A MODEL FOR ANALYSIS OF TAXATION OF CAPITAL INVESTMENT IN DEVELOPING COUNTRIES

by

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Abstract

This paper presents a model for analysis of the taxation of capital investment. The model can be applied to an investment project consisting of up to four depreciable assets and land. The model uses tax, financing, and economic factors to calculate a single cash flow for the project. The model combines the tax treatment and replacement investment for all assets with project-wide flows (e.g. investment income and debt service payments) in order to compute a marginal effective tax rate for the project as a whole. The model is designed for general purpose use and provides a common methodology for analyzing the taxation of capital investment across countries.

The model satisfies Samuelson's (1964) fundamental theorem of tax invariance and the requirement that the marginal effective tax rate for expensing an all equity financed investment is zero. The model performed as expected regarding the values and changes in value of the marginal effective tax rate for various financing options and alternative tax treatments for depreciation and capital gains. The model can have practical application for analyzing the effects of tax systems in a wide range of developing countries.
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I. Introduction

Tax policy is receiving more attention as an instrument for growth in developing countries. The Baker Plan gives prominence to tax reform as an action to facilitate efficient investment, both domestic and foreign.\(^1\) Developments in international financial markets will draw more attention to after-tax rates of return for investments and, as a consequence, to careful analysis of capital taxation in developing countries. For example, the newly created Emerging Markets Growth Fund will invest in the share capital of companies in developing countries with attractive investment prospects. Such prospects are determined, in part, by the tax treatment of investments in developing countries.

This paper presents a model for quantitative analysis of the taxation of investment in developing countries. An important feature of the model is that it brings the analysis of the taxation of investment substantially closer to the actual tax treatment of an investment project. As such, it can be of practical use for business applications and tax policy analysis. The model also provides a common methodology for analyzing the taxation of investment across countries.

An important measure of the taxation of capital investment is the tax burden as a percentage of the rate of return from the investment.\(^2\) More specifically, this measure is the "marginal effective tax rate" (METR) for an investment and equals the difference between the before-tax rate of return on the investment and the after-tax rate of return, as a percentage of the
The METR is useful for measurement and comparative purposes because it converts all types of taxes to a common value, and accounts for variations in timing of tax payments and in tax bases. Fully and properly calculated, the METR summarizes all of the direct tax consequences for investments. The model presented in this paper computes METR's for a wide range of investment projects and tax systems that encompass many countries. The METR is designed to shed some light on the efficiency implications of a country's tax system. The model was constructed for general purpose use and only requires the specification of parameters in a straightforward menu format.

The main features of the METR model and its advantages over previous models are described in Section II. A brief mathematical description of the model is given in Appendix A. The model is used for an analysis of the effects of alternative treatments of depreciation and capital gains and different financing options on the taxation of investment; this analysis is presented in Section III. Some assessment of the relative importance of tax and financing provisions and concluding remarks are given in Section IV.

II. The Marginal Effective Tax Rate Model for Investments

The model presented in this paper uses tax, financing, and economic factors to calculate the cash flows that can be expected from an investment project. The cash flow approach combines the individual streams for each asset (credits, depreciation, replacement investment) with the income generated by the project and other project-wide flows (e.g. debt service payments) to yield a single before-tax cash flow and single after-tax cash flow for the
entire project. These two cash flows are used to compute a marginal effective
tax rate (METR) for the project as a whole. 4/

The METR model is designed for general purpose use. The model re­
quires specification of parameters in three categories: (1) parameters that
define the investment project; (2) parameters that define the tax system; and
(3) economic parameters. The model is flexible enough to accommodate invest­
ment projects and tax systems in a wide range of countries. A brief mathe­
matical description of the METR model is given in Appendix A. This section
describes the main features of the model.

The METR model allows an investment project to consist of up to four
depreciable assets. The share of each asset in the total investment can be
freely set in the model. The investment may include land, which is not
depreciable, by setting the sum of the shares of the depreciable assets to be
less than 100 percent, with land making up the difference. 5/ The mix of
assets can correspond to an actual investment project, a representative in­
vestment (e.g. a typical manufacturing plant), or the composition of capital
in a country or industry. Investment tax credits, tax depreciation schedules,
and economic depreciation rates can be set separately for each asset. The
model allows credits and incentives to be specified for the entire project as
well. As mentioned, the model combines the tax treatment and replacement
investment for all assets with project-wide flows in order to compute a METR
for the project as a whole.

