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Article

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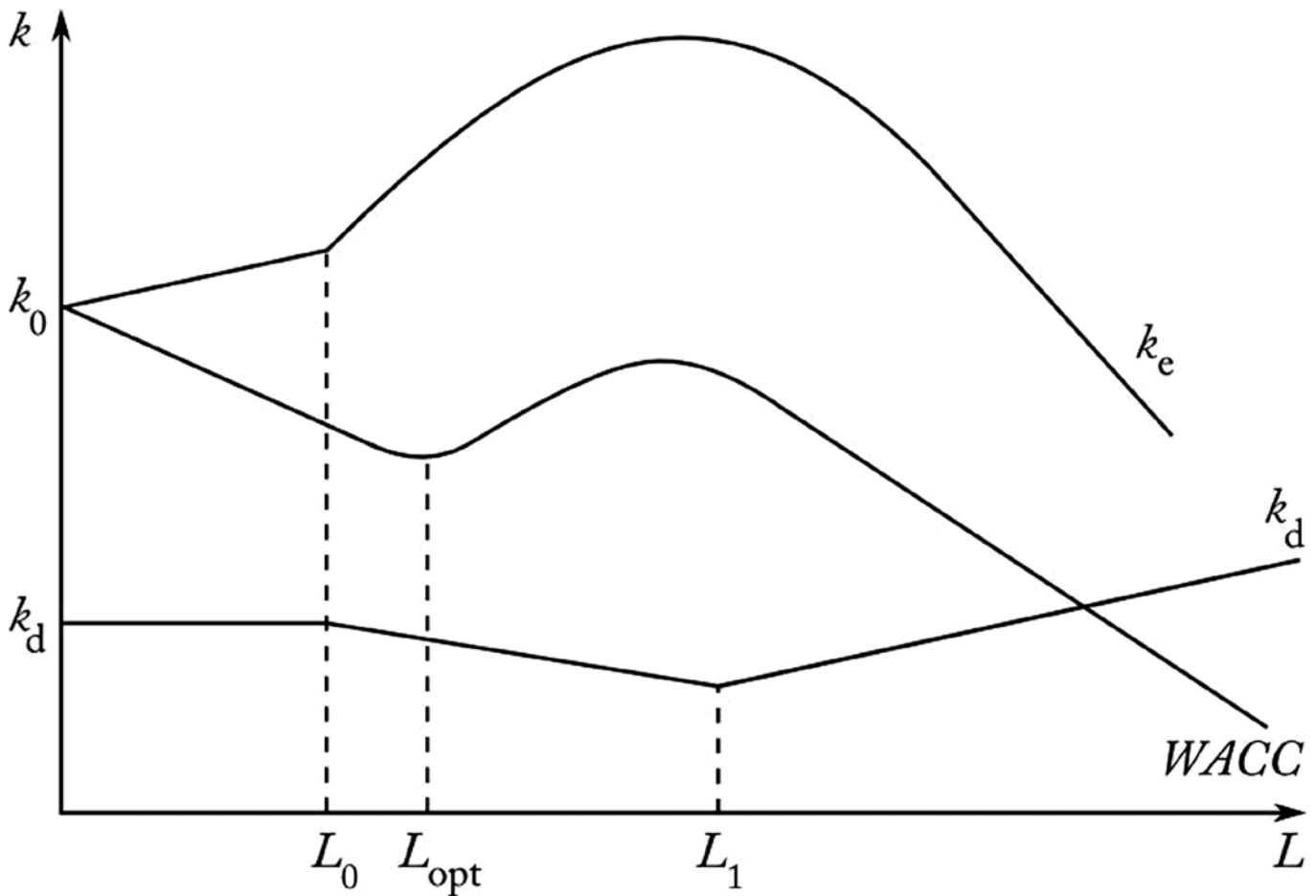
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RESEARCH ARTICLE

Mechanism of formation of the company optimal capital structure, different from suggested by trade off theory

Peter Brusov^{1*}, Tatiana Filatova² and Natali Orekhova³

Abstract: Under condition of proved by us insolvency of well-known classical trade off theory it becomes important to identify mechanisms for forming the optimal capital structure of a company. This paper presents one of the real such mechanisms based on the decrease of debt cost with leverage, which is determined by growth of debt volume. This mechanism is absent in perpetuity Modigliani–Miller theory, even in modified version, developed by us, and exists within more general modern theory of capital cost and capital structure by Brusov–Filatova–Orekhova, or BFO theory.

