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DOES DEBT MATURITY MATTER FOR INVESTMENT DECISIONS?

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Abstract

In the conventional literature related to investment decisions, less attention has been paid to the length of maturity when investment is debt-financed. In such a case a firm pays the creditor not only the sum of annual interest (*initial investment cost multiplied by real interest rate*) for the entire borrowing years but also the total amount of initial investment cost at the end of the borrowing period. In this study, the effects of selecting different maturity years on firms' investment decisions are compared on the basis of the simple net present value (NPV) model. Without taxation, the NPV is equal to the present value (PV) of future gross return less the PV of the cost of investment. An investment project is considered to be profitable when the NPV is positive. After the introduction of a corporate income tax, the PV of an asset amounts to the sum of PVs of net return (gross return less taxes) and tax savings led by an incentive depreciation provision. If the investment is debt-financed, the interest payment additionally reduces the corporate tax base. The research findings suggest that (1) *ceteris paribus* an optimum maturity year appears to exist that maximises the NVP, and (2) the change of optimum debt maturity tends to correlate positively with the corporate tax rate but negatively with the interest rate. In the case of prevailing inflation, there is a mismatch between the nominal interest rate that is a discounting factor for all observed in- and outflows and the real interest rate by which the annual interest payment is determined for the entire maturity period.

JEL Classification: H25, H32, M21, G31.

Keywords: debt maturity, investment decision, net present value, corporate taxation, inflation.

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I Introduction

In the corporate finance literature it is suggested that maturity of debt in forms of bank credit and bond can play an important role in reducing costs associated with debt financing (Ozkan, 2000). When investment is debt-financed, an investing firm pays the creditor not only the sum of annual interest (i.e. initial investment cost multiplied by the real interest rate) for the entire borrowing years but also the total amount of initial investment cost at the end of the borrowing period.

Among previous research works on this matter, Goswami, Noe and Rebello (1995) argue that long-term debt is the preferred financing instrument of choice when the degree of asymmetric information increases over time. A positive correlation is also often observed between the size of firm and debt maturity as shown by Jalilvand and Harris (1984). Issuing costs of a public bond are fixed for the largest part and therefore are independent of the magnitude of debt. This enables the realisation of economies of scale. For this reason, larger firms will issue public debt which generally has a longer maturity than private debt, for instance.¹ Furthermore, studies made by Brick and Ravid (1985), Kane, Marcus and McDonald (1985), and Scholes and Wolfson (1992) highlight the parallel development of the interest tax shield on debt (consequently the value of firm) and the term structure of debt. When the term structure of the interest rate slopes upward, long-term debt is optimal since the saving from leverage due to the interest tax shield is accelerated (borrower's incentive) and recognition of interest income is delayed (lender's incentive). By contrast, a negative relation of debt maturity appears to be pronounced with growth opportunity (Myers, 1977; Titman, 1992). The short-term debt mitigates the underinvestment problem² if it matures before growth options are exercised, as there remains an opportunity for lenders and borrowers to re-contract. Firms with a better credit

¹ Larger firms also appear to have lower agency costs. According to Smith and Warner (1979), small firms are more likely to face potential conflict of interest between a firm's shareholders and bondholders such as risk shifting and claim dilution. This problem can be reduced by issuing more shorter-term debts. Moreover larger firms have a much easier access to the capital markets (Titman and Wessels, 1988), and small firms are generally precluded from accessing long-term debt markets, since the proportion of their collateralisable assets to future investment opportunities is relatively small (Whited, 1992).

² According to Myers (1977), it is possible under debt financing that managers do not carry out investment with a positive net present value. When leverage is high, residual claims will be very low and profits from investment will only benefit creditors. Managers will be reluctant to pursue future investments which, however, reduce the investment opportunity set and ultimately firm value.

record tend to borrow on the long-term (Flannery, 1986; Mitchell, 1991). A high liquidity ratio may reduce the fund raising capacity of the firms as excessive liquidity reduces managers' ability to commit credibly to an investment activity, which will, in turn, shorten the maturity for available debts (Diamond, 1991; Myers and Rajan, 1998). The principle of matching debt and asset maturity has traditionally been acknowledged as a useful benchmark for selecting the borrowing years, because in this way the risk that cash inflows are insufficient to cover the interest payments and capital outlays is reduced (Morris, 1976; Myers, 1977; Hart and Moore, 1994; Stohs and Mauer, 1996; Emery, 2001).³ Leland and Thoft (1996) show that optimal leverage depends on debt maturity and is lower when the firm is financed by short-term debt. Furthermore, debt maturity is determined as a result of a trade-off between tax advantages and leverage-related costs, including agency costs, suggesting that riskier firms should issue short-term debt in addition to using less debt.

