Requirement of a Time-invariant Tax Rate for Neutral Taxation in Theory and Practice

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I. Introduction

Following the resource boom in the 1970s, various countries have introduced new resource taxation in order to capture economic rents from their mineral sectors without, avowedly, distorting their mineral developments.(1) Taxation as an instrument for effecting such an objective is referred to as "neutral" taxation. Resource taxation based on the concept of neutral taxation is a significant change in the field of taxation. The idea of neutral taxation has also been taken up in practical proposals for tax reform as in Meade [9] and U.S. Treasury [12]. Therefore, in order to properly comprehend and evaluate these new resource taxes and tax-reform proposals, it is necessary to examine the concept of neutral taxation and the ways in which neutral taxation would operate in practice.

Although much has been written on the concept of neutral taxation, it appears

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(1) Some examples include the South African mineral taxation (White [13] and Gush [5]; the Bougainville (Papua New cuinea) copper taxation (White [13]); and the Manitoba metallic mineral royalty and the Saskatchewan uranium royalty both in Canada (White [13] and Kwon [7]).

that the main attention has been put on the mechanical exposition of the neutral tax using an unnecessarily high level of mathematics, and that the practical usefulness and the underlying nature of the tax have been overlooked. There are three well-known ways of levying a neutral tax. The first one is the so-called Brown scheme which allows an immediate write-off of investment expenditures in the year of acquisition (Brown [3]). The second one, which may be referred to as the Samuelson scheme, permits annual economic depreciation and interest costs to be deductible (Samuelson [10]). The third one, which has not been properly placed in the literature, is the rate-of-return tax scheme. This allows an annual deduction amounting to a certain threshold rate of return on investment.

Although these schemes are well-known, little attention has been directed to their relationships and to modifications required to implement them. In particular, it has been recently pointed out that, if the tax rate changes over time, only the Samuelson scheme achieves tax neutrality (Sandmo [11], and Boadway and Bruce [2]). This is true only in their theoretical forms, but in their most probable ways of implementation, the implications of changes in the tax rate for neutral taxation are quite different from their theoretical forms. Therefore, the purposes of this paper are four-fold: first, to develop an intuitive exposition of neutral taxation; second, to analyse the equivalence and differences among the schemes of neutral taxation; third, to address the modifications required to implement a neutral tax in practice; and finally, to examine the requirement of a time-invariant tax rate for neutral taxation in theory and practice.

The exposition will be made by means of familiar discount formulae applied to discrete time periods. In the real world, companies make up discrete annual accounts, and taxation is administered on a discrete annual basis. Thus, a discrete model provides a realistic framework of analysis. The exposition will be made assuming a single asset, first, without inflation, and then will be extended to incorporate inflation.

II. Concept of Neutral Taxation and Different Schemes

This paper is concerned solely with tax effects upon the investment decisions of a profit-maximizing firm. In this context, a (corporate) tax is defined as neutral if its imposition does not affect investment decisions of a profit-maximizing firm.(2) Although investment decisions of a firm may be influenced by the owners' preferences, it is assumed that they are made by the firm (or by its manager) so as to maximize profit, completely independent of the owners' preferences.(3)

A neutral tax thus defined can best be developed assuming a single asset. A profit-maximizing firm will undertake investments up to the marginal asset whose market value is equal to the present value of its operating income. Thus, the market value of the marginal asset at the beginning of year one in the absence of taxation can be written as

$$V_1=\sum_{t=1}^{n} R_t/(1+r)^t, \tag{1}$$

where V_1 is the market value (or price) of the marginal asset at the beginning of year one; R_t is the operating income of year t generated by the marginal asset net of all expenses except depreciation and interest costs; and r is the market rate of interest (assumed to be constant over time and unchanged by

(2) The general definition of a neutral tax is that, with the imposition of such a tax, the marginal rates of substitution and transformation remain unchanged from their pre-tax values. Since the marginal rates of substitution and transformation are predicated on relative prices, tax neutrality has usually been discussed in terms of tax effects on relative prices. Although any practical type of tax may have some effects on relative prices in a static and/or dynamic sense, attention has usually been placed in the past on the price effects of sales taxes in a static sense. Recently, the neutrality concept of taxation has been considered in terms of the neutrality of a corporate (or company) tax in the context of dynamic, investment decision-making. Various techniques of analysis of a company neutral tax available in the economic literature have been excellently synthesized and further extended by Boadway [1]. It appears, though, that Boadway's main attention has been paid to the technical exposition of the concept—not to its practical application.

