THE ROLE OF TAX DEPRECIATION FOR INVESTMENT DECISIONS: A COMPARISON OF EUROPEAN TRANSITION COUNTRIES

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Abstract

This study compares incentive effects of various tax depreciation methods currently adopted in European transition economies. In these countries straight-line, geometric-degressive and accelerated depreciation measures are quite popular in combination with different corporate tax rates. Their generosity is determined on the basis of Samuelson's true economic depreciation. For this purpose, the present value model is applied under the particular consideration of different financial structures. In this context the traditional Modigliani-Miller theorem for capital structure is revisited. Furthermore, the aspect of inflation is integrated into the model. The central issue is that the historical cost accounting method generally applied for the calculation of the corporate tax base causes fictitious profits in inflationary phases that are also taxed. Therefore, in an inflationary period generous tax depreciation provisions do not promote private investment as designed, but partly compensate such additional tax burdens caused by inflation.

JEL Classification: H25, H32, M21, G31.

Keywords: true economic depreciation, tax depreciation rules, corporate tax, investment decision, financial structure, net present value model, inflation, transition economies.

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Introduction

Promoting investment is of particular importance in the European transition economies since investments act as growth engine. In this context, the corporate tax regimes adopted in these countries play a crucial role for stimulating private investment. Accordingly, the tax systems have to be designed to attract capital. Apart from the tax rates, due attention has to be paid to depreciation, since it is one of the important factors affecting firms' investment decisions, as it is deducted from a gross stream of return generated from the asset when calculating tax profits. Along with straight-line depreciation (applied in Hungary and Bulgaria), geometric-degressive depreciation which may be employed in Poland and the Czech Republic and accelerated depreciation, all aim to encourage firm's investment activities (Sinn, 1987; King, 1977; King and Fullerton, 1984; Sandmo, 1974; Jacobs and Spengel, 1996; Alvarez, Kanniainen and Södersten, 1999). In assessing their relative generosity, a useful benchmark is that of Samuelson's true economic depreciation (TED), which is neutral with respect to investment decisions (Samuelson, 1964; Atkinson and Stiglitz, 1980).

The incentive effects of different tax depreciation rules combined with the corporate tax rate on firms' investment decisions can be compared on the basis of the net present value model (Devereux, Griffith and Klemm, 2002). Without taxation, the net present value (NPV) is equal to the present value of future gross return, discounted at an appropriate interest rate less the present value of the cost of investment. An investment project is therefore considered to be profitable when the NPV is positive. After the introduction of tax on corporate income, the present value of the asset generated from an investment amounts to the sum of present value of net return (gross return less taxes) and tax savings led by an incentive depreciation provision. If the investment is self-financed, the interest rate directly corresponds to the investor's opportunity cost. Under the assumption of a perfect competitive market structure, there is only one interest rate in the financial market.

In addition, anticipated effects of inflation on firms' investment decisions are examined in the context of corporate income taxation. The central issue is that the so-called historical cost accounting method, which is applied in practice when calculating the (corporate or income) tax base, causes fictitious profits in inflationary phases that are also subject to tax. This type of increased tax burden is generally called inflation losses (Aaron, 1976; Feldstein, 1979; Streißler, 1982; Gonedes, 1984; Kay, 1977; Kopcke, 1981). Therefore, in periods with inflation generous tax depreciation provisions do not adequately promote private investment as designed, but only (or partly) compensate the losses caused by inflation.

The aspect of inflation linked with different depreciation rules is of particular importance in transition countries, where their economies have continuously been confronted with rising prices during the last decade. Additionally, the different tax depreciation rules allowed in these countries can have different incentive effects. Accordingly, this study aims at examining the corporate tax incentive schemes in Bulgaria, the Czech Republic, Hungary, Macedonia, Poland, Romania and Slovenia. The empirical results show that, for example, in Poland — under the assumption that depreciation is measured based on the current replacement cost — the tax neutrality is guaranteed, since geometric-degressive depreciation is set to be same as the assumed true economic depreciation. In this case inflation and corporate tax do not negatively affect investment decisions. On the other hand, the combination of accelerated depreciation and the historical cost accounting method leads, in Romania, to a tax paradox which increases with debt-finance, although inflation results in an extra tax burden.

I. Samuelson's Tax Neutrality of True Economic Depreciation Revisited

Under the assumption that

- a self-financed investment costing C generates an infinite stream of future gross return,
- this return exponentially declines at the rate α $(0 < \alpha < 1)$[1] and
- all prices are constant over time ($\pi = 0$),

the present value of the asset before taxation at time u* is:

$$\text{(I-1)} \qquad PV_{u^*}^{E} = \int_{u^*}^{\infty} A_0\, e^{-\alpha u}\, e^{-r(u-u^*)}\, du = \frac{A_0 e^{-\alpha u^*}}{\alpha + r}$$

where A_u means gross return at time u and r is the real interest rate $(0 < r < 1)$ before imposing corporate tax.

On the basis of such a simple net present value model, Samuelson (1964) showed in his fundamental theorem of tax-rate invariance that corporate income taxation does not affect firms' investment decisions at all, when the true economic depreciation (TED) is deducted from an expected gross stream of return generated from the asset when calculating tax profits.

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1 The assumption of declining gross return in the course of time is often made in practice, because it is hardly possible to forecast the development of future profit. This type of assumption appears to be more plausible than the one with constant annual profit.

Taxation does not affect firms' investment decisions if

$$\text{(I-2)} \qquad PV_{u*}^{E} = PV(t)_{u*}^{E},$$

where $PV(t)_{u*}^{E}$ is the present value of the asset after the introduction of corporate tax rate t at time u*, discounted at r(1–t).

