ON THE ECONOMIC DISTORTION OF PURE RESOURCE RENT TAXATION

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ABSTRACT

It is often taken for granted that taxation of rents is economically nondistortive. In certain areas of natural resource use, e.g. oil extraction and fisheries, this nondistortion principle has been used to justify taxation of what is regarded as resource rents. This paper challenges the view that such taxation is generally nondistortive. Within the framwork of a general model of natural resource extraction, the paper argues that taxation of resource rents will in general affect the time profile of natural resource extraction. The paper, moreover, argues that through its impact on exit and entry, resource rent taxation will generally affect the number and composition of firms in the industry and may in this way have a secondary efficiency impact.

Keywords: Economic rents, taxation of economic rents, fisheries rents, taxation of fisheries rents.

INTRODUCTION

One of the more enduring myths in economics is that taxing resource rents does not distort economic activity. Curiously, however, in spite of considerable search in the economic literature, I have not managed to find anything resembling a proof of this proposition. Nevertheless, apparently on the basis of a mere belief in the myth, several economists have recommended special taxes on resource rents, including various types of mining [1],[2),(3],[4] and fisheries [5],[6].

The historical roots of this myth are relatively easy to locate. They can be traced to Henry George's [7] naive, if not to say vulgar, distortion of the Smith-Ricardian theory of land rent [8],[9]. Deeper roots go back to physiocratic writings in the 18th century [10].The reason why the myth has managed to stay current in certain quarters of economic discourse so long is more of a mystery. One possible explanation is the faith by many economists in the ability and willingness of governments to improve economic welfare. The drawback, of course, is that governments need to be financed. That, however, can only be accomplished by extracting funds from the public. Therefore, to be able to recommend governments on economical grounds in a consistent way, there is a need to find non-distortive taxation. The inevitable frustrations of this search, has I believe, induced some economists to apply less scrutiny to suggested candidates for non-distortive taxation.

There are, of course, many obvious problems with the myth that resource rent taxation is non-distortive. First, resource rents are not easy to identify and measure. Therefore, specifically taxing resource rents is a very difficult task in practice. Second, the basic assumption that resource rents are somehow independent of taxation is simply wrong. Resource rents depend on marginal profits of resource use. Marginal profits, obviously, depend on the level of resource use and investment in capital and technology which, in turn, must depend on retained profits. They also depend on the efficiency of the companies in the industry, which may be altered if some of them exit because of reduced retained profits. Thus, far from being exogenously given, resource rents are manifestly endogenous. Third, a substantial part of economic progress stems from the particularly risky process of exploration and discovery. A significant good part of this process has to do with the exploration and discovery of natural resources and finding new ways to use them. Clearly, this process will be hampered if the potential rewards in terms of resource rents are taxed. Finally, resource rent taxation in one industry, the fishery, say, will increase the likelihood of a similar taxation in other industries. This generates additional economy wide distortions.

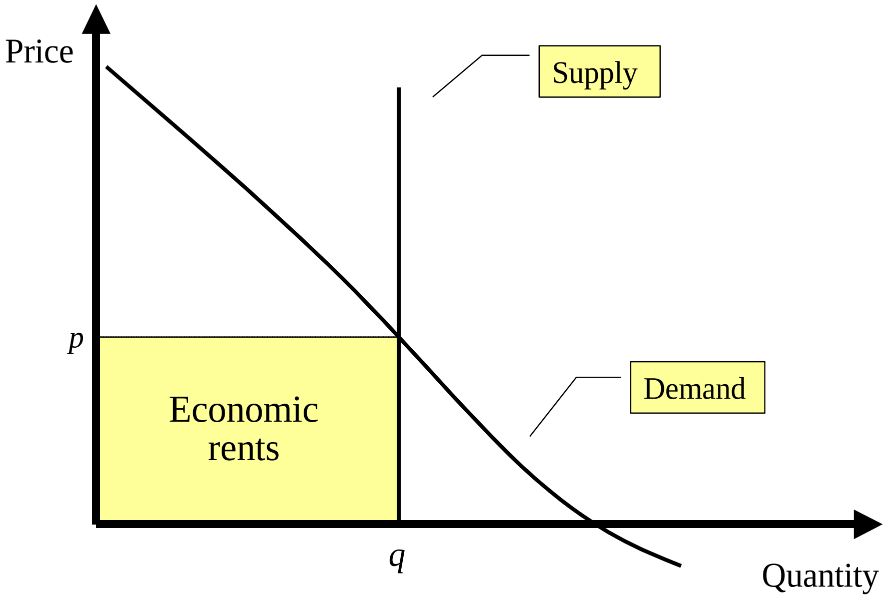
Due to the limitations of space, this paper will primarily explore the impact of resource rent taxation on the first two of the above problems with the myth, namely (i) extraction paths and (ii) entry an exit decisions. Only a few comments on the impact of resource rent taxes on the other two, (iii) exploration and discovery process and on (iv) other industries will be offered.

