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Incorporating CAPM into Capital Structure Theories: Accounting for Business and Financial Risks

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ABSTRACT

In order to create a methodology for assessing the company's main financial indicators, taking into account both business and financial risks, the CAPM and Fama-French models were included in the two main theories of capital structure - the Brusov-Filatova-Orekhova (BFO) theory and the Modigliani-Miller (MM) theory. CAPM takes into account systematic (business) risk, while capital structure theories take into account the financial risk of a specific company, associated with debt financing. As a result, generalized approaches (CAPM-BFO and CAPM–MM) were developed that take into account both types of risk: systematic (business) and financial. The Fama-French model with three and five factors is also considered and included. The latest versions of the two main theories of capital structure (BFO and MM), adapted to the established financial practice of the functioning of companies, are used, taking into account the real conditions of their work, such as variable income, frequent income tax payments, advance income tax payments, etc. Practical calculations have been made. They focus on (1) applying two versions of CAPM (market or industry) to real companies; (2) application to real companies of a new methodology developed by us for assessing the financial performance of a company, taking into account both business (market or industry) and financial risks. The calculations made for three real companies (Apple, Severstal, Polymetal) show that the financial performance of companies is highly dependent on the type of risks taken into account. Sometimes the difference between market and industry cases is small, sometimes it is significant. But the difference in financial indicators, while taking into account simultaneously financial and business risks, is always great. This means that taking into account simultaneously both financial and business risks is important for a correct assessment of the financial performance of companies. The developed approach makes it possible to use the powerful tools of these highly developed theories (BFO and MM) for the correct assessment of the main financial indicators of the company and their forecasting, taking into account both types of risks.

Keywords: business and financial risks; capital structure; Modigliani-Miller (MM) theory; Brusov-Filatova-Orekhova (BFO) theory; risk and profitability; CAPM 2.0; Fama-French model

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INTRODUCTION

In the real economy, financial and business risks exist. Financial risks are related to the use of debt financing and are described by capital structure theories. Business risks are associated with investments in a specific company (and not the entire market (industry)) and are described in CAPM (market or industry version).

Based on the portfolio theory by Harry Markowitz, the Capital Asset Pricing Model (CAPM) was developed independently [1–5] by Jack Traynor (1961), William F. Sharp (1964), John Lintner (1965) and Jan Mossin (1966). Two main capital structure theories, Brusov-Filatova-Orekhova (BFO) [6–7] theory and Modigliani-Miller (MM) theory [8–10] describe financial risks. The Miles-Ezzell model [11–13] offers an alternative approach to the problem of capital structure. This is discussed below, along with some others [14].

Statement of the problem: when assessing the profitability of an asset, take into account both financial and business risks. A fundamentally new approach to assessing the profitability of an asset is proposed. Transition from CAPM, which takes the same risk-free return for all assets as an initial assessment, to a new methodology, in which the average return of an asset, cleared of leverage, with the addition of a premium for business risk (market or industry), is taken as a seed return, significantly improves the accuracy of the estimate.

The incorporation of the CAPM [1–5] and Fama-French models [15–18] into the theory of capital structure will allow taking into account the business risk taken into account in these models, along with the financial risk taken into account in the Brusov-Filatova-Orekhova (BFO) [6–7] theory and Modigliani-Miller (MM) theory [8–10]. Hamada's attempt to account for the leverage level is discussed [19, 20].

CAPM
(CAPITAL ASSET PRICING MODEL)

Market Approach

CAPM is a simple, but widely used, one-factor model that describes the relationship between the expected return on assets (stocks, investments, etc.) and the risk-free rate, taking into account systematic (business) risk. This relationship is described by the equity risk premium, which depends on the asset's beta (which describes the asset's correlation or sensitivity to the market), the risk-free rate (say, the Treasury bill rate or the central bank's key rate), and the expected return in the market.

The following assumptions are made within the CAPM model:

1) All investors are risk averse and have the same time frame to evaluate information.

