APPROACHES TO THE VALUATION OF MONEY MARKET PAPERS[1]

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Abstract: *Money market securities are short-term debt securities, therefore they can only be valued using methods based on the present value of future cashflow and using simple discounting. Specific approaches to the valuation of these securities will depend on the form of their return-interest at maturity for deposit instruments such as certificates of deposit, or discount for treasury bills, commercial paper and promissory notes. To properly evaluate discount securities, such as treasury bills, one must also take into account the way these instruments are quoted on various markets – their rates (discount rate or rate of return) and day count convention used.*

Keywords: *certificates of deposit, treasury bills, intrinsic value, current market rate of return, holding period return, discount rate, rate of return, investment return*

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Introduction

Money market securities are short-term securities that businesses use to obtain short-term credit (commercial or bank) or to invest temporarily free funds. They can also serve as a means of payment.

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Companies can obtain credit only through certain money market securities, for example through bills of exchange (commercial or financial credit) or through commercial paper in countries with well-developed money markets. On the other hand, money markets provide more options for companies to invest temporarily free cash.

Money market securities are characterized by a high degree of liquidity, low risk, and smaller price fluctuations. Compared to capital market securities, they offer lower returns and under standard conditions, lower risk of significant capital losses.

Therefore, money market paper is valued only based on its intrinsic value and returns. Risk is being quantified to evaluate capital market debt securities (i.e. medium and long-term debt) and equity securities.

The most commonly used money market securities are certificates of deposit, treasury bills, commercial paper, bills of exchange, cheques, etc.

Money market securities can be classified based on the returns they earn for their holders – interest securities (interest-at-maturity securities), e.g. certificates of deposit, discount securities, e.g. treasury bills, and securities that do not generate any return, e.g. cheques. The approach to their valuation will therefore depend on the kind of return they generate – interest or discount.

The aim of this paper is to compare approaches to the valuation of interest and discount money market securities based on their intrinsic value and returns. For discount securities, we will discuss the differences in their valuation depending on whether they are quoted using a discount rate (d) or a rate of return (r). We have analysed Investment Return (IR) formula [20] and derived a set of formulas enabling a comparison of returns in different markets using different quotations, a discount rate (d) or a rate of return (r), and different day count conventions, standards ACT / 360 and ACT / 365, which is the key contribution of our paper. In addition, we have identified a formula to calculate a holding period return (r_h) on markets where treasury bills are quoted on the basis of a rate of return (r).

A substantial body of literature is dedicated to the topic of valuation. The majority is dedicated to corporate valuation and investing in equity securities [3, 6, 10, 11, 14, 15, 16, 17, 19, 21], and many others. In contrast to debt securities, which are only valued using income methods, i.e. methods based on the present value of future cash flows, various approaches can be used to value equity securities. In addition to income methods, which are among the most preferred methods to value equity as well, equity securities can be valued using comparative methods, methods based on stock market analysis, methods based on real options, combined methods, liquidation methods, etc. One of the best-known authors focused on the valuation of capital market debt securities is the American author Fabozzi [8]. International debt markets are discussed in the works of various authors (from which we abstract in this paper): [2, 3, 7, 8, 22]. Less extensive literature is devoted to the valuation of money market securities, this includes Blake [1], Jílek [13], Rose [20], Hrvoľová [11, 12]. Money market securities are debt securities (and not equity securities), and they can be therefore valued only using income methods, i.e. approaches based on the present value of future cash flows from these securities. Since these securities have a life span of up to one year, they are valued using simple discounting.

1. Valuation of Money Market Interest Securities

Certificates of deposit are a typical representative of money market paper earning interest. We will therefore illustrate the valuation of money market interest securities on an example of certificates of deposit (CD).

Certificates of deposit are official documents of short-term deposits. In this paper we will focus on the valuation of traditional certificates of deposit with a fixed interest rate and repayment of nominal (par) value at maturity of up to one year, although, due to the fast pace of innovation, we can also encounter various other modifications of certificates of deposit on financial markets.

