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Evaluating the Asset-Based Minimum Tax on Corporations

An Option-Pricing Approach

Antonio Estache
and
Sweder van Wijnbergen

The minimum asset tax, with its simple tax code and marginal impact on the marginal effective tax rate, is an appealing short cut to comprehensive tax reform — and in Brazil it could substantially improve revenue.

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This paper — a product of the Country Operations Division, Country Department I, Latin America and the Caribbean Region — is part of a larger effort in the region to assist the government of Brazil in reforming its tax system. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Antonio Estache, room E10 081, extension 81442 (April 1992, 28 pages).

In many countries, well-meant ad hoc tax incentives proliferate over time, creating an opaque corporate tax structure and many unanticipated tax loopholes. Tax authorities in several countries have considered and sometimes introduced minimum corporate taxes. These are designed to reduce losses in revenues and distortions in the allocation of resources that result from the interaction of various credits, exemptions, and so on.

Liability under such a tax is sometimes linked to profits but more often to assets, as these are harder to manipulate. Estache and van Wijnbergen refer to such a tax as a minimum asset tax (MAT).

The assessment of a minimum tax is usually based on the computation of the changes the minimum tax will introduce in marginal effective tax rates, using the standard King-Fullerton methodology. This methodology has great limitations as it does not deal with the revenue effects of the loopholes and cannot handle uncertainty. This is a serious shortcoming as the impact of the MAT depends on the stochastic characteristics of the link between assessed asset value and asset income in each period.

Estache and van Wijnbergen suggest an alternative approach based on option pricing, an approach designed to incorporate the impact of rate-of-return uncertainty on the burden a MAT will impose. This approach allows the assessment of the minimum's tax's expected tax burden. It also yields a measure of the value of a minimum tax to a government faced with great uncertainty about revenue prospects because of the proliferation of tax incentives. They use their methodology to assess a recent Brazilian MAT proposal using sectoral data on corporate income tax revenue and asset value. They conclude.

- Uncertainty should play an explicit role in evaluations of MAT proposals and corporate taxes generally. The option characteristics of the corporate tax completely dominate the impact of various tax provisions on the marginal effective tax rate (MERT) under full certainty.

- The MAT, with its simple tax code and marginal impact on the MERT, is an appealing short cut to comprehensive tax reform — and the revenue effects in Brazil could be substantial. In countries like Brazil — where rate-of-return uncertainty is more likely to be increased by macroeconomic uncertainty than by introduction of a MAT — if a MAT could reduce fiscal imbalances and thus macroeconomic uncertainty, it might also indirectly help lower the MERT more than it would raise it directly.

Two common assumptions turned out not to be true. First, because capital intensity varies greatly across sectors, the MAT does *not* reduce sectoral distortions. The standard deviation of the MERT is higher with MAT than without.

Second, although that variation gives the MAT a higher marginal impact, it is not true that high-risk firms are hardest hit by the MAT. High-risk firms tend to be high-rate-of-return firms, which reduces MAT's impact. Concern that the MAT would discriminate between the most innovative but riskiest firms seems to be unwarranted

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Evaluating the Asset Based Minimum Tax on Corporations: An Option Pricing Approach

by
Antonio Estache
and
Sweder van Wijnbergen

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1. Introduction

In many countries, the proliferation over time of often well-intended but ad-hoc tax incentives has created an opaque corporate tax structure and led to many unanticipated tax loopholes. These loopholes are often a significant source of revenue loss and create distortions in the allocation of resources, both across sectors and over time. In recent years, tax authorities in several countries therefore considered and sometimes actually introduced minimum corporate taxes. These taxes are designed to reduce both distortions and revenue losses triggered by the unintended interaction of various credits, exemptions and so on. Liability under such a tax is sometimes linked to profits, but more often to assets, since these are less easy to manipulate. We will therefore refer to such a tax as a Minimum Asset Tax (MAT).

The assessment of a minimum tax is generally based on the computation of the changes the minimum tax will introduce in marginal effective tax rates, in line with the by now standard King-Fullerton methodology. 1/ But this approach has in this particular instance severe limitations. While it provides useful insights on the distortions corporate taxes can introduce, it does not deal with the revenue effects of the loopholes and, a crucial point in this case, cannot handle uncertainty at all. This is a serious shortcoming, since, as we will show, the impact of minimum asset taxes depends very much on the stochastic characteristics of the link between assessed asset value and asset income in each period.

In this paper we suggest an alternative approach based on option pricing, an approach designed specifically to incorporate the impact of rate

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1/ For an overview of the issues raised by this approach see Auerbach (1990).

of return uncertainty on the burden a MAT will pose. The approach allows the assessment of the expected tax burden of a minimum tax. It also yields a measure of the value of a minimum tax to a government faced with a high degree of uncertainty about revenue prospects because of the proliferation of tax incentives.

We exploit the similarity between the asymmetries created by minimum taxes and the asymmetry that arises in the link between options and the valuation of the asset on which the options are written. We show how the addition of a minimum tax to a standard corporate tax in effect grants the Government a put option on its share of the business profits it already obtains under the regular tax system. From there on, standard option pricing methodology allows an assessment of the tax burden created by a MAT. We show how the MAT burden is influenced by various carry-over rules, different depreciation conventions, and, most importantly, by the degree of uncertainty. We finish with an assessment of the minimum asset tax recently considered in Brazil, using sectoral information about the stochastic characteristics of the link between asset values and income.

The remainder of the paper is organized as follows. Section 2 provides an overview of the design of minimum taxes. Section 3 describes the application of the option pricing approach to the assessment of minimum taxes. Section 4 shows the sensitivity of the tax burden to rate of return uncertainty and to various aspects of the tax law. Section 5 applies the methodology to an assessment of a recent Brazilian MAT proposal using sectoral data on corporate income tax revenue and asset value. Section 6 concludes.