2) Unlimited capital exists to borrow at the risk-free rate.

3) Investments can be divided into unlimited parts and sizes.

4) Taxes, inflation and transaction costs are absent.

5) Return and risk are linearly related.

CAPM (Capital Asset Pricing Model) describes the profitability of assets and is described by the following formula:

$$k_i = k_f + \beta_i \left(k_m - k_f\right). \quad (1)$$

Here, k_f is risk free profitability, β is the β-coefficient of the company. It shows the dependence of the return on the asset and the return on the market as a whole. The β-coefficient is described by the following formula:

$$\beta_i = \frac{\mathrm{cov}_{im}}{\sigma_m^2} = \rho_{im}\frac{\sigma_i}{\sigma_m}. \quad (2)$$

Here σ_i is the risk (standard deviation) of i-th asset, σ_m is market risk (standard deviation of market index), cov_{im} is covariance between i-th asset and market portfolio.

An investor invests in risky securities only if their return is higher than the return on risk-free securities, so always $k_i > k_f$ and $k_m > k_f$.

The beta-coefficient of a security, β has the meaning of the amount of riskiness of this security. It follows from formula (1) that:

1) if β = 1 the yield of the security is equal to the yield of the average market portfolio ($k_i = k_f$);

2) if β > 1, the security is more risky than the average on the security market ($k_i > k_f$);

3) if β < 1, the security is less risky than the average on the security market ($k_i < k_f$).

Securities betas are calculated using statistical data on returns on specific securities and the average market returns on securities traded on the market.

Disadvantages of the CAPM model

CAPM has some well-known disadvantages.

1. The CAPM formula only works under the assumption that purely rational players who make decisions that favor only investment returns dominate the market. This, of course, is not always true.

2. CAPM assumes that each market participant acts on the basis of the same information. In reality, relevant information is distributed unevenly among the public, so some participants may make decisions based on information that others do not.

3. Using beta as the main part of the formula. But beta takes into account only changes in the stock price in the market. However, the share price can change for reasons other than the market. Stocks can rise or fall in value for deliberate reasons, not just volatility.

4. CAPM only uses historical data. But historical stock price changes are not enough to determine the overall risk of an investment. Other factors should be considered, such as economic conditions, industry peculiarities and competitor characteristics, and internal and external activities of the company itself.

Another very important shortcoming of CAPM, which is eliminated as part of the new approach is that it assumes the same risk-free return on all assets as the original valuation. Also, CAPM takes into account the profitability of a particular asset only in the beta coefficient.

The model operates on only one factor that affects the future performance of a stock. In 1992, E.F. Fama and K.R. French [15–18] proved that future returns are also affected by factors such as company size and industry affiliation.

The model has a number of limitations: it does not take into account taxes, transaction costs, non-transparency of the financial market, etc.

Finally, to predict future returns, a retrospective level of market risk is used, which leads to a forecast error.

Industry Approach

CAPM has an alternative approach that refers to the industrial index rather than the market.

$$k_i = k_f + \beta_i \left(k_I - k_f\right). \quad (3)$$

Here, k_f is risk free profitability, is the β-coefficient of the company. In this case it shows the dependence of the return on the asset and the return on the industry as a whole. The β-coefficient now is described by the following formula

$$\beta_i = \frac{\mathrm{cov}_{iI}}{\sigma_I^2} = \rho_{iI}\frac{\sigma_i}{\sigma_I}. \quad (4)$$

Here σ_i is the risk of i-th asset, σ_I is industry risk (standard deviation of industry index), cov_{iI} is covariance between i-th asset and industry index. Note, that the industry approach better describes the return on an asset than the market approach.

The CAPM approach is still evolving and we will describe one of the directions of this development below.

The Symmetric CAPM

The Capital Asset Pricing Model (CAPM) assumes a Gaussian or Normal distribution. In practice, this assumption may be violated. In [21], a symmetric CAPM is proposed, assuming distributions with lighter or heavier tails than the normal distribution. Elliptic distributions (normal, exponential and Student-t) are considered.