The method of using a single cash flow for an investment project in
order to compute its METR contrasts with the approach taken by King-Fullerton
(1984). Their underlying methodology is based on considering a hypothetical
investment in each asset alone and computing a marginal effective tax rate for
each asset. The marginal effective tax rates for individual assets are averaged to yield a marginal effective tax rate for the full project. It is a weighted average in which the weights equal the shares of each asset in the investment project.

Taking the average of marginal effective tax rates for single assets is not the same as computing the marginal effective tax rate for an investment made up of several assets. In general, the methods will yield different marginal effective tax rates for the same investment. To see this, regard the cash flow method as a methodology that computes the rate of return for a linear combination of assets. In contrast, consider the cost-of-capital method as one that computes the linear combination of internal rates of return for single assets. The internal rate of return calculation is nonlinear. The linear combination of internal rates of return does not equal the internal rate of return of a linear combination.

An actual investor is unlikely to look at the return from an investment project as an average of returns from hypothetical separate investments in the assets that make up the project (how is the single stream of income divided among the assets?). Investors usually look at the cash flow and rate of return for the project as a whole. Consequently, the cash flow method produces measures of effective taxation that have greater practical significance for investors and policy-makers.

The model has an option for specifying that replacement investment take place for each asset. Replacement investment for an asset equals its economic depreciation. Such replacement investment preserves the real value of each asset and keeps their shares in the project equal to their shares in the initial investment. Credits and depreciation allowances are applied to
replacement investment just as they are for the initial investment. In other words, the same credit and schedule of depreciation allowances (expressed as percentages of the amount invested) that applied to each asset in the initial investment are applied to replacement investment for each asset in all periods.

Financing of the investment project can be specified in the model for debt ratios from 0 to 100 percent. Financing can be done with a conventional loan that is amortized over any specified period. The model also has an option for refinancing that keeps the debt ratio constant at its initially specified level. The tax deduction for interest can be treated in several ways. One way is to allow the deduction of nominal interest payments from taxable income, a common practice in many countries. Another is to index interest deductions for the effect of inflation on the balance of the loan. Alternatively, interest may be indexed at any specified rate.

The discrete time specification of the model provides a realistic analysis of the tax treatment of capital investment. An investment in capital produces income and tax liabilities over many periods with the pattern of taxes not being smooth over time. Taxes may be postponed because of income recognition rules or accelerated deductions offered as incentives. The discrete, multi-period framework of the METR model incorporates these features of the tax treatment of capital investment exactly as they operate.

Depreciation allowances in all countries are given for discrete time periods and often have discontinuities in the schedule. For example, countries that use the declining balance formula often allow switchover to straight line depreciation. This switchover occurs when straight line deprecation on the remaining basis using the remaining number of years in the
depreciable life exceeds declining balance depreciation. The METR model replicates the way this switchover takes place. It also allows for this switchover under depreciation systems indexed for inflation.

The carryover of losses is another feature of the taxation of income from capital that can be readily handled by the discrete time specification of the METR model. The carryover of losses requires the specification of a time period in which losses (or gains) occur and over which losses are to be carried. The model allows for the specification of the periods (starting from the first) from which losses can be carried forward and the number of periods they can be carried into the future.

The model allows taxes to be exempt for a specified number of periods at the beginning of the operating life of the project. The model also has an option for a surtax that can be applied at the beginning of the project.

The length of time that the investment is in operation can be set to be from 1 to 30 periods. At the end of this period, the assets are sold at prices that reflect inflation and, if there is no replacement investment, economic depreciation. In the final period net sale proceeds are added to the before-tax cash flow. Net sale proceeds equal the sale price of the project minus the payoff of any loan balance. The calculation of gross capital gains can be selected from a number of options. Some common options are that gross capital gains equal either the sale price minus original cost or the sale price minus the remaining basis for all depreciable assets and the cost of the land. The amount of capital gains included in taxable income can be set to any proportion of gross capital gains. The proportion can reflect a statutory exclusion rate or a measure of effective capital gains taxation.
The parameters and options in the METR model are broad and flexible enough to accommodate a wide range of investment projects and countries.

III. Tax Analysis with the METR Model

This section presents an analysis of the effect of taxation and financing on capital investment using the METR model. This analysis has a few purposes. One is to demonstrate the range and capability of the model. Another is to measure the impact of different tax and financing provisions by calculating their effect on the marginal effective tax rate. A further purpose is to arrive at some assessment of the relative importance of tax and financing provisions on capital investment.