Investors are interested in determining the intrinsic value of certificates of deposit in order to assess whether the market has priced the CDs properly or if they are overvalued or undervalued, investors can decide to sell or buy accordingly.

An investor can buy certificates of deposit on the primary money market or on the secondary money market. If a certificate of deposit is purchased on the primary money market and held to maturity, an investor will be interested primarily in the level of *interest* and the *future value (FV)* of a certificate of deposit. The amount of interest, and thus the future value of a CD, depends on its interest rate, maturity, and to some extent also on the day count standard used by a bank. Interest rates, regardless of the maturity of a CD, are listed as nominal interest rates on an annual basis (p. a.) and assuming a receipt of interest once a year.

Interest and future value of certificates of deposit with a fixed interest rate can be calculated using the following formulas, assuming standard ACT / 365 which banks generally prefer when calculating interest on deposit products (if another standard is used, the formulas must be adapted to the given standard).

$$Interest = NV \, . \, \frac{i}{365} \, . \, m_{im} \, . \qquad (1)$$

Calculation of interest on a CD uses a simple interest rate.

In case of a reinvestment in the same certificate of deposit within a year, an investor might be interested in an *effective annual interest rate (r_e)* that can be calculated using the following formula:

$$r_e = (1 + \frac{i}{365} \, . \, m_{im})^{365/m_{im}} - 1 \, . \qquad (2)$$

Future value of a CD can be determined as the sum of its nominal (par) value and its interest:

FV = NV + interest, (3)

where

NV is the nominal (par) value of CD;

i is the nominal interest rate of CD at issuance;

m_{im} is the number of days from issuance to maturity (issuance – maturity);

FV is the future value of CD;

r_e is the effective interest rate;

365/m is an element, which represents the annualisation of the interest rate.

Investors in certificates of deposit can have an opportunity to either retain these short-term securities until maturity or sell them on the secondary market. The price of a certificate of deposit before its maturity on the secondary market may not be equal to the sum of its nominal (par) value and the corresponding part of its interest. It may be higher or lower depending on the current market situation. Therefore, the rate of return (r) of a certificate of deposit which is purchased on the secondary market may not be equal to the interest rate determined at issuance (i).

The calculation of a *rate of return (r)* of a CD, which an investor buys on the secondary market after issuance and retains it to maturity, is presented by formula No. 4:

$$r = \left[NV / P. (1 + \frac{i}{365} \, . \, m_{im}) - 1 \right] . \, 365 / m_{sm} \, , \qquad (4)$$

where

P is the actual market price on the secondary market;

m_{im} is the number of days between issuance and maturity (issuance – maturity);

m_{sm} is the number of days between settlement and maturity (settlement – maturity).

Intrinsic value (theoretical market price) of a certificate of deposit on the secondary market is calculated as the present value of future cash flow (NV + interest), using the current market rate of return of a similar financial instrument (certificate of deposit) as a discount factor:

$$P = \frac{NV + NV.\frac{i}{365}.m_{im}}{(1+\frac{r}{365}.m_{sm})} = \frac{NV.(1+\frac{i}{365}.m_{im})}{(1+\frac{r}{365}.m_{sm})} = \frac{FV}{(1+\frac{r}{365}.m_{sm})} \quad . \tag{5}$$

The actual (current) market price P can be divided into two parts - accrued interest and a principal.

$$Accrued\ interest = NV.\frac{i}{365}.m_{is}, \tag{6}$$

$$Principal = P - Accrued\ interest, \tag{7}$$

where

m_{is} is the number of days between issuance and settlement (issuance–settlement).

If an investor buys a certificate of deposit on the secondary market after it was issued and sells it before maturity, the investor will be interested in the rate of return for the period he/she held the certificate of deposit.

