RISK AND THE POLITICAL ECONOMY OF RESOURCE DEVELOPMENT

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Optimal Resource Taxation

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11 Optimal Resource Taxation

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Given that the policy-maker knows the 'optimal' path of extraction of a natural resource, the problem of optimal resource taxation is to raise revenue in a way that minimises the divergences from this path. The issue is simple, but its investigation is a complex matter. Some of the problems arising are taken up in this chapter.

OPTIMALITY AND THE MARKET ECONOMY

From the viewpoint of Paretian welfare theory, there are two basic requirements that an optimal extraction path should satisfy: (i) intersectoral efficiency, and (ii) intertemporal optimality. Before tackling the taxation problem, it is useful to consider these requirements in some detail. Society has various means by which consumption facilities can be shifted from the present to the future. Among these means capital formation and the conservation of natural resources seem to be the most important. Intersectoral efficiency refers to the composition of the overall stock of wealth transferred to the future. It prevails if it is impossible to restructure this stock of wealth in a way that increases the utility from consumption at any one point in time without decreasing it at another. In the simple case where the extraction cost can be expressed as a function of the flow of extraction, the optimal structure of wealth is characterised by the so-called Solow–Stiglitz efficiency rule which requires the price of the resource net of marginal extraction cost, P, to grow at a rate given by the marginal product of capital, f_K, i.e:

$$\hat{p} = f_K \tag{11.1}$$

Optimising the structure of wealth does not mean that the optimal amount of wealth is shifted to the future. Provided that the preferences of the current generation and its altruistic concern for future generations is accepted, intertemporal optimality prevails if

$$\gamma = \hat{p} = f_K \tag{11.2}$$

where γ is the rate of time preference of households.

In a competitive market economy with well-established property rights, there are strong forces that make it likely that the two conditions are at least roughly satisfied. Condition 11.1 can be expected to hold because on the one hand, capital-using firms invest up to the point where the marginal product of capital equals the market rate of interest, r, and because on the other hand, resource-extracting firms follow the Hotelling rule $\hat{p} = r$, according to which the present value of the price, $p(t)\, exp - \int_0^t r(s)\, ds$, is constant for all points in time t, $t \geq 0$. Condition 11.2 can be expected to hold because, in addition, households save up to the point where their rates of time preference equal the market rate of interest.

There are a number of reasons for doubting that conditions 11.1 or 11.2 hold in reality even in the absence of taxes, and their acceptability as optimality criteria can also be questioned. A frequently mentioned problem is market imperfection, but the literature on this subject shows clearly that, unlike the static case, oligopolies and monopolies do not imply a clear bias compared to the competitive outcome (e.g. Weinstein and Zeckhauser, 1975). Of greater practical relevance seems to be the problem created through imperfectly guaranteed property rights which give an incentive to over-extract and imply that $\hat{P} > r$. (For the risk of nationalisation, see Long, 1975. For the extraction of common property resources, see McMillan and Sinn, 1982.) There are economists who deny that condition 11.2 is the appropriate criterion for intertemporal optimality, arguing that people should leave more wealth to their children than they actually do. Some of these economists base their objections on ethical views different from the individualistic ones underlying Paretian welfare theory. (See Pigou, 1932, p. 29n; and Page, 1977, part II. See also the discussion of the so-called isolation paradox by Sen (1961), Marglin (1963) and others. According to this 'paradox', condition 11.2 may not be an optimality criterion even though individual preferences are respected.)

TAXING THE RESOURCE SECTOR

Studying the question of how the resource sector should be taxed in the absence of taxes on other sectors is a problem that does not yield directly applicable conclusions, although it helps to clarify the issue. Suppose a government wants to extract money from the resource sector without violating the conditions for intersectoral efficiency and intertemporal optimality. What kind of tax should it apply? A unit tax on extraction is not suitable. Since the present value of extraction cost can be reduced by postponing extraction, this tax distorts 11.1 and 11.2 inducing both an inefficiently high share of the resource stock in the total stock of wealth and over-conservation compared to intertemporal optimality. An *ad valorem* tax on the proceeds from resource extraction has similar implications. This tax too, therefore, is not an attractive candidate. (See Dasgupta and Heal, 1979, ch. 12; Sinn, 1980; and Dasgupta, Heal and Stiglitz, 1980.) (Note that in the absence of extraction costs the *ad valorem* tax coincides with a cash-flow tax).