2. The Design of a Minimum Tax [2/]

A minimum tax is a simple broad based tax, with no or few tax preferences. It can be levied on income or on assets, and usually complements or substitutes for a complex, highly distortionary, inequitable or widely avoided tax. In fact, a minimum tax can have two different purposes. First, if it complements or replaces a tax with eroding revenue (due to an abundance of tax incentives, or widespread tax evasion and avoidance for instance), it determines a minimum average tax rate for business activities. [3/] This reduces the government's uncertainty regarding its revenue prospects. Second, it may reduce the variance of effective tax rates across tax payers and assets by imposing a lower bound on the marginal effective tax rate faced by a tax payer on the income derived from any asset. This reduces uncertainty regarding the allocational effects of tax incentives. In most countries that have a minimum tax, they are a complement to the corporate income tax. In a few, they complement individual income taxes.

Minimum taxes generally belong to one of the following two categories: alternative taxes or add-on taxes. An add-on minimum tax complements an existing tax. The base of an add-on tax could be book profits or assets. In general, it ensures a minimum level of revenue from the taxation of business activities in all sectors of the economy.

An alternative minimum tax is more like a substitute for--or replacement of--another tax. It can take two general forms. In the first form, the tax

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2/ For a more detailed overview of issues raised by the design of minimum taxes and for additional references, see Estache (1990).

3/ It can also result in an international redistribution if the minimum tax is such that it reduces opportunities for international tax averaging.

payer is required to compute its tax liability under the normal tax regime as well as under a parallel tax regime and then pays the larger amount. The parallel regime can have either a simplified definition of income or the firm's assets as a base. Some countries simply allow a deduction of the minimum tax liability from the regular income tax liability.[4/] Under the second form, the alternative tax computed can be deducted from the regular income tax base rather than from the tax itself. For a given alternative tax base and tax rate, this second option will in general provide larger revenue to the government to the extent that firms will end up paying both taxes--one in full, the other one partially-- rather than only the highest one. [5/] Under either scheme, the rate is typically set in such a way that, on average, only tax payers relying heavily on tax incentives end up paying a tax on their assets. For the other tax payers, only the income tax is relevant.

Of the 99 countries covered by the 1989 Price Waterhouse survey, 21 use a minimum tax. Out of these, 18 have selected capital as a base for their minimum tax. The minimum tax is an add-on minimum tax on capital or a firm's net worth in 8 countries, and an alternative tax in the other countries. The alternative minimum taxes on capital can be credited against the income tax liability or can be counted as an expense in the computation of the income tax base. When a firm has no taxable profits, it ends up paying a tax on capital. Countries in this case include Austria, Canada, Colombia, Guatemala, Mexico, Paraguay and Switzerland.

4/ If the minimum tax liability is larger than the regular income tax liability and no provision is allowed to carry the difference forward, this case is essentially equivalent to the more familiar case because the tax payer ends up paying the full amount of the minimum tax. The case is somewhat different when carry forward provision are allowed, so that the difference can be used as a credit against future corporate income tax liabilities.

5/ For a very detailed discussion of this, see Lyon (1989).

The rationale for an asset based minimum tax reflects a combination of both revenue and administrative reasons. In many countries, the identification of the income tax base is difficult; but the direct taxation of business activities has to yield a minimum revenue level so as to avoid political debates on the distribution of the tax burden. Assets provide a simple, clearly identifiable tax base for most firms with the exception of the financial sector. The choice of assets as a base also minimizes administrative costs, given that the alternative would be to single out a correct measure of income in a jungle of tax income measures distorted by tax incentives.

3. A Framework To Assess the Value of Minimum Taxes

3.1 Introduction

As just shown, minimum taxes are often tied to assets rather than income since, for non-financial firms, assets are much harder to hide or disguise than income. A second reason for tying a minimum tax to assets is that income provides a very uncertain tax base. From the government point of view, income uncertainty is due as much to the normal business cycle fluctuations as it is due to uncertainty about taxpayers' use of tax incentives to reduce taxable income. Even if theory suggests that income taxes should, in general, be preferred to asset based taxes, assets-based taxes can provide a useful hedge to governments against the risks of revenue shortfalls due to an intensive use of tax incentives in the income tax liability computations.

To avoid a situation in which assets become the tax base as a rule rather than an exception, the asset based minimum tax should be designed carefully. This means that the revenue it is expected to yield and its effects

on the capital stock should principally depend on the revenue and allocational effects of the income-based tax. In other words, the value to the government of the minimum tax depends on the value the basic underlying income tax. It does so in an asymmetric manner. In the typical format, the minimum asset tax only comes in operation if the tax liability associated with the regular income tax falls below a certain percentage of asset value.

This asymmetry is similar to the asymmetry in option contracts in financial markets. Options are securities whose values depend on those of other more primitive securities or assets. There are two basic forms of options. A (European) call option grants its holder the right to buy an asset at a specific date for a specific price (the exercise or strike price). A put option grants its holder the right to sell the assets at a specific date for the exercise or strike price. Our approach to the evaluation of an alternative minimum tax on assets exploits this analogy to option contracts.[6/]

Like the METR (or King-Fullerton) approach, we take pre-tax assets (A) and income (Y) flows as exogenous. Assume for simplicity that $Y = \gamma.A$; γ is a random productivity parameter with a lognormal distribution $\log \gamma = N(\mu, \sigma^2)$. The extension to a distribution allowing for negative profits is trivial but not pursued here. t_m is the rate at which a minimum tax is assessed over the asset base of the corporation. t_c is the standard corporate tax rate. The actual tax liability T is the maximum of the asset based tax and the income tax:

6/ A few authors have applied option theory to tax issues. Majd and Myers (1985, 1987) define the government's right to tax as an european call option on each year's operating cash flows because the government shares profits but not losses. Schnabel and Roumi (1990) view the government's tax claim as a combination of a call and a put option written on the firm's pre-tax value. The call option is associated with tax payments and is owned by the government. The put option is associated with tax shields and is owned by the firm.

