WACC: definition, misconceptions and errors

Pablo Fernandez
IESE Business School, University of Navarra
Camino del Cerro del Aguila 3. 28023 Madrid, Spain.
E-mail: fernandezpa@iese.edu

Abstract

The WACC is just the rate at which the Free Cash Flows must be discounted to obtain the same result as in the valuation using Equity Cash Flows discounted at the required return to equity (Ke)

The WACC is neither a cost nor a required return: it is a weighted average of a cost and a required return. To refer to the WACC as the "cost of capital" may be misleading because it is not a cost.

The paper includes 7 errors due to not remembering the definition of WACC and shows the relationship between the WACC and the value of the tax shields (VTS).

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1. Definition of WACC

There are two basic methods for valuing companies by discounted cash flows:

<u>**Method 1**. Using the expected equity cash flow (ECF) and the required return to equity (Ke).</u>

Equation [1] indicates that the value of the equity (E) is the present value of the expected equity cash flows (ECF) discounted at the required return to equity (Ke).

[1] $E_0 = PV_0 [Ke_t; ECF_t]$

Equation [2] indicates that the value of the debt (D) is the present value of the expected debt cash flows (CFd) discounted at the required return to debt (Kd).

[2] $D_0 = PV_0 [Kd_t; CFd_t]$

<u>**Method 2**. Using the free cash flow and the WACC (weighted average cost of capital).</u>

The **free cash flow (FCF)** is the hypothetical equity cash flow when the company has no debt. The expression that relates the FCF (Free Cash Flow) with the ECF is:

[3] $ECF_t = FCF_t + \Delta D_t - I_t (1 - T)$

ΔD_t is the increase in debt, and I_t is the interest paid by the company. $CFd_t = I_t - \Delta D_t$

Equation [4] indicates that the value of the debt (D) plus that of the shareholders' equity (E) is the present value of the expected free cash flows (FCF) that the company will generate, discounted at the weighted average cost of capital (WACC):

[4] $E_0 + D_0 = PV_0 [WACC_t ; FCF_t]$

The WACC is the rate at which the FCF must be discounted so that equation [4] gives the same result as that given by the sum of [1] and [2]. By doing so, the expression of the WACC (Weighted Average Cost of Capital) is given by [5] (see Exhibit 1):

[5] $WACC_t = [E_{t-1} Ke_t + D_{t-1} Kd_t (1-T)] / [E_{t-1} + D_{t-1}]$

T is the effective tax rate applied to interest in equation [3].

$E_{t-1} + D_{t-1}$ are **not** market values nor book values: in actual fact, E_{t-1} and D_{t-1} are the values obtained when the valuation is performed using formulae [1], [2] or [4].[1]

D = Value of debt E = Value of equity Ebv = Book value of equity ECF = Equity cash flow FCF = Free cash flow N = Book value of the debt	I = Interest paid PV = Present value r = Cost of debt R_F = Risk-free rate g = Growth rate	WACC = Weighted average cost of capital Ke = Required return to levered equity Kd = Required return to debt VTS = Value of the tax shield P_M = Required market risk premium Vu = Value of equity in the unlevered company Ku = required return to unlevered equity

The WACC is a weighted average of **two very different magnitudes**:

- a cost: the cost of debt, and
- a required return: the required return to equity (Ke). Although Ke is called many times cost of equity, there is a big difference between a cost and a required return.

Then, the WACC is neither a cost nor a required return, but a weighted average of a cost and a required return. To refer to WACC as "cost of capital" may be misleading because it is not a cost.

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[1] Consequently, the valuation is an iterative process: the free cash flows are discounted at the WACC to calculate the company's value (D+E) but, in order to obtain the WACC, we need to know the company's value (D+E).

2. Some errors due to not remembering the definition of WACC

2.1. Using a wrong tax rate T to calculate the WACC. The correct tax rate (T) that should be used every year is the T that relates the ECF and the FCF in equation [3], as it is shown in Exhibit 1.

2.2. Calculating the WACC using book values of debt and equity. The appropriate values of debt and equity are the ones resulting from the valuation (E and D).