Keywords: optimal capital structure, trade off theory, Brusov–Filatova–Orekhova (BFO) theory, Modigliani–Miller theory

1. Introduction

Analyzing the validity of well-known trade off theory (Brennan & Schwartz, 1978; Leland, 1994), we have investigated the problem of existing of company optimal capital structure within Modigliani–Miller theory (Modigliani & Miller, 1958, 1963, 1966), modified by us by removing the suggestion about risk-free debt capital (MMM theory), as well as within modern theory of capital cost and capital structure by Brusov–Filatova–Orekhova (BFO theory) applicable to companies with arbitrary lifetime and investment projects of arbitrary duration (Brusov & Filatova, 2011; Brusov, Filatova, Eskindarov, et al., 2011; Brusov, Filatova, Orekhova, et al., 2011; Brusov, Filatova, & Orekhova, 2013b; Filatova, Orekhova, & Brusova, 2008). Within both theories (MMM and BFO), the absence of the optimal capital

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PUBLIC INTEREST STATEMENT

Establishing the optimal capital structure of a company is important and cannot be explained by trade off theory at all. This paper develops an alternative mechanism based on the decrease of debt cost with leverage, which is determined by growth of debt volume. This mechanism is absent within any version of Modigliani–Miller theory, but exists within a more general modern theory of capital cost and capital structure called Brusov–Filatova–Orekhova theory (BFO theory).

structure has been proved under the modeling of financial distress and danger of bankruptcy by increase in debt cost. This proves the insolvency of the classical trade off theory (Brusov, Filatova, & Orekhova, 2013a), which is based on the following suggestions (Brennan & Schwartz, 1978; Leland, 1994):

At low leverage levels, the advantages of using of debt financing (which is cheaper than equity one) are connected to the fact that the weighted average cost of capital (WACC) decreases with leverage and consequently the company capitalization grows. Starting from some leverage level, as financial distress appears and grows, bankruptcy risk grows as well. With an increase of WACC, the decrease of company capitalization starts. The leverage level, at which profits of debt capital using are approximately equal to the bankruptcy cost, determines the company optimal capital structure.

As our investigations show (Brusov et al., 2013a), within both theories, growth of WACC and consequent decreases of company capitalization are absent. We have given the explanation of for such phenomena: for leverage levels above some value L^* , the equity cost decreases with leverage, providing continuously (at all leverage levels) reduction of WACC.

Our conclusion is as follows: the mechanism of formation of the company optimal capital structure suggested in the trade off theory about 40 years ago turns out to be insolvent (Brusov et al., 2013a). The continuous and unlimited reduction of WACC and consequent unlimited growth of company capitalization with leverage seems to contradict the existing experience.

In studying the problems associated with existing concepts of company optimal capital structure, we investigate the influence of debt cost on equity cost and on WACC. We have discovered the presence of correlations between debt cost and equity cost, which could give an another mechanism of formation of the company optimal capital structure (different from the trade off one) at leverage levels which are far enough from the “critical” levels, at which financial distress appears and the bankruptcy risk increases. The discovery of such a mechanism is the main purpose of this paper.

Suggested mechanism of formation of the company optimal capital structure is based on the decrease of debt cost, which (in some range of leverage levels) is determined by increasing the debt volume.

2. Absence of suggested mechanism of formation of the company optimal capital structure in modified Modigliani–Miller theory (MMM theory)

Let us show first that in Modigliani–Miller theory (Modigliani & Miller, 1958, 1963) modified by us by removing the suggestion about risk-free debt capital, suggested that a mechanism of formation of the company optimal capital structure is impossible.

Consider the case of arbitrary dependence of debt cost on leverage $f(L)$.

Suppose, that debt cost k_d is described by the following function

$$k_d = \begin{cases} k_{d0} = \text{const}; & \text{at } L \leq L_0 \\ k_{d0} + f(L); & \text{at } L > L_0 \end{cases} \quad (1)$$

Here $f(L)$ is arbitrary (growing or decreasing) function of leverage level L . We are interested in leverage levels $L > L_0$, because at $L < L_0$ the standard Modigliani–Miller theory works, and WACC is decreased with leverage

$$\text{WACC} = k_0(1 - w_d t) \quad (2)$$

while an equity cost grows linearly with leverage

$$k_e = k_0 + L(k_0 - k_d)(1 - t) \quad (3)$$

Here k_e is an equity cost; k_0 is an equity cost of financially independent company; k_d is debt cost; t is tax on profit rate; WACC is a weighted average cost of capital.

In this case for WACC one has

$$WACC = k_e w_e + k_d w_d (1 - t) = k_e \frac{1}{1 + L} + k_d \frac{L}{1 + L} (1 - t) = \frac{1}{1 + L} [k_e + k_d L (1 - t)] \quad (4)$$

Substituting Equations 1 and 3 into Equation 4, one has finally for WACC,

$$\begin{aligned} WACC &= \frac{1}{1 + L} [k_0 + L(k_0 - k_d)(1 - t) + Lk_d(1 - t)] \\ &= \frac{1}{1 + L} [k_0 + k_0 L(1 - t)] = \frac{k_0 [1 + L(1 - t)]}{1 + L} = k_0 [w_e + w_d(1 - t)] = k_0 (1 - w_d t) \end{aligned} \quad (5)$$

One can see, that WACC, does not depend on $f(L)$. Moreover, it is described by the same expression (Equation 2), as in case of riskless debt capital. Note that obtained result is consistent with the conclusions of Rubinstein (1973) and Stiglitz (1969), that cost of company within Modigliani–Miller theory is not changed upon introduction of debt riskiness. In our approximation, as well as at Hsia (1981) debt cost is not already constant.