(1) $T = \max (t_m A, t_c Y)$

or, using $Y=\gamma A$,

(2) $T = \max (t_m A, t_c \gamma A)$

Dividing by A, an expression for the average tax rate on assets obtains:

(3) $T/A = \max (t_m, t_c \gamma)$

$= t_c \gamma + \max [(t_m - t_c \gamma), 0]$

To address the incentive aspects of a minimum tax, it is also important to discuss the effects of this tax on the rate of return of the firm. The rate of return before taxes is defined as:

(4) $R_{bt} = Y/A = \gamma$

while the after tax rate of return is:

(5) $R_{at} = (Y - \max (t_m A, t_c \gamma A))/A$

The latter can be rewritten as:

(6) $R_{at} = \gamma - \max (t_m, t_c \gamma)$

$= \gamma (1-t_c) - \max (t_m - t_c \gamma, 0)$

With these results, an effective tax rate can also be defined:

(7) $METR = (R_{bt} - R_{at})/R_{bt} = t_c + \max (t_m - t_c \gamma, 0)/\gamma$

3.2 Option pricing and the Minimum Asset Tax

To clarify the link with options, consider a simple proportional corporate profit tax, at a rate t_c, prior to the introduction of a minimum asset tax. Assume, for presentational purposes, a simple one period set up, with assets A yielding random income $Y=\gamma A$ before they evaporate. We car then write the pre-tax value of the corporation, V_T, as:

(8) $V_T = \mathcal{E}\gamma A$

$= \mathcal{E}((1-t_c)Y + t_cY)$

$= V_P + V_G$

where V_P is the stockmarket value of the firm and V_G the expected tax burden. $\mathcal{E}$ is the expectations operator defined over the distribution of γ. (8) indicates that the state's right to profit tax payments, valued at V_G, is equivalent to an equity participation by the state in the firm at rate t_c of the total pre-tax value.

With a minimum asset tax, V_P is reduced and V_G increased by the expected excess of minimum asset payments over the regular corporate tax. Thus, assuming profits materialize at time i, V_G becomes:

(9) $V_G = (\mathcal{E}t_cY + \mathcal{E}\max[(t_mA-t_cY),0])e^{-ri}$

$= e^{-ri}t_c\mathcal{E}Y + P(t_mA,t_cY,r,i,\sigma.t_c)$

where $P(t_mA,t_cY,r,i,\sigma)$ is the current value of a <u>put option</u> written on the government's share in corporate profits t_cY with exercise price t_mA, for an interest rate r, maturity i and standard deviation of profits σ. If γ is lognormal, the pricing of the put can be done using standard Black-Scholes option pricing formulas. Thus the minimum asset tax can be seen as an enhancement of the government's equity participation in the corporation through an option contract written on the government's share in profits, a contract designed to eliminate downside risk for the state.

Extensions to a multi-period model are straightforward in the simple case of zero intertemporal cross-correlation of profits and in the absence of carry-over provisions:

(10) $V_G = \Sigma_i \ (\ e^{-ri}t_c\mathcal{E}Y + P(t_mA,t_cY,r,i,\sigma t_c))$

The multi-period setting does not change the basic point: that the minimum asset tax adds a series of put options on the firm's underlying profits to the claims the Government holds on the firm through its regular corporate tax claims. The value of those put options cannot be adequately assessed without explicitly incorporating the variance of profit streams.

Practical aspects of the tax code lead to significantly more complicated valuation problems than the simple multi-period example given in (10). The most important source of complication is the fact that no tax system we are aware of actually provides subsidies when profits are negative. In the simple case where tax credits cannot be accumulated, this leads to an additional option aspect of the tax code: in that case the corporate tax itself is equivalent to straight equity participation plus a put option with strike price zero written on the profits of the firm. However, since the MAT is an alternative tax, the value of this option is absorbed into the MAT.

Further complications arise out of the existence of carry-over provisions with expiration dates. This not only introduces the need to take into account the stock of existing tax credits when calculating corporate tax liabilities, but also requires keeping track of the age structure of those credits. A final complication arises when, as is for example the case in Mexico, the MAT is in fact a minimum payment provision rather than a minimum tax. For example, in Mexico a MAT of 2% of assets is applied, but any excess of MAT over corporate tax liabilities can be carried over for at most three years, to be applied against any future excess of MAT over regular corporate tax liabilities. Such carry-over provisions clearly lower the tax burden, but unless they are indexed by the opportunity cost of funds to the firm (the

market rate of interest), they do not fully make up for the state's failure to take part of the losses as and when they occur.

All these complications have an impact on the effective tax burden imposed by the MAT, but preclude full analytical expressions for the appropriate pricing formulas. We therefore resort to simulation techniques to demonstrate the increase in the tax burden imposed by MATs under various tax structures and different assumptions about the firm's variability.

4 Monte Carlo Evaluation of the Minimum Asset Tax

In the first part of this section, we use the option pricing approach to assess the MAT under a variety of different tax rules regarding depreciation, carry forward provisions, and for different levels of uncertainty. The second part of the paper applies the methodology to a sample of Brazilian firms from the manufacturing and sservice sector. All these complications have a potentially important impact on the effective tax burden imposed by the MAT. However, introducing these real world complications also means that analytical solutions to the valuation problem cannot be obtained. We therefore resort to the technique of Monte Carlo integration to solve the asset pricing equations involved, and to demonstrate the increase in the tax burden imposed by MATs under various tax structures and different assumptions about the firms' profits variability.