A tax that does not distort the efficiency conditions 11.1 and 11.2 is a tax on the real cash flow as proposed by Brown (1948), Smith (1963), Garnaut and Clunies-Ross (1975, 1979) and Kay and King (1978, pp. 200–3). Garnaut and Clunies-Ross suggest a modified version of the cash-flow tax with various tax thresholds. This particular version of the tax is clearly non-neutral. The authors also discuss a special method of carrying forward tax rebates. This method, albeit important from a practical point of view, does not add much to the theoretical problems of the tax and is therefore disregarded. Let R denote the revenue from selling the resource and C the firm's outlays. Assume the firm can manipulate the time paths of R and C choosing the time paths of a vector u of control variables out of a set U of feasible policies. Then, without taxation, the firm's goal is

$$\max_u \int_0^\infty [R(t,u) - C(t,u)] \exp - \int_0^t r(s)\, ds\, dt \text{ subject to } u\, U \tag{11.3}$$

and subject to a number of constraints like $R \geq 0$, $C \geq 0$, or $\int_0^t R(s)\, ds \leq \bar{R}_0$, where $\bar{R}_0$ is the initial stock of the resource. With taxation at a rate τ, $0 \leq \tau < 1$, the goal becomes

$$\max_u \int_0^\infty (1-\tau)\, [R(t,u) - C(t,u)] \exp - \int_0^\infty r(s)\, ds\, dt \tag{11.4}$$

subject to the same constraints. Since $(1-\tau)$ is a strictly positive constant, it can be taken to the front of the maximisation operator. Therefore the problem 11.4 obviously implies the same time paths of the optimal control parameters as 11.3 does, and hence the tax on the real cash flow of the mining firm has no behavioural implications. Occasionally it is argued that the mere fact of the tax reducing the maximum present value of the net cash flow may imply that the best policy will not be carried out at all. This line of reasoning, however, misunderstands the logic of the discounting rule, according to which any policy with a strictly positive present value of the net cash flow is preferable to investing available funds in the capital market.

The optimal extraction policy of the firm under the real cash-flow tax is still characterised by the Hotelling rule $r = \hat{p}$. No other taxes being involved, this rule, together with $r = f_K$ and $\gamma = r$, implies conditions 11.1 and 11.2 as in the *laissez-faire* case, that is, both intersectoral efficiency and intertemporal optimality. We refer to this tax as a 'Brown' tax after Brown (1948). An important assumption underlying the neutrality of the Brown tax is that interest on the resource firm's debt is not tax-deductible. This assumption implies that the firm is indifferent to financing its expenses $C(t)$ through retained earnings, issues of shares and issues of debt. The assumption is also necessary for straightforward discounting to make sense.

A tax very similar to the Brown tax is the one on dividends proposed by the Meade Committee (1978). The special feature of this is that, in addition to the real cash flow, the cash flow between the firm and its creditors is subject to taxation. By simple reasoning similar to that proving the neutrality of the Brown tax, it can be shown that this tax, too, does not affect the firm's economic behaviour and hence does not distort the conditions for intersectoral efficiency and intertemporal optimality.

Some economists find it hard to understand the neutrality of the cash-flow taxes. To them it seems counter-intuitive that a tax, which raises revenue, has no disincentive effects on taxpayers. But an explanation can easily be given. By introducing the tax law, the government acquires the right to some percentage of each dollar earned and at the same time promises to contribute the same percentage to each dollar of *future* outlays. It establishes itself as a silent partner of the owners of the firm. Analytically the process of acquiring the partnership can be decomposed into two steps. First, the government levies a once-and-for-all tax on the mining firm. In the Brown case this tax is a tax on the value of the stock of the resource *in situ* (plus possibly the stock of capital employed by the resource-extracting firm). In the case of the dividend tax proposed by the

Meade Committee it is a tax on the value of equity of the mining firm, which falls short of the base of the Brown tax by the volume of debt. Second, the government uses the tax revenue to buy a partnership, at fair terms, from the existing owners of the firm without acquiring full or partial control over management. Few economists would argue that Step Two provides a significant incentive for changing the economic policy of the mining company. Thus, the first step is a potential source of distortion. But a wealth tax, imposed once at a particular point in time, does not create any substitution effects either at that point in time or afterwards. There will be anticipatory effects, however, if the tax is expected by the taxpayers before it is actually imposed. The tax is a kind of sunk-cost which is irrelevant for decision-making after it has occurred. The only effect of the tax is an income effect on the behaviour of the households owning the mining firm, but this income effect does not violate the conditions for intersectoral efficiency and intertemporal optimality.

THE SECOND-BEST PROBLEM

Let us now consider the more realistic problem that, in addition to the resource sector, other sectors are subject to taxation. The first-best solution to the optimal taxation problem now is to introduce cash-flow taxes of the kind suggested by Brown or the Meade Committee on these other sectors as well. Then, with $r = f_K$, $\gamma = r$, and $\hat{p} = r$, the conditions 11.1 and 11.2 will hold regardless of which tax rates are applied to the various sectors. Despite its analytical appeal, this radical solution does not, however, seem to be realisable at present.