This study begins with revisiting the Miller-Modigliani paper (1958) which demonstrates that not only the capital structure of a firm but also debt maturity is irrelevant in a perfect capital market. Unlike the theoretical and empirical investigations mentioned above, this study suggests a possibility of an optimal debt maturity year, which delivers *ceteris paribus* the maximum net present value. Furthermore, it aims at elaborating the sensitivity of optimum debt maturity to the variation of corporate tax, interest and inflation rates.

The present value model is a well-known basic investment decision model. 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 annual tax base is reduced by the sum of annual interest payments, whereas the discount rates also declines with the tax rate. A tax paradox occurs when tax depreciation is greater than Samuelson's true economic depreciation (TED). Under the assumption of a perfect competitive market structure, only one interest rate exists in the financial market. In the case of prevailing inflation, there is a mismatch between the nominal interest rate that is a discounting factor for all observed in- and outflows and the real interest rate by which the annual interest payment is determined

³ According to this principle, debt with a maturity shorter than the maturity of asset is risky, because the asset may not yield enough profits to pay the debt. Debt with a maturity longer than the asset maturity

for the entire maturity period.

II Modigliani-Miller Theorem of Capital Structure Revisited

Miller and Modigliani (1958) asserted that under certain assumptions such as (1) perfect markets (i.e. no taxes or transaction costs), (2) cash flows that are independent of financial structure, and (3) 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 illustrated in terms of the present value model as follows.

Assume that for equity-finance the following condition is satisfied in the equilibrium

$$\Psi_0 = C \quad (\text{II-1})$$

where Ψ_0 is the present value of future gross return at year 0 generated by an investment costing C .

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

$$\begin{aligned} C^*_0 &= \int_0^s rCe^{-ru} du + Ce^{-rs} \\ &= (1-e^{-rs})C + Ce^{-rs} = C \end{aligned} \quad (\text{II-2})$$

where r = real interest rate ($0 < r < 1$) and s = debt maturity years ($s > 0$).

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. $C^*_0 = C = \Psi_0$). At the same time equation (II-2) suggests that the debt maturity is also irrelevant under the

is also risky, since debt has to be repaid when the asset no longer yields a return.

assumed capital market condition.

In the equilibrium without tax, equation (II-3) additionally proves that inflation does not matter for financial decision-making either if the annual interest payment is made based on the nominal interest rate for s years long.

$$\begin{aligned}
 nC^*_0 &= \int_0^s (r+\pi)Ce^{-(r+\pi)u} du + Ce^{-(r+\pi)s} \\
 &= (r+\pi)C \left\{ \frac{1 - e^{-(r+\pi)s}}{r+\pi} \right\} + Ce^{-(r+\pi)s} = C = \Psi_0 \quad (\text{II-3})
 \end{aligned}$$

where nC^*_0 = the nominal present value of total cost at year 0 and π = inflation rate ($0 < \pi < 1$).

If the interest payment takes place annually, applying the real interest rate in spite of prevailing inflation, as it is the case in practice, then

$$\begin{aligned}
 nC^*_0 &= \int_0^s rCe^{-(r+\pi)u} du + Ce^{-(r+\pi)s} \\
 &= rC \left\{ \frac{1 - e^{-(r+\pi)s}}{r+\pi} \right\} + Ce^{-(r+\pi)s} = \frac{C}{r+\pi} \{ r + \pi e^{-(r+\pi)s} \} < C \quad (\text{II-4})
 \end{aligned}$$

III Optimal Debt Maturity Revealed in Net Present Value Model

III.1 Without Inflation

Under the assumption that

- an investment costing C generates an infinite stream of future gross return,

- this return exponentially declines at the rate α ($0 < \alpha < 1$)⁴ and
- all prices are constant over time ($\pi = 0$),

a debt-financed investment project is on the margin of acceptance in the absence of taxation, when

$$\begin{aligned}
 Ce^{-rs} &= \int_0^{\infty} A_0 e^{-(\alpha+r)u} du - \int_0^s rCe^{-ru} du \\
 &= \frac{A_0}{\alpha+r} - (1 - e^{-rs})C
 \end{aligned} \tag{III-1}$$

where A_0 = gross return at the year of investment.