The analysis presented in this section is carried out using a representative investment project. The project consists of 5 assets: land, an industrial building, instruments, machinery and equipment (M&E), and vehicles. Each asset's share in the project, economic depreciation rate, and straight-line depreciation rate are presented in Table 1.

Several alternatives for the tax treatment of depreciation are examined in the analysis. One alternative is to have tax depreciation equal economic depreciation. Another is to allow first-year expensing. The assets are also depreciated under the straight-line schedules given in Table 1. These schedules are representative of tax depreciation in many countries. The analysis examines the effect of basing depreciation on historical cost and indexing depreciation for inflation.

The project includes replacement investment at the rate of economic depreciation given for each asset in Table 1. There are no investment tax credits or incentive allowances on a project-wide basis or for individual
Table 1: Shares and Tax Treatment of Assets in the Representative Investment Project

<table>
<thead>
<tr>
<th>Assets</th>
<th>Share in the Project</th>
<th>Straight-Line Depreciation Rate</th>
<th>Economic Depreciation Rate a/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building</td>
<td>35%</td>
<td>4.0%</td>
<td>3.60%</td>
</tr>
<tr>
<td>Instruments</td>
<td>25%</td>
<td>12.5%</td>
<td>15.00%</td>
</tr>
<tr>
<td>Gen. Ind. M&amp;E</td>
<td>20%</td>
<td>12.5%</td>
<td>12.25%</td>
</tr>
<tr>
<td>Vehicles</td>
<td>10%</td>
<td>25.0%</td>
<td>30.00% b/</td>
</tr>
<tr>
<td>Land</td>
<td>10%</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

a. Economic depreciation rates were obtained from Hulten and Wykoff (1981).

b. This is a round figure between the 25.4 percent rate for trucks, buses, and trailers and 33.3 percent rate for automobiles in Hulten and Wykoff (1981).
assets. This focuses the analysis on the effects of differences in tax depreciation and capital gains treatment.

Investment income is the marginal increase in net revenue that results from the investment project. Investment income increases at the rate of inflation which is 5 percent. Investment income keeps pace with inflation because replacement investment preserves the productive capacity of the project. The level of investment income is set to yield a real before-tax rate of return of 10 percent.

The statutory tax rate applied to taxable income from the investment project is 40 percent. The investment project is in operation for 10 years. At the end of this period the assets are sold. The real value of each asset has been held constant by replacement investment. Consequently, inflation is the only reason the sale price of an asset exceeds its original price. In other words, any price increase in assets, or so-called capital gain, is purely nominal. Three alternatives for taxation of (nominal) capital gains are analyzed: full taxation of capital gains, taxation of 50 percent of capital gains, and no taxation of capital gains.

The analysis is carried out with the investment project financed with equity entirely and with debt at debt ratios of 50 percent and 70 percent. The financing is done with a conventional loan with a term equal to the operating life of the project, which is 10 years. Two alternatives for allowing a tax deduction for interest expenses are examined: deduction of nominal interest payments and deduction of interest indexed for the effect of inflation on the balance of the loan. Another financing alternative is examined in which there is continual refinancing in order to keep the debt ratio constant.
and interest deductions are indexed for inflation. This alternative will be referred to as economic debt.

Financing is done at an interest rate equal to the before-tax rate of return. As a result, the before-tax rate of return is unaffected by different levels of debt financing. Specifically, because the interest rate equals the before-tax rate of return, debt financing does not change the present value of the before-tax cash flow. 11/ Therefore, debt financing only affects the after-tax rate of return; this effect depends on the tax treatment of interest.

The METR's for the representative investment project for the depreciation and financing alternatives discussed above are reported in Table 2.

The first row of results in Table 2 presents the effects of different financing options when tax depreciation equals economic depreciation. The first option is all equity financing (column (3)). This case meets the conditions of the fundamental theorem of tax invariance given by Samuelson (1964). This theorem establishes that the effective tax rate for an income-generating asset equals the statutory rate if tax depreciation equals economic depreciation. The METR calculated from the METR model is 40 percent which is the statutory rate. Thus, the model satisfies Samuelson's fundamental theorem of tax invariance. This result provides an analytical reference point for interpreting the other results in Table 2.