The random number generator used for the Monte Carlo integration is based on three linear congruential generators as suggested in Press et alii (1986), and combined with a shuffle routine suggested by Knuth (1981). This procedure was followed to avoid the collapse in dimensionality that occurs

with most standard random number generators, and to obtain the maximum cycle time available on 32-bit PCs. The resulting series of uniform (0,1) deviates was transformed into normal deviates using the Box-Muller method (cf Press e.a. (1986)). This process was repeated 1000 times for each evaluation. The results reported are averages over those runs.

4.1 A Simulation Model

Assume a start-up investment of size 1 in period zero, yielding revenues from period 1 onwards and depreciating exponentially at a rate of 5% per annum. Part of the profits are devoted to reinvestment so as to maintain the capital stock at its initial level of 1. This is maintained during 50 periods, after which what remains is sold off, with the revenues added to the project's revenue stream. The project's annual gross real before tax return has four components: (i) the expected net real rate of return; (ii) a random term with mean zero and positive variance; (iii) the economic rate of depreciation δ (iv) an inflation component.

This before tax rate of return, together with the stock of tax liabilities carried over from earlier years, and the existing tax code lead to a time-dated series of corporate tax liabilities. If in any year these liabilities fall short of a stipulated percentage of asset value, the MAT kicks in. MAT liabilities can be extinguished by qualifying MAT tax credits since such a provision is usually included in the tax law. We model the MAT as a minimum payment provision--as it is in Mexico for instance, and include the possibility of MAT credit accordingly.

Depreciation can reflect economic depreciation or can follow the straight line approach currently prevailing in Brazil. This allows us to show the impact of mismatches between econonic depreciation and allowed accounting methods. The marginal effective tax rate is obtained from a comparison of the before and after taxes net present value of the project. They are expressed as a percentage of the before tax net present value of the project.

4.2 Simulating The Incentive Effects of Various Tax Designs

Marginal effective tax rates are traditionally computed ignoring the interactions between the design of the tax system and the degree of uncertainty on the firm's profit. This section illustrates, in a simple tax structure, the importance of uncertainty for both the incentive of firms to invest and government revenue. For each simulation, results can be compared along two dimensions: (i) with increasing degrees of uncertainty on firms' returns; (ii) with and without a MAT.

a. The Base Case

The base case reproduces the main features of Brazil's corporate tax design. The corporate tax (CIT) rate is 35%. [7/] Capital gains are taxed at the same rate. Carry forward of losses for the CIT is allowed for 4 years.[8/] None is allowed for the MAT to ensure a predictable minimum tax revenue. The

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7/ In fact, the Brazilian base rate is 30% but a 5% surcharge is due on large profits and the states can levy a 5% surcharge on the federal corporate tax liability.

8/ The law should require that carry forward provisions rules be designed to minimize the possibilities that firms do not use up all losses in the computation of the income tax in years in which the MAT is binding, waiting instead to use them up in years in which losses can be used to minimize taxable profits without being subject to the MAT. One such design would be to impose that losses be used in full, irrespective of whether the MAT kicks in.

taxation of business profits is also assumed to be protected from inflation through indexation--as is the case in Brazil. The firm makes an investment with an exponential economic depreciation of 5% a year but must adopt a straight line depreciation at the same rate. The rate of interest is assumed to be 5% and the before tax rate of return is 20%. Inflation is assumed to be 100%--but it only matters when the system is not fully indexed as the results below confirm. The standard deviation of the rate of return is 0 to identify a base with no uncertainty on profits. Table 1 below summarizes the features of the base case.

Table 1: Base case assumptions

Corporate tax (CIT) rate	35%
Minimum asset tax (MAT) rate	0%
Depreciation Method	Straight Line/5% a year
Economic Depreciation	Exponential/5% a year
Interest Rate	5%
Before Tax Rate of Return	20%
Carry Forward of Losses for CIT	4 years
Carry Forward of Losses for MAT	0 years
Annual Inflation Level	100%
Standard Deviation of Profits	0

Under these assumptions, the marginal tax rate is 32.27%. This is below the statutory 35% corporate tax rate because the net present value of depreciation allowances calculated using 5% straight line exceeds the net present value of economic depreciation if the latter is exponential at a rate of 5%. Thus profits for tax purposes fall short of economic profits, and the effective tax rate falls below the statutory rate accordingly.

Using this base case as benchmark, we explore the impact of various changes in tax provisions and of changes in intrinsic uncertainty. Consider the latter first.

a. Uncertainty Affects the Incentive to Invest

Uncertainty is measured by the standard deviation of profit streams around the expected before tax rate of return. The larger the standard deviation, the larger the uncertainty. To illustrate its importance, we calculate MERTs for standard deviations varying between 0 and 8. These levels cover the range of uncertainty actually observed in Brazil across sectors (cf section 4.3 below). All the other assumptions of the base case are maintained, including the before tax rate of return of 20%. Table 2 summarizes the result under two tax systems: (i) without any minimum asset tax provision, (ii) with a 2% minimum tax on assets.

The first two columns give the marginal effective tax rate (MERT) without and with the MAT respectively. They measure the size of the intertemporal distortions due to the tax system--how much the tax system reduces the incentive to invest. The third column indicates the revenue level without MAT, for each degree of uncertainty. The fourth column gives the absolute revenue yield of the introduction of a minimum tax, again for every level of uncertainty. The fifth column gives the percentage increase in revenue due to the introduction of the minimum tax. The last one expresses the increase in MERT per unit of increase in revenue, to indicate how much each extra dollar of revenue costs in terms of increased tax wedge.