2.3. Calculating the WACC assuming a capital structure that is neither the current one nor the forecasted: the debt to equity ratio used to calculate the WACC is different than the debt to equity ratio resulting from the valuation. This error appears in a valuation by an investment bank. Current debt was 125, the enterprise value was 2180, and the debt to equity ratio used to calculate the WACC was 50%.

This is wrong because the outstanding and forecasted debt should be used to calculate the WACC. The equity value of a firm is given by the difference between the firm value and the outstanding debt, where the firm value is calculated using the WACC, and the WACC is calculated using the outstanding (market value of) debt. Alternatively, if the firm starts with its current debt and moves towards another financial structure, then a variable WACC (different for each year) should be used, and the current debt should be deducted from the enterprise value.

2.4. The Enterprise Value (E + D) does not satisfy the time consistency formulae. Fernández (2002, page 401) shows that the relationship between the enterprise values of different years is:

$E_t+D_t = (E_{t-1}+D_{t-1})\ (1+WACC_t) – FCF_t$.

And the relationship between the equity values of different years is:

$E_t = E_{t-1}\ (1+Ke_t) – ECF_t$.

2.5. Considering that WACC / (1-T) is a reasonable return for the company’s stakeholders. Some countries assume that a reasonable return on a telephone company’s assets is WACC / (1-T). Obviously, this is not correct. And the error is still higher if the return is multiplied by book values.

2.6. Using the wrong formula for the WACC when the value of debt (D) is not equal to its book value (N). Fernández (2002, page 416) shows that the expression for the WACC when the value of debt (D) is not equal to its book value (N) is WACC = (E Ke + D Kd – N r T) / (E + D). Kd is the required return to debt and r is the cost of debt.

2.7. Another example. The valuation of a broadcasting company performed by an investment bank (see Table 1), which discounted the expected FCFs at the WACC (10%) and assumed a constant growth of 2% after 2008. The valuation provided lines 1 to 7, and stated that the WACC was calculated assuming a constant Ke of 13.3% (line 5) and a constant Kd of 9% (line 6). The WACC was calculated using market values (the equity market value on the valuation date was 1,490 million and the debt value 1,184 million) and the statutory corporate tax rate of 35%.

The valuation also included the equity value at the end of 2002 (3,033; line 8) and the debt value at the end of 2002 (1,184; line 10). Table 2 provides the main results of the valuation according to the investment bank.

Table 1. Valuation of a broadcasting company performed by an investment bank

Data provided by the investment bank in italics

		2002	2003	2004	2005	2006	2007	2008
1	FCF		*-290*	*-102*	*250*	*354*	*459*	*496*
2	ECF		*0*	*0*	*0*	*0*	*34*	*35*
3	Interest expenses		*107*	*142*	*164*	*157*	*139*	*112*
4	Effective tax rate		*0.0%*	*0.0%*	*0.0%*	*0.0%*	*12.0%*	*35.0%*
5	Ke		*13.3%*	*13.3%*	*13.3%*	*13.3%*	*13.3%*	*13.3%*
6	Kd		*9.0%*	*9.0%*	*9.0%*	*9.0%*	*9.0%*	*9.0%*
7	WACC used in the valuation		*10.0%*	*10.0%*	*10.0%*	*10.0%*	*10.0%*	*10.0%*
8	Equity value (E)	*3,033*	3,436	3,893	4,410	4,997	5,627	6,341
9	ΔD = ECF - FCF + Int (1-T)		397	244	-86	-197	-303	-389
10	Debt value (D)	*1,184*	1,581	1,825	1,739	1,542	1,239	850
11	D/(D+E)	28.1%	31.5%	31.9%	28.3%	23.6%	18.0%	11.8%
12	WACC using lines 4,5,6,8,10		12.09%	11.95%	11.93%	12.08%	12.03%	11.96%

Table 2. Valuation using the wrong WACC of 10%

Present value in 2002 using a WACC of 10%	
Present value in 2002 of the free cash flows 2003-2008	647
Present value in 2002 of the residual value (g=2%)	3,570
Sum	4,217
Minus debt	-1,184
Equity value	3,033

The valuation has **two major errors**:

a. Wrong calculation of the WACC. To calculate the WACC, we need to know the evolution of the equity value and the debt value. We calculate the equity value based on the equity value provided for 2002. The formula that relates the equity value in one year to the equity value in the previous year is $E_t = E_{t-1} (1+Ke_t) - ECF_t$.