(3) This amounts to assuming that the Fisher separation theorem holds, which in turn follows from the assumption of perfect and costless capital market. For a full discussion of the Fisher separation theorem, see Fama and Miller [4].

the introduction of the tax). Since equation (1) is for the marginal asset, the interest rate (r) equals the internal rate of return to the asset, and its market value equals to its market price (or cost).

Equation (1) is the general Fisherian formula for asset valuation. With a perfect capital market, current market value necessarily equals present value. As a result, a maximization of the present value of profits over time is equivalent to a maximization of the market value of a firm. It is thus possible to develop the concept of tax neutrality in terms of the value of assets instead of profits. In order to maximize its market value, a firm will undertake investments up to the marginal asset whose internal rate of return is exactly equal to the market rate of interest, as shown by equation (1).[(4)]

Since equation (1) holds over time, the change in the market values of the asset over any period (t) can be derived as

$$V_t - V_{t+1} = R_t - rV_t, \quad t=1, 2, \cdots, n. \tag{2}$$

Equation (2) represents true economic depreciation which is defined as a decline in the market value of the asset. Thus, economic depreciation for one year is equal to the present value of the expected earnings as of the beginning of the year minus the present value of the remaining earnings as of the beginning of the next year.[(5)]

Equation (2) can be re-arranged as

$$R_t = V_t - V_{t+1} + rV_t, \quad t=1, 2, \cdots, n. \tag{3}$$

Equation (3) shows that the operating income generated by the marginal asset in any period equals the sum of economic depreciation ($V_t - V_{t+1}$) and interest (actual or imputed) on the undepreciated value of the asset (rV_t), the sum

(4) This is referred to as the "market value rule" by Fama and Miller [4].

(5) Equation (2) shows that the arithmetic sum of annual economic depreciation over the asset's life is equal to the original asset value under the assumption that the asset value at the end of the nth year (V_{n+1}) equals zero. The requirement of V_{n+1} being zero says nothing more than that V_t, if it continues to grow at all, does so at a rate less than the discount rate (r) per year. This requirement is consistent with the equilibrium of the capital market which requires in turn that V_t converges to a finite limit as t approaches infinity.

being equal to the opportunity cost of the asset.(6) By taking the present values of both sides of equation (3), it can be seen that the sum of the present values of economic depreciation and interest costs should be equal to the original value of the asset.

A neutral tax, as defined above, does not affect investment decisions of a profit-maximizing firm. A tax will not affect investment decisions if it does not affect the market price (value) of the marginal asset. Finally, the market price will remain unaffected by a tax if it provides tax-deductions equal in amount to the market price. In this regard, equations (1) and (3) show that tax neutrality can be effected either (a) by allowing an immediate write-off of the asset, or (b) by allowing annual economic depreciation and interest (actual or imputed) on the undepreciated value of the asset to be deductible for tax purposes. The former is referred to in the literature as the Brown scheme (Brown [3]), and the latter as the Samuelson scheme (Samuelson [10]). Each of these schemes provides tax-deductions, over the life of the asset, the present value of which equals the market price of the asset. This is equivalent to leaving the market price of the asset untaxed and thereby unaffected, rendering the tax neutral. Hence, a neutral tax of any scheme will generate zero tax revenue (in terms of present value) over the life of the marginal asset.

An intuitive explanation of the Brown scheme is that a tax reduction (or tax-refund) equal to the tax rate times the market price of the asset is immediately provided; that annual taxes are imposed at the same rate on operating income over time; and that the present value of tax payments is equal to the

(6) This result is nothing more than saying that a profit-maximizing firm undertakes investments up to the marginal one, and that the marginal investment generates the marginal revenue product (or operating income) just equal to the sum of economic depreciation and interest on the capital, thereby earning zero pure profit. Since the price of capital (service) is equal to the marginal revenue product, the right-hand side of equation (3) is usually referred to as the rental price of capital. Furthermore, with a fixed depreciation rate (d) as a fraction of the undepreciated asset value and the value of the asset being one, equation (3) is expressed as $c=d+r$, where c is referred to as the "rental price of capital" (Hall and Jorgenson [6]).