For derivative from WACC, on leverage level one has

$$(WACC)'_L = k_0 \frac{[(1 - t)(1 + L) - 1 - L(1 - t)]}{(1 + L)^2} = -k_0 \frac{t}{(1 + L)^2} < 0 \quad (6)$$

We have proved the following theorem:

In modified Modigliani–Miller theory (allowing riskiness debt capital) under arbitrary change of debt cost with leverage (growing, as well as decrease) weighted average cost of capital, WACC always fall down with leverage. This means the absence of the company optimal capital structure and proves insolvency of well-known classical trade off in its original formulation.

3. Formation of the company optimal capital structure within Brusov–Filatova–Orekhova (BFO theory)

The situation is different in modern theory of capital cost and capital structure by Brusov–Filatova–Orekhova (BFO theory). As it will be shown below, decrease of debt cost with leverage leads to formation of minimum in dependence of WACC on leverage at moderate leverage levels far from the “critical” levels, at which financial distress appear and the bankruptcy risk increases. Existence of such minimum leads to appearance of maximum in capitalization of the company. So, we suggest a new mechanism of formation of the company optimal capital structure, different from one, suggested by (already insolvent) trade off theory.

Before studying the problem within BFO theory (Brusov et al., 2013a, 2013b) let us consider one-year companies, which have been studied by Myers (2001). This case is the particular case of more general BFO theory.

For WACC of one-year company one has

$$WACC = k_0 - \frac{1 + k_0}{1 + k_d} k_d w_d t \quad (7)$$

Here w_d is the debt ratio.

The debt cost k_d still has the following form

$$k_d = \begin{cases} k_{d0} = \text{const}; & \text{at } L \leq L_0 \\ k_{d0} + f(L); & \text{at } L > L_0 \end{cases} \quad (8)$$

Thus, WACC, at leverage levels $L > L_0$ is equal to

$$\text{WACC} = k_0 - \frac{1+k_0}{1+k_{d0}+f(L)} (k_{d0}+f(L)) \frac{L}{1+L} t \quad (9)$$

and, obviously, depends on the form of $f(L)$. Thus, the difference of the simplest case of one-year companies from perpetual ones, which, as we have shown above, is independent of the form of $f(L)$, becomes obvious.

We will not analyze here one-year companies in detail, but instead we will go now to the analysis of companies with arbitrary lifetime, described by BFO theory (Brusov et al., 2013a, 2013b).

Let us consider a few dependences of debt cost on leverage $f(L)$. We consider decrease of debt cost at exponential rate as well as at quadratic rate with weak fall $\alpha = .01$ as well as with strong fall $\alpha = .1$ of debt cost.

3.1. Decrease of debt cost at exponential rate

We have the following parameters

$$L_0 = 1; \quad k_0 = 0.22; \quad k_d = 0.12; \quad t = 0.2$$

and the debt cost has the form

$$k_d = \begin{cases} k_{d0} = \text{const}; & \text{at } L \leq L_0 = 1 \\ k_{d0} + \alpha - \alpha \cdot 3^{L-L_0}; & \text{at } L > L_0 = 1 \end{cases} \quad (10)$$

Calculation of the WACC, will be done, using the BFO formula

$$\frac{1 - (1 + \text{WACC})^{-n}}{\text{WACC}} = \frac{1 - (1 + k_0)^{-n}}{k_0 \left(1 - t \left(\frac{L}{1+L} \right) (1 - (1 + k_d)^{-n}) \right)} \quad (11)$$

By the function “Matching parameter” in Excel we will find the WACC values.

Then, using obtained values of WACC, we will find the cost of equity values k_e by the equation:

$$\text{WACC} = k_e w_e + k_d w_d (1 - t)$$

$$k_e = \text{WACC} (1 + L) - k_d L (1 - t) \quad (12)$$

Equation 12 is the definition of the WACC, for the case of existing of taxing.

The application of BFO Equation 11 is very wide: authors have applied it in corporate finance, in investments, in taxing, in business valuation, in banking and some other areas (Brusov et al., 2013b; Brusov, Filatova, Orehova, Brusov, & Brusova, 2011a, 2011b). Using this Equation 11, one can study the dependence of the WACC, as well as the equity cost k_e on leverage level L , on tax on profit rate t , on lifetime of the company n .

The case $\alpha = .01$. Let us consider first the case $\alpha = .01$.

We will study below the dependence of debt cost k_d , equity cost k_e and WACC, on leverage level L in case of k_d exponential decrease (Figure 1 and Table 1).

From Figure 2, it is clearly seen the existence of optimal WACC value (minimum) at all lifetimes of the company ($n=1, 3, 5, 10$) (Figures 3–5).

The case $\alpha = .1$. Let us consider now the case $\alpha = .1$ (Figures 6–9 and Table 2).