In addition, the authors of [21] study the methods of leverage and local impact for diagnostics in a symmetric CAPM. It is concluded that the considered models give better results than the CAPM with Gaussian distribution.

In [22–24], empirical studies were carried out under the assumption that stock returns have distributions with heavier tails than the normal distribution.

The Student-t distribution instead of the normal distribution was considered in [23] and in [25], taking into account the maximum likelihood method for estimating its parameters. Paper [24] concluded that asset valuation should be carried out within the framework of the CAPM and the discounted dividend model.

HAMADA MODEL

The Modigliani-Miller theory, with the accounting of taxes has been united with CAPM (capital asset pricing model) in 1961 by Hamada [19, 20]. For the cost of equity of a leveraged company, the below formula has been derived.

$$k_e = k_f + \beta_U\left(k_m - k_f\right) + \beta_U\left(k_m - k_f\right)\frac{D}{S}(1-t). \quad (5)$$

The first term represents risk-free profitability k_f, the second term is business risk premium, $\beta_U\left(k_m - k_f\right)$, and the third term is financial risk premium $\beta_U\left(k_m - k_f\right)\frac{D}{S}(1-t)$.

In the case of an unlevered company ($D = 0$), the financial risk (the third term) is zero, and its shareholders receive only a business risk premium.

Hamada used an empirical approach in incorporating the level of leverage into the CAPM. One of the main objectives in his research was to distinguish companies without leverage from companies with leverage. The latter make up almost the majority of real companies. In 1972, he surveyed 304 companies, among which he found 102 non-leveraged and 202 leveraged [20]. Comparing the equity returns of two types of companies, he got his formula for the β-factor, which takes into account the level of leverage.

In our approach, we do the opposite thing: we incorporate CAPM and Fama-French models into two main theories of the capital structure — the Brusov-Filatova-Orekhova (BFO) theory and the Modigliani-Miller (MM) theory. In addition, we do this analytically.

Our methodology, developed below, avoids this problem of finding non-leveraged companies (which practically do not exist) by clearing the average return of an asset from leverage using the formula (7), which allows to find k_0 value (cost of equity at zero leverage level).

Equating CAPM formula (1) to the right side of formula (3), one gets:

$$k_f + \beta\left(k_m - k_f\right) = k_f + \beta_U\left(k_m - k_f\right) + \\ + \beta_U\left(k_m - k_f\right)\frac{D}{S}(1-t) \quad (6)$$

or

$$\beta = \beta_U\left(1 + \frac{D}{S}(1-t)\right) = \beta_U\left(1 + L(1-t)\right), \quad (7)$$

where β is beta-coefficient for leveraged company.

The Incorrectness of Hamada's Approximation

The Miles-Ezzell model versus the Modigliani-Miller theory has been discussed in [26, 27] (see below).

If we try to combine the CAPM and MM theory not phenomenologically, like Hamada, but analytically, then the incorrectness of Hamada's approximation becomes obvious [28–31]. Substituting the CAPM formula:

$$k_0 = k_f + \beta_U\left(k_m - k_f\right) \quad (8)$$

into Modigliani-Miller formula for equity cost

$$k_e = k_0 + L\left(k_0 - k_d\right)(1-t), \quad (9)$$

one gets the following result

$$k_e = k_0 + L\left(k_0 - k_d\right)(1-t) = \\ = k_f + \beta_U\left(k_m - k_f\right) + L\left(k_f + \beta_U\left(k_m - k_f\right) - k_d\right)(1-t) = \\ = k_f\left(1 + L(1-t)\right) + \beta_U\left(k_m - k_f\right)\left(1 + L(1-t)\right) - Lk_d(1-t). \quad (10)$$

The second term is the same as in Hamada's formula (7), but the first term is renormalized value of risk-free profitability and the last term, which depends on the cost of debt kd, is missing from Hamada's formula (7).