RESOURCE RENTS

The concept of resource rents, or, for that matter, economic rents in general, has been somewhat loosely used in economic writings. For instance, in many influential papers on resource rent taxation (see e.g. [1] and [11]), resource rents seem to be used almost synonymously with profits. For our purposes, however, it is necessary to be completely clear about the concept.

Armen Alchian in the New Palgrave Dictionary of Economics [12] essentially defines economic rents as the payment (imputed or otherwise) to a factor in fixed supply. Alchian illustrates his definition with the familiar diagram in Figure 1 often used to illustrate Ricardo's theory of land rents.

Figure 1
Economic Rents



In this diagram, there is a demand curve and a supply curve for the factor. The market-clearing price is *p*. However, since the quantity of the factor is assumed fixed, the corresponding supply, *q*, would be forthcoming even if the price were zero. Hence, the entire price, *p*, may be regarded as a surplus. The total surplus or economic rent attributable to the limited factor is the rectangle $p \cdot q$.

For later purposes it is useful to note that economic rents can also be written as $D(q) \cdot q$, where $D(q)$ represents the value of the demand function at *q*. It is well known (see e.g. [13]) that in competitive markets when the factor is used for production purposes $D(q)$ represents the marginal profits of using the factor. When, on the other hand, the factor is used directly for consumption $D(q)$ would be proportional to the marginal utility of consuming the factor.

Note that the economic rents, depicted in Figure 1, also represent profits to the owner of the factor in fixed supply. This amount would, in fact, be equivalent to his rental income for renting out the factor. It doesn't, however, represent the total economic benefits of the supply *q*. This is measured by the sum of economic rents and the demanders' surplus (some times called intramarginal rents) represented by the upper triangle in the diagram. Thus, if the demanders are producers using their own fixed factor, their profits would be the sum of economic rents and the demanders' surplus.

This basic theory of economic rents can easily be extended to natural resource extraction, at least in a formal sense. Consider a natural resource extraction industry such as the fishery characterized by the instantaneous profit function:

$$\Pi(q,x), \text{ defined for } q,x \geq 0, \tag{1}$$

where q denotes resource extraction and x the stock of the resource both at time t. This profit function is taken to have the usual concavity properties. For analytical convenience it is, moreover, assumed that the profit function is differentiable as needed.

The resource is assumed to evolve according to the differential equation:

$$\dot{x} = G(x) - q, \text{ defined for } x \geq 0, \tag{2}$$

where $G(x)$ is the renewal function of the natural resource having the usual continuity and concavity properties and a point $x_1>0$ such that such that $G(x_1)=0$. Obviously, if the resource is non-renewable, $G(x)\equiv 0$, $\forall\ x$. If the resource is renewable, $\exists\ x$ such that $G(x)>0$. As the $\Pi(q,x)$ function, the function $G(x)$ is assumed to be as differentiable as needed.

The firms in the industry, and, consequently, the industry as a whole, may be maximizing the present value of profits. For this purpose they can decide to be active and, if active, select a time path of extraction, $\{q\}$. Among the necessary conditions for this maximization is the condition:

$$\Pi_q(q,x) = \lambda,$$

where λ represents the shadow value of the resource. It is helpful to realize that even if the industry in not optimally run, but individuals maximize profits, the same formal relationship applies with λ being replaced with another (suboptimal) resource price.

Now, in accordance with the standard theory of economic rents discussed above, resource rents may be defined as

$$R(q,x) = \mathrm{D}(q,x)\cdot q = \Pi_q(q,x)\cdot q, \tag{3}$$

where $\Pi_q(q,x)$ is the demand for the extracted resource. Note that these resource rents are instantaneous rents. They refer to a point in time. Resource rents for the extraction programme as a whole would be given by the present value of the complete time path of rents.

From the perspective of resource rent taxation, however, the crucial message of equation (3) is that resource rents are a function of both the extraction rate and the level of the resource as well as of other variables entering but not explicit in the profit function. We refer to this as result 1.