When equation (I-2) is applied, one can derive

$$\text{(I-3)} \qquad \frac{\partial PV_{u*}^{E}}{\partial u*} = \frac{\partial PV(t)_{u*}^{E}}{\partial u*}.$$

Differentiating (I-1) with respect to u*

$$\text{(I-4)} \qquad \frac{\partial PV_{u*}^{E}}{\partial u*} = \frac{-\alpha A_0 e^{-\alpha u*}}{\alpha + r} = -\alpha\, PV_{u*}^{E}\ .$$

Consequently, tax neutrality is guaranteed when

$$\text{(I-5)} \qquad \frac{\partial PV(t)_{u*}^{E}}{\partial u*} = -\alpha PV_{u*}^{E}\ .$$

True economic depreciation (TED) is defined as the negative change in value of the asset in the course of time. Therefore, the TED rate can be calculated as follows:

$$\text{(I-6)} \qquad \frac{TED_{u*}}{PV_{u*}^{E}} = \alpha,$$

which is the same as the rate with which the gross return declines in the course of time.[2]

Furthermore, if we have a TED function with respect to u, which also declines at the rate α, then

$$\text{(I-7)} \qquad TED_{u} = \alpha PV_{0}^{E} e^{-\alpha u}\ .$$

[2] In the case of assuming a constant gross return function ($\alpha = 0$) with regard to time u, this model automatically leads to the 'unusual' conclusion that the TED rate is zero. Furthermore, with an exponentially ascending gross return function, the TED rate is unrealistically negative, which is interpreted by Samuelson (1964) as the appreciation of asset value in the course of time.

In the case that TED is permitted as a tax-deductible depreciation expense,

$$\text{(I-8)} \qquad PV(t)_{u^*}^{E} = (1-t)\int_{u^*}^{\infty} A_0 e^{-\alpha u} e^{-r(1-t)(u-u^*)}\, du$$

$$+ \; t\int_{u^*}^{\infty} \alpha\, PV_0\, e^{-\alpha u}\, e^{-r(1-t)(u-u^*)}\, du$$

$$= \frac{(1-t)A_0\, e^{-\alpha u^*}}{\alpha + r(1-t)} + \frac{t\alpha PV_{u^*}^{E}}{\alpha + r(1-t)} = PV_{u^*}^{E}$$

Thus, the condition shown in equation (I-5) is also satisfied.

II. Modigliani-Miller Theorem of Capital Structure Revisited

Modigliani and Miller (1958) asserted that under certain assumptions such as perfect markets (i.e. no taxes or transaction costs), the cash flows that are independent of financial structure, and riskless debt such that firms and individuals can borrow and lend at a risk free interest rate, the market value of a firm is independent of its capital structure. This theory can also be shown in terms of the present value model as follows.

For equity finance the following condition satisfies in the equilibrium

$$\text{(II-1)} \qquad PV_0^{E} = C$$

In the case of financing the investment cost C through debt, a firm pays the creditor not only the annual interest of rC for s year long but also the entire amount of C to the creditor at the end of this maturity year. Therefore, the present value of total cost at year 0 (C^*_0) can be expressed:

$$\text{(II-2)} \qquad C^*_0 = \int_0^{s} rCe^{-ru}\, du + Ce^{-rs}$$

$$= (1-e^{-rs})C + Ce^{-rs} = C \;\; .$$

Hence, in the absence of tax, for example, the condition shown in equation (II-1) applies in the equilibrium regardless of the financial structure (i.e. $C^*_0 = C = PV_0$).

In the equilibrium without tax, equation (II-3) additionally proves that inflation does not matter for financial decision making either.

$$\text{(II-3)} \qquad nC^*_0 = \int_0^s (r+\pi)Ce^{-(r+\pi)u}\,du + Ce^{-(r+\pi)s}$$

$$= (r+\pi)C\left\{\frac{1-e^{-(r+\pi)s}}{r+\pi}\right\} + Ce^{-(r+\pi)s} = C = PV_0^E,$$

where nC^*_0 = the nominal present value of total cost at 0 and π = inflation rate.

III. Effects of Various Tax Depreciation Rules on Investment Decision Revealed in Present Value Model

In the practice of tax policy, different tax depreciation rules are employed which do not typically ensure TED; furthermore, their generosity has been extended to stimulate private investment. These tax depreciation measures include:

- straight-line depreciation
- geometric-degressive depreciation
- accelerated depreciation

In the following we will discuss several types of investment decisions made in different real economic situations — with or without taxes, investments financed by equity or debt, and different depreciation allowances.

1. No taxes

1.1. Equity finance

In the absence of taxation an equity-financed investment project is on the margin of acceptance at the year of investment, when

$$\text{(III-1)} \qquad C = PV_0^E = \int_0^\infty A_0 e^{-(\alpha+r)u}\,du = \frac{A_0}{\alpha+r}.$$

In this case, the NPV amounts to zero.

1.2. Debt finance

For the debt-financed investment the comparable condition applies, when

$$\text{(III-2)} \qquad Ce^{-rs} = \int_0^\infty A_0 e^{-(\alpha+r)u}\,du \; - \int_0^s rCe^{-ru}\,du$$

$$= \frac{A_0}{\alpha+r} - (1-e^{-rs})C \;=\; PV_0^E - (1-e^{-rs})C\,.$$

2. Taxation and straight-line depreciation

In the case of adopting straight-line depreciation over Γ years, the amount of depreciation expense of the period u is calculated

$$\text{(III-3)} \qquad D_u^{sld} = \frac{C}{\Gamma}\,,$$

where u = 1, 2, ... Γ.

2.1. Equity finance

In the case of equity finance the present value of the asset with straight-line depreciation at the year 0 is

$$\text{(III-4)} \qquad PV(t)_0^{E,\,sld} = (1-t)\int_0^\infty A_0 e^{-\{\alpha+r(1-t)\}u}\,du \;+\; t\int_0^\Gamma (C/\Gamma)e^{-r(1-t)u}\,du$$

$$= \frac{A_0}{\alpha+r} + tC\left\{\frac{1-e^{-r(1-t)\Gamma}}{r(1-t)\,\Gamma} - \frac{\alpha}{\alpha+r(1-t)}\right\}$$

$$= PV_0^E + tC\left\{(DA) - \frac{\alpha}{\alpha+r(1-t)}\right\}\,.$$

DA denotes the value of straight-line depreciation allowances per monetary unit like the euro or dollar (Atkinson and Stiglitz, 1980).

Hence, the application of straight-line depreciation is advantageous and a tax paradox occurs, when

$$\text{(III-5)} \quad DA > \frac{\alpha}{\alpha + r(1-t)} .$$

If $DA = \dfrac{\alpha}{\alpha + r(1-t)}$, there exists a critical Γ^*.

For shorter tax-lives than Γ^* straight-line depreciation provides investment incentives.