immediate tax reduction. Hence, the market price of the asset is independent of the tax. The Brown scheme is in effect equivalent to multiplying both sides of equation (1) by one minus the tax rate, thereby preserving the equality in the imposition of the tax as well as in its absence. It should therefore be noted that in order for the Brown scheme to hold the tax rate should remain constant over time.(7) An intuitive explanation of the Samuelson scheme is that the deductions of depreciation and interest costs are annually allowed for tax purposes, and that they are annually equal in amount to operating income, thereby annual taxable income being zero. Hence, the annual tax liability from the marginal asset is zero regardless of the tax rate. As a result, the Samuelson scheme, unlike the Brown scheme, does not require a time-invariant tax rate.(8)

Another scheme for neutral taxation is the rate-of-return tax. The essential features of the rate-of-return tax are as follows. It levies no tax, nor does it provide tax refunds, when the actual rate of return on investment is below a certain threshold rate of return. Once the actual rate of return exceeds the threshold rate, the tax is imposed on the basis of a progressive rate structure. The typical rate structure of a rate-of-return tax is shown as(9)

$$U=a\left(1-\frac{b}{x}\right), \tag{4}$$

where U is the rate-of-return tax rate as a fraction of annual operating income (R_t); a is a constant representing the maximum marginal tax rate; b is the threshold rate expressed as a decimal fraction of the original asset (V_1); and x is the actual (annual) rate of return to the original asset.

(7) The requirement of a time-invariant tax rate for the Brown scheme has recently been proved by Sandmo [11] and Boadway and Bruce [2], using mathematical tools. As shown later, this requirement does not arise if a proper loss-carry-over system exists instead of a tax-refund.

(8) For a mathematical proof of this, see Sandmo [11] and Boadway and Bruce [2]. Again as shown later, a practical application of the Samuelson scheme may require a time-invariant tax rate.

(9) Among those who have contributed to the discussion of the rate-of-return tax are: MacKenzie and Bilodeau [8] and White [13].

It can be seen from equation (4) that as long as the actual rate of return (x) is less than or equal to the threshold rate (b), the rate-of-return tax rate is negative or zero. In this case, neither a tax liability, nor a tax-refund arises. As the actual rate of return exceeds the threshold rate, the tax rate (U) increases at a decreasing rate up to the maximum marginal rate (a), generating an increasing tax liability. Insofar as the threshold rate is set properly, the actual rate of return to the marginal asset over its life should be equal to the threshold rate. Thus, the tax rate and accordingly the tax liability from the marginal asset are both zero regardless of the level of the maximum marginal tax rate as shown in equation (4), rendering the rate-of-return tax neutral.

If, as a special case, the actual rate of return for any year is estimated to be the ratio of operating income (R_t) to the original asset value (V_1), then the rate-of-return tax liability in year t (RRT_t) can be written as(10)

$$RRT_t = a(R_t - bV_1). \tag{5}$$

Equation (5) shows that the threshold return on the original asset (bV_1) is annually deducted for the purpose of the rate-of-return tax. The present value of these annual tax-deductions, discounted at the threshold rate (b), is equal to the market value of the marginal asset, assuming the asset life is sufficiently long. Insofor as operating income is stable over time and the asset life is sufficiently long, annual interests on the original asset would not surpass its annual operating income, because the former is the opportunity cost of the marginal asset. Hence, annual taxable income and thus the annual tax liability of the rate-of-return tax are both zero regardless of the tax rate. Thus, the rate-of-return tax with the actual rate of return measured as above does not require a time-invariant tax rate.

The three neutral tax schemes as discussed above are in effect special cases. Tax neutrality can be effected by allowing any type of tax-deductions as long as the present value of tax-deductions over the asset life is equal to the market

(10) This is equivalent to assuming that operating income is constant over time and the asset life is sufficiently long. This is the way of measuring the actual rate of return for the Saskatchewan uranium royalty. See Kwon [7].

price of the asset, thereby leaving the asset untaxed. For example, suppose that economic depreciation is a fixed fraction (d) of the undepreciated asset value as under the declining balance method of depreciation. Then combination of equations (1) and (3) yields the following result,

$$V_1=\sum_{t=1}^{n}\{d(1-d)^{t-1}V_1+r(1-d)^{t-1}V_1\}/(1+r)^t. \tag{6}$$

From equation (6), it can be shown that the sum of the present values of economic depreciation and interest costs is equal to the original asset value for any depreciation rate, assuming the asset life is sufficiently long. The loss or gain in depreciation deduction in a year, resulting from the rate (d) being lower or higher than the true economic depreciation rate, is exactly offset by the change in the undepreciated value of the asset and interest thereon.