Let us valuate the optimum position L^* and its depth $\Delta WACC$, using obtained results (see Table 3).

Figure 1. Dependence of debt cost k_d on leverage level L in case of its exponential decrease at $\alpha = .01$.

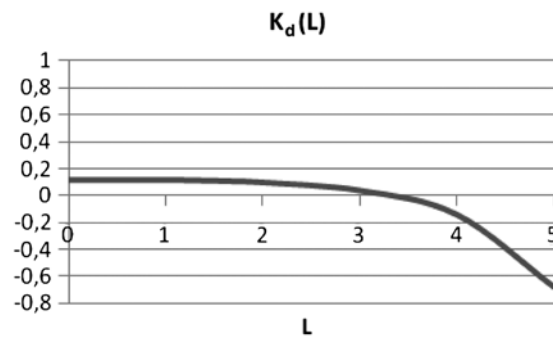


Table 1. k_d, k_e , and WACC for companies with lifetimes $n = 1, 3, 5, 10$

L	0	.5	1	1.1	1.3	1.6	2	3	4
k_d	.12	.12	.12	.1188	.1161	.1107	.1	.04	-.14
WACC ($n=1$)	.220	.211	.207	.206	.205	.206	.206	.214	.252
k_e ($n=1$)	.220	.257	.294	.302	.320	.358	.417	.736	1.819
WACC ($n=3$)	.219	.208	.201	.201	.199	.199	.198	.209	.279
k_e ($n=3$)	.219	.252	.281	.291	.307	.340	.395	.716	1.955
WACC ($n=5$)	.220	.206	.200	.199	.197	.197	.196	.207	.301
k_e ($n=5$)	.220	.250	.279	.287	.303	.335	.388	.710	2.067
WACC ($n=10$)	.220	.206	.199	.198	.196	.196	.194	.205	.383
k_e ($n=10$)	.220	.249	.277	.285	.301	.332	.383	.699	2.474

Figure 2. Dependence of WACC on leverage level L in case of exponential decrease of debt cost at $\alpha = .01$.

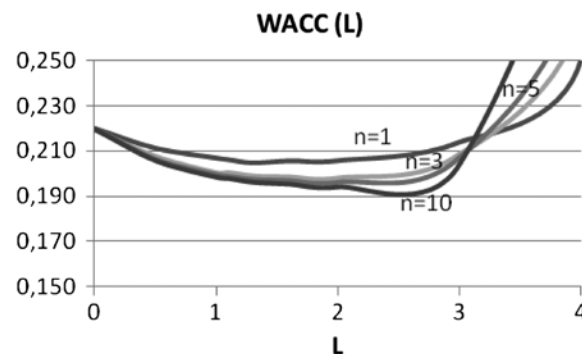


Figure 3. Dependence of equity cost k_e on leverage level L in case of exponential decrease of debt cost at $\alpha = .01$.

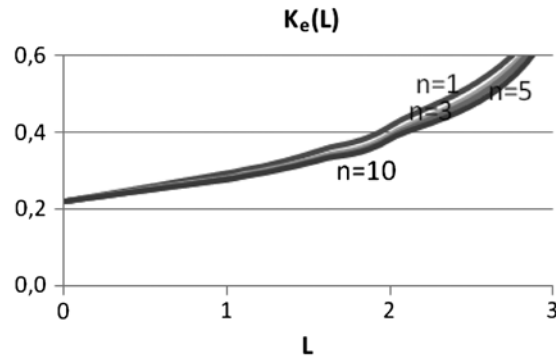


Figure 4. Dependence of debt cost k_d , equity cost k_e , and WACC on leverage level L in case of exponential decrease of debt cost k_d at $\alpha = .01$ for three-year company.

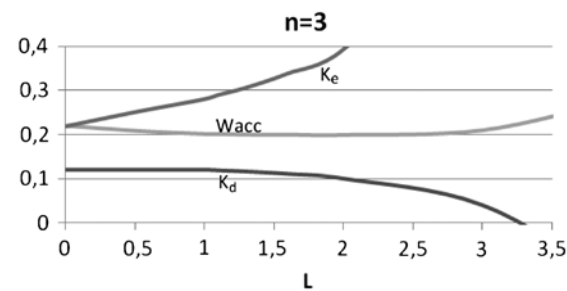


Figure 5. Dependence of debt cost k_d , equity cost k_e , and WACC on leverage level L in case of exponential decrease of debt cost k_d at $\alpha = .01$ for ten-year company.

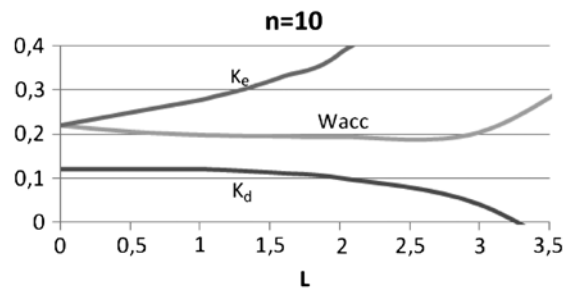


Figure 6. Dependence of WACC on leverage level L in case of exponential decrease of debt cost k_d at $\alpha = .1$.