To calculate the debt value, we may use the formula for the increase of debt, shown in line 9. The increase of debt may be calculated if we know the ECF, the FCF, the interest and the effective tax rate. Given line 9, it is easy to fill line 10.

Line 11 shows the debt ratio according to the valuation, which decreases with time.

If we calculate the WACC using lines 4, 5, 6, 8 and 10, we get line 12. The calculated WACC is higher than the WACC assumed and used by the investment bank.

b. The capital structure of 2008 is not valid for calculating the residual value because in order to calculate the present value of the FCF growing at 2% using a single rate, a constant debt to equity ratio is needed.

To perform a correct valuation, assuming a constant WACC from 2009 on, we must recalculate Table 1. Tables 3 and 4 contain the valuation correcting the WACC. To assume a constant WACC from 2009 on, the debt must also increase by 2% per year (see line 9, 2009). This implies that the ECF (line 2) in 2009 is much higher than the ECF in 2008.

Simply by correcting the error in the WACC, the equity value is reduced from 3,033 to 2,014.

Table 3. Valuation calculating the WACC correctly

		2002	2003	2004	2005	2006	2007	2008	2009
1	FCF		-290	-102	250	354	459	496	505.9
2	ECF		0	0	0	0	34	35	473.2
3	Interest expenses		107	142	164	157	139	112	76.5
4	Effective tax rate		0.0%	0.0%	0.0%	0.0%	12.0%	35.0%	35.0%
5	Ke		13.3%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%
6	Kd		9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%
8	Equity value (E)	2,014	2,282	2,586	2,930	3,320	3,727	4,187	4,271
9	ΔD = ECF - FCF + Int (1-T)		397	244	-86	-197	-303	-389	17
10	Debt value (D)	1,184	1,581	1,825	1,739	1,542	1,239	850	867
11	D/(D+E)	37.0%	40.9%	41.4%	37.2%	31.7%	25.0%	16.9%	16.9%
12	WACC calculated with 4,5,6,8,10		11.71%	11.54%	11.52%	11.70%	11.59%	11.44%	12.04%

Table 4. Valuation using the corrected WACC from Table3

Present value in 2002 using the WACC calculated in Table 3	
Present value in 2002 of the free cash flows 2003-2008	588
Present value in 2002 of the residual value (g=2%)	2,610
Sum	3,198
Minus debt	-1,184
Equity value	**2,014**

3. The WACC and the value of tax shields (VTS)

The value of tax shields (VTS) defines the increase in the company's value as a result of the tax saving obtained by the payment of interest. However, there is no consensus in the existing literature regarding the correct way to compute the VTS. Modigliani and Miller (1963), Myers (1974), Luehrman (1997), Brealey and Myers (2000) and Damodaran (2006) propose to discount the tax savings due to interest payments on debt at the cost of debt (Kd), whereas Harris and Pringle (1985) and Ruback (1995, 2002) propose discounting these tax savings at the cost of capital for the unlevered firm (Ku). Miles and Ezzell (1985) propose discounting these tax savings the first year at the cost of debt (Kd) and the following years at Ku.

