drèze and Stern (1987).) It is, of course, theoretically possible, and even likely, that a series of complex interactions through a system of markets might be such that any given project or policy, no matter how small, would ultimately affect virtually *every* household in an economy to some small degree. But a practical-minded economist might anticipate that these effects, if not literally zero, are often 'negligible', and that the evaluation of the most important 'pecuniary externalities' associated with a project need not be hopelessly complex. Behind such an argument is intuition like the following: a given policy will have a major impact on certain prices, the distributional consequences of which are of first-order importance for benefit–cost analysis. But a policy which directly affects only one region or sector of an economy will generally result in rather small price changes in other sectors or regions, and these can safely be ignored. This view is exemplified by Squire and van der Tak (1975, p. 22), who write that if different distributional weights apply to different groups in society,

> there is... no remedy but to trace as well as possible [the price changes throughout the economy that ensue from a public project]. Whether this is a serious qualification in practice depends on the extent to which the project results in price changes. If induced price changes are minor, or if income distribution weights of affected groups are approximately the same, exclusion of such external price effects from the economic analysis of the project may result in a reasonable approximation.

* I am grateful to three anonymous referees, and an anonymous Associate Editor, for a wide variety of useful and thought-provoking comments on an earlier version of this paper. A substantial part of the work on this paper was done during a sabbatical visit to CORE, Université Catholique de Louvain, during academic year 1986–7, where I benefited from comments by R. Boadway. I am very grateful to CORE for its hospitality and support. Also, some work was done while at the Institut für Gesellschafts- und Wirtschaftswissenschaften at the Universität Bonn, and I would like to acknowledge support from the Deutsche Forschungsgemeinschaft through the Sonderforschungsbereich 303.

This intuition certainly seems most reasonable, and it is probably tacitly accepted rather widely.[1]

However, it overlooks the fact that while many of the price changes resulting from some project may be rather small, they may be spread over large numbers of households. *It does not therefore necessarily follow that the aggregate effect is small.* That is, the sum of very many very small numbers need not be negligible.

The purpose of this paper is to show that one cannot, in general, justify the practice of assuming indirect price effects to be negligible – that in fact, the real income effects arising from project-induced equilibrium price changes are typically of first-order importance, even for small projects.

The paper is organised as follows. First, Section I presents a simple model in which a very small project may result in a very small (of the order of 10^{-6}) change in equilibrium wages. It is then shown that the distributional impact of the project is nevertheless far from negligible in the sense that the evaluation of the project may be quite substantially affected by distributional considerations (e.g. showing distributional benefits on the order of 10% of project outlays). Section II discusses how one might practicably take into account such minute effects on equilibrium prices, and relates the analysis of small projects to the overall framework of project evaluation for an entire economy. Section III provides a brief conclusion.

I. THE NON-NEGLIGIBLE DISTRIBUTIONAL IMPACT OF A SMALL PROJECT

Suppose that a government project will require the use of dn_0 units of labourers – say, bricklayers.[2] Entry into bricklaying is assumed to be free, so that the net wage of w received by bricklayers is the same as that received by workers in other industries. Suppose that the amounts of at least some other factors of production can be regarded as fixed for the time period under consideration, so that the marginal product of labour schedule in industry i, $i = 0, 1, \dots, k$, denoted by $\Phi_i(n_i)$, is a strictly decreasing function of the amount of labour n_i employed in industry i. Suppose also that relative output prices are

[1] The statement by Squire and van der Tak is particularly worth quoting because it is relatively explicit. Many other writers seem to hint at the same idea, however. For example, in discussing pecuniary externalities, Sugden and Williams (1978, p. 144) note that if distributional considerations are taken into account, 'the analyst must investigate all the *significant* pecuniary external effects' of a project (emphasis added). As another example, Rosen (1985, p. 82) notes that 'economists are usually forced to assume... that the effects of [project-induced] price changes on income distribution are minor. In many cases, this is probably a good assumption.'

[2] The choice of bricklayers for illustration is inspired by Brown (1924), to whose arguments the essential insights of this paper can be traced. Brown (1924, pp. 147–53) analyses the incidence of a tax on bricklayers. Bricklayers may constitute a very small part of the labour market, and as labour is reallocated so as to equalise net wage rates between bricklaying and other occupations, the gross wage of bricklayers may rise substantially while the wage of other workers may fall only slightly. Brown argues, however, that on balance the wages of workers in general will fall by the amount of the tax, that is, the small reduction in net wages for workers as a whole will be equal to the total tax collected. Despite its appearance over half a century ago, Brown's argument does not seem to be widely known. It has recently been formalised and verified by Bradford (1978) and Mieszkowski and Zodrow (1984), and developed independently by Courant and Rubinfeld (1978), who apply it to the analysis of the incidence of a property tax levied by a single small and open jurisdiction.