The fundamental theorem of tax invariance is obtained with debt financing if interest is indexed for inflation so that only true economic interest is deducted from taxable income. This is the case with economic debt, the next financing option after all equity financing. The METR equals the statutory rate of 40 percent for both 50 percent and 70 percent debt
Table 2: Marginal Effective Tax Rates for Alternative Depreciation Methods and Financing Options

<table>
<thead>
<tr>
<th>Depreciation</th>
<th>Capital Gains Taxation</th>
<th>All Equity</th>
<th>Economic Debt</th>
<th>Conventional Debt</th>
<th>Loan &amp; Interest Indexation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Economic</td>
<td>NA</td>
<td>40.0 (a)</td>
<td>40.0 (e)</td>
<td>40.0 (e)</td>
<td>25.0</td>
</tr>
<tr>
<td>(2) SLD (f)</td>
<td>Full</td>
<td>49.9</td>
<td>61.7</td>
<td>81.7</td>
<td>45.4</td>
</tr>
<tr>
<td>(3) SLD</td>
<td>50%</td>
<td>41.9</td>
<td>43.9</td>
<td>47.0</td>
<td>33.7</td>
</tr>
<tr>
<td>(4) SLD</td>
<td>Zero</td>
<td>34.4</td>
<td>28.7</td>
<td>21.2</td>
<td>23.1</td>
</tr>
<tr>
<td>(5) Ind. SLD</td>
<td>Full</td>
<td>38.0</td>
<td>35.7</td>
<td>32.4</td>
<td>27.7</td>
</tr>
<tr>
<td>(6) Ind. SLD</td>
<td>50%</td>
<td>32.3</td>
<td>24.3</td>
<td>13.1</td>
<td>19.6</td>
</tr>
<tr>
<td>(7) Ind. SLD</td>
<td>Zero</td>
<td>26.9</td>
<td>14.0</td>
<td>-3.1</td>
<td>12.1</td>
</tr>
<tr>
<td>(8) Expensing</td>
<td>Full</td>
<td>0.0 (j)</td>
<td>-190.3 (j)</td>
<td>-214.2 (j)</td>
<td>-132.8 (j)</td>
</tr>
</tbody>
</table>

Note: The real before-tax rate of return is fixed at 10 percent. The statutory tax rate is 40 percent. It is assumed that negative taxable income offsets positive taxable income and, therefore, reduces overall tax liability, or, equivalently, that the tax system gives refunds on losses at the same rate it taxes profits.

a. Economic debt has two features: (1) there is refinancing every period in order to keep the debt ratio constant and (2) the interest deduction for tax purposes is reduced by the effect of inflation on the loan balance.

b. Conventional debt has two features: (1) a conventional loan whose term equals the operating period for the investment project, i.e. 10 years and (2) deduction of nominal interest payments from taxable income.

c. Depreciation allowances are computed using the inflation indexed declining balance formula with rates equal to the economic depreciation rates given in Table 1.

d. Equals the statutory tax rate. Thus, the model satisfies Samuelson’s (1964) fundamental theorem of tax invariance.

e. Satisfies Samuelson’s (1964) fundamental theorem of tax invariance as modified for debt financing.
f. Straight-line depreciation using the schedules given in Table 1.

g. Indexed straight-line depreciation. The straight-line rates given in Table 1 for the four assets are applied to their inflation indexed bases.

h. The full cost of the investment is deducted when the investment is made, i.e. in the period before the first period of operation.

i. Satisfies the requirement that full expensing of an all equity financed investment yields a zero METR (see McLure (1986)).

j. 70 percent debt financing yields an infinite negative METR (see Endnote 14).
financing. Thus, the METR model satisfies the fundamental theorem of tax invariance for debt financed investment as well.

The fact that the METR equals the statutory rate at any debt ratio as long as there is interest indexing and economic depreciation for tax purposes demonstrates an important point. Interest, properly measured, is a cost of doing business. Incurring an additional deductible cost will not, by itself, lower the effective tax rate for an investment. An advantage of leverage, abstracting from inflation, is that it reduces the equity needed per dollar of depreciation in excess of economic depreciation. When tax depreciation equals economic depreciation and interest is indexed for inflation the advantages of leverage are taken away. As a result, the METR equals the statutory rate.\textsuperscript{12}

The financing option after economic debt is a conventional loan. This loan is amortized over the period of operation of the project which is 10 years. Also, nominal interest payments are deducted for tax purposes. As expected, the METR tax rate is reduced substantially below the statutory rate; it is 25 percent for 50 percent debt financing and 9.5 percent for 70 percent debt financing. Nominal interest deductions confer a tax advantage to debt financing because nominal interest payments overstate true interest expenses when there is inflation. This is the only advantage because tax depreciation equals economic depreciation; i.e. there is no advantage from the tax treatment of depreciation and capital gains for leverage to enhance.