Table 2: Incentive and Revenue effects of a MAT Under Uncertain

Rate of return uncertainty	No MAT MERT	2% MAT MERT	Tax Revenue Without MAT	Absolute Revenue Gain (*) due to MAT	Relative Revenue Gain due to MAT	Increased MERT per unit of Revenue to MAT
	(1)	(2)	(3)	(4)	(5)	(6)
0.0	32.3%	32.27%	1.2065	0	0	0
0.1	32.3%	32.45%	1.2078	0.0065	0.5%	26.6%
0.5	37.10%	39.05%	1.3931	0.0731	5.3%	26.7%
0.8	44.59%	46.86%	1.6787	0.0855	5.1%	26.5%
1	50.13%	52.50%	1.8909	0.0893	4.7%	26.5%
3	108.93%	111.53%	4.1815	0.0995	2.4%	26.1%
5	167.01%	169.61%	6.5224	0.1015	1.6%	25.6%
8	250.83%	253.38%	10.0468	0.1025	1.0%	24.9%

* The revenue gain from the introduction of a MAT is the difference between the net present value of after tax cash flows from a unitary investment after tax with and without MAT for each level of uncertainty.

Without uncertainty--and with positive profits--, the MAT option is never exercised, so with and without MAT MERTs are the same. With low uncertainty--say a standard deviation of 0.1--, a 2% minimum tax does not matter much either, because the spread around the 20% rate of return still leads to enough taxable profits for the MAT not to come into play. Of course, the lower the average rate of return, the more likely it is that a given MAT provisions will become binding. Hence, the lower the average rate of return, the more valuable the MAT option. For instance, assuming a before tax rate of return of 10% instead of 20% would allow the MAT to kick in much earlier. In that case, for a standard deviation of 0.1, the MERT is 26.75% without MAT and 28.28% with MAT. Of course this claim assumes that the MAT rate remains the same as expected rate of returns are lowered.

As uncertainty increases, five characteristics emerge. First, within a tax regime--i.e. down a column--, the marginal tax rate increases with uncertainty, even without a MAT, and in fact quite dramatically so. For instance, for a standard deviation of 0.5, the MERT without a MAT is already 5 percentage points larger than without uncertainty. This is due to the fact that the Government, while taking its share of profits, does not share in the losses, since firms receive no subsidies through the corporate tax when profits turn negative.

The downside risk insurance that the Government receives due to the failure to provide for losses essentially gives the Government a put option in addition to the equity participation implicit in the corporate tax system.[9/] It is this put option that increases in value when uncertainty goes up. As uncertainty increases, years with losses become more frequent, and the losses larger. As a result, the value of this put option and the down side risk insurance it provides increase, and so does, therefore, the MERT.

An important implication of this result is that ignoring the role of uncertainty, as is done in standard applications of the King-Fullerton approach to compute MERTs, leads to underestimates of the disincentive effects of corporate taxation. This effect may be part of the explanation of why the wave of Latin American tax reforms triggered by the US 1986 tax reform act has to date failed to generate strong positive incentive effects: due to the debt crisis, and, in some places, incoherent macroeconomic policies, uncertainty increased as tax rates were lowered and tax systems streamlined.

9/ Of course equity participation coupled with a put option to insure against downward risk is equivalent to a call option; this is the way Majd and Myers (1987) present the corporate tax.

Second, the third column shows that revenue--i.e. the average tax rate--increases with uncertainty. This is due to the increased value of the put option: with larger swings the Government earns more on the larger up swings, but because of the put option it owns through the failure to provide for loss sharing, it is protected against the larger downswings.

Third, at least for the stochastic process chosen for γ, in any sector with large rate of return uncertainty the standard 2% minimum tax seems a less important determinant of the MERT than uncertainty itself. In other words, the MERT increases much faster with the degree of uncertainty than with the introduction of a MAT. This observation could provide an endorsement for the introduction of a minimum tax in countries where profit uncertainty reflects macroeconomic uncertainty due to fiscal imbalance. If a minimum tax can contribute significantly to the reduction of a fiscal deficit it thereby reduces uncertainty about future rate of returns. In that case, the initial increase in MERT due to the introduction of the MAT could very well be offset later on by the favorable impact of higher tax revenues on the degree of uncertainty and from there on the MERT.

Fourth, the revenue effect of the introduction of a minimum tax follows a rather particular pattern. Revenue gains first increase with uncertainty quite steeply. But once uncertainty reaches 0.5, the marginal revenue effect of the MAT starts to flatten out; although higher uncertainty still brings higher revenue gains from the MAT, it does so at an increasingly slower rate. This is probably at least in part a consequence of the particular stochastic process underlying asset returns: since the marginal impact of a MAT really is proportional to the difference between two put options (the one embedded in the regular tax structure and the one

representing the down side risk insurance provided through the MAT), there is no a priori presumption on the rate at which the marginal impact of the MAT should respond to higher uncertainty. We find it to be a declining rate.

Fifth, it remains true however, that the increase in MERT an introduction of the MAT leads to is higher at higher levels of uncertainty. This establishes a presumption that the MAT tends to penalize high risk firms more than low risk firms for given rate of return. However un .. standard asset pricing principles one would expect high risk firms also to offer higher average rate of returns; since the latter tend to diminish the impact of a MAT of a given rate, it is not necessarily true that a MAT unduly falls on high risk firms. This is in the end an empirical matter, to which we return in our analysis of the Brazilian data (cf Section 4.3).

b. Loss Carry Forward Provisions and Uncertainty

The previous section shows that minimum taxes are likely to penalize new firms facing a high degree of uncertainty on their profits. This effect can to some extent be offset by allowing losses to be carried forward, to be applied against taxable income in periods where the latter is positive. However carry-forward provisions are no substitute for full loss provision unless there is no limit on the number of years losses can be carried forward and unless they are indexed by the nominal interest rate.[10/] Table 3 shows that in an uncertain world, as illustrated by a standard deviation of 1, the lower the number of years losses can be carried forward, the higher the effective tax rate. Granting infinite carry forward--or 50 years, which is as

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10/ A recent overview of the issues raised by tax losses is found in Mintz, J. (1989).

close as we can get to infinity in this 50 period model-- will cut the effective tax rate, at that level of uncertainty, from the current 50.1% to 44.21%. The cost in terms of revenue is however large as revenue falls to about 88.2% of its current level.