Consequently,

$$\Psi_0 = \frac{A_0}{\alpha+r} = C \tag{III-2}$$

In this case, the net present value $Y (= \Psi_0 - C)$ amounts to zero.

After the introduction of a tax on corporate income (t), the annual tax base is reduced by the sum of the annual interest payment, whereas the discount rate is also reduced by the tax rate. Samuelson (1964) showed in his fundamental theorem of tax-rate invariance that corporate income taxation does not affect firms' investment decisions at all, when true economic depreciation (TED) — the negative change in value of asset in the course of time — is deducted from an expected gross stream of return when calculating tax profits, and when the TED rate is the same as α . In other words, a tax paradox occurs when the tax depreciation is greater than TED (King, 1977; Atkinson and Stiglitz, 1980; King and Fullerton, 1984; Sinn, 1987).

⁴ 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.

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

$$D_u^{\text{gdd}} = \delta C e^{-\delta u} \quad (\text{III-3})$$

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

Hence, with debt finance and geometric-degressive depreciation, the net present value of the asset at time 0 is

$$\begin{aligned} Y &= (1-t) \int_0^{\infty} A_0 e^{-\{\alpha+r(1-t)\}u} du - (1-t) \int_0^s r C e^{-r(1-t)u} du + tC \int_0^{\infty} \delta e^{-\{\delta+r(1-t)\}u} du - C e^{-rs} \\ &= \frac{A_0}{\alpha+r} + tC \left\{ \frac{\delta}{\delta+r(1-t)} - \frac{\alpha}{\alpha+r(1-t)} \right\} - \{1 - e^{-r(1-t)s}\} C - C e^{-rs} \end{aligned} \quad (\text{III-4})$$

When $\delta > \alpha$, geometric-degressive depreciation provides incentives.

There is an optimal debt maturity s^* when the first order condition of equation (III-4) is zero and its second derivation is negative:

$$\frac{\partial Y}{\partial s} = r C e^{-rs} - r(1-t) C e^{-r(1-t)s} = 0 \quad (\text{III-5})$$

The second derivation of equation (III-4) is always smaller than zero

$$\frac{\partial^2 Y}{\partial s^2} = -r^2 C e^{-rs} + r^2 (1-t)^2 C e^{-r(1-t)s} < 0 \quad (\text{III-6})$$

since the sum of $r^2 C e^{-rs}$ is always larger than the second term of equation (III-6) by the given parameter constellation.

Therefore, the optimal debt maturity s^* can be derived from equation (III-5)

$$s^* = \frac{\ln(1/1-t)}{rt} \quad (\text{III-7})$$

The sensitivity of s^* in relation to the changes of r can be expressed

$$\frac{\partial s^*}{\partial r} = - \frac{\ln(1/1-t)}{r^2 t} < 0 \quad (\text{III-8})$$

Ceteris paribus the condition shown in equation (III-8) is always smaller than zero, implying the negative correlation between s^* and r .

The optimal debt maturity s^* varies also when t changes

$$\frac{\partial s^*}{\partial t} = \frac{1}{rt(1-t)} - \frac{\ln(1/1-t)}{rt^2} > 0 \quad (\text{III-9})$$

By the given parameter selection the first term of equation (III-9) is always larger than the second one. Thus equation (III-9) demonstrates the positive relationship between s^* and t .

III.2 With Inflation

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

$$A_u = A_0 e^{-\alpha u} e^{\pi u} = A_0 e^{-(\alpha-\pi)u} \quad (\text{III-10})$$

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.