In the last two columns of Table 2 interest deductions are indexed for inflation for 50 percent and 70 percent debt financing with a conventional loan. In the first row, where tax depreciation equals economic depreciation, interest indexing brings the METR's back up to the statutory rate. Because
this result obtains at any debt ratio, the steady decline in the debt ratio due to the amortization of a conventional loan has no bearing on this result.

In the second row of Table 2 tax depreciation follows the straight-line schedules given in Table 1 for the four depreciable assets and capital gains are fully taxed. With all equity financing the METR for the project is 49.9 percent. The reason that the METR exceeds the statutory rate can be stated in a number of equivalent ways. One is that the straight-line depreciation allowances and inclusion of nominal capital gains in taxable income overstate, in present value terms, economic income from the project over its operating life. Another is that the straight-line depreciation schedules and nominal capital gains do not account fully for true economic costs. Still another way to state this fact is that the tax liability under the straight-line depreciation schedules and inclusion of nominal capital gains exceeds, in present value terms, the tax liability under economic depreciation. These statements are equivalent with the fact that the METR exceeds the statutory rate in the all equity financed case.

There are two main factors from a tax policy perspective that contribute to the METR exceeding the statutory rate. One is that depreciation allowances are based on historical cost. The depreciable basis is not adjusted for inflation \(^{13/}\) which erodes the real value of depreciation allowances. The other reason is that nominal capital gains are taxed as ordinary income. In other words, capital gains are not indexed for inflation, which is a consequence of depreciation not being indexed. When tax depreciation equals economic depreciation there are no nominal capital gains because the depreciable basis is adjusted for inflation. In fact, in every period the depreciable basis equals the sale price of the asset.
In the second row the METR's with economic debt financing exceed the METR for all equity financing. (The METR's are 61.7 and 81.7 percent for the debt ratios of 50 and 70 percent, respectively.) This result illustrates a point. As mentioned above, leverage is advantageous when it reduces the amount of equity invested per dollar of depreciation in excess of economic depreciation. However, as the METR for all equity financing shows, depreciation falls short of economic depreciation in the second row of Table 2. Therefore, leverage will be disadvantageous if only true interest costs are deducted, i.e., interest is indexed for inflation. The disadvantage is greater for higher leverage. These points are born out by the METR's in cols. (4) and (5) of the second row.

In the second row where the project is financed with conventional debt and nominal interest payments are deducted from taxable income the METR declines. One reason for this is the tax advantage of the nominal interest deduction. The other reason is the amortization of the loan which reduces the debt ratio over time and, therefore, the disadvantage of leverage. This can be seen from the results for conventional debt with interest indexation in columns (8) and (9).

In the second row, when interest on a conventional loan is indexed for inflation, the METR increases above the statutory rate in both the 50 percent and 70 percent debt financed cases. The METR's in both these cases, however, do not return to their levels in the case where continual refinancing keeps the debt ratio constant (i.e. columns (4) and (5)). The reason is that a conventional loan is paid off over the life of the project. As the debt ratio declines the disadvantage of leverage that is present in the second row due to the tax treatment for depreciation and capital gains is reduced. It is
the amortization of the debt in columns (8) and (9) that results in the METR's being less than in columns (4) and (5).

The fact that the METR for 70 percent debt financing (58.2 percent) exceeds that for 50 percent debt financing (54.7 percent) is another illustration of the disadvantage of leverage in the second row of the table. Thus, this point can be seen by comparing the results at different debt ratios for a given type of debt or comparing conventional debt with constant debt at a particular initial debt ratio.

The tax treatment in the third row of Table 2 differs from the second by including half, instead of all, of capital gains in taxable income. Such a reduction in capital gains taxation is used in many countries as a rough adjustment for inflation. The METR for all equity financing (41.9 percent) is greater than the statutory rate. Thus, depreciation and capital gains treatment in the third row confers a tax disadvantage as in row (2). The results in row (3) follow the same pattern in row (2) except at lower METR's. The reasons for this pattern are the same as well.

Tax treatment in the fourth row of Table 2 completely excludes capital gains from taxation. This reduces the METR for all equity financing below the statutory rate to 34.4 percent. Thus, depreciation and capital gains treatment in the fourth row confers a tax advantage relative to economic depreciation. Consequently, debt financing will reduce the METR below its level for all equity financing. The results in the rest of the fourth row bear this out.