Table 3: Incentive and Revenue Effects of Carry Forward Provisions

(for a standard deviation of 1)

years of Carry Forward	BASE MERT	Revenue as % current	2% MAT MERT	Revenue as % of current	5% MAT MERT	Revenue as % current
4	50.1%	100%	52.5%	104.7%	56.1%	111.9%
10	44.7%	89.2%	47.2%	94.2%	51.0%	101.7%
50	44.2%	88.2%	46.7%	93.2%	50.5%	100.7%

The introduction of a 2% minimum asset tax would reduce the loss by maintaining revenue at 93.2% of its current level. This suggest that the efficiency costs of a minimum tax can be offset by a extension of the carry forward provision length. However, to ensure that the revenue objectives of the tax are met, the MAT rate needs to be adjusted as well. For a 50 years carry forward period, a 5% MAT would do the job in terms of revenue but it would do so by offsetting the effect on the MERT of the increase in the carryforward provision. On the other hand, for a 4 year carry forward period of 4 years, by adopting a 5% minimum tax on assets, the government could increase its revenue by almost 11%. This would be achieved at the cost of an increase in MERT to 56.1%. A major difference between the two tax designs however, is that the high-MAT/long-carry-forward-period design reduces the distortions against risk takers implied by the limit on the carry forward provision in the other tax set up.

Throughout we have assumed that there was no carry forward provision under the MAT itself. But in some countries, payments under the MAT in excess of regular corporate tax liabilities can also be carried forward, to be applied against tax liabilities in excess of the MAT in years where that situation actually occurs. For example Mexico's MAT allows for three years of carry-over of excess MAT payments (and five years of carry over of regular losses under the straight corporate tax law).

Table 4: Effects of Carry Forward Provisions for Excess MAT Payments

(for a standard deviation of 1)

years of Carry Forward	MAT	MERT	Revenue as % current
0	0.02	52.50%	104.7%
5	0.02	51.19%	102.1%
20	0.02	50.17%	101.2%
NA	0.0	50.13%	100%

The table makes clear that as MAT carry-over periods lengthen, the MERT converges back to its no-MAT value. Thus with sufficiently long carry-over provisions for excess payments under MAT, the MAT acts more as a tax smoothing device rather than a real minimum tax. For that reason a MAT with long carry-over periods allowed is better seen as a minimum payment device rather than a minimum tax device.

c. Depreciation Method

The standard depreciation method in Brazil's tax system is straight line depreciation. Economic depreciation is assumed to follow an exponential path in the base case, although at the same rate as the Straight Line schedule. Thus economic depreciation always falls short of accounting or tax depreciation: while the rate is the same, under exponential depreciation the base over which this rate gets applied shrinks over time. As a consequence, the effective tax rate decreases, as the tax base gets eroded by what increasingly amounts to an accelerated depreciation provision. Table 5 shows, for an uncertainty level of 1, that the distortion is significant at about 1.1% and that it benefits the firm. Revenue is however lower under the current system than it could be without the accelerated depreciation allowance implicit in the straight line schedule.

Table 5: Straight Line vs. Exponential Depreciation

Depreciation Method Allowed	Uncertainty Level	No MAT MERT	2% MAT MERT	Revenue Gain
Straight Line	1	50.1%	52.5%	4.7%
Exponential	1	51.2%	54.3%	3.8%

The minimum tax overcorrects for the distortion. Under the current system, the introduction of the minimum tax leads to a MERT of 52.5% vs a MERT of 54.3% that would prevail if legal depreciation were to match economic depreciation. It also leads to a significant revenue increase as revenue collected with a minimum tax is 4.7% larger if straight line depreciation prevails and 3.8% larger if exponential depreciation prevails in the law.

4.3 The Lessons for Brazil

The analysis of this section is based on an extensive sample of firms in Brazilian manufacturing and services. For each of 35 subsectors (cf Table 6 for details), the 50 corporations with the largest sales revenue are identified. For each firm, the ratio of before tax profits to assets value is computed. The average rate of return per sector and the standard deviation for each one of the sectors is based on this 50 firms sample.

The average standard deviation accross subsectors is 0.70 but in the sample it ranges from 0.19 for the non-metal industries to 11.02 for the Assistance Services. Graph 1 shows for 1989 that there is a strong positive correlation between the rate of retrun and the standard deviation. The larger the standard deviation, a proxy for risk involved in the sector, the larger the average return. Table 6 summarizes the main results of the simulations.

The average before tax rate of return is 48% but with a wide spread, going from 2% for Cooperatives to 401% for the "Assistance Services" subsector.