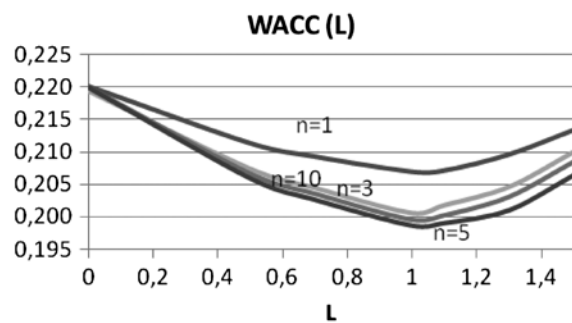


Figure 7. Dependence of equity cost k_e on leverage level L in case of exponential decrease of debt cost k_d at $\alpha = .1$.

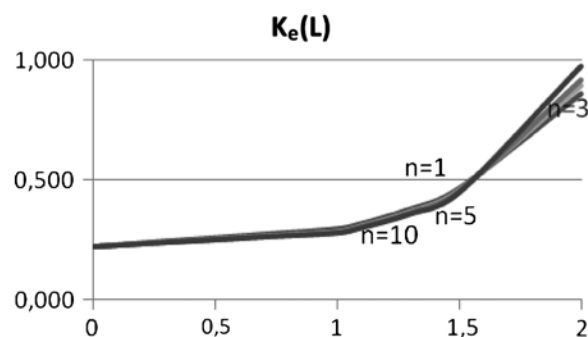


Figure 8. Dependence of debt cost k_d , equity cost k_e , and WACC on leverage level L in case of exponential decrease of debt cost k_d at $\alpha = .1$ for three-year company.

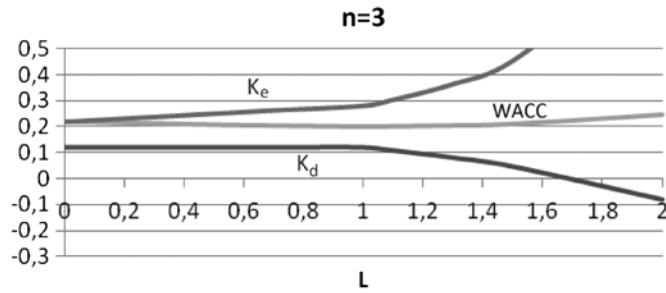


Figure 9. Dependence of debt cost k_d , equity cost k_e , and WACC on leverage level L in case of exponential decrease of debt cost k_d at $\alpha = .1$ for ten-year company.

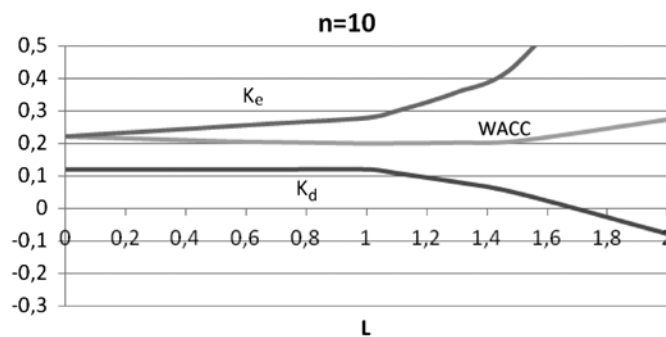


Table 2. Debt cost k_d , and WACC for companies with lifetimes $n = 1, 3, 5, 10$

L	0	.5	.7	1	1.1	1.3	1.5	2	4
k_d	.12	.12	.12	.12	.108	.081	.047	-.08	-2.48
WACC ($n=1$)	.220	.211	.209	.207	.207	.210	.213	.233	-.107
k_e ($n=1$)	.220	.257	.272	.294	.316	.377	.463	.860	9.384
WACC ($n=3$)	.219	.207	.204	.201	.202	.205	.210	.244	.079
k_e ($n=3$)	.219	.251	.264	.281	.304	.365	.455	.892	10.314
WACC ($n=5$)	.220	.207	.204	.200	.200	.203	.208	.252	.132
k_e ($n=5$)	.220	.250	.262	.279	.301	.362	.451	.916	10.578
WACC ($n=10$)	.220	.206	.203	.199	.199	.201	.206	.272	.170
k_e ($n=10$)	.220	.249	.261	.277	.299	.357	.446	.976	10.768

Table 3. Optimum position L^* and its depth $\Delta WACC$ for lifetimes $n = 1, 3, 5, 10$

n	Optimum position L^*				Optimum depth $\Delta WACC$			
	1	3	5	10	1	3	5	10
$\alpha = .01$	1.3	2	2	2	1.7%	2.2%	2.4%	2.6%
$\alpha = .1$	1-1.1	1	1-1.1	1-1.1	1.5%	2.1%	2.2%	2.3%

3.2. The quadratic decrease of debt cost k_d with leverage

Let us consider the quadratic decrease of debt cost k_d with leverage.