Holding period return (r_h) of a certificate of deposit can be calculated using the following formula:

$$r_h = \left[\frac{(1+\frac{r_p}{365}.m_{pm})}{(1+\frac{r_s}{365}.m_{sm})} - 1\right].\frac{365}{m_{pm} - m_{sm}} \ , \tag{8}$$

where

r_h is the holding period rate of return of CD;

r_p is the rate of return of CD on the date of purchase;

r_s is the rate of return of CD on the date of sale;

m_{pm} is the number of days between purchase and maturity (purchase – maturity);

m_{sm} is the number of days between sale and maturity (sale – maturity).

We will illustrate all of the formulas in a specific example.

If we assume 120-day certificate of deposit issued at NV 100,000 euros, with an interest rate of 2.50% and standard ACT / 365, then we will use the above listed formulas to calculate the following:

a) interest (monetary value),

b) future value (FV),

c) effective interest rate (r_e),

d) actual rate of return (r) of a CD for an investor who bought it on the secondary market with 30 days remaining to maturity at a market price of 100,400 euros,

e) holding period return (r_h) if an investor buys a CD with 50 days remaining to maturity and a rate of return of 2.45% and sells it with 15 days left to maturity and a rate of return of 2.60%.

a) Interest = 100,000 . (0.025/365) . 120 = 821.92 euros,

b) FV = 100,000 + 821.92 = 100,821.92 euros,

c) $r_e = [\ 1 + (0.025/365)\ .\ 120]^{\ 365/120} - 1 = 0.02521$, e. g. 2.521 %,

d) r = [100,000/100,400 . (1 + (0.025/365) . 120) - 1] . 365/30 = 0.051128, e. g. 5.1128, %.

e) $$r_h = \left[\frac{(1+\frac{0.0245}{365}.50)}{(1+\frac{0.026}{365}.15)} - 1 \right] . \frac{365}{50-15} = 0.0238,\ e.g.\ 2.38\ \%.$$

Numerical values in task d) were chosen to show a significant difference between the interest rate at the time when the CD was issued (2.50%), which would have been the return for an investor who bought it on the primary market at nominal value (100,000 euros) and kept it until maturity, and the return which the investor achieved on the secondary market (5.1128%), although he bought the CD at a higher price (100,400 euros) than the nominal value.

What is the reason for the significantly higher return for the investor on the secondary market? The source of returns for investors in financial securities is not only the interest that the investor earns but also the price that the investor pays for the instrument. The significantly higher return for the investor on the secondary market has been achieved because of the advantageous purchase price (100,400 euros).

The investor would achieve the same return as the CD's interest rate at issuance (2.50%) if the secondary market price was equal to the nominal value plus the accrued interest for the 90 days that the original owner who sells the CD on the market held it for – in our example:

100,000 + [100,000 . (0.025 / 365) . 90] = 100,000 + 616.44 = 100,616.44 euros, that is:

r = [100,000/100,616.44 . (1 + 0.025/365 . 120) - 1]. 365/30 = 0.024846635, which is approximately 2.5%.

If an investor bought the CD on the secondary market for 100,400 euros, he/she paid a net price (price for the principal) amounting to only 100,400 - 616.44 = 99,783.56 euros.

What could be the reason for the lower price of the CD (100,400 euros) for the seller than the sum of the nominal value and 90-day accrued interest (100,616.44 euros)?

This may be the result of an excess in supply over demand, an urgent need for cash for the seller, but also a change in the current market rates of return of comparable financial instruments. For example, if interest rates on the money market for the same CD issued later rose from 2.50% to 5.1128% (e.g. due to a significant increase in inflation), the market price would have been the same as in the example in the task d), that is:

$$P = \frac{100{,}000.(1 + \frac{0.025}{365}.120)}{(1 + \frac{0.051128}{365}.30)} = \frac{100{,}821.92}{(1 + \frac{0.051128}{365}.30)} = 100{,}400\ euros.$$

2. Valuation of Money Market Discount Securities

Discount (D) as a form of return is the difference between a *nominal value (NV)* due at maturity of a security and its lower issue *price (P)* on the primary market or its purchase price on the secondary market. The most widespread money market discount securities are treasury bills (T-bills), which will be used to illustrate the valuation of these types of instruments in this paper.