The unweighted average revenue gain from the minimum tax would be around 5% of current corporate tax revenue.[11/] This number is however likely to be a substantial underestimate for a variety of reasons. First, the model does not exhaustively account for all the fiscal incentives allowed by the Brazilian law; the data to do that are simply not available. It compares revenue under a straight corporate income tax and revenue under an asset tax. If incentives take the form of a reduction in profits for tax purposes, it would be reflected in the data. But if they take the form of rates reduction or tax liability cuts, they are not picked up. The results thus tend to overestimate average tax rates and hence revenue in the base case. Second, we do not know the distribution of assets between short and long lived; we have assumed that all are long term lived. In Brazil, short lived assets face lower effective and average tax rates, so by assuming all assets to be long lived, we overestimate income tax liabilities. Third, and perhaps more importantly, the revenue gains are unweighted. Calculating a weighted average is unfortunately not possible since we do not have output data for each sector on a matching sectoral definition. Many of the sectors where the gains from a MAT could be significant have a large relative share of production in the economy and should be large tax payers under the current regime.

11/ This assumes that the federal government can tax all non-monetary assets. This is however not the case currently in Brazil. Real Estate (land and buildings) is taxed by municipalities and vehicles are taxed by the states).

Table 6: Minimum Revenue Gains from a MAT in Brazil

	prof bt/ net assets	std dev	MERT no MAT	MERT cum MAT	NVBT	NPVat no MAT	NPVat cum MAT	REV INCR	EFFCY COST
Minerals extr.	0.08	0.37	0.4263	0.4771	1.7426	0.9898	0.8112	11.9%	0.6
Non-metal indu	0.18	0.19	0.3235	0.3345	3.3798	2.2862	2.2493	3.4%	0.3
Steel	0.14	0.61	0.5366	0.5711	2.6701	1.2372	1.1451	6.4%	0.4
Mechanic	0.41	1.59	0.4508	0.4617	7.6252	4.1881	4.1043	2.4%	0.1
Transport Equip.	0.89	4.76	0.539	0.5444	16.4939	7.6031	7.5141	1.0%	0.1
Wood	0.11	0.37	0.385	0.4347	2.1077	1.2752	1.1814	10.1%	0.5
Furniture	1.44	7.38	0.5282	0.5315	26.6221	12.5598	12.4716	0.6%	0.0
Rubber	0.27	0.37	0.3385	0.3479	5.0287	3.3266	3.2791	2.8%	0.2
Leather	0.13	0.21	0.3252	0.3493	2.4675	1.665	1.6055	7.4%	0.4
Chemicals	0.74	3.88	0.5397	0.5462	13.7285	6.3198	6.2306	1.2%	0.1
Pharmaceutical	0.30	2.01	0.6073	0.6238	5.6311	2.2112	2.1183	2.7%	0.2
Plastics	0.43	2.2	0.5201	0.5312	8.0107	3.8445	3.7558	2.1%	0.1
Textile	0.35	1.48	0.4679	0.481	6.5262	3.4729	3.3873	2.8%	0.2
Clothing & Textile	1.16	4.88	0.4806	0.4846	21.4303	11.1313	11.0462	0.8%	0.0
Food Products	0.13	0.22	0.3276	0.3525	2.4678	1.6594	1.598	7.6%	0.4
Beverages	0.16	0.26	0.3323	0.3518	3.0188	2.0144	1.9561	5.8%	0.3
Graphics	0.38	3.32	0.7185	0.7315	7.3179	2.06	1.9648	1.8%	0.1
Other Industry	0.19	0.49	0.3733	0.3841	3.5722	2 2387	2.1644	5.6%	0.3
Shoes	0.09	0.5	0.5065	0.5596	1.7469	0.8621	0.7683	10.5%	0.6
Construction	0.88	2.6	0.4264	0.4313	16.2492	9.3202	9.2412	1.1%	0.1
Public Utilities	0.02	0.4	1.0852	1.3184	0.4657	-0.0443	-0.1483	20.4%	2.1
Communications	0.83	2.24	0.3975	0.4022	15.3144	9.2276	9.1546	1.2%	0.1
Repairs	0.79	4.07	0.5271	0.5331	14.6453	6.9262	6.8377	1.1%	0.1
Personal Serv. (1)	0.25	0.32	0.3351	0.3447	4.6619	3.0995	3.055	2.8%	0.2
Radio-TV	0.20	0.3	0.335	0.3492	3.7484	2.4928	2.4396	4.2%	0.3
Other Services	4.01	11.2	0.4063	0.4073	73.8674	43.7934	43.6589	0.2%	0.0
Personal Serv. (2)	0.4	0.61	0.3481	0.355	7.4099	4.8302	4.778	2.0%	0.1
Financial sector	0.25	0.45	0.3485	0.3614	4.6662	3.0401	2.9789	3.7%	0.2
Wholesale trade	0.17	0.25	0.3298	0.3466	3.1991	2.1438	2.0904	5.1%	0.3
Retail trade	0.10	0.34	0.3831	0.437	1.9241	1.1677	1.0832	11.2%	0.5
Real Estate mgt	0.22	0.51	0.3653	0.3823	4.1205	2.6134	2.5451	4.7%	0.2
Other Services	0.11	0.62	0.5186	0.5633	2.1161	1.0165	0.9242	8.4%	0.5
Cooperatives	0.02	0.81	2.0693	2.2863	0.4784	-0.5126	-0.6166	10.5%	2.1
Foundations	0.46	0.67	0.3482	0.3539	8.5073	5.545	5.4863	1.6%	0.1
Average	0.48	1.80	0.50	0.53	8.9	4.87	4.79	5.0%	0.35
Standard Deviation	0.70	2.38	0.31	0.35	12.67	7.45	7.45	0.04	0.47

Such sectors include Industries of Public Utility (a gain of 20.4%), Mineral extraction (11.9%), Wholesale Trade (11.2%), Clothing and Shoes (10.5%), Food Products (7.6%) or Steel (6.4%). Important sectors that would

hardly be affected by the tax include the Chemical (1.2%), Mechanical (2.4%) and Transport Material (1%) industries as well as retail trade and the financial sector. While the last two sectors are not really capital intensive and hence should not be expected to be dramatically affected by an asset based tax, the result is more surprising for some of these industries where capital is a crucial factor of production.