So the difference with Hamada's formula is:

while in Hamada's formula only beta coefficient is renormalized, in formula (10) the first term (risk-free return) is also renormalized by the same factor $\left(1 + L(1-t)\right)$ and the last term, depending on the cost of debt k_d, appears, which is absent in Hamada's formula. Factor $(1-t)$ (tax corrector) exists due to the tax shield.

The incorrectness of Hamada's approximation becomes obvious.

Note that recently the authors [28–31] for the first time generalized CAPM to take into account both business and financial risks and developed a new model CAPM 2.0. They showed that R. Hamada's attempt to take into account both business and financial risks [19, 20] was untenable, and the formulas he obtained, which are widely used in practice, are incorrect. The authors of [28–31] derived correct formulas that take into account both business and financial risks. The application of the new CAPM 2.0 model to a number of companies is considered, and the difference between the results obtained within the framework of CAPM 2.0 and CAPM is demonstrated.

Disadvantages of Hamada's approach:

Difficulty in finding a non-leveraged company. It is clear that the vast majority of companies are leveraged because they use debt financing.

FAMA-FRENCH MODELS

Fama-French Three-factor Model

Fama-French three-factor model [15–18] takes into account two additional risk factors, namely, size and book-to-market equity along with market beta:

$$k_e = k_f + \beta_U\left(k_m - k_f\right) + s \cdot SMB + h \cdot HML, \quad (11)$$

were *SMB* — the difference between the returns of companies with large and small capitalization; *HML* — the difference between the returns of companies with low and high intrinsic value (indicator B/P).

Fama-French Five-factor Model

$$k_e = k_f + \beta_U\left(k_m - k_f\right) + s \cdot SMB + \\ + h \cdot HML + r \cdot RMW + c \cdot CMA, \quad (12)$$

where *RMW* — return on equity; *CMA* — company capital expenditure.

CAPITAL STRUCTURE THEORIES

Modigliani-Miller Theory

The first quantitative theory of capital structure was the well-known theory of Nobel laureates Modigliani-Miller [8–10]. This theory was based on many restrictions. One of the main limitations of the Modigliani-Miller theory about the eternity of companies was removed by Brusov et al. in 2008 [6–7], and modern theories of the cost of capital and capital structure — the Brusov-Filatova-Orekhova theory (BFO-theory) was created for companies of arbitrary age (BFO-1 theory) and for companies of arbitrary lifetime (BFO-2 theory) [14]. Brusov-Filatova-Orekhova (BFO) theory, has modified the Modigliani and Miller theory with this respect. The authors departed from the Modigliani-Miller assumption about the eternity (infinity of lifetime) of companies and developed an innovative quantitative theory for assessing the main parameters of the financial activity of companies of arbitrary age. The results of the modern BFO theory turn out to be quite different from the results of the Modigliani-Miller theory. They show that the latter, through its perpetuity, underestimates the weighted average cost of capital, the cost of equity of the company, and significantly overestimates the company's value.

Such an incorrect assessment of key performance indicators of companies' financial performance was one of the implicit causes of the 2008 global financial crisis.

Brusov-Filatova-Orekhova (BFO) Theory

In the Modigliani-Miller theory, there is no time factor (time is equal to infinity), which does not allow to study the dependence of the company's financial performance on the time factor. But Brusov-Filatova-Orekhova theory (BFO-theory) was created for companies of arbitrary age and allows to study the dependence of the company's financial performance on the time factor.

Brusov-Filatova-Orekhova and its perpetual limit — Modigliani-Miller (MM) theory — are described by the following formulas for the weighted average cost of capital *WACC:*

$$\frac{1-(1+WACC)^{-n}}{WACC}=\frac{1-(1+k_0)^{-n}}{k_0\cdot\left(1-w_d t\left[1-(1+k_d)^{-n}\right]\right)} \quad (13)$$

$$WACC=k_0\cdot(1-w_d t), \quad (14)$$

here $w_d=\frac{D}{D+S}$ — the share of debt capital; $k_e, w_e=\frac{S}{D+S}$ – the cost and the share of the equity capital of the company, and $L=D/S$ — financial leverage; D — the value of debt capital.