2.2. Debt finance

If the same investment is financed by debt completely, then

$$\text{(III-6)} \quad PV(t)_0^{F,\,sld} = (1-t)\int_0^{\infty} A_0 e^{-\{\alpha + r(1-t)\}u}\, du - (1-t)\int_0^{s} rCe^{-r(1-t)u}\, du + t\int_0^{\Gamma} (C/\Gamma)e^{-r(1-t)u}\, du$$

$$= PV(t)_0^{E,\,sld} - r(1-t)C\left\{\frac{1-e^{-r(1-t)s}}{r(1-t)}\right\}$$

$$= PV(t)_0^{E,\,sld} - \{1 - e^{-r(1-t)s}\}C .$$

3. Taxation and geometric-degressive depreciation

The amount of geometric-degressive depreciation expense in the period u is measured

$$\text{(III-7)} \quad D_u^{gdd} = \delta Ce^{-\delta u}$$

where δ is the geometric-degressive depreciation rate ($0 < \delta < 1$) and $Ce^{-\delta u}$ shows the net book value of capital good in the period u.

3.1. Equity finance

With equity finance and geometric-degressive depreciation the present value of the asset at time 0 is

$$\text{(III-8)} \qquad PV(t)_0^{E,\,gdd} = (1-t)\int_0^{\infty} A_0 e^{-\{\alpha+r(1-t)\}u}\,du + tC\int_0^{\infty} \delta e^{-\{\delta+r(1-t)\}u}\,du$$

$$= PV_0^{E} + tC\left\{\frac{\delta}{\delta+r(1-t)} - \frac{\alpha}{\alpha+r(1-t)}\right\}.$$

If $\delta = \alpha$, then $PV(t)_0^{E,\,gdd} = PV_0^{E}$ just as in the case with TED. If $\delta > \alpha$, then $PV(t)_0^{E,\,gdd} > PV_0^{E}$ which, in turn, means that geometric-degressive depreciation provides incentives.

Proposition 1 *In the situation of equity financing and geometric-degressive depreciation, if $\delta > \alpha$ there exists a corporate tax rate (t_{max}) that maximises the NPV of the asset.*

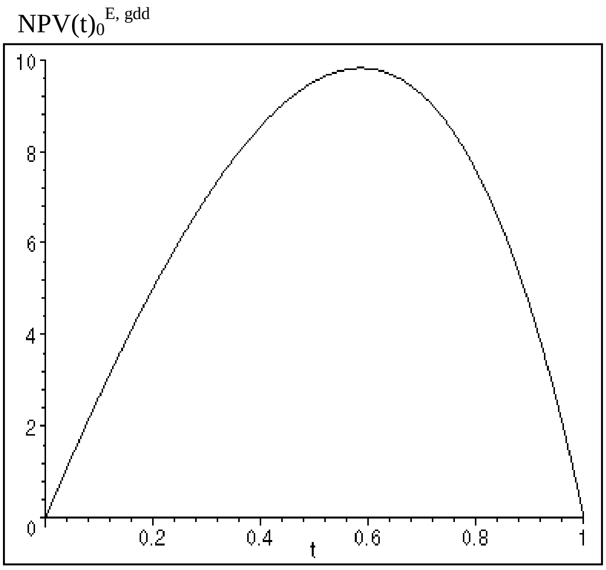
Proof In order to get the maximum corporate tax rate, we differentiate equation (III-8) with respect to t

$$\text{(III-9)} \qquad \frac{\partial PV(t)_0^{E,\,gdd}}{\partial t} = 0.$$

After solving equation (III-9), the optimum corporate tax rate (t_{max}^{gdd}) can be obtained as a function of α, δ and r

$$\text{(III-10)} \quad t_{max}^{E,\,gdd} = \frac{\alpha\delta + \alpha r + \delta r + r^2 - \sqrt{\alpha^2\delta^2 + \alpha^2\delta r + \alpha\delta^2 r + \alpha\delta r^2}}{\alpha r + r^2 + \delta r}$$

Figure 1 Optimal corporate tax rate in the case of adopting geometric-degressive depreciation



Assumptions: $\alpha = 0.2; r = 0.1; \delta = 0.3; A_0 = 100; C = 333.3$

Source: Own calculations

For example, δ=30% in Macedonia. Under the assumptions shown in the Figure 1 the net present value reaches maximum, when t = 59%.

3.2. Debt finance

Analogous to equation (III-6) in the case of debt financing

(III-11) $$PV(t)_0^{F,\,gdd} = PV(t)_0^{E,\,gdd} - \{1 - e^{-r(1-t)s}\}C \ .$$

4. Taxation and accelerated depreciation

Accelerated depreciation is used in practice as an investment promotion scheme in combination with the straight-line depreciation method. Accelerated depreciation expense (as a certain percentage share of investment cost) is tax-deductible in the first year of the tax-life of a capital good.[3] Consequently, total depreciation expense in the first year reaches

[3] Apart from the extra financial resources released in the beginning of an asset life (the so-called liquidity advantage), which can again be used for an additional investment in the future (Nam, 1995), accelerated depreciation reduces uncertainties and risks linked to the investment, since the total tax-life of a capital

(III-12) $$D_1^{ad+sld} = \sigma C + \frac{C}{\Gamma} ,$$

where σ indicates the accelerated depreciation rate ($0 < \sigma < 1$).

Because an extra amount of expense can be deducted in the first year, the total tax-life of a capital good is reduced correspondingly from Γ to Ω. And

(III-13) $$\Omega = (1 - \sigma)\Gamma .$$

4.1. Equity finance

If there is equity finance, the present value of the asset with accelerated depreciation at time 0 is

(III-14) $$PV(t)_0^{E,\,ad} = (1\text{–}t) \int_0^{\infty} A_0 e^{-\{\alpha+r(1-t)\}u}\, du + t \int_0^{1} \sigma C e^{-r(1-t)u}\, du$$

$$+ t \int_0^{\Omega} (C/\Gamma) e^{-r(1-t)u}\, du$$

$$= PV_0^E + tC\left[\frac{\sigma\{1-e^{-r(1-t)}\}}{r(1-t)} + \frac{1-e^{-r(1-t)\Omega}}{r(1-t)\Gamma} - \frac{\alpha}{\alpha+r(1-t)}\right] .$$

4.2. Debt finance

When the same depreciation method prevails but the investment cost is fully covered by debt,

(III-15) $$PV(t)_0^{F,\,ad} = PV(t)_0^{E,\,ad} - \{1 - e^{-r(1-t)s}\}C .$$

good is significantly shortened (Tichy, 1980).