fixed and normalised to unity. In a competitive equilibrium, if the total supply of labour is fixed at n, we have

$$\Phi_i(n_i) = w \quad (i = 0, \ldots, k), \tag{1}$$

$$\Sigma_i n_i = n. \tag{2}$$

One can invert Φ_i to obtain $n_i(w)$, the demand for labour in industry i, with $n_i'(w) < 0$. Substituting into (2) yields one equation determining the equilibrium net wage w as a function of n. Now if the demand for bricklayers is exogenously increased by dn_0, w must rise by

$$\begin{aligned} dw &= -\frac{dw}{dn_0}\,dn_0 = -\frac{1}{\Sigma_i n_i'}\,dn_0 \\ &= \frac{w}{\Sigma_i n_i \epsilon_i}\,dn_0, \end{aligned} \tag{3}$$

where $\epsilon_i = -(w/n_i)\,n_i'$ is the demand elasticity for labour in industry i. (Here an exogenous increase in n_0 is treated like a reduction in labour supply to the private sector.) If we let $\sigma_i = n_i/n$ be the employment share in industry i and let $\epsilon^* = \Sigma_i \sigma_i \epsilon_i$ be the aggregate demand elasticity for labour, we have

$$\frac{dw}{w} = \frac{\sigma_0}{\epsilon^*}\frac{dn_0}{n_0}. \tag{4}$$

Thus, if bricklaying is a very small part of the labour market (σ_0 very small), or if the project's demand for bricklayers is very small (dn_0/n_0 small), the effect of the project on equilibrium wages will be very small as well.

The case that we have just analysed would appear to be one in which induced wage changes might reasonably be ignored, according to the view of benefit cost analysis cited in the introduction. Suppose, for example, that the project in question will increase the demand for bricklayers by $dn_0/n_0 = 0{\cdot}001$, that is, 0·1 % of the initial pool of bricklayers will be employed on the project. Suppose that bricklayers constitute 1/4 % of the workforce: $\sigma_0 = 0{\cdot}0025$. If the elasticity of demand for labour (ϵ^*) is, say, 1, we find that the project will increase the equilibrium wage by $2{\cdot}5 \times 10^{-6}$, surely a virtually imperceptible change, and one that benefit–cost analysts would like to ignore.

Consider, however, the effect of the project on the total income of all workers. Since labour is inelastically supplied, any increase in the total income of workers constitutes an increase in real income. We find, using (4),

$$d(wn) = ndw = \frac{w}{\epsilon^*}\,dn_0. \tag{5}$$

If the elasticity of demand for labour is 1, total wage income rises by the amount of the outlay for bricklayers on this project – say, \$100,000 for concreteness' sake.

An increase of \$100,000 in the income of workers is very small compared to the entire economy, of course. Now suppose that according to the relevant ethical standards, transfers from taxpayers (who are paying for the project) to workers produce a net social welfare benefit of 20% of the amount transferred. Then the hiring of bricklayers for \$100,000 produces an indirect benefit on this account of \$20,000. This is also a very small amount compared to the entire economy. But suppose that the wages of bricklayers constitute 50% of the project's cost. Then the pro-worker redistribution entailed by the project raises its benefits, or lowers its costs, by an amount equal to 10% of the total project costs. From the viewpoint of this small project, its redistributive impact is *not* small. And this is the relevant viewpoint for the benefit–cost analyst.

Much of this argument has been couched in terms of a particular example, and different numerical results would emerge if one were to make different numerical assumptions. The general conclusion is obviously not sensitive to the numbers selected, however.

II. PRACTICAL APPLICATION IN A SIMPLE CASE

It is really too much to expect benefit–cost analysts to predict changes in equilibrium prices from small projects, which might be on the order of 10^{-6}, say. On the other hand, we have just seen that ignoring such effects could result in significant errors in the evaluation of a small project. Of course, the total social loss from this error would be small.

But now suppose that this project is just one of many similarly small projects that are collectively not small. In fact, imagine the problem of the director of an agency (e.g. the Little–Mirrlees 'COPE') charged with the evaluation of all of the projects in a given economy. To manage this process efficiently, the director assigns teams to work on the evaluation of individual projects. One possible approach would be to ask the analysts to predict and weight accordingly the distributional effects of the price changes induced by their individual small projects. If they could do this accurately, distributional effects would be properly accommodated in the evaluation of each individual project, and the director could simply choose that combination of projects yielding the greatest net social benefit. This method would fail in practice, however, because it would be impossible to predict the tiny price changes resulting from small projects. The distributional benefits and costs of all projects would then be ignored. The total social loss from these errors would be large.