Treasury bills are short-term debt securities based on a discount. Their maximum repayment period is one year. Treasury bills are usually issued by governments or central banks. Governments can issue T-bills to cover short-term budget deficit and central banks can use T-bills to manage liquidity in the banking sector. Treasury bills are an important instrument of fiscal policy and monetary policy which is why the volume of T-bill issuance is influenced also by the phase of an economic cycle. For example, during a recession, governments may try, in line with central banks' monetary policy, to boost economic growth by various development programs financed by T-bills.

Treasury bills are among the most important money market securities. They are characterized by almost zero risk of insolvency and a high degree of liquidity. The treasury bill market is one of the largest and most developed. Short maturities lead to low risk of capital losses due to changes in interest rates. The advantage of these short-term securities is that they allow both their investors and issuers to react quickly when inflation and interest rates change.

The above-mentioned advantages of T-bills however suggest that these instruments provide relatively low levels of return. Treasury bill rates can form the basis for other interest rates in the money market.

The advantages of this type of instrument for an investor are that they can be used for example to reduce the risk of an investment portfolio, as an instrument in repurchase agreements or as collateral in obtaining other forms of credit.

Treasury bills are sold at a discount below their nominal (par) value. Nominal (par) value will be received by the last owner at maturity. The return for this type of security is therefore the difference between the purchase price and the nominal (par) value.

An investor in T-bills needs to assess the benefits of the form of their primary sale (American or Dutch auction), but also their price, returns and tax implications from holding the securities.

2.1. Approaches to the Valuation of Treasury Bills

Approaches to the valuation and pricing of treasury bills depend on whether the T-bills are quoted on the basis of a *discount rate (d)* or a *rate of return (r).* A discount rate (d) is always less than its equivalent rate of return (r) because it is derived from a higher base –- its nominal value (NV), which is higher than its purchase price (P), NV > P. Price (P), on the other hand, is used as a denominator to calculate a rate of return (r).

A discount rate (d) and a rate of return (r) are calculated using formulas No. 9 and 10:

$$d = \frac{D}{NV} \cdot \frac{360}{m_{sm}} \tag{9}$$

$$r = \frac{D}{P} \cdot \frac{360}{m_{sm}} \tag{10}$$

where

D is the discount;

NV is the nominal value, payable at maturity;

P is the purchase price;

m_{sm} is the number of days between sale and maturity (sale – maturity);

$360/m_{sm}$ is an element representing the annualisation of the rates.

Treasury bills in the US and in the UK are quoted on the basis of a discount rate (d). Nevertheles, both countries apply a different day count convention when calculating the discount rates of their T-bills – standard ACT / 360 is used in the US, while standard ACT / 365 (366 for leap years) is used in the UK.

Slovakia, the Czech Republic and other European countries issue treasury bills with a quotation on the basis of a rate of return (r) using standard ACT / 360.

If treasury bills are quoted on the basis of a discount rate (d), their discount (D) and purchase price (P - price on the primary market at issuance or sale price on the secondary market) are, for a given discount rate (d), calculated using the following formulas:

$$Discount = NV\,.\,d\,.\,(m_{sm}/360) \text{ , and} \tag{11}$$

$$price\,(P) = NV - discount = NV\,.\,(1 - d\,.\,m_{sm}/360)\,. \tag{12}$$

In addition to the level of profit in the form of a discount, an investor is also naturally interested in the rate of appreciation of an investment, i.e. the relationship between the discount (D) and the price (P) at which he/she bought treasury bill – rate of return (r) from formula No. 10 can be adjusted as follows:

$$r = \frac{D}{P} \cdot \frac{360}{m_{sm}} = \frac{d}{1 - d(m_{sm}/360)}\,. \tag{13}$$

The formula suggests that a rate of return (r) of treasury bills is greater than a discount rate (d), r > d. This is understandable because (as we mentioned above), to calculate a rate of return (r), a discount (D) is divided by a price (P) and not by a nominal value (NV).