The value of the levered firm may be written as:

$$E + D = Vu + VTS \quad (1)$$

where E is the value of the equity, D is the value of the debt, Vu is the value of the unlevered equity and VTS is the value of tax shields. From equation (1), we may derive equation (2):

$$E\,Ke + D\,Kd = Vu\,Ku + VTS\,K_{TS} \quad (2)$$

where Ke, Kd, Ku and K_{TS} are the required returns to the expected cash flows of equity, debt, assets (free cash flow) and tax shields. Modigliani-Miller consider that K_{TS} = Kd and Harris-Pringle consider that K_{TS} = Ku. These two scenarios correspond to two different financing strategies: the first one is valid for a company that has a preset amount of debt and the second one should be valid for a company that has a fixed leverage ratio in market value terms [D = L (D + E)]. However, as Miles and Ezzell (1985) and Arzac and Glosten (2005) prove, the required return for the tax shield (K_{TS}) of a company that has a fixed leverage ratio in market value terms is Kd for the tax shields of the first period and Ku thereafter. It is not possible to derive a debt policy such that the appropriate discount rate for the tax shields is Ku in all periods. $D_t = L\,(D_t + E_t)$ implies that D_t is also proportional to FCF_t. The Miles and Ezzell (1985) correct formula for the VTS of a perpetuity growing at a rate g is:

$$VTS^{ME} = \frac{D\,Kd\,T}{(Ku - g)} \frac{(1 + Ku)}{(1 + Kd)} \quad (3)$$

Formula (3) is identical to formulae (21) of Miles and Ezzell (1985), (13) of Arzac and Glosten (2005) and (7) of Lewellen and Emery (1986). However, Farber, Gillet and Szafarz (2006) and Harris and Pringle (1985) present a formula that does not correspond to ME assumption:

$$VTS^{HP} = \frac{DKd\,T}{(Ku - g)} \quad (4)$$

If debt is adjusted continuously, not only at the end of the period, then the ME formula (3) changes to

$$VTS = D\,\rho\,T / (\kappa - \gamma) \quad (5)$$

where $\rho = \ln(1+ Kd)$, $\gamma = \ln(1+g)$, and $\kappa = \ln(1+ Ku)$. Perhaps formula (5) induces Farber *et al* (2006) and Harris and Pringle (1985) to use (4) as the expression for the value of tax shields when the company maintains a constant market value leverage ratio (but then Kd, g and Ku should also be expressed in continuous time). (4) is incorrect for discrete time: (3) is the correct formula.

Fernandez (2007) values a firm when its debt policy is determined by a book-value ratio. He argues that when managers have a target capital structure, it is usually in book-value terms (as opposed to market-value terms), in large part because this is what credit rating agencies pay attention to. He gets the VTS of a company that maintains a fixed book-value leverage ratio:

$$VTS^{FER} = \frac{D\,Ku\,T}{Ku - g} \qquad (6)$$

Fernandez (2007), using data of US companies, compares the correlation coefficients of the increases of debt with the increases of assets measured in book-value terms, and in market-value terms. He finds that the average and the median of the book-value correlation coefficients are higher (and the standard deviation smaller) in book-value terms than in market-value terms. According to ME, the correlation between ΔD and Δ(D+E) should be 1, but it is only 0.23 on average. The correlation between ΔD and Δ(D+Ebv) was 0.77 on average.

For perpetuities with a constant growth rate (g), the relationship between expected values in t=1 of the free cash flow (FCF) and the equity cash flow (ECF) is:

$$ECF_0(1+g) = FCF_0(1+g) - D_0\,Kd\,(1\text{-}T) + g\,D_0 \qquad (7)$$

The value of the equity today (E) is equal to the present value of the expected equity cash flows. If Ke is the average appropriate discount rate for the expected equity cash flows, then E = $ECF_0(1+g)$ / (Ke -g), and equation (8) is equivalent to:

$$E\,Ke = Vu\,Ku - D\,Kd + VTS\,g + D\,Kd\,T \qquad (8)$$

And the general equation for the Ke is:

$$Ke = Ku + \frac{D}{E}\left[Ku - Kd(1-T)\right] - \frac{VTS}{E}(Ku - g) \qquad (9)$$

The WACC is the appropriate discount rate for the expected free cash flows, such that $D_0+E_0= FCF_0(1+g)$ / (WACC-g) . The equation that relates the WACC and the VTS is (11):

$$WACC = Ku - \left(\frac{VTS}{D+E}\right)(Ku - g) \qquad (10)$$

4. An example

The following example is taken from Fernandez (2009). The balance sheet and income statement forecasts for the next 5 years are shown in **Table 5**. After year 3, the balance sheet and the income statement are expected to grow at an annual rate of 2%. Using the balance sheet and income statement forecasts in Table 5, we can readily obtain the cash flows given in **Table 6**. Obviously, the cash flows grow at a rate of 2% after year 4.