Economic debt reduces the METR to 28.7 and 21.2 percent at debt ratios of 50 and 70 percent, respectively. The METR is lower at the higher debt ratio because of the greater leverage of the tax advantage from depre-
ciation and capital gains treatment. In the second and third rows where the
depreciation and capital gains treatment confers a tax disadvantage, the
higher debt ratio raises the METR.

Conventional debt reduces the METR below its level for economic
debt. There are two opposing effects here. The deduction of nominal interest
reduces the METR. The decline in the debt ratio over the term of the loan
raises the METR. Clearly, the advantage of nominal interest deduction
outweighs the disadvantage of the amortization of the loan. The effect of
amortization is clearly evident when interest is indexed in the last two
columns of the fourth row.

Interest indexation for a conventional loan raises the METR above its
levels for conventional debt and economic debt at each debt ratio. The METR's
increase to 31.8 and 30.0 percent at the 50 and 70 percent debt ratios respec-
tively. The reason for the increase relative to conventional debt is the loss
of the advantage of the nominal interest deduction. The reason for the in-
crease relative to economic debt is the loss of the advantage of the constant
debt ratio.

With a conventional loan and interest indexation in the fourth row,
the METR for 70 percent debt (30.0 percent) is less than that for 50 percent
debt (31.8 percent). This follows from the tax advantage of depreciation and
capital gains treatment. In the second and third rows where the opposite is
true the higher debt ratio raises the METR.

The nontaxation of capital gains in row (4) brings out a point about
the straight-line depreciation schedules relative to economic depreciation.
With economic depreciation there are no capital gains due to indexation of
depreciation for inflation. Consequently, the comparison between rows (1) and
(4) with respect to depreciation and capital gains is between depreciation allowances under the straight-line schedules and economic depreciation in Table 1. For some assets, like buildings and M&E, the straight-line depreciation rate exceeds the economic depreciation rate. However, even when the straight-line rate is less than the economic depreciation rate a tax advantage may still result. The reason, abstracting from inflation, is that the straight-line rate applies to original cost, not an exponentially declining balance. At some point straight-line depreciation exceeds economic depreciation. Another way to say this is that straight-line depreciation occurs over a finite life rather than being stretched out indefinitely as is the case for economic depreciation. A tax advantage for this reason is more likely to occur for shorter depreciable lives. The relevant point is that the present value of straight-line depreciation exceeds the present value of economic depreciation.

The tax treatment in rows (5)-(7) add the indexation of depreciation allowances to the depreciation and capital gains treatment in rows (2)-(4). The indexation of depreciation reduces the METR for any combination of financing, depreciation and capital gains treatment.

The METR's for indexed depreciation under all three alternatives for capital gains taxation are less than the statutory rate. The pattern of METR's in any of rows (5)-(7) is the same as in row (4). The points to be made about the pattern are also the same.

The expensing of the cost of capital investment, i.e. the tax deduction of the full cost of the investment when it is made, is examined in the last row of Table 2. Consistent with expensing is full taxation of capital gains. Under these conditions an all equity financed investment should have a
zero METR. A derivation and discussion of this result is given by McLure (1986). The METR model satisfies the requirement that the METR for expensing an all equity financed investment is zero.

McLure (1986) shows that METR's for expensing a debt financed investment should be less than zero. This result is obtained by the METR model. The model was only able to compute a METR for 50 percent debt financing. The METR's are -190.3, -214.2, and -132.8 percent for economic debt, conventional debt, and conventional debt with interest indexing, respectively. The METR's for 70 percent debt financing are infinitely negative. 14/

The analysis in this section shows that the model satisfies theorems and principles regarding the values and changes in value of the METR for various financing options and tax treatments for depreciation and capital gains.

IV. Conclusion

This paper presented a model for the analysis of the taxation of capital investment. The model can be applied to an investment project consisting of up to four depreciable assets and land. The model uses tax, financing, and economic factors to calculate a single cash flow for the project. The model combines the tax treatment and replacement investment for all assets with project-wide flows in order to compute a METR for the project as a whole. The model is designed for general purpose use and provides a common methodology for analyzing the taxation of capital investment across countries.

The model was shown to satisfy Samuelson's (1964) fundamental theorem of tax invariance and the zero METR requirement for expensing (see McLure (1986)). The METR model was used for an analysis of the effects of different
financing options and alternative treatments of depreciation and capital gains. The METR's calculated from the model had values and changes in value that came out as expected. In other words, the model performed fully as expected.