IV. Consideration of Inflation

The investigated transition economies have suffered from the rapidly rising prices during the last decade. The past inflation rate ranged in the Czech Republic between 52% in 1991 and 4.9% in 2001 compared to that in Poland between 70.3% in 1991 and 5.6% in 2001, while some years even recorded triple digit inflation in Bulgaria and Romania. For example, the annual change in the consumer price level varied between 333.5% in 1991 and 8.0% in 2001 in Bulgaria (EBRD, 2002). Due to the significance of inflation in these countries, in the following chapter we revise the above analysis by relaxing the assumption of constant prices.

In an economy with the constant inflation rate π, the stream of gross return which is generated by an investment costing C at time u is

$$\text{(IV-1)} \quad A_u = A_0 e^{-\alpha u} e^{\pi u} = A_0 e^{-(\alpha-\pi)u} \quad .$$

In this case, the sum of annual gross return exponentially decreases at the rate α ($0 < \alpha < 1$) but increases at the rate π in the course of time.

1. Straight-line depreciation

1.1. Equity finance

In the case of equity financing and employing the historical cost accounting method,[4] the nominal present value of the asset with straight-line depreciation at time 0 is

$$\text{(IV-2)} \quad nPV(t)_0^{E,\, sld} = (1-t)\int_0^{\infty} A_0 e^{-\{\alpha-\pi+\mu(1-t)\}u}\, du + t\int_0^{\Gamma} (C/\Gamma) e^{-\{\mu(1-t)\}u}\, du$$

$$= \frac{(1-t)A_0}{\alpha-\pi+\mu(1-t)} + \frac{tC\{1-e^{-\mu(1-t)\Gamma}\}}{\mu(1-t)\Gamma}$$

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[4] Under the historical cost accounting the capital to be recovered before a profit is recognised as simply the amount of money originally invested in the firm. Historical profit is, therefore, the current period's revenues minus the historical cost of the inputs necessary to secure them, the current period's expenses. It has long been recognised that increases in input prices can cause historical cost accounting to seriously overstate a firm's ability to distribute its reported profits, continue producing the same

$$= PV_0^E + tC \{ \frac{1-e^{-\mu(1-t)\Gamma}}{\mu(1-t)\Gamma} - \frac{\alpha-\pi}{(\alpha-\pi)+\mu(1-t)} \} \ .$$

where μ is the nominal interest rate ($\mu = r+\pi$).

1.2. Debt finance

With debt finance,

(IV-3) $\quad nPV(t)_0^{F,\, sld} = nPV(t)_0^{E,\, sld} - \{1 - e^{-\mu(1-t)s}\}C \ .$

2. Geometric-degressive depreciation

2.1. Equity finance

Correspondingly, with geometric-degressive depreciation, nominal present value with equity finance is

(IV-4) $\quad nPV(t)_0^{E,\, gdd} = (1-t)\int_0^{\infty} A_0\, e^{-\{\mu(1-t)+(\alpha-\pi)\}u} du + tC\int_0^{\infty} \delta\, e^{-\{\delta+\mu(1-t)\}u}\, du$

$$= PV_0^E + tC \{ \frac{\delta}{\delta+\mu(1-t)} - \frac{\alpha-\pi}{(\alpha-\pi)+\mu(1-t)} \}$$

2.2. Debt finance

With debt finance,

(IV-5) $\quad nPV(t)_0^{F,\, gdd} = nPV(t)_0^{E,\, gdd} - \{1 - e^{-\mu(1-t)s}\}C \ .$

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physical volume of goods and services, and understate the firm's capital.

Box 1: Geometric-degressive depreciation, inflation and current cost accounting[5] in Poland

In Poland, for example, geometric-degressive depreciation must be calculated based on the current replacement cost if the annual inflation rate is higher than 10%. In this case the nominal present value at year 0 can be expressed if there is equity finance

$$\text{(IV-6)} \qquad nPV(t)^*{}_0^{E,\,gdd} = (1-t)\int_0^{\infty} A_0\, e^{-\{\mu(1-t)+(\alpha-\pi)\}u}du + tC\int_0^{\infty} \delta\, e^{-\{(\delta-\pi)+\mu(1-t)\}u}\,du$$

$$= PV_0^E + tC\left\{\frac{\delta-\pi}{(\delta-\pi)+\mu(1-t)} - \frac{\alpha-\pi}{(\alpha-\pi)+\mu(1-t)}\right\}.$$

Apart from the assumption $\delta = \alpha = 20\%$ in Poland, tax depreciation is additionally measured based on the current replacement cost, then $nPV(t)^*{}_0^{gdd} = PV_0^E = C$ in the equilibrium. The so-called tax neutrality is guaranteed in this case and inflation does not disturb the investment decision at all. For the case of debt finance the nominal net present value is also zero in the equilibrium, since $nPV(t)^*{}_0^{F,\,gdd} = Ce^{-\mu(1-t)s}$.

3. Accelerated depreciation

3.1. Equity finance

Furthermore, when accelerated depreciation and historical cost accounting method are adopted

$$\text{(IV-7)} \qquad nPV(t)_0^{E,\,ad} = (1-t)\int_0^{\infty} A_0 e^{-\{(\alpha-\pi)+\mu(1-t)\}u}\,du + t\int_0^{1} \sigma C e^{-\mu(1-t)u}\,du$$

$$+\, t\int_0^{\Omega} (C/\Gamma)e^{-\mu(1-t)u}\,du$$

[5] If input prices change, it is necessary to recover the cost of replacing the services consumed in producing the goods or services for sale at their current prices. Therefore, the current cost accounting is generally understood as accounting for the current replacement cost of non-monetary assets.

$$= PV_0^{E} + tC\left[\frac{\sigma\{1-e^{-\mu(1-t)}\}}{\mu(1-t)} + \frac{1-e^{-\mu(1-t)\Omega}}{\mu(1-t)\Gamma} - \frac{\alpha-\pi}{(\alpha-\pi)+\mu(1-t)}\right] .$$

3.2. Debt finance

On the other hand, with debt finance,

(IV-8) $$nPV(t)_0^{F,\,ad} = nPV(t)_0^{E,\,ad} - \{1 - e^{-\mu(1-t)s}\}C .$$

V. Consideration of the Fictitious Profit and the Inflation Losses in Present Value Model

The size of fictitious profits and the additional corporate tax burden, which are caused by the application of the historical cost accounting method in the inflationary phase, can also be measured on the basis of the net present value model.[6] Such inflation losses lead to the reduction of nominal net present value. More precisely, the amount of increased tax burden caused by inflation can be described as the difference between the two nominal PVs, one with depreciation measured on the basis of current (replacement) value of a capital good and the other with that determined on the basis of the historical cost accounting method.