When employing the historical accounting method, the nominal net present value at the

year 0 is⁵

$$\begin{aligned}
 Y(n) &= (1-t) \int_0^{\infty} A_0 e^{-\{(\alpha-\pi)+\mu(1-t)\}u} du - (1-t) \int_0^s r C e^{-\mu(1-t)u} du + tC \int_0^{\infty} \delta e^{-\{\delta+\mu(1-t)\}u} du \\
 &\quad - C e^{-\mu s} \\
 &= \frac{A_0}{(\alpha-\pi)+\mu} + tC \left\{ \frac{\delta}{\delta+r(1-t)} - \frac{\alpha}{\alpha+r(1-t)} \right\} - \frac{r}{\mu} \{1 - e^{-\mu(1-t)s}\} C - C e^{-\mu s}
 \end{aligned} \tag{III-11}$$

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

When the first order condition of equation (III-11)

$$\frac{\partial Y(n)}{\partial s} = \mu C e^{-\mu s} - \frac{\mu r(1-t) C e^{-\mu(1-t)s}}{\mu} = 0 \tag{III-12}$$

subject to

$$\frac{\partial^2 Y(n)}{\partial s^2} = -(-\mu)^2 C e^{-\mu s} + \frac{(-\mu)^2 r(1-t)^2 C e^{-\mu(1-t)s}}{\mu} < 0 \tag{III-13}$$

⁵ Under 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 physical volume of goods and services, and understate the firm's capital. 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, in periods with inflation generous tax depreciation provisions do not adequately promote private investment as intended but only (or partly) compensate the losses caused by inflation (Aaron, 1976; Kay, 1977; Feldstein, 1979; Kopcke, 1981; Gonedes, 1984; Nam and Radulescu, 2003).

then the optimum debt maturity $s(n)^*$ exists

$$s(n)^* = \frac{\ln [\mu / \{r(1-t)\}]}{\mu t} \quad (\text{III-14})$$

The optimal debt maturity $s(n)^*$ varies according to π

$$\frac{\partial s(n)^*}{\partial \pi} = \frac{1}{\mu^2 t} - \frac{\ln [\mu / \{r(1-t)\}]}{\mu^2 t} > 0 \quad (\text{III-15})$$

Equation (III-15) is always positive by the given parameter selection and suggests the parallel development of $s(n)^*$ with π .

IV Model Simulation

Firstly we consider the case without inflation. Table 1 shows the changes of (real) net present value with geometric-degressive depreciation (Y) according to the debt maturity period (s). For the calculation three corporate tax rates are considered (i.e., $t = 15\%$, 25% and 35%). Ceteris paribus the decrease in (real) interest rate from 8% to 4% leads to the changes in the margin of acceptance for the investment project. The TED rate ($= \alpha$) is assumed to be 20% ,⁶ whereas δ amounts to 30% , meaning that in our partial model simulation tax depreciation provides investment incentives. Taking the case with $t = 35\%$ and $r = 8\%$ as an initial one, s^* is around 16 years with $Y = 63$. The change of r to 4% increases s^* to about 30 years (with $Y = 71$), as already indicated in equation (III-8). With $r = 4\%$ the decrease in t from 35% to 25% (or 15%) leads to the decrease in s^* to 28 years with $Y = 28$ (or $Y = 48$). This parallel relationship is technically expressed in equation (III-9). This empirical founding suggests that s^* reacts quite sensitively to the real interest

⁶ In a number of studies, including Sinn, Leibfritz and Weicherieder (1999), Bordinon, Giannini and Panteghini (1999), as well as Nam and Radulescu (2003), the economic asset life is (sometimes implicitly) assumed to be around 10 years for equipment. From this asset life one can derive α by the

rate movement.

In a similar way Table 2 illustrates the changes of nominal net present values $Y(n)$ caused by the variation of s . Apart from the standard assumptions made in Table 1, two inflation rates ($\pi = 3\%$ and 6%) are additionally taken into account in the computation implying that μ amounts to 7% and 11% , respectively. In the case of adopting $t = 25\%$ and $r = 8\%$, the falling π from 6% to 3% leads to the decrease of $s(n)^*$ from 24 years with $Y(n) = 165$ to 22 years with $Y(n) = 115$. Such a movement appears to be less significant with $r = 4\%$.