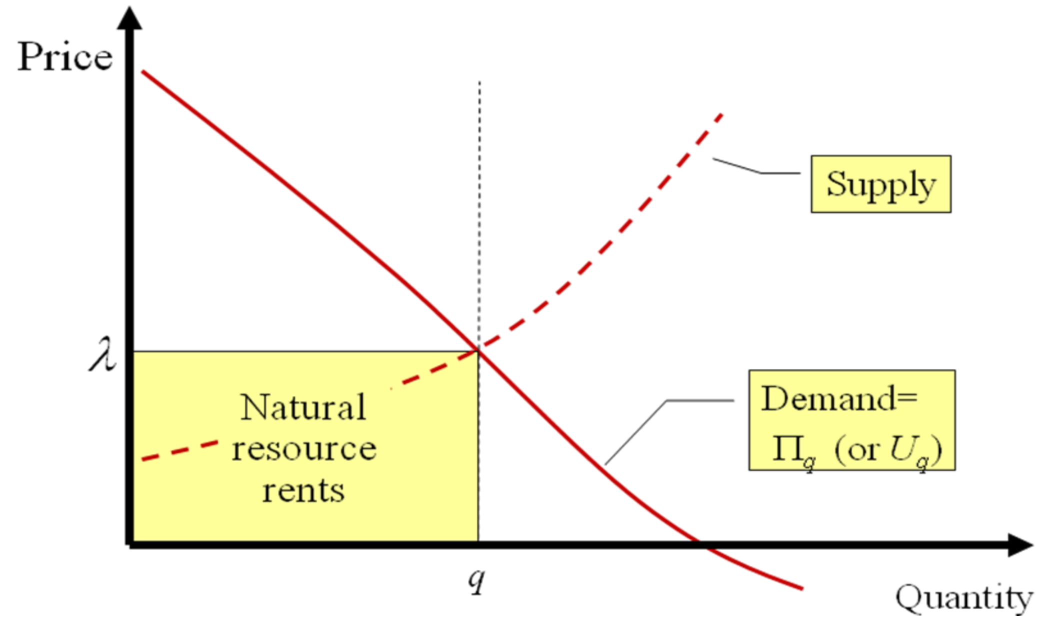
Result 1

Resource rents depend in general on the extraction rate, the level of the resource and other variable affecting the marginal profit function..

In an optimally run resource extraction industry, the supply price of the resource at quantity *q* would be given by the co-state variable or shadow price, λ. This is a function depending on the state of the resource, *x*, and the level of extraction, *q*, as well as the other variables of the problem. If positive extraction is optimal there is, at each point of time, a supply/demand equilibrium defined by the equation $\Pi_q = \lambda$. It follows that for a resource extraction industry, we may draw a resource rent diagram corresponding to the conventional one in Figure 1.

Figure 2

A Resource Extraction Industry: Resource Rents



As the supply curve of *q* (really the shadow price λ) is drawn in Figure 2, the area referred to as “Resource rents” does not appear to be economic rents at all, although parts of it may represent a producer’s surplus (in this case resource owner’s surplus). Note, however, that λ is merely an imputed or notional price. It represents the opportunity cost of reducing the size of the resource, sometimes referred to as a user cost [14]. It does not represent outlays of money. Thus, in a certain sense it is not marginal cost at all. It is certainly not a marginal cost in the sense of Ricardo and the definition of economic rents discussed above. Thus, the multiple $\lambda \cdot q$ represents economic rents in the traditional sense and this is the way we will regard it in this paper. In any case this multiple seems the closest parallel to economic rents that can be found in a resource extraction industry.

RESOURCE RENT TAXATION: GENERAL ANALYSIS

Consider a natural resource extraction industry such as the fishery characterized by equations (1) and (2) above.

Now, as discussed in the previous section, resource rents may be defined as

$$R(q,x) = D(q,x) \cdot q = \Pi_q(q,x) \cdot q, \qquad (3)$$

where $\Pi_q(q,x)$ is the demand for resource extraction.

Consider now the imposition of a tax on resource rents. Let the amount of the tax be:

$$T = \tau \cdot R(q,x), \tag{4}$$

where $R(q,x)$ represents resource rents as defined in (3) and τ is the rate of taxation. More generally a resource rent tax would be $T = \Psi(R(q,x))$, where Ψ is an increasing function. This generalization, however, would not qualitatively alter the results of the analysis.