A problem, which seems practically more relevant but also theoretically more difficult, is the second-best problem of how pre-existing tax laws applying to non-resource income should be supplemented by taxes on natural resources. To study this problem consider the simple case where ordinary capital income, that is, interest income and (retained and distributed) profits of non-resource firms, is taxed according to the Schanz–Haig–Simons rules, which require interest on debt and economic depreciation to be tax-deductible. For simplicity it is assumed that each type of capital income is taxed at the common rate τ.

It seems useful to approach the second-best problem by first considering a basic theorem of dynamic tax theory. This theorem, which was proved independently by Johansson (1961) and Samuelson (1964), says that, despite taxation, the non-resource sector employs capital up to

the point where the marginal product equals the market rate of interest as it does in the *laissez-faire* case:

$$r = f_K \tag{11.5}$$

The theorem implies that capital income taxation, as such, does not create distortions within the non-resource sector. It does not imply that, in the absence of a resource sector, the condition for intertemporal optimality is satisfied. Indeed, since households save up to the point where their rate of time preference equals the net market rate of interest,

$$r(1-\tau) = \gamma \tag{11.6}$$

this condition is violated, which can be seen by comparing 11.6 with 11.2 and 11.5. Capital income taxation drives a wedge between the marginal product of capital and the rate of time preference.

There is thus a dilemma concerning the problem of taxing the resource sector. Since it is impossible to satisfy both the criterion for intersectoral efficiency and that for intertemporal optimality, a choice has to be made between them.

Suppose we want to ensure intersectoral efficiency. In this case a straightforward application of the Johansson–Samuelson theory suggests that capital gains on the resource stock should be treated as negative depreciation and should therefore be taxed. Indeed, if capital gains are taxed at the rate τ the net rate of return on holding the resource stock is $(1-\tau)\,p$ and, since the net rate of return on investment in the capital market is $(1-\tau)\,r$, an equilibrium in the resource market prevails if

$$\hat{p} = r \tag{11.7}$$

Together with 11.5, this implies 11.1, and hence the tax system brings about intersectoral efficiency (Dasgupta and Heal, 1979; Dasgupta, Heal and Stiglitz, 1980).

Suppose in turn that we now want to ensure the condition for intertemporal optimality at least with respect to the path of resource extraction (i.e. $\gamma = \hat{p}$). In this case a tax on the real cash flow of the firm is appropriate. By a reasoning analogous to that used in connection with 11.3 and 11.4, it can be shown that such a tax does not affect the ranking of alternative extraction policies for any given time path of the net market rate of interest $(1-\tau)\,r$, which now replaces r in these two

formulae. Hence the equilibrium condition for the resource market is

$$\hat{p} = (1-\tau)r \tag{11.8}$$

and, taking account of 11.6, we find, as desired, that $\gamma = \hat{p}$. Thus, at least partially, intertemporal optimality can be ensured with regard to resource extraction.

An assumption underlying this line of reasoning is that interest on debt paid by the resource firm is tax-deductible to a degree that ensures the equality between the net interest cost to the firm and the net rate of interest $r\,(1-\tau)$ faced by the shareholders. This assumption implies a financial equilibrium of the firm and is necessary if $r\,(1-\tau)$ is to be used as a discount rate. If debt interest is not tax-deductible, it is possible to assume alternatively that interest income earned by the resource firm is taxed at least at the rate that the returns from financial investments of shareholders is taxed. This alternative assumption implies that the resource firm does not borrow in the capital market and is not concerned with lending or may even be averse to it. Again the cash flow therefore has to be discounted at the rate $(1-\tau)\,r$.

The choice between 11.7 and 11.8, or combinations of these, is a difficult problem, and a solution cannot be presented here. In the light of the Johansson–Samuelson theorem, a systematic tax law may seem to require a capital-gains tax on natural resources. But if the over-all excess burden of taxation is to be minimised, it might seem wise, on the other hand, to try to satisfy the condition for intertemporal optimality rather than that for intersectoral efficiency. Actually, the wisdom of this attempt is suggested by an analysis of resource taxation that was carried out in the framework of an intertemporal perfect-foresight equilibrium model where the natural resource enters the utility functions of households in a separable way (Sinn, 1980). If the result achieved in this analysis carries over to more complicated cases or at least turns out to be somewhere in the middle of the theoretically possible spectrum of results, then a good case can be made for applying cash-flow taxes to the resource sector even though other sectors of the economy are taxed according to other rules.

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