As shown above, in the case of employing the historical cost accounting method, the nominal present value of the asset with straight-line depreciation at time 0 is

(V-1) $$nPV(t)_0^{E,\,sld} = (1-t)\int_0^{\infty} A_0 e^{-\{\alpha-\pi+\mu(1-t)\}u}\,du + t\int_0^{\Gamma} (C/\Gamma)e^{-\{\mu(1-t)\}u}\,du$$

$$= \frac{(1-t)A_0}{\alpha-\pi+\mu(1-t)} + \frac{tC\{1-e^{-\mu(1-t)\Gamma}\}}{\mu(1-t)\Gamma} .$$

[6] There have been a number of attempts to estimate the current value of a capital good on the basis of indexation. "Such a method would provide for equitable accounting whether inflation rates were high or low. [But] many agree that it would be too complicated to compute the rate of inflation for the multitude of different assets. The idea of using an overall index was rejected on the grounds that some assets such as computers actually [decline] in price over time and this method would bias investment towards those assets that increased in price" (Evans, 1983, p.150).

On the other hand, when depreciation expense is determined on the basis of current investment cost, the nominal value of the asset with the same depreciation method at time 0 is

$$\text{(V-2)} \quad nPV(t)_0^{E,\, sld}* \;=\; (1-t)\int_0^{\infty} A_0 e^{-\{\alpha-\pi+\mu(1-t)\}u}\,du + t\int_0^{\Gamma} (C/\Gamma)e^{-\{\mu(1-t)-\pi\}u}\,du$$

$$= \frac{(1-t)A_0}{\alpha-\pi+\mu(1-t)} + \frac{tC\{1-e^{-\{\mu(1-t)-\pi\}\Gamma}\}}{\{\mu(1-t)-\pi\}\Gamma}$$

where the current investment cost at time u is $Ce^{\pi u}$.

The difference between $nPV(t)_0^{E,\, sld}$ and $nPV(t)_0^{E,\, sld}*$ is defined as the present value of additional corporate tax burden (inflation losses) at time 0 ($ATB_0^{E,\, sld}$), which is caused by the fictitious profit. With the critical tax-life of a capital good Γ^*, therefore

$$\text{(V-3)} \quad ATB(\Gamma^*)_0^{E,\, sld} \;=\; tC\left[\frac{1-e^{-\{\mu(1-t)-\pi\}\Gamma^*}}{\{\mu(1-t)-\pi\}\Gamma^*} - \frac{1-e^{-\mu(1-t)\Gamma^*}}{\mu(1-t)\Gamma^*}\right] \;=\; tC(FP_0^{E,\, sld})$$

where $FP_0^{E,\, sld}$ indicates the present value of fictitious profit per monetary unit at time 0 in the case of adopting straight-line depreciation. In order to examine whether and to what extent generous tax depreciation provisions promote private investments in inflationary situations, the value $FP_0^{E,\, sld}$ (with Γ^*) can be adopted as the benchmark. For this type of examination, the difference in financial structure does not play any role, since the annual interest is also calculated based on the historical total sum of debt at the fixed rate at the year 0.

Proposition 2 *When the amount of annual depreciation expense is calculated on the basis of historical cost, as it is the case in practice in transition economies, the incentive effect of geometric-degressive depreciation on private investment in an inflationary phase can also be measured by*

$$\text{(V-4)} \quad nPV(t)_0^{E,\, gdd} - nPV(t, \Gamma^*)_0^{E,\, sld}$$

$$= tC\left[\frac{\delta}{\delta+\mu(1-t)} - \frac{1-e^{-\mu(1-t)\Gamma^*}}{\mu(1-t)\Gamma^*}\right] \;=\; tC(IE_0^{E,\, gdd})$$

where $nPV(t)_0^{gdd}$ is the nominal present value of the asset at time 0 with geometric-degressive depreciation.

Proposition 3 *When the amount of annual depreciation expense is calculated on the basis of historical cost, the incentive effect of accelerated depreciation on private investment in an inflationary phase can be measured by*

(V-5) $nPV(t)_0^{E,\,ad} - nPV(t, \Gamma^*)_0^{E,\,sld}$

$$= tC\left[\frac{\sigma\{1-e^{-\mu(1-t)}\}}{\mu(1-t)} + \frac{e^{-\mu(1-t)\Gamma^*} - e^{-\mu(1-t)\Omega^*}}{\mu(1-t)\Gamma^*}\right] = tC(IE_0^{E,\,ad})$$

where $nPV(t)_0^{ad}$ is the nominal present value of the asset with accelerated depreciation at time 0 and Ω^* denotes the reduced tax-life of a capital good, when $\Gamma = \Gamma^*$.

Therefore, generous tax depreciation measures simply compensate the inflation losses in full-scale, if

(V-6) $IE_0^{E,\,sld} = FP_0^{E,\,sld}$

(V-7) $IE_0^{E,\,gdd} = FP_0^{E,\,sld}$

(V-8) $IE_0^{E,\,ad} = FP_0^{E,\,sld}$

In spite of inflation, tax depreciation rules shown above guarantee investment promotion effects, when IE values (i.e. $IE_0^{E,\,sld}$, $IE_0^{E,\,gdd}$ and $IE_0^{E,\,ad}$) are greater than $FP_0^{E,\,sld}$.

VI. International Comparison of Effects of Tax Incentive System on Equipment Investment

Table 1 compares the highest corporate tax rate (for retained earnings), tax depreciation methods and the extent of their generosity, which are presently allowed in the context of tax law in seven selected Eastern European countries. In the ranking of the statutory corporate tax rate, the Czech Republic ranks first at 31%, followed by Poland (28%) and Romania and Slovenia (25%). The corporate tax rate is the lowest in Macedonia (15%). In Hungary and Slovenia only the straight-line depreciation method can be adopted for equipment. As mentioned above, in countries like Poland, the Czech Republic and Macedonia geometric-degressive depreciation is usually applied as the investment incentive scheme for equipment, of which, however, the rate ranges from 20% (Poland) to 30% (Macedonia).[7] Furthermore, accelerated depreciation can be combined with straight-line depreciation in Romania and even for certain assets acquired after 1998 in Bulgaria. The normal tax-life for equipment amounts to 10 years in the selected countries (except for the Czech Republic where the computations are based on a 12-year tax life).