We will study below the dependence of debt cost k_d , equity cost k_e and WACC, on leverage level L in case of k_d quadratic decrease.

We use the same parameters, as above

$$L_0 = 1; \quad k_0 = 0.22; \quad k_d = 0.12; \quad t = 0.2$$

with the following dependence of debt cost k_d on leverage

$$k_d = \begin{cases} k_{d0} = \text{const}; & \text{at } L \leq L_0 = 1 \\ k_{d0} - \alpha \cdot (L - L_0)^2; & \text{at } L > L_0 = 1 \end{cases}$$

3.3. Three-year companies

For three-year companies we get the following results (Figures 10 and 11, Table 4).

Figure 10. Dependence of debt cost k_d , equity cost k_e , and WACC on leverage level L in case of quadratic decrease of debt cost k_d at $\alpha = .01$ for three-year company.

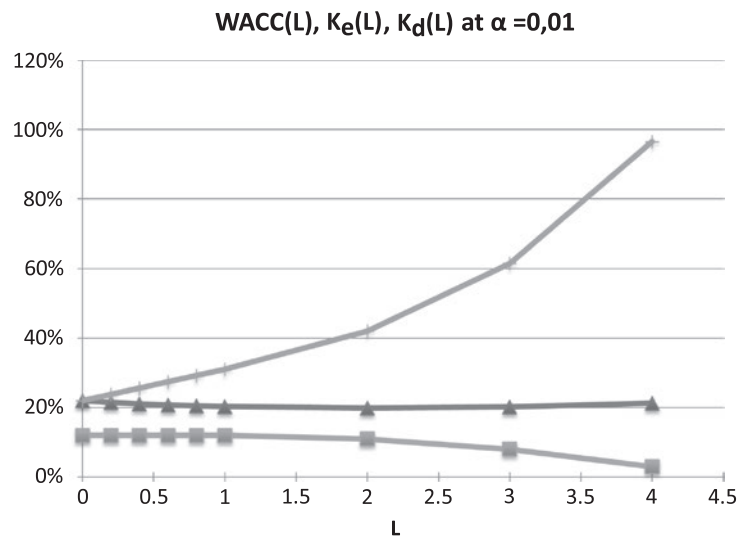


Figure 11. Dependence of debt cost k_d , equity cost k_e , and WACC on leverage level L in case of quadratic decrease of debt cost k_d at $\alpha = .1$ for three-year company.

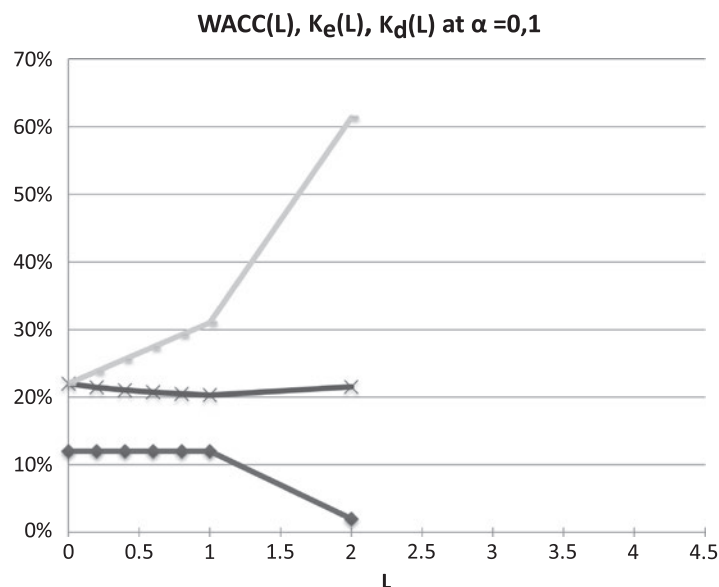


Table 4. k_d , k_e , and WACC for three-year companies

α	L	0	.2	.4	.6	.8	1	2	3	4
	w_d	.000	.167	.286	.375	.444	.500	.667	.750	.800
	w_e	1.000	.833	.714	.625	.556	.500	.333	.250	.200
.01	k_d	.12	.12	.12	.12	.12	.12	.11	.08	.03
.1	k_d	.12	.12	.12	.12	.12	.12	.02		
.01	WACC	.220	.214	.210	.207	.205	.203	.199	.202	.212
.1	WACC	.220	.214	.210	.207	.205	.203	.215		
.01	k_e	.22	.24	.26	.27	.29	.31	.42	.62	.97
.1	k_e	.22	.24	.26	.27	.29	.31	.61		

3.4. Ten-year companies

For ten-year companies we get the following results (Figures 12 and 13, Table 5).

Figure 12. Dependence of debt cost k_d , equity cost k_e , and WACC on leverage level L in case of quadratic decrease of debt cost k_d at $\alpha = .01$ for ten-year company.