Table 5. Balance sheet and income statement forecasts

	0	1	2	3	4	5
WCR (working capital requirements)	400	430	515	550	561.00	572.22
Gross fixed assets	1,600	1,800	2,300	2,600	2,913.00	3,232.26
- accumulated depreciation		200	450	720	995.40	1,276.31
Net fixed assets	1,600	1,600	1,850	1,880	1,917.60	1,955.95
TOTAL ASSETS	**2,000**	**2,030**	**2,365**	**2,430**	**2,478.60**	**2,528**
Debt (N)	1,500	1,500	1,500	1,500	1,530.00	1,560.60
Equity (book value)	500	530	865	930	948.60	967.57
TOTAL LIABILITIES	**2,000**	**2,030**	**2,365**	**2,430**	**2,478.60**	**2,528**
Income statement						
Margin		420	680	740	765.00	780
Interest payments		120	120	120	120.00	122
PBT (profit before tax)		300	560	620	645.00	658
Taxes		105	196	217	225.75	230.27
PAT (profit after tax = net income)		**195**	**364**	**403**	**419.25**	**427.64**

Table 6. Cash flow forecasts

	1	2	3	4	5
PAT (profit after tax)	**195**	**364**	**403**	**419.25**	**427.64**
+ depreciation	200	250.00	270.00	275.40	280.91
+ increase of debt	0	0.00	0.00	30.00	30.60
- increase of working capital requirements	-30	-85	-35	-11	-11.22
- investment in fixed assets	-200	-500.00	-300.00	-313.00	-319.26
ECF	**165.00**	**29.00**	**338.00**	**400.65**	**408.66**
FCF [3]	**243.00**	**107.00**	**416.00**	**448.65**	**457.62**
CFd	**120.00**	**120.00**	**120.00**	**90.00**	**91.80**

The risk-free rate is 6%. The cost of debt is 8%. The corporate tax rate is 35%, and the required return to the unlevered equity (Ku) is 10%.

The valuation according to Fernandez (2007) is given in **Table 7**. The value of the debt is equal to the nominal value (book value) given in Table 5 because we have considered that the required return to debt is equal to its cost (8%). The required return to equity (Ke) and the VTS have been calculated using (9) and (6).

The valuation according to Miles and Ezzell (1985) is given in **Table 8**. The required return to equity (Ke) and the VTS have been calculated using (9) and (3).

The valuation according to Myers (1974) is given in **Table 9**.

Table 7. Valuation according to Fernandez (2007)

	0	1	2	3	4	5
Ke	10.49%	10.46%	10.42%	10.41%	10.41%	10.41%
E = PV(Ke;ECF)	**3,958.96**	**4,209.36**	**4,620.80**	**4,764.38**	**4,859.66**	**4,956.86**
D = PV(CFd;Kd)	1,500.00	1,500.00	1,500.00	1,500.00	1,530.00	1,560.60
E+D = PV(WACC;FCF)	5,458.96	5,709.36	6,120.80	6,264.38	6,389.66	6,517.46
WACC	9.04%	9.08%	9.14%	9.16%	9.16%	9.16%
[4] - D = E	**3,958.96**	**4,209.36**	**4,620.80**	**4,764.38**	**4,859.66**	**4,956.86**
VTS = PV(Ku;D T Ku)	623.61	633.47	644.32	656.25	669.38	682.76
Vu = PV(Ku;FCF)	4,835.35	5,075.89	5,476.48	5,608.12	5,720.29	5,834.69
VTS + Vu	5,458.96	5,709.36	6,120.80	6,264.37	6,389.66	6,517.46
[9] - D = E	**3,958.96**	**4,209.36**	**4,620.80**	**4,764.37**	**4,859.66**	**4,956.86**