Some assessment of the relative effects of tax provisions was provided by the analysis. The tax treatment of capital gains is an important determinant of the taxation of investment. The METR declines substantially going from full to zero taxation of capital gains using the straight-line depreciation schedules given in Table 1. The deduction of nominal interest payments confers a significant tax advantage. For example, at the 50 percent debt ratio, the METR declines from the statutory rate with economic depreciation and economic debt to 25 percent when nominal interest is deducted. The full expensing of the cost of investment reduces the METR to zero for all equity financing and below zero with debt financing.

Although useful as an illustration of the model and informative about the effect of tax provisions on capital investment, the analysis in this paper does not pertain to any particular country. The performance of the METR model indicates that it can have practical application for analyzing the effects of tax systems in a wide range of developing countries on capital investment.
Endnotes


3. The model is written in LOTUS, Version 2, and is available on diskette.

4. More specifically, let b denote the real before-tax rate of return and a, the real after-tax rate of return. The marginal effective tax rate is given by \( \frac{(b - a)}{b} \). More detail on the calculation of METR is given in Appendix A.

5. If the sum of the shares is less than 100 percent the remainder is assumed to be land which is not depreciable. The sum of the shares of depreciable assets should not be more than 100 percent. An investment entirely in one asset is given by setting the share of that asset to 100 percent.

6. An after-tax rate of return may be calculable for 100 percent debt financing because of the particular pattern of credits and depreciation allowance for the investment project being analyzed. However, for 100 percent debt financing, an equilibrium condition should be applied in which the real after-tax rate of return equals the real after-tax interest rate and the level of investment income is set to yield zero
after-tax profits in present value terms where the discount rate equals the after-tax rate of return. For a derivation and discussion of this equilibrium condition see Auerbach (1981a,b).

7. The specification of parameters in the model determines whether the time period is years, months, or any other time period. Usually, rates of return, inflation, interest, and depreciation are given on an annual basis so that the time period is a year.

8. However, the straight-line depreciation schedules do not correspond to the tax system of any particular country.

9. "Net" is taken to mean net of wages and purchases of intermediate goods and services.

10. This is the fixed-p case in the King-Fullerton (1984) terminology.

11. There are, of course, substantial changes in this cash flow. The amount of equity put up for the investment is reduced by the amount of financing. Interest and principal payments reduce the before-tax cash flow while the investment project is in operation. However, because the real interest rate equals the real before-tax rate of return, these changes in the cash flow do not change its present value. Consequently, the level of investment income that yields a 10 percent real before-tax rate of return remains the same at different debt ratios.
12. This result does not depend on keeping the debt ratio constant, as was done in columns (4) and (5) of Table 2. In the last two columns of the table the debt ratios decline steadily to zero by the end of the last period.

13. Under economic depreciation the basis is adjusted for depreciation allowances already taken and indexed for inflation. More specifically, the basis in a given period is reduced by the depreciation allowance in that period and the net amount is increased by the inflation rate to yield the basis for next period's depreciation allowance.

14. Because the statutory rate exceeds the percentage of the investment (30 percent) being put up as equity in the 70 percent debt financed case, the after-tax rate of return is infinite. Specifically, the net effect of 70 percent debt financing and expensing is that, after tax, the investor receives 10 percent of the value of the investment when it is made. The investor's after-tax cash flow is positive when the investment is made and in all operating periods up to the last. In the last period the after-tax cash flow is negative due to the full taxation of capital gains. This negative amount is not large enough to outweigh the preceding positive amounts at any positive rate of return. Essentially the investment has a positive after-tax cash flow in all periods including when the investment is made which implies an infinite after-tax rate of return. This, in turn, implies an infinite negative METR.
Appendix A

Methodology of the Marginal Effective Tax Rate (METR) Model

The marginal effective tax rate (METR) uses tax, financing, and economic factors to compute the cash flows that can be expected from an investment project. The cash flows combine the individual streams for each asset (credits, depreciation, replacement investment) with the income generated by the project and other project-wide flows (e.g. debt service payments) to yield a single before-tax cash flow and single after-tax cash flow for the entire project. These two cash flows are used to compute a marginal effective tax rate (METR) for the project as a whole.