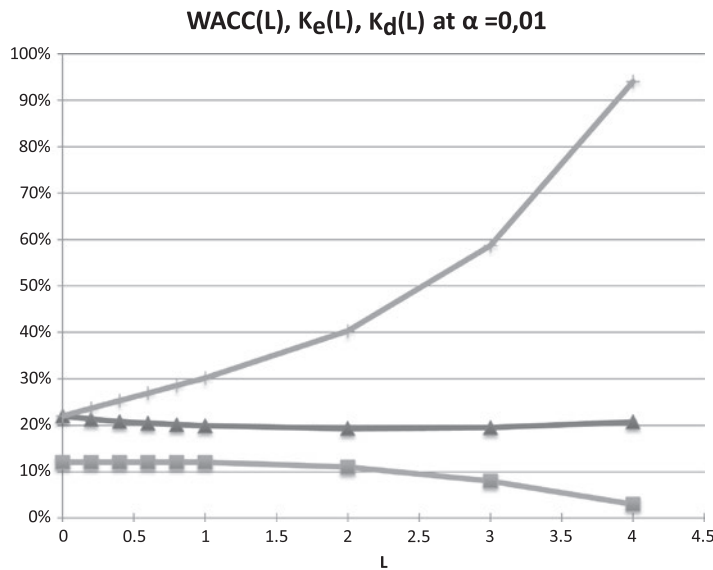


Figure 13. Dependence of debt cost k_d , equity cost k_e , and WACC on leverage level L in case of quadratic decrease of debt cost k_d at $\alpha = .1$ for ten-year company.

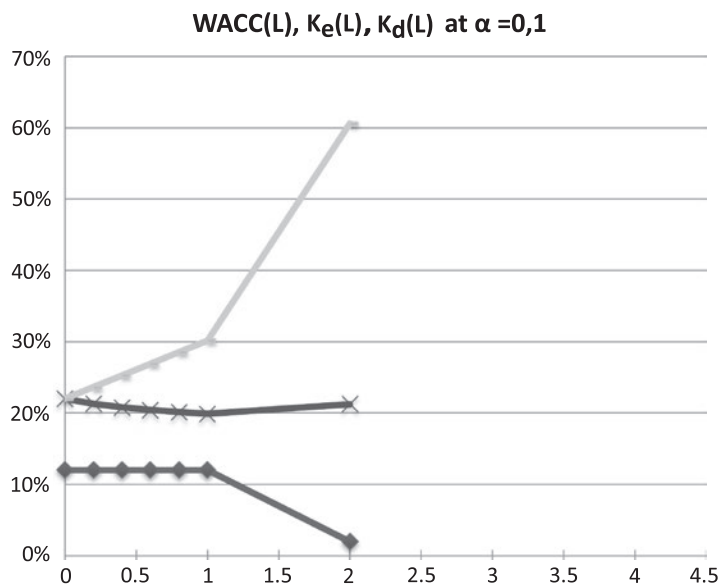


Table 5. k_d , k_e , and WACC for ten-year companies

α	L	0	.2	.4	.6	.8	1	2	3	4
	w_d	.000	.167	.286	.375	.444	.500	.667	.750	.800
	w_e	1.000	.833	.714	.625	.556	.500	.333	.250	.200
.01	k_d	.12	.12	.12	.12	.12	.12	.11	.08	.03
.1	k_d	.12	.12	.12	.12	.12	.12	.02		
.01	WACC	.220	.213	.208	.205	.202	.200	.194	.197	.210
.1	WACC	.220	.213	.208	.205	.202	.200	.214		
.01	k_e	.22	.24	.25	.27	.29	.3	.41	.6	.95
.1	k_e	.22	.24	.25	.27	.29	.3	.61		

Table 6. Optimum position L^* and its depth $\Delta WACC$ for lifetimes $n = 1, 3, 5, 10$

n	Optimum position L^*				Optimum depth $\Delta WACC$			
	1	3	5	10	1	3	5	10
$\alpha = .01$	2	2	2	2	2.7%	2.1%	2.6%	2.6%
$\alpha = .1$	1-1.1	1	1-1.1	1-1.1	2.1%	1.7%	2.2%	2.2%

Let us evaluate the optimum position L^* and its depth $\Delta WACC$, using obtained results (see Table 6).

4. Discussion of results

Thus, we have considered the impact of reducing of the cost of debt k_d with increases of debt volume. The article deals with two cases: quadratic and an exponential dependence of cost of debt k_d on leverage. We have considered other dependences as well, giving similar results.

It is shown that in considered cases, the equity capital cost of firm correlates with the debt cost that leads to the emergence of an optimal capital structure of companies. Cause of the emergence of an optimal structure is that the speed of increase of equity cost k_e of the firm begins to grow, starting from some leverage level L^* that not only compensates of the fall in cost of debt k_d with leverage, but it has also led to an increase in WACC with leverage, starting from some leverage level. This leverage level determines the optimal capital structure of the company.