An alternative approach is possible, however. To illustrate it, let us continue the example of Section I. Suppose, as before, that a \$1.00 increase in real income for workers generates a \$1.20 increase in social benefits, or, more generally, a social gain of $1+\beta$ where $\beta \neq 0$. The director of the project evaluation agency could require the project evaluation teams to add $\beta(w/\epsilon^*)\,(\sum_{i=0}^{k} dn_i)$ to the benefit calculation for a project that employs dn_i workers of type i. Recalling (5), which applies to the special case where $dn_i = 0$, $i = 1, \ldots, k$, it is clear that $(w/\epsilon^*)\,(\sum_{i=0}^{k} dn_i)$ is the change in total wage income that results from a project employing $\sum_{i=0}^{k} dn_i$ workers in total. Provided that the agency director's central research group could estimate ϵ^*, the demand elasticity for labour in the economy as a whole, it would be a simple matter for the low-level project evaluation teams to take distributional impacts into account. Given that values for β and ϵ^* are supplied by the director, the teams need only know $w(\sum_{i=0}^{k} dn_i)$, that is, each project's total wage bill, to determine its distributional benefits.

This approach to project evaluation completely obviates the need for analysts to observe or predict the general equilibrium price changes that result from small projects. The approach is in fact quite similar in spirit to that of Little–Mirrlees or Dasgupta *et al.*, in the sense that the 'centre' is to determine the values of certain critical parameters which are then to be used by all project-level analysts. Note, however, that the centre is required not merely to make ethical judgements as represented by an income distribution parameter β. It must also compute the values of critical market parameters – in the present model, the elasticity of demand for labour, ϵ^*. The use of an unadjusted distributional parameter β, rather than a parameter adjusted by the elasticity, β/ϵ^*, would in general lead to incorrect evaluation of distributional effects.[3]

III. CONCLUSION

The primary purpose of the foregoing discussion has been to show that the small equilibrium price-changes that emanate from small public projects are not necessarily negligible for the purposes of project evaluation. Section II has shown how one might attempt to take these effects into account in practice. However, it does so only in an extremely simplified context. Although it might be applicable almost as it stands for some purposes, it would be clearly inadequate for others, and it is obviously important to consider more general cases. As noted, for example, the effect of a project on returns to factors other than labour (e.g. returns to capital) should also be taken into account. Also, in more complex economies, a project that employs bricklayers may affect the returns to different types of workers, and the returns to capital, land, etc. in many different sectors or industries, through a complex series of interactions. To understand the ultimate implications of these interactions for factor returns requires, in general, a knowledge of a substantial number of own- and cross-price elasticities of demand and supply.

The preceding analysis has not only assumed that the economy has a very simple structure. It has also ignored the potentially important role played by other policy instruments, such as taxes, in the evaluation of the distributional impact of a public project. As is well known from Diamond and Mirrlees (1971), for example, the government need not consider distributional adjustments in evaluating a small project in an economy where a full set of commodity taxes is available and has been optimised. While few would wish to

[3] This analysis has focused on the impact of a project on equilibrium wages. The returns to other factors will also be affected by projects, however. For example, if there is one other factor of production that is domestically owned and inelastically supplied to each sector or industry i of the economy (e.g. entrepreneurial ability or capital), then a small increase in wages will result in a small reduction in the returns to this factor, the distributional impact of which must also be taken into account. (If this factor is not domestically owned, then its loss of income can be ignored for the purposes of nationalistic project evaluation.) Although such income losses will partially offset the redistributive benefit of the small project, this fact does not change the main point of the analysis, which is that these distributional impacts will be of first-order importance for the evaluation of small projects.

argue that real economies exhibit optimal tax policies, the Diamond and Mirrlees analysis shows that taxes can have a profound impact on project evaluation and will certainly be relevant even when not set optimally. The present discussion has (implicitly) ignored the presence of all non-lump-sum taxes in the economy. This again circumscribes its applicability.

Actually, theoretical analyses which incorporate the full general equilibrium ramifications of public projects, and which take into account the role of government tax instruments, have already appeared in the literature – see, e.g. Boadway (1976) and Drèze and Stern (1987). The latter study, in particular, shows how an expression for the shadow value of labour can be developed which, in a simple case analogous to that analysed here, reflects (*a*) the distributional weights applied to workers versus profit recipients and (*b*) the elasticity of demand for labour. The shadow values derived by Dreze and Stern also can be made to reflect properly any tax distortions that might be present in the economy.

Thus the results of the analysis in this paper can be seen, in some sense, as a special case of those already available in the literature. However, the extreme simplicity of the present analysis may be a virtue. Recently, Drèze and Stern (1987, p. 949) have written that 'project evaluation manuals... often lack full rigour in their treatment of prices, e.g., by assuming fixed producer prices or relying on partial equilibrium analyses of the effects of price changes', in contrast to the literature on the theory of second best. They go on to say that 'a better integration between these two lines of research is an important step towards the understanding of shadow pricing rules in economies where some important markets... may be considered to clear by [competitive] price adjustment'. Insofar as it helps to reveal exactly why and how the rather commonsense (and perhaps also rather commonplace) approach cited in the introduction can go astray, the present analysis may help to bridge part of this gap between the rigourous theory of project evaluation and its practical application.

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Date of receipt of final typescript: January 1988

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