In the literature Rose, [20], we have encountered a relationship that the author called *Investment Return (IR),* a coupon-equivalent yield which, according to the author, enables us to compare returns of various debt securities.

Investment Return (IR) is calculated using the following formula:

$$IR = \frac{365.\,d}{360 - (d.\,m_{sm})}. \tag{14}$$

To understand the explanatory power of this formula, we have analysed it by comparing it to other formulas used to calculate a rate of return (r). We have found that if we take formula No. 10 above, but adjust it for standard ACT / 365 (or 366 in leap years) and substitute its components, discount (D) and price (P), with their formulas No. 11 and 12 respectively, we will get the above IR formula No. 14 – e. g.:

- substitute for $D = NV.\,d.\,(m_{sm} / 360)\ a$ and for $P = NV.\,(1 - d.\,m_{sm} / 360)$.

Then we get: $IR = \dfrac{NV.\,d.\dfrac{m_{sm}}{360}}{NV.(1 - d.\dfrac{m_{sm}}{360})}.\dfrac{365}{m_{sm}}$ and with simplifications:

$$IR = \frac{d.365}{360.(1 - d.\frac{m_{sm}}{360})} = \frac{365.\,d}{360 - (d.m_{sm})}.$$

This means that Investment Return (IR) allows us to convert a discount rate (d) with standard ACT / 360 into a rate of return (r) with standard ACT / 365.

All the relationships presented above assumed a purchase of treasury bills quoted on the basis of a discount rate (d) that an investor buys on the primary or secondary market and holds until maturity.

If an investor purchases treasury bills after their primary issuance and sells them before maturity, he/she will be interested in a *holding period return (r_h).*

Holding period return (holding return) can be calculated as:

$$r_h = \left[\frac{(1 - d_s.\,m_{sm} / 360)}{(1 - d_p.\,m_{pm} / 360)} - 1 \right].\frac{360}{m_{pm} - m_{sm}}, \tag{15}$$

where

d_p is the discount rate of T-bill on the date of purchase (purchase);

d_s is the discount rate of the T-bill on the date of sale (sale);

m_{pm} is the number of days between purchase and maturity (purchase – maturity);

m_{sm} is the number of days between sale and maturity (sale – maturity).

If treasury bills are quoted on the basis of a rate of return (r), their purchase price (P) on the primary or secondary market can be calculated with a generally known formula for zero coupon bonds with a single cash flow at maturity equal to their nominal value (NV):

$$P = \frac{NV}{(1 + r.\, m_{sm} / 360)} \text{ or } P = \frac{NV}{(1 + \frac{r}{360}.\, m_{sm})}, \tag{16}$$

where

r is the current market rate of return of a comparable financial instrument

We have mentioned that in Slovakia treasury bills are quoted on the basis of their rate of return (r). A purchase price of a treasury bill on the Slovak money market is calculated by the following formula, as defined by The National Bank of Slovakia:

$$Purchase\ price = \frac{NH.\,360}{(DTM.\,US) + 360}, \tag{17}$$

where

DTM is the days to maturity;

NH is the nominal value;

US is the rate of return required by the buyer.

If formula No. 17 is rewritten with the symbols used in this paper and if we divide both the numerator and the denominator by 360, we will get to a formula identical to formula No. 16:

$$P = \frac{NV.360\ \ /360}{\left[(m_{sm}.r) + 360\right]\ /360} \rightarrow \frac{NV}{1 + r.m\ /360}.$$

If we want to determine a discount rate (d) corresponding to the known rate of return (r) of a T-bill with the same nominal value, maturity and standard, we could derive the appropriate formula from the second part of formula No. 13:

$$r = \frac{d}{1 - d.(m_{sm}/360)} \rightarrow \quad d = \frac{r}{1 + r.(m_{sm}/360)}\ . \tag{18}$$

We can derive Investment Return (IR) with standard ACT / 365 in a similar way as we did in the case of T-bills quoted on the basis of a discount rate (d). The starting point will be the same, meaning:

$$r = \frac{D}{P}.\frac{365}{m_{sm}},$$

but we will substitute the discount (D) with a formula D = NV – P,

where price (P) will be further substituted with a formula $P = \dfrac{NV}{(1 + r.\, m_{sm} / 360)}$.