It is found that, in all examined cases (quadratic as well as exponential one fall of debt cost) in the case of weak drops in debt cost with leverage ($\alpha = .01$), the optimal capital structure of the company is formed at bigger leverage values than the beginning of the fall (in our case $L^* \approx 2L_0$), and in the case of a stronger fall of k_d ($\alpha = .1$) the optimal capital structure of the company is formed directly near the start point of the fall of k_d ($L^* \approx L_0$).

It turns out that the depth of optimum (and, accordingly, the achieved in optimum company capitalization) is bigger at weak drops of debt cost with leverage ($\alpha = .01$), that is due to the more long-term fall in this case of the WACC with leverage L .

5. Conclusion

- (1) The Modigliani–Miller theory in its classical version in principle does not consider risky debt funds, therefore, within this theory it is not possible to investigate the current problem.
- (2) In the modified (by us) theory of Modigliani–Miller with the modeling of riskiness of debt funds by dependence of their cost of leverage level, as shown in this article, at arbitrary change of debt cost with leverage (the growing as well as the fall) the WACC always decreases with leverage, that demonstrates the absence of the optimal capital structure and proves insolvency of well-known classical trade off theory in its original formulation as well as the inability to implement the mechanism of formation of an optimal capital structure proposed in this article.

(3) Within modern theory of capital cost and capital structure by Brusov–Filatova–Orekhova (BFO theory) it is shown that decrease of debt cost with leverage leads to formation of minimum in dependence of the WACC on leverage at moderate leverage levels far from critical ones, at which financial distress appear and the bankruptcy risk increases. Existence of minimum in dependence of the WACC on leverage leads to maximum in company capitalization.

Thus, a new mechanism of formation of the company optimal capital structure, different from one, suggested by trade off theory (now insolvent) and which is based on the decrease of debt cost with leverage, has been developed by us in this paper (Figure 14).

The cause of optimum formation is as follows: decrease of debt cost with leverage leads to more significant grows of equity cost, which is not compensated by the fall of the debt cost and WACC starts to increase with leverage at some (moderate) leverage level. On the other hand, the increase of debt cost with leverage at higher leverage level leads, as we have shown before (Brusov et al., 2013a), to the fall of WACC with leverage.

Thus within BFO theory under suggestion of decrease of debt cost at moderate leverage levels and of its increase at high leverage levels WACC first decreases with leverage, then, going through minimum, starts to grow and finally fall continuously (under growing or constant debt cost).

Let us discuss the continuous reduction of WACC with leverage at high leverage levels in more detail. Note that at high leverage levels (contrary to the case at moderate leverage levels, where debt cost can decrease via the growth of debt volume), debt cost increases because financial distressed appear and the bankruptcy risk increases. As it has been proved by us in our previous paper (Brusov et al., 2013a), where the insolvency of well-known classical trade off theory has been demonstrated, any type of growth of debt cost leads to continuously fall of WACC with leverage.

Note, that in classical Modigliani–Miller theory WACC always falls with leverage via expression

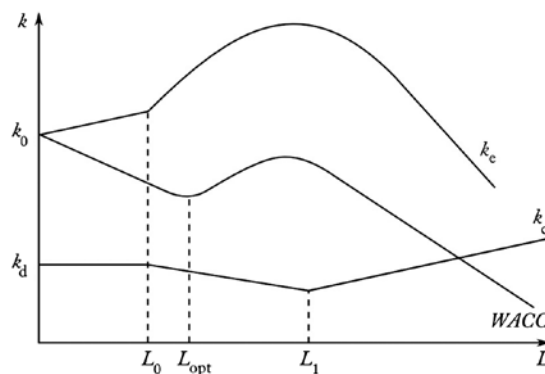
$$WACC = k_0(1 - w_d t)$$

where WACC falls from k_0 to $k_0(1 - t)$, when $L \rightarrow \infty$.

As we have shown in current paper above in modified Modigliani–Miller theory (allowing riskiness debt capital) under arbitrary change of debt cost with leverage (growing, as well as decrease) WACC always fall down with leverage.

Obtained by us within Brusov–Filatova–Orekhova theory conclusions concerning the existence of optimal capital structure do not depend qualitatively on velocity of debt cost fall. Only optimum depth and its position (but not its existence) depend on the particular form of dependence of debt cost on leverage (mainly on velocity of debt cost fall and significantly less on the particular form of function $f(L)$).

Figure 14. Mechanism of formation of the company's optimal capital structure, different from one, suggested by trade off theory. Decrease of debt cost with increase credit volume in leverage range from L_0 up to L_1 leads to formation of optimum in dependence WACC (L) at $L = L_{opt}$.



Results of this paper (under the condition of proved by us the insolvency of the classical trade off theory) allow companies to manage the debt volume in order to form a real optimal capital structure, where the WACC has minimum and consequently the company capitalization has a maximum. Suggested mechanism is real, because it is based on real situation in business: a credit rate depends on debt volume—banks give a lower credit rate for higher debt volume.

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