From the perspective of the industry the profit maximization problem now is:

$$\underset{\{q\},T,x(T)}{maximize}\ V = \int_0^T [\Pi(q,x) - \tau \cdot R(q,x)] \cdot e^{-r \cdot t} dt, \tag{I}$$

$$\begin{aligned} \textit{Subject to}: \quad & \dot{x} = G(x)\text{-}q \\ & x(0) = x_0 \\ & x,q,T \geq 0. \end{aligned}$$

The necessary conditions for solving (II) include [15]:

$$\Pi_q - \tau \cdot R_q - \lambda \leq 0,\ q \geq 0,\ (\Pi_q - \tau \cdot R_q - \lambda) \cdot q = 0, \tag{I.1}$$

$$\dot{\lambda} - r \cdot \lambda = -\Pi_x + \tau \cdot R_x - \lambda \cdot G_x, \tag{I.2}$$

$$\dot{x} = G(x) - q, \tag{I.3}$$

$$H(T) = \Pi(q(T),x(T)) - \tau \cdot R(q(T),x(T)) + \lambda(T) \cdot (G(x(T)) - q(T)) = 0, \tag{I.4}$$

$$\lambda(T) \geq 0,\ x(T) \geq 0,\ \lambda(T) \cdot x(T) = 0. \tag{I.5}$$

The taxation of resource rents (indicated by the symbol τ) modifies most of these necessary conditions. Modification of the first two necessary conditions will in general alter the optimal paths of the control and state variables as well as the equilibrium position of these variables in the case of renewable resources. Modification of the fourth necessary condition suggests that the imposition of a resource rent tax may influence when a programme is terminated.

It is important to realize that condition (I.4) is really a component of a set of more general entry/exit conditions. Condition (I.4) represents the condition for the optimal exit of firms already in the industry. The corresponding condition for optimal entry of firms into the industry would be

$$H(0) = \Pi(q(0),x(0)) - \tau \cdot R(q(0),x(0)) + \lambda°(0) \cdot (G(x(0)) - q(0)) \geq 0, \tag{I.6}$$

where $\lambda°(0)$ represents the firms' shadow price evaluation of the resource.

Condition (I.6) must be carefully interpreted. First, $\lambda°(0)$ is the shadow value of the resource as seen from a firm outside the industry. This does not have to be in accordance with the shadow value assessed by firms already in the industry. For a firm outside the industry $\lambda°(0)$ could for instance be zero. If that is the case (I.6) reduces to the more familiar entry condition $\Pi(q(0),x(0)) - \tau \cdot R(q(0),x(0)) \geq 0$, i.e., that expected profits from entry are positive. Second, the variables $q(0)$ and $x(0)$ represent the optimal levels of these variable, if the firm enters. Third, the resource rent tax, $\tau \cdot R(q(0),x(0))$, should be interpreted as what the firm expects to be charged.

Taking, (I.4) and (I.6) together, it is clear that resource rent taxes may alter the conditions for entry to and exit from the industry. Hence, if firms are not identical, such taxes, even if they will not close the industry prematurely, may alter the composition of firms participating in the industry.

To summarize, we have found that resource rent taxes will generally affect extraction paths, sustainable equilibria, the opening and closing of the industry and the composition of companies in the industry. We thus have the basic result of this paper:

Result 2
Resource rent taxes are in general distortive.

The economic intuition for Result 2 is straight-forward. Resource rents depend on the extraction path selected by the industry. They also depend on the participation of individual firms or, for that matter, the industry as a whole in the extraction activity. Thus, the industry and its constituent firms can to some extent counteract the burden of the taxation by altering these variables.

It is important to realize, however, that Result 1 does not assert that that resource rent taxes are distortive in all cases. In certain, probably quite unrealistic situations, resource rent taxes do not have appear to have any distortive impact. One such case is a renewable resource industry with linear extraction technology and identical firms.

A NUMERICAL EXAMPLE

Let us now illustrate the distortive nature of resource rent taxation in the fishery with a numerical example. For ease of computation and exposition the example will be based on a very simple standard model.

The fishery profit function is specified as:

$$\Pi(q,x)= p\cdot q - C(q,x) = p\cdot q - (a+b\cdot q^2\cdot x^{-1}), \tag{5}$$

where q represents the harvest rate and x the fish stock biomass both at a point of time. p is the unit price of harvest and a and b are positive parameters.

The biomass growth function is taken to be the logistic function:

$$G(x) = \alpha\cdot x - \beta\cdot x^2, \tag{6}$$

where α and β are parameters with α representing the intrinsic growth rate and α/β the maximum equilibrium biomass often referred to as the virgin stock equilibrium.