Table 8. Valuation according to Miles and Ezzell

	0	1	2	3	4	5
VTS = PV[Ku; T D Kd] (1+Ku)/(1+Kd)	508.13	516.16	525.00	534.72	545.42	556.33
Ke	10.76%	10.71%	10.65%	10.63%	10.63%	10.63%
E	**3,843.5**	**4,092.1**	**4,501.5**	**4,642.8**	**4,735.7**	**4,830.4**
WACC	9.199%	9.235%	9.287%	9.304%	9.304%	9.304%

Table 9. Valuation according to Myers

	0	1	2	3	4	5
VTS = PV(Kd;D Kd T)	663.92	675.03	687.04	700.00	714.00	728.28
Ke	10.42%	10.39%	10.35%	10.33%	10.33%	10.33%
E	**3,999.27**	**4,250.92**	**4,663.51**	**4,808.13**	**4,904.29**	**5,002.37**
WACC	8.995%	9.035%	9.096%	9.112%	9.112%	9.112%

5. Conclusions

The WACC is just the rate at which the Free Cash Flows (FCF) must be discounted to obtain the same result as the valuation using Equity Cash Flows.

The WACC is neither a cost nor a required return: it is a weighted average of a cost and a required return. To refer to the WACC as the "cost of capital" may be misleading because it is not a cost.

The paper includes 7 errors due to not remembering the definition of WACC.

The paper also shows that the relationship between the WACC and the value of the tax shields (VTS).

The WACC is a discount rate widely used in corporate finance. However, the correct calculation of the WACC rests on a correct valuation of the tax shields. The value of tax shields depends on the debt policy of the company. When the debt level is fixed, the tax shields should be discounted at the required return to debt. If the leverage ratio is fixed at market value, then Miles-Ezzell applies. Other debt policies should be explored. For example, Fernandez (2007) develops valuation formulae for the situation in which the leverage ratio is fixed at book values and argues that it is more realistic to assume that a company maintains a fixed book-value leverage ratio than to assume, as Miles-Ezzell do.

Exhibit 1
Calculating the WACC

The intertemporal form of equations [1], [2] and [4] is:

[1i] $E_{t+1} = E_t (1+Ke_{t+1}) - ECF_{t+1}$

[2i] $D_{t+1} = D_t (1+Kd_{t+1}) - CFd_{t+1}$

[4i] $[E_{t+1} + D_{t+1}] = [E_t + D_t] (1+WACC_{t+1}) - FCF_{t+1}$

The sum of [1i] and [2i] must be equal to [4i]:

$[E_t + D_t] + E_t Ke_{t+1} + D_t Kd_{t+1} - [ECF_{t+1} + CFd_{t+1}] = [E_t + D_t] (1+WACC_{t+1}) - FCF_{t+1}$

As $CFd_{t+1} = D_t Kd_{t+1} - [D_{t+1} - D_t]$ and $ECF_{t+1} = FCF_{t+1} + [D_{t+1} - D_t] - D_t Kd_{t+1} (1-T)$

$[ECF_{t+1} + CFd_{t+1}] = FCF_{t+1} + D_t Kd_{t+1} -- D_t Kd_{t+1} (1-T)$

and

$[E_t + D_t] + E_t Ke_{t+1} + D_t Kd_{t+1} (1-T)] - FCF_{t+1} = [E_t + D_t] (1+WACC_{t+1}) - FCF_{t+1}$

$[E_t + D_t] WACC_{t+1} = E_t Ke_{t+1} + D_t Kd_{t+1} (1-T)$

The WACC is:

$$WACC_{t+1} = \frac{E_t Ke_{t+1} + D_t Kd_{t+1} (1-T)}{E_t + D_t}$$

T is the effective tax rate applied to interest in equation [3].

$E_t + D_t$ are **not** market values nor book values: in actual fact, E_t and D_t are the values obtained when the valuation is performed using formulae [1], [2] or [4].

WACC is a rate that may be multiplied by market values [E + D], but it is not appropriate to multiply the WACC by book values.

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