To simplify the procedure, we will assume that $1 + r.(\dfrac{m_{sm}}{360}) = x$, i.e.: $P = \dfrac{NV}{x}$.

$$IR = \frac{NV - \frac{NV}{x}}{\frac{NV}{x}}.\frac{365}{m_{sm}} = \frac{\frac{NV.x - NV}{x}}{\frac{NV}{x}}.\frac{365}{m_{sm}} = \frac{x.\, NV.(x-1)}{x.\, NV}.\frac{365}{m_{sm}} = (x-1).\frac{365}{m_{sm}} =$$

$$= (1 + r.\frac{m_{sm}}{360} - 1).\frac{365}{m_{sm}} = \frac{r.m_{sm}}{360}.\frac{365}{m_{sm}} = \frac{r.365}{360}, e.g.$$

$$IR = \frac{r.365}{360}. \qquad (19)$$

We have derived the remaining formulas to compare the various possible types of quotations of T-bills – both in terms of quoted rates (discount rate or rate of return) and different standards (ACT / 360 and ACT / 365). We have summarised the full set of formulas in Table No.1.

Table 1

Comparison of Treasury Bill Returns

Known input values					
		$d_{ACT/360}$	$d_{ACT/365}$	$r_{ACT/360}$	$r_{ACT/365}$
Calculated values	$d_{ACT/360}$		$\dfrac{d.360}{365}$	$\dfrac{r}{1 + r.\frac{m_{sm}}{360}}$	$\dfrac{360.r}{365 + (r.m_{sm})}$
	$d_{ACT/365}$	$\dfrac{d.365}{360}$		$\dfrac{365.r}{360 + (r.m_{sm})}$	$\dfrac{r}{1 + r.\frac{m_{sm}}{365}}$
	$r_{ACT/360}$	$\dfrac{d}{1 - d.\frac{m_{sm}}{360}}$	$\dfrac{360.d}{365 - (d.m_{sm})}$		$\dfrac{r.360}{365}$

	$r_{ACT/365}$	$\frac{365.d}{360-(d.m_{sm})}$	$\frac{d}{1-d.\frac{m_{sm}}{365}}$	$\frac{r.365}{360}$	

Source: Haruštiak, L. Own calculation.

Holding period return (r_h) of treasury bills quoted on the basis of a rate of return (r) is not calculated using formula No. 15 by simply replacing the discount rate (d) with a rate of return (r), as one might mistakenly assume

$$r_h = \left[\frac{(1-d_s.m_{sm}/360)}{(1-d_p.m_{pm}/360)} - 1\right].\frac{360}{m_{pm}-m_{sm}}, \text{ e. g.}$$

$$r_h = \left[\frac{(1-r_s.m_{sm}/360)}{(1-r_p.m_{pm}/360)} - 1\right].\frac{360}{m_{pm}-m_{sm}},$$

but using formula No. 8 adapted to standard ACT / 360

$$r_h = \left[\frac{(1+r_p.m_{pm}/360)}{(1+r_s.m_{sm}/360)} - 1\right].\frac{360}{m_{pm}-m_{sm}}.$$

We will prove this in a numerical example, based on which we will also illustrate all other relationships from the T-bill formulas in this paper.