Maximizing the present value of profits for this fishery along the same lines as in problem (I) above leads to the equilibrium conditions:

$$\alpha - 2\beta\cdot x + \frac{b\cdot q^2\cdot x^{-2}}{p-2b\cdot q\cdot x^{-1}} = r\,, \tag{7}$$

$$\alpha\cdot x - \beta\cdot x^2 = 0. \tag{8}$$

It may be mentioned that the second term on the lhs of (7) is often referred to as the marginal stock effect [16]. In an optimal equilibrium, this term is positive encouraging conservation of the resource.

As discussed in the section 2 above, a resource tax on this fishery is defined as:

(9) $\tau \cdot R(q,x) = \tau \cdot \Pi_q(q,x) \cdot q = \tau \cdot (p \cdot q - 2b \cdot q^2 \cdot x^{-1})$

Subtracting (9) from the profit function defined by (5) produces after some rearrangements:

(10) $\Pi(q,x,\tau) = p \cdot (1-\tau) \cdot q - (a+(1-2\tau) \cdot b \cdot q^2 \cdot x\text{-}1)$.

So, the impact of the resource rent tax is to reduce both the net price of production and the marginal costs of extraction.

Substituting $p \cdot (1-\tau)$ and $(1-2\tau) \cdot b$ in for p and b in (7) it is now straight-forward to derive the profit maximizing equilibrium conditions under the resource rent tax. The result is:

$$\alpha - 2\beta \cdot x + \frac{b \cdot (1-2\tau) \cdot q^2 \cdot x^{-2}}{p \cdot (1-\tau) - 2b \cdot (1-2\tau) \cdot q \cdot x^{-1}} = r, \qquad (11)$$

$$\alpha \cdot x - \beta \cdot x^2 = 0.$$

Inspection of (11) reveals that a positive resource rent tax will reduce the marginal stock effect (the third term in (11)) and, consequently, lead to a lower equilibrium biomass level. Obviously, if there is no resource rent tax, $\tau = 0$, (11) reduces to (7). It is easy to verify that the same applies if the basic profit function, (5), is linear in harvests, q.

So, in general, the equilibrium conditions for this fishery are modified by the imposition of the resource rent tax. This confirms a result previously derived by Johnson [17]. It immediately follows that the resource rent tax will also alter the optimal adjustment paths of the fishery.

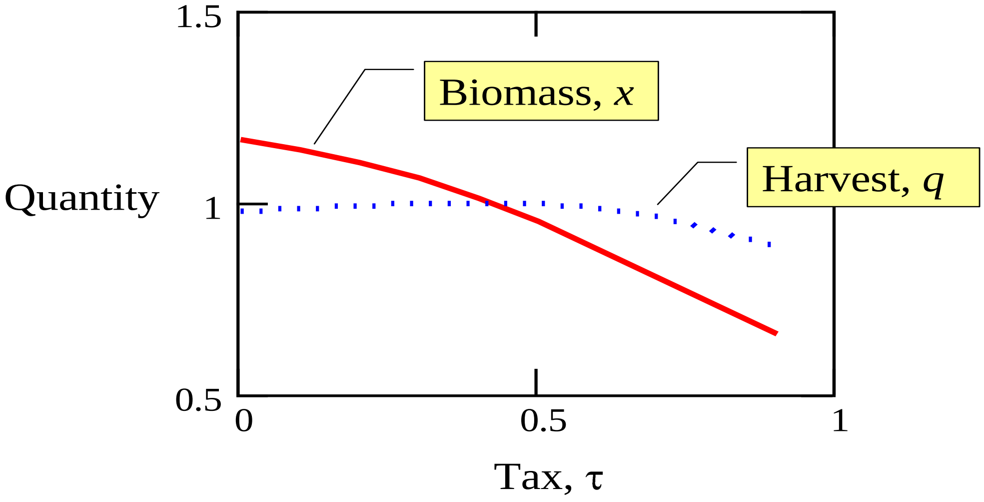
By assuming certain values of the parameters, it is possible to numerically illustrate this result. The parameter values are:

Parameter	Value
p	1
a	0.2
b	0.3
α	2
β	1
r	0.1

Given these parameters, we can now calculate the equilibrium biomass level and the corresponding social profits and tax revenues as a function of the tax rate, τ. The relationship between the biomass level and the tax rate is illustrated in Figure 3.