In the case of a fixed depreciation rate, tax-deductions do not necessarily match operating income in amount on an annual basis, although they would do so over the life of the asset. As a result, tax liabilities may arise over time negatively or positively before an asset is fully recovered. Thus, tax neutrality does not hold unless the tax rate remains constant over time.

Equation (6) shows the essence of the rate-of-return tax. If the depreciation rate (d) is equal to zero, then the right-hand side of equation (6) reduces to be the present value of annual interests on the original asset. The rate-of-return tax allows annual interests on the original asset deductible, as shown by equation (5).

It will be recalled that the analysis so far has been undertaken by means of a marginal asset (or investment), and that none of the neutral tax schemes generates net tax revenue, in terms of the present value, over the life of the asset. However, a zero tax on a marginal asset is certainly consistent with a positive tax on intramarginal assets, and the above analysis of tax neutrality based on the marginal asset can also be applied to intramarginal assets. The market prices of assets—marginal or not—are identical and equal to the market price (value) of the marginal asset under a competitive market. Therefore, the opportunity cost of an intramarginal asset should also be equal to that of the marginal asset, but the operating income generated by the former should be larger than that by the latter. Hence, an intramarginal asset generates pure profit which is defined as operating income less its opportunity cost. Since a neutral tax provides tax-deductions equal to the market price of an intramarginal asset or to its opportunity cost, the market price will remain unaffected by the tax, rendering the tax neutral. A neutral tax will then decrease only pure profit in proportion to the tax rate.

III. Tax Neutrality under Inflation

So far the analysis of tax neutrality has been undertaken in the absence of inflation, and all the variables were stated in real terms. The above analysis can be readily extended to incorporate inflation, insofar as the inflation is perfectly anticipated. For simplicity, it is assumed that a single inflation rate (p), constant over time, is applied to all relevant variables. Thus, both the market value of an asset and operating income will be adjusted over time by the same inflation rate. Following the Fisherian adjustment of the real interest rate for inflation, the nominal interest rate becomes $r+p+rp$, p being the inflation rate. The tax is assessed on the basis of nominal taxable income, and the tax rate is assumed to remain unchanged in the presence of inflation. Under inflation, the current market value of the marginal asset in the absence of taxation will then be written as

$$W_1=\sum_{t=1}^{n} R_t(1+p)^t/(1+r')^t, \tag{7}$$

where W_1 is the asset value at the beginning of period one under inflation, and r' is the nominal interest rate. The Brown scheme can easily be applied by allowing an immediate write-off of the current market price of an asset.

From equation (7), it can be shown that operating income, economic depreciation and interest costs are related under inflation as

$$R_t(1+p)^t = W_t - W_{t+1} + r' W_t, \quad t=1, 2, \ldots, n. \tag{8}$$

Hence, the Samuelson scheme holds under inflation by deducting true economic depreciation under inflation ($W_t - W_{t+1}$)—the replacement-cost depreciation—and nominal interest on the undepreciated current market price of an asset ($r' W_t$). [11]

It can be shown from equations (3) and (8) that depreciation and interest costs under inflation are related to those in the absence of inflation as

$$W_t - W_{t+1} + r' W_t = (1+p)^t (V_t - V_{t+1} + r V_t). \tag{9}$$

Equation (9) shows that the sum of the replacement-cost depreciation and nominal interest on the undepreciated current value of an asset can be obtained by revaluing the sum of the historical-cost depreciation and real interest on the undepreciated real asset by the inflation rate. Through the latter route, can the Samuelson scheme also be implemented under inflation. For the rate-of-return tax, the threshold and actual rates of return must be measured in nominal terms under inflation.