Table 1 Optimal Debt Maturity in the Absence of Inflation

s	Y					
	t = 15%		t = 25%		t = 35%	
	r = 4%	r = 8%	r = 4%	r = 8%	r = 4%	r = 8%
2	7.4	11.1	11.9	18.1	16.1	24.9
4	11.3	16.4	18.6	27.3	25.6	38.1
6	14.7	20.2	24.4	33.9	33.9	47.8
8	17.6	22.7	29.3	38.4	41.0	54.6
10	20.0	24.2	33.5	41.3	47.1	59.2
12	22.0	24.9	37.0	42.8	52.3	61.9
14	23.6	25.0	39.9	43.4	56.7	63.3
16	24.9	24.7	42.2	43.2	60.3	63.4
18	25.8	24.1	44.1	42.4	63.3	62.8
20	26.6	23.3	45.6	41.2	65.6	61.5
22	27.1	22.3	46.6	39.7	67.5	59.6
24	27.4	21.2	47.4	38.0	68.9	57.5
26	27.6	20.0	47.8	36.2	69.8	55.1
28	27.6	18.9	48.0	34.3	70.4	52.6
30	27.5	17.7	48.0	32.4	70.7	50.0
32	27.2	16.6	47.8	30.5	70.6	47.4
34	26.9	15.5	47.4	28.6	70.3	44.8
36	26.5	14.5	46.9	26.9	69.8	42.2
38	26.1	13.6	46.2	25.2	69.2	39.8
40	25.5	12.7	45.5	23.6	68.3	37.4
42	25.0	11.8	44.7	22.1	67.3	35.1
44	24.4	11.0	43.7	20.6	66.2	33.0
46	23.8	10.3	42.8	19.3	65.0	31.0
48	23.1	9.7	41.8	18.1	63.7	29.1
50	22.4	9.1	40.7	17.0	62.3	27.3
Other common assumptions	Debt finance; C = 416.7 with r = 4% but 357.1 with r = 8%; A ₀ = 100; α = 20% and δ = 30%					

Source: Own calculations

Table 2 Optimal Debt Maturity in Inflationary Phase

s	Y(n)			
	$\pi = 3\%$		$\pi = 6\%$	
	$\mu = 7\%$	$\mu = 11\%$	$\mu = 10\%$	$\mu = 14\%$
2	36.8	37.8	59.9	56.2
4	62.8	60.9	101.7	90.7
6	84.7	78.0	135.2	115.2
8	103.2	90.3	161.8	132.2
10	118.7	99.2	183.0	144.0
12	131.6	105.3	199.8	152.0
14	142.5	109.5	213.1	157.3
16	151.6	112.2	223.7	160.7
18	159.1	113.7	231.9	162.7
20	165.3	114.5	238.4	163.9
22	170.4	114.8	243.4	164.5
24	174.6	114.6	247.3	164.7
26	178.0	114.2	250.3	164.6
28	180.8	113.6	252.6	164.4
30	183.0	112.9	254.4	164.0
32	184.7	112.2	255.7	163.7
34	186.1	111.5	256.7	163.3
36	187.2	110.7	257.4	163.0
38	188.0	110.1	257.9	162.7
40	188.5	109.4	258.2	162.4
42	188.9	108.8	258.5	162.1
44	189.2	108.3	258.6	161.9
46	189.3	107.8	258.7	161.7
48	189.4	107.4	258.7	161.5
50	189.4	107.0	258.7	161.4
Other common assumptions	Debt finance; C = 416.7 with r = 4% but 357.1 with r = 8%; A ₀ = 100; α = 20%, δ = 30% and t = 25%			

Source: Own calculations

V Conclusion

The selection of maturity years can play a significant role in reducing costs related to the debt-financed investment. In this case an investing firm pays the creditor the sum of annual interest for the borrowing years in addition to the repayment of the total amount of initial cost at the end of the borrowing period. Referring to the already existing theoretical framework suggesting different relationships of debt maturity with the determinants like firm size, growth opportunity, liquidity risk, creditworthiness, interest tax shield, asset maturity, leverage, agency costs, etc., the effects of choosing maturity years on firms' investment decisions are compared on the basis of the simple net present value (NPV) model. After the brief theoretical demonstration of the irrelevance of debt maturity in a perfect capital market, this study highlights the existence of optimum maturity s^* at which, ceteris paribus, the (real and nominal) NPV reaches a maximum. Furthermore, this study also elaborates the sensitivity of s^* to the variation of corporate tax, interest and inflation rates. As also illustrated in the partial model simulation based on the selected parameters, the optimum debt maturity is correlated positively with the corporate tax rate but negatively with the interest rate. In the case of prevailing inflation, a further positive relationship is observed between s^* and the inflation rate.

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