According to the net present value calculated under the standard assumptions for the case of investing in equipment (i.e. A_0 = 100, r = 10%, α = 20%, C = 333.3), the Romanian tax incentives which can be adopted for the specific investments guarantee the most favourable conditions for the investors in the case of ignoring the impact of anticipated inflation (see Table 1). In a descending order, Slovenia, Bulgaria, Macedonia and Hungary also provide investment incentives. On the other hand, the Polish corporate tax systems remains tax-neutral, since δ is set to be the same as the assumed α, and, therefore, NPV reaches zero in this country. In the Czech Republic — with equity finance and without inflation — a negative net present value was computed.[8]

Moreover Tables 1 - 4 indicate that the NPV for equipment investments financed with debt is higher than that with equity finance. Even the Czech system tends to promote private investment if it is financed by debt. In addition the gap between the nominal NPV with debt finance and that with equity finance becomes continuously larger with rising inflation. This evidence confirms the conventional wisdom.

As mentioned above, the application of the historical cost accounting method when calculating the corporate tax base causes fictitious profits in inflationary phases that are also subject to tax. Therefore, the extra tax burden increases with the corporate tax rate by the given inflation rate. For example, in spite of inflation, the 'true' investment incentive effects can be guaranteed in Romania (under the given assumptions for other relevant parameters), when $IE_0^{E, ad}$ (the difference between nominal present value per monetary unit at the investment year with accelerated depreciation combined with straight-line depreciation) exceeds $FP_0^{E, sld}$ (the nominal present value of fictitious profit per monetary unit at the same year in the case of adopting straight-line depreciation). According to the model simulation summarised in Table 5, the current Romanian and Slovenian tax incentive systems no longer stimulate private investment in equipment when, ceteris

7 In the Czech Republic there is a special depreciation scheme over 12 years. Following the tax law, the geometric-degressive depreciation rates applied start with 8.33% for the first year, and first rise and then decline during the subsequent years (Table 1).

8 Under the given assumptions made for the calculation, the net present value with Γ = 10 changes marginally from –1.0 and –2.3 to –0.2, when the corporate tax rate increases from 10% and 40% to 90%. In many other similar studies the critical (or economic) asset-life (Γ*) is (sometimes implicitly) assumed to be around 10 years for equipment (see also Sinn, Leibfritz and Weichenrieder, 1999, Leibfritz and Meuerer, 1985; Bordignon, Giannini and Panteghini, 1999).

paribus, the annual inflation rate reaches 12%. On the other hand, the Hungarian system appears to be less robust against inflation, since the investment incentives start to become negative already at an inflation rate of 4%, whereas incentive effects cannot be expected in Bulgaria when the inflation rate is higher than 6%.

Table 1 International comparison of tax incentives measured in terms of net present value without inflation: investment in equipment with the normal tax-life of 10 years

Country	Statutory corporate tax rate for retained earnings (%)	Tax depreciation rules	Net present value			
			Equity finance (= $PV(t)_0^E$ with various depreciation rules – C)	Debt finance (= $PV(t)_0^F$ with various depreciation rules – Ce^{-rs})		
				s=5	s=10	s=15
Poland	28[1]	Geometric-degressive depreciation (20%)[2]	0.0	30.4	39.6	38.8
Czech Republic	31	Geometric-degressive depreciation in 12 years *	-20.1	12.9	23.6	23.1
Macedonia	15	Geometric-degressive depreciation (30%)	3.9	19.6	23.7	22.6
Hungary	18	Straight-line depreciation (14.5%)[3]	3.1	22.2	27.3	26.2
Slovenia	25	Straight-line depreciation in 3 years	14.0	40.9	48.8	47.9
Romania	25	Accelerated depreciation (50%) + straight-line depreciation in 10 years[4]	14.3	41.2	49.1	49.1
Bulgaria	20	Straight-line depreciation in 5 years[5]	7.3	28.6	34.5	33.3
Common assumptions	$C = PV_0^E = 333.3$; $A_0 = 100$; $r = 10\%$; $\alpha = 20\%$; $0 < u < \infty$					

* The depreciation rate amounts to 8.33% for the first year and 15.28%, 13.89%, 12.5%, 11.11%, 9.72% , 8.33% , 6.94% , 5.56%, 4.17%, 2.78% and 1.39% for the consequent years, respectively.

1. The rate will be reduced to 24% in 2003 and 22% for 2004 and future years.
2. In general the straight-line method is applied, in certain cases the declining-balance method may be allowed too. For certain types of assets (such as machinery that may become obsolete because of technological developments), depreciation rates may be doubled.
3. For automation equipment, computers, equipment for environmental protection, medical equipment the rate of 33% applies.
4. Assets may be depreciated using the straight-line method. Useful life for machinery – 4 to 10 years. If the cumulative inflation rate for the preceding 3 years exceeded 100%, assets may be re-valued annually. Companies may use accelerated depreciation if they meet certain criteria subject to the approval of the Ministry of Finance.
5. For some assets which are acquired on or after 1.01.1998 accelerated depreciation at a rate of up to 30% is allowed.

Sources: IBFD (1999), Central & East European Tax Directory; Wirtschaftsrecht der Osteuropäischen Staaten (1998), Lieferung, October 1999; Ernst & Young: Worldwide Corporate Tax Guide: http://www.ey.com/global/gcr.nsf/EYPassport/Welcome-Worldwide_Corporate_Tax_Guide-EYPassport; Own calculations.