Figure 3

Resource rent taxation and the optimal equilibrium biomass: An example

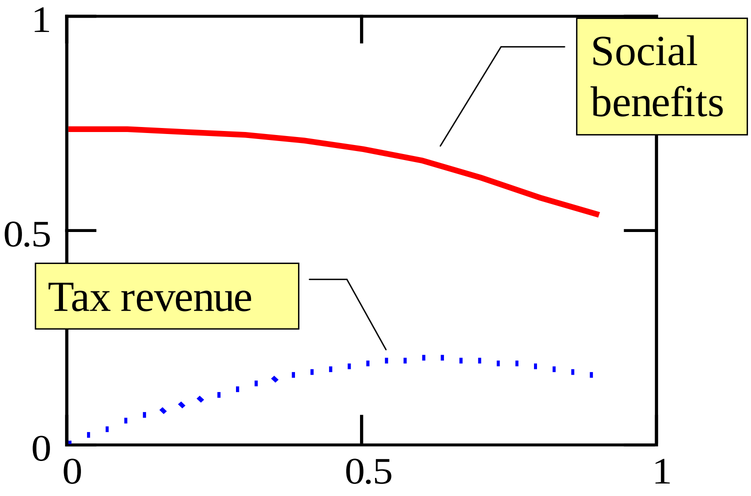


As illustrated in Figure 3, the optimal equilibrium biomass level is monotonically declining and (for these numerical values at least) quite sensitive to the resource rent tax rate. Thus, a resource rent tax rate of 0.5 reduces the equilibrium biomass by almost 20% and a tax rate of 0.9 reduces it by babout 50%. The harvest rate, also depicted in Figure 4, is, on the other hand, much less sensitive to the resource rent tax. This, of course, is because the resource rent tax initially moves the equilibrium biomass toward the maximum sustainable level. Thus with a resource tax rate of 0.5 the harvest increases by 1.4% compared to no resource rent tax.

Social benefits (profits before taxes), as predicted, decline monotonically with the tax rate. The tax revenue, on the other hand increases up to a certain point and declines after that. Thus, it exhibits the famous Laffer-curve shape. These relationships are illustrated in Figure 4.

Figure 4

Resource rent taxation and the optimal equilibrium biomass: An example



DISCUSSION

The basic result of this paper is that resource rent taxation is generally distortive. As demonstrated, it normally induces firms to alter the time path of extraction and may influence their entry and exit decisions and, therefore, the particular resource stocks that come under exploitation.

Although this result contradicts certain widely held beliefs concerning resource rent taxation, it can hardly be said to be surprising. After all, resources rents clearly depend on the level of extraction. Consequently, the same applies to the resource rent tax. This means that firms can reduce their resource rent tax-burden by adjusting the level of extraction. This they will do if it increases their retained profits. The paper suggests that only in very special situations, namely linear profit functions and identical firms, will this not necessarily be the case.

The model on which these results are based is quite simple. This, however, apparently does not subtract from the generality of the results. The indications are that the more general the model the less likely it is that resource rent taxation will be nondistortive. Among other things not allowed for in the model are explorations and investment in new resource developments. It seems pretty obvious, however, that resource rent taxation will reduce such activities if only for the reason that the expected returns will now be less than before. If the companies are risk averse the impact will be greater.

In the examples presented it was found that the distortionary impact of resource rent taxation is toward less conservation of natural resources than would otherwise be the case. While, this has not been established as a general principle, this finding may be a matter of some additional concern.

By its distortionary impact, resource rent taxation reduces the funds available for consumption and investment. For this reason, resource rent taxation is likely to have a negative impact on aggregate investment and hence the growth path of the economy. This negative impact will be counteracted if the resource tax revenues are more effectively used by the tax collector (government) than the private sector and exacerbated if the opposite holds true. For economies heavily dependent on natural resource extraction industries, these macro-economic impacts of resource rent taxation may be quite significant.

It is important to realize that the distortionary impact of resource rent taxation does not by any means rule it out as a sensible tax alternative. When it comes to the financing of government expenditures the relevant question is not whether a given tax option is distortive or not, but whether it is more or less distortive than the other alternatives available. The above analysis does not answer this question. In fact, a priori, it seems unlikely that this question can be answered on a theoretical basis.

The result that resource rent taxation is generally distortive raises the question of whether there exists a form of taxation to collect resource rents that is non-distortive. The above analysis says nothing about that. Note, however, that such non-distortive taxation, if it exists, would not be resource rent taxation. It would be something else. Indeed, if it is to be truly non-distortive it could not be related to any decision variables of the firms.

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