The before-tax (BTCF) and after-tax (ATCF) cash flows can be summarized as follows:

(1) \[ BTCF_i = - E_i - dK_i + R_i - Int_i - Prin_i + NetSales_i \]

(2) \[ ATCF_i = BTCF_i - t(1+s) [R_i - Dep_i - InvDedi - IntDedi - Carryover_i + CapGain_i + BalAdj_i] + cDiv_i \]

where

- \( E_i \) = amount of equity used to finance the investment in period \( i \)
- \( d \) = economic depreciation rate for capital stock
- \( K_i \) = capital stock in period \( i \)
\[ R_i = \text{investment income in period } i \]
\[ \text{Int}_i = \text{interest payment in period } i \]
\[ \text{Prin}_i = \text{principal payment in period } i \]
\[ \text{NetSales}_i = \text{net sales proceeds in period } i \]
\[ t = \text{statutory tax rate} \]
\[ s = \text{surtax rate} \]
\[ \text{Dep}_i = \text{depreciation allowances in period } i \]
\[ \text{InvDed}_i = \text{investment deductions in period } i \]
\[ \text{IntDed}_i = \text{interest deductions in period } i \]
\[ \text{Carryover}_i = \text{carryover losses in period } i \]
\[ \text{CapGain}_i = \text{capital gains in period } i \]
\[ \text{BalAdj}_i = \text{balancing adjustment in period } i \]
\[ c = \text{dividend credit rate} \]
\[ \text{Div}_i = \text{dividends in period } i \]

The equity used to finance the investment is a positive amount in the period before the investment generates income, i.e. \( E_0 > 0 \), and is zero afterwards. The rate of return underlying the MCR calculation is a return to equity.

Replacement investment is undertaken which reduces the before-tax cash flow. Replacement investment equals the amount of economic depreciation for each asset. 1/

The investment project starts generating income in period 1. Investment income is the increase in net revenue that results from the investment project. Investment income keeps pace with inflation because replacement investment preserves the productive capacity of the project.
Interest and principal payments on debt used to finance the investment are subtracted from the before-tax cash flow. When the investment is sold, the proceeds are added to the before-tax cash flow. Net sale proceeds equal the sale price minus the payoff of the balance of a loan, if applicable.

The after-tax cash flow equals the before-tax cash flow minus taxes paid and plus credits. The statutory tax rate, t, plus any surtax rate, s, are multiplied by taxable income to yield the regular tax liability. Taxable income is given by the term in brackets. Taxable income, in its most basic form, equals investment income minus depreciation allowances, investment deductions, and interest deductions. Investment deductions, if given, are given in addition to depreciation allowances and are intended to serve as an incentive for investment. They may be given for the project as a whole or on an asset-specific basis. A positive taxable income may be reduced by losses being carried forward. If taxable income is negative and full loss offset is not assumed then the loss is carried forward. When the asset is sold, any taxable capital gains or balancing adjustment are added to taxable income.

The last term in equation (2) pertains to any special tax treatment for dividends. In particular, a credit may be given on dividends at the personal level to offset the taxation of dividends at the corporate level. Such credits reflect an attempt to eliminate the double taxation of dividends. When such credits exist, the corporate tax on dividends (at least to the extent it equals the credit) really functions as a withholding tax for the personal income tax. Consequently, such credits are added back to corporate after-tax income (i.e. subtracted from corporate taxes) in the calculation of effective corporate tax rates.
If \( b \) denotes the real before-tax rate of return and \( a \), the real after-tax rate of return, then the marginal effective tax rate is given as follows:

\[
(3) \quad \text{METR} = \frac{(b - a)}{b}
\]

This formula has been used extensively in the literature on the taxation of capital investment. \(^3\)
Endnotes to Appendix A

1. If the investment project includes more than one asset then $dK$ represents the sum of the depreciation rates for each asset times their respective capital stocks.

2. "Net" is taken to mean net of wages and purchases of intermediate goods and services.

References


244. Labor Markets in Sudan: Their Structure and Implications for Macroeconomic Adjustment, by P.R. Fallon.

245. The VAT and Services, by J.A. Kay and E.H. Davis.

246. Problems in Administering a Value-Added Tax in Developing Countries: an Overview, by M. Casanegra de Jantscher.

247. Value-Added Tax at the State Level, by S. Poddar.

248. The Importance of Trade for Developing Countries, by B. Balassa.


250. Economic Incentives and Agricultural Exports in Developing Countries, by B. Balassa.


255. On the Progressivity of Commodity Taxation, by S. Yitzhaki.