Table 2 International comparison of tax incentives measured in terms of net present value with 2% inflation: investment in equipment with the normal tax-life of 10 years

Country	Statutory corporate tax rate for retained earnings (%)	Tax depreciation rules	Nominal net present value			
			Equity finance (= $nPV(t)_0^E$ with various depreciation rules – C)	Debt finance (= $nPV(t)_0^F$ with various depreciation rules – $Ce^{-\mu s}$)		
				s=5	s=10	s=15
Poland	28[1]	Geometric-degressive depreciation (20%)[2]	2.1	35.6	42.2	38.2
Czech Republic	31	Geometric-degressive depreciation in 12 years *	-19.7	19.3	27.1	23.0
Macedonia	15	Geometric-degressive depreciation (30%)	5.4	22.6	25.2	22.5
Hungary	18	Straight-line depreciation (14.5%)[3]	4.6	25.5	28.8	25.7
Slovenia	25	Straight-line depreciation in 3 years	17.5	47.1	52.6	48.8
Romania	25	Accelerated depreciation (50%) + straight-line depreciation in 10 years[4]	17.8	47.4	53.0	49.2
Bulgaria	20	Straight-line depreciation in 5 years[5]	9.5	32.8	36.7	33.3
Common assumptions	$C = PV_0^E = 333.3$; $A_0 = 100$; $r = 10\%$; $\alpha = 20\%$; $0 < u < \infty$; $\pi = 2\%$					

* The depreciation rate amounts to 8.33% for the first year and 15.28%, 13.89%, 12.5%, 11.11%, 9.72% , 8.33% , 6.94% , 5.56%, 4.17%, 2.78% and 1.39% for the consequent years, respectively.

1. The rate will be reduced to 24% in 2003 and 22% for 2004 and future years.
2. In general the straight-line method is applied, in certain cases the declining-balance method may be allowed too. For certain types of assets (such as machinery that may become obsolete because of technological developments), depreciation rates may be doubled.
3. For automation equipment, computers, equipment for environmental protection, medical equipment the rate of 33% applies.
4. Assets may be depreciated using the straight-line method. Useful life for machinery – 4 to 10 years. If the cumulative inflation rate for the preceding 3 years exceeded 100%, assets may be re-valued annually. Companies may use accelerated depreciation if they meet certain criteria subject to the approval of the Ministry of Finance.
5. For some assets which are acquired on or after 1.01.1998 accelerated depreciation at a rate of up to 30% is allowed.

Sources: IBFD (1999), Central & East European Tax Directory; Wirtschaftsrecht der Osteuropäischen Staaten (1998), Lieferung, October 1999; Ernst & Young: Worldwide Corporate Tax Guide: http://www.ey.com/global/gcr.nsf/EYPassport/Welcome-Worldwide_Corporate_Tax_Guide-EYPassport; Own calculations.

Table 3 International comparison of tax incentives measured in terms of net present value with 4% inflation: investment in equipment with the normal tax-life of 10 years

Country	Statutory corporate tax rate for retained earnings (%)	Tax depreciation rules	Nominal net present value			
			Equity finance (= $nPV(t)_0^E$ with various depreciation rules – C)	Debt finance (= $nPV(t)_0^F$ with various depreciation rules – $Ce^{-\mu s}$)		
				s=5	s=10	s=15
Poland	28	Geometric-degressive depreciation (20%)[2]	4.8	40.6	44.2	37.5
Czech Republic	35	Geometric-degressive depreciation in 12 years *	-18.1	22.0	26.5	19.3
Macedonia	15	Geometric-degressive depreciation (30%)	7.1	25.4	26.3	22.2
Hungary	18	Straight-line depreciation (14.5%)[3]	6.3	28.5	29.9	25.1
Slovenia	25	Straight-line depreciation in 3 years	21.2	52.8	55.6	49.3
Romania	25	Accelerated depreciation (50%) + straight-line depreciation in 10 years	21.7	53.3	56.1	49.8
Bulgaria	20	Straight-line depreciation in 5 years[5]	11.8	36.7	38.4	33.1
Common assumptions	$C = PV_0^E = 333.3$; $A_0 = 100$; $r = 10\%$; $\alpha = 20\%$; $0 < u < \infty$; $\pi = 4\%$					

* The depreciation rate amounts to 8.33% for the first year and 15.28%, 13.89%, 12.5%, 11.11%, 9.72% , 8.33% , 6.94% , 5.56%, 4.17%, 2.78% and 1.39% for the consequent years, respectively.

1. The rate will be reduced to 24% in 2003 and 22% for 2004 and future years.
2. In general the straight-line method is applied, in certain cases the declining-balance method may be allowed too. For certain types of assets (such as machinery that may become obsolete because of technological developments), depreciation rates may be doubled.
3. For automation equipment, computers, equipment for environmental protection, medical equipment the rate of 33% applies.
4. Assets may be depreciated using the straight-line method. Useful life for machinery – 4 to 10 years. If the cumulative inflation rate for the preceding 3 years exceeded 100%, assets may be re-valued annually. Companies may use accelerated depreciation if they meet certain criteria subject to the approval of the Ministry of Finance.
5. For some assets which are acquired on or after 1.01.1998 accelerated depreciation at a rate of up to 30% is allowed.

Sources: IBFD (1999), Central & East European Tax Directory; Wirtschaftsrecht der Osteuropäischen Staaten (1998), Lieferung, October 1999; Ernst & Young: Worldwide Corporate Tax Guide: http://www.ey.com/global/gcr.nsf/EYPassport/Welcome-Worldwide_Corporate_Tax_Guide-EYPassport; Own calculations.

Table 4 International comparison of tax incentives measured in terms of net present value with 6% inflation: investment in equipment with the normal tax-life of 10 years

Country	Statutory corporate tax rate for retained earnings (%)	Tax depreciation rules	Nominal net present value			
			Equity finance (= $nPV(t)_0^E$ with various depreciation rules – C)	Debt finance (= $nPV(t)_0^F$ with various depreciation rules – $Ce^{-\mu s}$)		
				s=5	s=10	s=15
Poland	28	Geometric-degressive depreciation (20%)[2]	8.0	45.6	46.1	37.0
Czech Republic	35	Geometric-degressive depreciation in 12 years *	-16.3	25.9	26.9	17.1
Macedonia	15	Geometric-degressive depreciation (30%)	5.4	24.5	23.7	18.5
Hungary	18	Straight-line depreciation (14.5%)[3]	8.3	31.5	30.8	24.7
Slovenia	25	Straight-line depreciation in 3 years	25.1	58.3	58.2	50.0
Romania	25	Accelerated depreciation (50%) + straight-line depreciation in 10 years[4]	25.7	58.9	58.8	50.6
Bulgaria	20	Straight-line depreciation in 5 years[5]	14.4	40.4	39.8	33.0
Common assumptions	$C = PV_0^E = 333.3$; $A_0 = 100$; $r = 10\%$; $\alpha = 20\%$; $0 < u < \infty$; $\pi = 6\%$					

* The depreciation rate amounts to 8.33% for the first year and 15.28%, 13.89%, 12.5%, 11.11%, 9.72% , 8.33% , 6.94% , 5.56%, 4.17%, 2.78% and 1.39% for the consequent years, respectively.