IV. Implementation of Neutral Tax Schemes

In order to implement any schemes of neutral taxation in practice, substantial modifications are required. As is usual in the literature of neutral taxation, it has so far been assumed that the price (or cost) of an asset is provided at the outset of an investment undertaking, and that a tax-refund is provided for losses. In practice, however, expenses for an investment project occur for a number of years before the project begins to generate operating income, and tax-refunds for losses are politically impalatable and thus impractical. Hence, in implementing such schemes, there should be appropriate methods for calculating

(11) Combination of equations (1) and (7) yields the relation between W_t and V_t as

$$W_t = V_t (1+p)^{t-1}. \tag{i}$$

Since equation (i) holds over time, the following can be derived,

$$W_t - W_{t+1} = (1+p)^t (V_t - V_{t+1}) + \{(1+p)^t - (1+p)^{t-1}\} V_t. \tag{ii}$$

This says that the replacement-cost depreciation equals the historical-cost depreciation revalued by the inflation rate (the first term on the right-hand side) plus capital gains from the undepreciated asset over one year (the second term on the right-hand side).

the cost of an investment project and for dealing with losses.

In order to be consistent with tax neutrality, the value of a multi-year investment project should be obtained by accumulating annual investment expenses compounded by the (threshold) interest rate up to the start of the commercial production stage. In implementing the Brown scheme for a multi-year project, the amount of the immediate write-off equals such compounded investment expenses.(12) Therefore, although the Brown scheme, unlike the other two, does not require the (threshold) interest rate in its theoretical form, it will do so in practice.

Accumulated investment expenses will normally exceed operating income during the earlier part of the life of a project, thereby generating losses. The Brown scheme has so far assumed that a tax-refund for loss equal to the loss times the tax rate is provided. However, this type of loss-offset system is impractical. Instead, a practical one consistent with tax neutrality would be to carry forward the loss without limit allowing interest thereon at the threshold rate. Such a loss-carry-over system also requires the threshold interest rate. It should be noted that, if the Brown scheme operates with a loss-carry-over system as above instead of with a tax-refund for loss, it does not require a time-invariant tax rate. This is so because, until an asset is fully recovered, there will be no annual taxable income, thereby rendering the tax rate immaterial.(13)

In order to implement the Samuelson scheme, true economic depreciation of an asset must be annually estimated. Since economic depreciation represents a decrease in the value of an asset over time, it should be measured by evaluating the asset value in each period of the asset life, and comparing the

(12) Although there are some errors in the compounding process, both the Manitoba metallic minerals royalty and the Saskatchewan uranium royalty obtain the costs of the capital assets by compounding annual investment expenses up to the commercial production stage. See Kwon [7].

(13) It appears that the literature has overlooked this aspect, indicating a lack of attention to the implementation of neutral taxation.

values over time. This would be extremely difficult. It should be noted that if the tax is imposed on an annual basis with economic depreciation as measured above, the Samuelson scheme does not require any loss-offset system. This is so because operating loss from an asset in a year will be compensated by an appreciation of the asset. As shown by equation (3), operating loss in a year $(-R_t)$, if occurring, will be the sum of the appreciation of the assets $(-(V_t - V_{t+1}))$ and interest on the undepreciated asset, the latter being positive as long as the undepreciated asset exists.(14) As a result, the loss for tax purposes is still zero even if operating loss $(-R_t)$ occurs. This indicates that, in order to implement the Samuelson scheme, both economic depreciation and economic appreciation of the asset must be measured, and the latter must be added to operating income in computing annual taxable income.

If the Samuelson scheme is implemented, it would probably be done by applying a pre-determined statutory rate to the undepreciated asset, like the declining balance method of depreciation. As indicated earlier, tax neutrality can also be achieved by appropriately adjusting the undepreciated asset and interest thereon. Since tax-deductions do not necessarily match operating income on an annual basis under this type of implementation, taxable income (or loss) would arise prior to a full recovery of an asset. This requires a time-invariant tax rate to maintain tax neutrality. If loss occurs, it must be carried over without limit allowing interest thereon. Further, the Samuelson scheme, if implemented with a fixed depreciation rate, requires the asset life to be sufficiently long, because the sum of the present values of depreciation and interest costs equals the original price of an asset only if the asset life is long. Although it is typically assumed in the literature of neutral taxation that the

(14) This can also be shown by one of the characteristics of the internal rate of return. The internal rate of return—the interest rate in equation (1)—is equal to the return on the undepreciated asset in each period of the asset life, if income is defined as operating income (R_t) minus economic depreciation $(V_t - V_{t+1})$. That is, equation (3) can be re-arranged as $(R_t - (V_t - V_{t+1}))/V_t = r$ for all t. Hence, as long as V_t exists with a positive value, economic appreciation will be more than operating loss. For this characteristics of the internal rate of return, see equation (1′) of Samuelson [10].

asset life is infinitely long, it is normally limited in practice. If so, a tax-refund corresponding to the undepreciated balance of the asset should be provided at the end of the actual asset life. This also requires a time-invariant tax rate to maintain tax neutrality. Therefore, in practice, unlike in theory, the Samuelson scheme—not the Brown scheme—may require a time-invariant tax rate.