To put all this in perspective, average corporate tax rates in Brazil range between 10 and 18% (between 1981 and 1988), as opposed to the 35% flat rate assumed in our analysis. None of the factors affecting our estimate of the average corporate tax rate would affect the MAT (in fact that is the point of a MAT); thus the revenue gain from a MAT could easily be four to five times higher than suggested in Table 6.

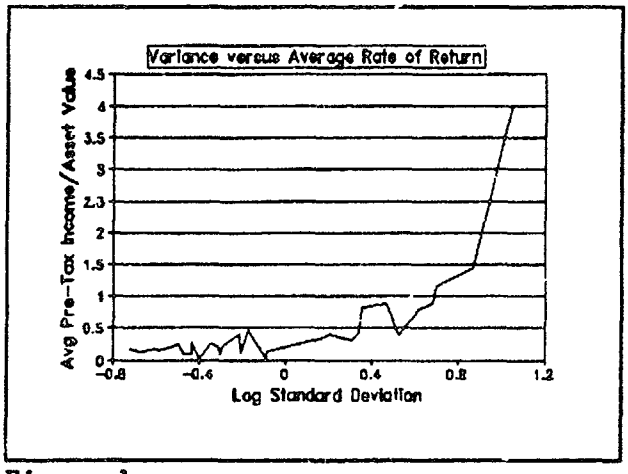
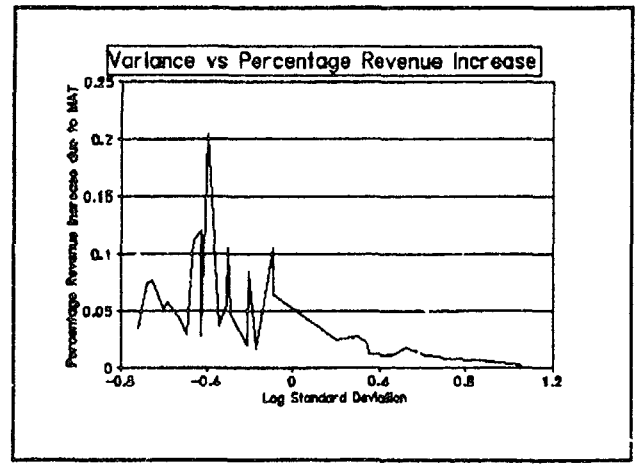


Figure 1

A common argument to justify the introduction of a minimum tax is that it can reduce intersectoral distortions. The Brazilian simulation show that when assets are used as a base for a minimum tax, this does not necessarily hold. The standard deviation of marginal effective tax rates increases from .31 to .35 with the introduction of a 2% minimum tax. This reflects the wide variety of capital intensity in modes of production accross sectors. The larger the capital intensity, the higher the effect of an asset based tax. This may be explained by the distortion the tax creates against capital intensive sectors as illustrated by the following example. Minerals extraction, the wood processing industry and the rubber industry face the same degree of uncertainty, with a standard deviation of 0.37. The revenue gain from the minimum tax is the largest for the sector with the lowest rate of return, minerals and the lowest for the sector with the highest rate of return, rubber. Mineral also happens to be the more capital intensive of the three sectors.

The final result is perhaps the most interesting one. We already pointed out that a higher variance raises the impact of a MAT, but that a lower



expected rate of return leads to a smaller impact of a MAT. But a high variance will typically also mean higher expected revenue; so the net effect of higher variance on the impact of a MAT is not clear a priori. Brazilian data suggest that the higher rate of return effect eventually overtakes the direct impact of more uncertainty: the sectors with the highest variance in fact face the smallest increase in their MERT after an introduction of a MAT (Figure 2). The reason becomes clear once we inspect the correlation between variance and average rate of return (Figure 1): the figure indicates a strong positive link between the two, as one would expect with risk averse investors.

5 Conclusions

Four main conclusions emerge from this analysis. First, uncertainty needs to play an explicit role in an evaluation of MAT proposals, and, in fact, of corporate taxation in general. We provide several examples, well within the parameter range of the Brazilian data analyzed also, where the option characteristics of the corporate tax itself completely dominate the impact of the various tax provisions on the MERT under full certainty. In particular, because of the absence of adequately indexed carry-over provisions, higher rate of return uncertainty significantly raises the tax burden for given expected rate of return.

Second, the MAT, with its simple tax code and in the end quite marginal impact on the MERT, is an appealing short cut to a comprehensive tax reform. We suggest that the revenue effects could be substantial in Brazil. This raises an intriguing possibility: in countries like Brazil, rate of return uncertainty is likely to be much more increased by macroeconomic uncertainty than by the introduction of a MAT, which in turn traces back to fiscal imbalances. If a MAT can contribute to reducing macroeconomic uncertainty by reducing fiscal imbalances, it will also contribute to lowering the MERT

indirectly by more than it would raise it directly for given starting level of uncertainty. In sum, in those circumstances the MAT could in fact lower rather than raise the MERT!

The final conclusion is that two a priori plausible presumptions in fact seem to be incorrect, at least in the sample we looked at. First, because of the high variance of capital intensity accross sectors, the MAT does not reduce sectoral distortions; the standard deviation of the MERT with MAT is higher than without. Second, although it is true that high variance leads to a higher marginal impact of the MAT, it is not true that high risk firms tend to be hit harder by the MAT. The explanation is that high-risk firms tend to also be high rate of return firms, and the latter element reduces the impact of a MAT. In our Brazilian sample, the latter effect in fact dominates. So a concern that the MAT would discriminate against the most innovative but riskiest firms seems unwarranted.

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