1. The rate will be reduced to 24% in 2003 and 22% for 2004 and future years.
2. In general the straight-line method is applied, in certain cases the declining-balance method may be allowed too. For certain types of assets (such as machinery that may become obsolete because of technological developments), depreciation rates may be doubled.
3. For automation equipment, computers, equipment for environmental protection, medical equipment the rate of 33% applies.
4. Assets may be depreciated using the straight-line method. Useful life for machinery – 4 to 10 years. If the cumulative inflation rate for the preceding 3 years exceeded 100%, assets may be re-valued annually. Companies may use accelerated depreciation if they meet certain criteria subject to the approval of the Ministry of Finance.
5. For some assets which are acquired on or after 1.01.1998 accelerated depreciation at a rate of up to 30% is allowed.

Sources: IBFD (1999), Central & East European Tax Directory; Wirtschaftsrecht der Osteuropäischen Staaten (1998), Lieferung, October 1999; Ernst & Young: Worldwide Corporate Tax Guide: http://www.ey.com/global/gcr.nsf/EYPassport/Welcome-Worldwide_Corporate_Tax_Guide-EYPassport; Own calculations.

Table 5 International comparison of investment promotion effect of tax depreciation rules in inflationary phases measured in terms of nominal net present value

Inflation rate %	Poland	Macedonia	Hungary	Slovenia	Romania	Bulgaria
	TC (IE_0^E with various depreciation rules – $FP_0^{E, sld}$)					
1	–0.3	5.3	4.0	13.1	14.9	8.6
2	–2.0	4.0	2.2	11.8	13.5	7.0
3	–3.7	2.7	0.5	10.5	12.1	5.5
4	–5.3	1.5	-1.3	9.2	10.7	4.0
5	–6.8	0.4	-3.0	7.9	9.3	2.5
6	–8.4	-0.8	-4.6	6.6	7.9	1.0
7	–9.9	-1.9	-6.2	5.3	6.6	-0.5
8	–11.3	–3.0	-7.8	4.0	5.2	-1.9
9	–12.8	–4.0	-9.3	2.7	3.8	-3.4
10	–14.2	–5.1	-10.8	1.4	2.4	–4.8
11	–15.6	–6.1	-12.3	0.1	1.1	–6.2
12	–17.0	–7.0	-13.7	-1.2	-0.3	–7.6
13	–18.4	–8.0	-15.1	-2.5	-1.7	–8.9
14	–19.8	–9.0	-16.5	-3.9	-3.1	–10.3
15	–21.1	–9.9	-17.9	-5.2	-4.5	–11.6
16	–22.4	–10.8	-19.2	-6.5	-5.8	–12.9
17	–23.8	–11.7	-20.5	-7.8	-7.2	–14.3
18	–25.1	–12.6	-21.8	-9.2	-8.6	–15.6
19	–26.4	–13.4	-23.1	–10.5	–10.0	–16.9
20	–27.7	–14.3	-24.3	–11.8	–11.4	–18.1
21	–29.0	–15.1	-25.6	–13.2	–12.8	–19.4
22	–30.3	–16.0	-26.8	–14.5	-14.2	–20.7
Specific assumptions	t=28%; δ=20%	t=15%; δ=30%	t=18%; Γ=7 years	t=25%; Γ=3 years	t=25%; σ=50%	t=20%; Γ=5 years
Common assumptions	$C=PV_0 = 333.3$; $A_0=100$; r=10%; α=20%; Γ = Γ* =10 years and 0 < u < ∞					

Source: Table 1 and own calculations

VII. Conclusion

When calculating corporate tax profits, depreciation is deducted from a gross stream of return generated from the asset. From the point of view of the competitive firm which tries to maximise profits, this study compares — on the basis of net present value models and their simulation — incentive effects of various tax depreciation methods under the particular consideration of financial structure and inflation. These effects are determined based on the Samuleson's true economic depreciation. For the purpose of international comparison, seven Eastern European countries are investigated — Bulgaria, the Czech Republic, Hungary, Macedonia, Poland, Romania and Slovenia.

Ceteris paribus, the Romanian tax depreciation system which can be adopted for the specific investments presently guarantees the most favourable conditions for the investors, followed by Slovenia, Bulgaria, Macedonia and Hungary. The Polish corporate tax systems remains tax-neutral, since its depreciation rate is the same as the assumed TED rate. In general the corporate tax system more strongly triggers the investment financed by debt, whereas the gap between the nominal NPV with debt finance and that with equity finance is positively correlated with the inflation rate. The latter empirical evidence confirms the conventional wisdom.

This study suggests a possibility for existing a corporate tax rate which maximises the NPV of the asset. Taking the Macedonian geometric-degressive depreciation rate (= 30%) as an example, the model simulation made in this study demonstrates that the optimum tax rate would reach around 60%, which is far higher than the current rate of 15% in this country. This fact tends to revive the 'old' argument that tax incentives can also be guaranteed to firms in a combined form of a higher tax rate with a generous depreciation scheme. Prior to the beginning of 1980s such an opinion was quite popular in European countries. Thereafter, Europe experienced a series of corporate tax reforms, of which reasons and purposes have been primarily explained in the context of tax competition.

The aspect of inflation linked with different depreciation rules is of particular importance in transition countries where their economies have been confronted with rising prices during the last decade. In particular the application of the historical cost accounting method causes fictitious profits in inflationary phases. Therefore, the extra tax burden increases with the corporate tax rate by the given inflation rate. In this sense the selection of lower corporate tax rates can also be justified in most of the investigated countries. Under the given parameter assumptions and the annual inflation rate of 12%, however, even the most favourable Romanian scheme does not seem to provide any 'true' incentive effects but only adequately compensates such inflation losses.

Future research appears to be necessary in order to systematically compare the present value approach and its major outcomes with the cost of capital or marginal effective rate methodology that is often used in a similar context (Devereux, Griffith and Klemm, 2002; Chennells and Griffith, 1997). Furthermore, since the investigated countries have different risk profiles which implicitly determine the respective interest rates, it would be interesting to consider the aspect of different interest rates for future research as well. This could deliver a better insight into how and to what extent the various tax regimes applied in these transition countries influence firms' investment decisions.

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