The Brown scheme does not require annual depreciation, nor does it require an annual adjustment of the undepreciated asset value and interest thereon. Hence, it may be simpler to implement than the Samuelson scheme. Given a loss-carry-over system instead of a tax refund for loss, it is likely in practice that the Brown scheme does not require a time-invariant tax rate while the Samuelson scheme may do so. With a loss-carry-over system, no tax will be imposed under the Brown scheme until the original asset is fully recovered, while the Samuelson scheme with a fixed depreciation rate may impose taxes prior to a full recovery of an asset. Hence, given the uncertainty involved in the asset life, companies would prefer the Brown scheme. This would be particularly so if no tax-refund system is provided for the undepreciated balance of an asset under the Samuelson scheme.

In implementing the rate-of-return tax, the annual rate of return to the original asset must be measured annually from the first year of production up to any particular year. Given a limited life span of an asset, the internal rate of return up to and including the present year would be an appropriate measure of the rate of return.(15) If operating income is stable over time, the actual rate thus calculated will be low (or negative) at an earlier part of the asset life, and will increase over time to reach (and exceed in the case of an intra-marginal asset) the threshold rate. Thus, the rate-of-return tax will not be imposed until the original asset is recovered at the threshold rate. However, this approach involves substantial annual computation, and if operating income is unstable over time, this method may not provide an unique rate of return.

If the ratio of annual operating income to the original asset is adopted as

(15) This is an approach proposed by MacKenzie and Bilodeau [8].

the actual rate of return, then operating income should be stable over time and the asset life should be sufficiently long in order to effect tax neutrality. Otherwise, taxable income can be positive before an asset is fully recovered. If so, a time-invariant tax rate is required to maintain tax neutrality. If the life of an asset is limited, a tax-refund corresponding to the unrecovered balance of the asset at the end of the actual asset life should be provided. This also requires a time-invariant tax rate. From the administrative point of view, the Brown scheme appears to be simpler to implement than the rate-of-return tax, because the former requires less information.

V. Summay and Conclusions

A neutral tax does not affect the investment decisions of a profit-maximizing firm. A tax will not affect investment decisions, if it does not affect the market price of an asset. The market price of an asset will not be affected by a tax if the tax provides tax-deductions equal in amount to its market price. Tax neutrality thus defined can be effected by an infinite number of schemes. Three well-known schemes are: the Brown, the Samuelson, and the rate-of-return tax schemes. In essence, each of these schemes allows tax-deductions over the life of an asset, the present value of which is equal to the market price of the asset, rendering the tax neutral. Since the present value of operating income from the marginal asset equals its market price, a neutral tax of any scheme will generate zero tax revenue (in terms of present value) when applied to a marginal asset. If it is applied to an intramarginal asset, then only pure profit will decrease in proportion to the tax rate.

The question of changes in the tax rate over time has an important bearing on the neutrality. Given a tax-refund for loss, which is usually assumed to exist in the literature of neutral taxation, the Brown scheme requires a time-invariant tax rate, while the other two schemes do not. However, with a proper loss-carry-over system instead of a tax-refund system, the Brown scheme does not require a time-invariant tax rate. On the contrary, both the Samuelson and the rate-of-return tax schemes may do so in their most probable ways of implementation.

In conclusion, the Brown scheme is subject to fewer constraints in practice than the other two, and requires the least amount of information and computation over the life of an investment project. Hence, the Brown scheme appears to be preferable in practice.(16) It may also be preferred by firms because it would involve less uncertainty in recovering their capital prior to a positive tax payment.

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(16) An evaluation of the Saskatchewan uranium royalty and the Manitoba metallic minerals royalty, which are based on, respectively, the Brown and the Samuelson schemes, has evidently shown that the Samuelson scheme is in effect extremely complex. See Kwon [7].

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