By way of example, suppose an issuance of T-bills on a market using standard ACT / 360. The T-bills are issued with a nominal value of 100,000 euros, a rate of return (r) of 2.00% and 364 days to maturity. We'll be interested in:

a) issue price (P),

b) discount (D),

c) Investment Return (IR), i.e. a rate of return (r) with ACT / 365,

d) corresponding discount rate (d) on a market with the same standard (ACT / 360),

e) discount (D) from the corresponding discount rate (d) on a market with the same standard,

f) price (P) from the corresponding discount rate (d) on a market with the same standard,

g) IR from the corresponding discount rate (d),

h) holding period return (r_h) for an investor who buys T-bills on the secondary market with 100 days remaining to maturity and a rate of return of 2.20%, and sells them with 10 days left to maturity and a rate of return of 2.15%,

i) price (P) on the secondary market with 61 days remaining to maturity and a current market rate of return of comparable financial instruments of 3.50%.

a) $EK = \frac{100{,}000.\,360}{(364.\,0{,}02) + 360} = 98{,}017.86\,eur$, or

$$EK = \frac{100{,}000}{(1 + \frac{0{,}02}{360}.\,364)} = 98{,}017.86\,eur,$$

b) D = 100,000 – 98,017.86 = 1,982.14 euros, or

D = 98,017.86 . 0.02/360 . 364 = 1,982.14 euros,

c) $IR = \frac{0{,}02\,.\,365}{360} = 0.020278,\, that\ is\ 2.03\%$,

d) $d = \frac{0.02}{1 + 0.02.(364/360)} = 0.0196036,\ e.g.\ 1.96\ \%$, or

$$d = \frac{1{,}982.14}{100{,}000}.\frac{360}{364} = 0.0196036,\ that\ is\ 1.96\%,$$

e) $D = 100{,}000.\,\frac{0.0196036}{360}.\,364 = 1{,}982.14\,eur$,

f) P_0 = 100,000 – 1,982.14 = 98,017.86 euros,

g) $IR = \frac{365.\,0.0196036}{360 - (0.0196036.\,364)} = 0.020278,\ e.g.\ 2.03\ \%$,

$$\text{h)}\quad r_h = \left[\frac{(1+0.022\ .100/360)}{(1+0.0215.10/360)} - 1\right].\frac{360}{100-10} = 0.022042391,\ e.g.\ 2.204\,\%.$$

The accuracy of the equations will be proven, if we get the same result when we derive the appropriate discount rate (d) at the time of purchase and sale and use formula No. 15:

$$d_p = \frac{0.022}{1+0.022.(100/360)} = 0.02186637217,$$

$$d_s = \frac{0.0215}{1+0.0215.(10/360)} = 0.02148716739,$$

$$r_h = \left[\frac{(1-0.0214871673\,9.10/360)}{(1-0.02186637217.100/360)} - 1\right].\frac{360}{100-10} = 0.022042391, e.g.\ 2.204\,\%,$$

$$\text{i)}\quad P_0 = \frac{100{,}000}{(1+\frac{0.035}{360}.61)} = 99{,}410.44\ eur.$$

Conclusion

We have focused on the valuation of two groups of money market securities – certificates of deposit, which are based on interest, and treasury bills, which are based on a discount. Since money market securities are short-term, with a lifespan of up to one year, and are associated with low risk, we have focused on their valuation only in terms of their intrinsic value and returns.

Our key contribution to this subject is a set of formulas allowing the conversion of various forms of T-bill returns from one to another and thus compare the returns of securities quoted on different markets – both in terms of the different quoted rates (discount rate or rate of return) as well as different day count conventions (standards ACT / 360 and ACT / 365). These formulas, which were derived from analysing the relationships in Investment Return (IR) formula, are summarised in Table No. 1.

In addition, we have identified a suitable formula to calculate a holding period return of treasury bills quoted on the basis of a rate of return. Furthermore, we have demonstrated that the formula used by The National Bank of Slovakia to calculate prices of treasury bills is the same as the formula which is clearly identifying that the price of a treasury bill is the present value of a single future cash flow from the instrument, discounted by a current market rate of return of a comparable instrument using simple discounting.

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