Alternative Expression for *WACC*

Alternative formula for the *WACC*, different from Modigliani-Miller one has been derived in [11, 12] from the *WACC* definition and the balance identity:

$$WACC=k_0(1-w_d t)-k_d t w_d+k_{TS} t w_d, \quad (15)$$

where k_0, k_d and k_{TS} are the expected returns respectively on the unlevered company, the debt and the tax shield.

Some additional conditions are required for equation (13) practical applicability. If the WACC is constant over time, as stated in [11], the levered company capitalization is found by discounting with the WACC of the unlevered company.

In textbooks [32], formulas for the special cases, where the WACC is constant, could be found.

In 1963, Modigliani and Miller assume that the debt value D is constant. Then, as the expected after-tax cash flow of the unlevered firm is fixed, V_0 is constant as well. By assumption, $k_{TS}=k_D$ and the value of the tax shield is $TS = tD$. Thus, the capitalization of the company V is a constant and the alternative formula (13) becomes a formula for a constant *WACC:*

$$WACC=k_0(1-w_d t). \quad (16)$$

Because the debt k_D and the tax shield k_{TS} have debt nature it seems reasonable that the expected returns on they are equals as suggested by "classical" Modigliani-Miller (MM) theory, which has been modified by Brusov et al. [6, 10, 14] for cases of practical meanings.

The Miles-Ezzell Model Versus the Modigliani-Miller Theory

Denis M. Becker in 2021 discussed [26] the differences between the Modigliani-Miller theory and the Miles-Ezzell model [11–13], which deal with the stochasticity of free cash flows. The author conducts a numerical experiment that allows you to determine the values and discount rates using a risk-neutral approach. He analyzes three formulas:

Modigliani-Miller theory [8–10]

$$WACC = k_0 \cdot (1 - w_d t), \quad (17)$$

Miles-Ezzell model [11–13],

$$WACC = k_0 - t \cdot w_d \cdot k_f \cdot \frac{1 + k_0}{1 + k_f}, \quad (18)$$

I.A. Cooper and K.G. Nyborg [27]

$$WACC = k_0 - k_f \cdot w_d t, \quad (19)$$

where k_f stands for the risk-free rate, which equals the required return of the debt holders.

The author shows that in the Miles-Ezzell model, all cash flows and values depend on the path, in contrast to the Modigliani-Miller theory. Also in the Miles-Ezzell model, all discount rates are time independent, with the exception of the discount rate used to discount tax shields, which depends on the duration of the cash flows. Conversely, in the Modigliani-Miller theory, all discount rates change over time, except for the constant tax shield discount rate. This affects the applicability of the well-known formula for annuities and the development of models for estimating both finite and perpetual cash flows.

In this paper Becker [26] raises the issue of paying the debt body together with payment of interest on the debt. Regarding this issue, we would like to note that in both classical MM and BFO theories, the body of the debt is not paid. In the framework of the Modigliani-Miller theory, such an account is fundamentally impossible, while in the BFO theory it can be done and was done in the framework of the BFO-2 theory, where the amount of debt D decreases with time. This decrease in the value of debt D results in a decrease in the tax shield.

In Brusov-Filatova-Orekhova and its perpetual limit — Modigliani-Miller (MM) theory, one of the most important parameters is the equity cost of an unlevered company k_0. Knowing it, one can evaluate the main financial indicators, such as the cost of capital raised, the discount rates $WACC$ and k_e, the value of the company, V, the cost of equity capital, k_e, and their dependence on debt financing, taxation, company age, etc.

One way to find k_0 is as follows: if we know $WACC$ and L, we substitute these values into the formulas for $WACC$ (or BFO, or MM) and find k_0 from here.

INCORPORATING CAPM AND FAMA-FRENCH MODELS INTO CAPITAL STRUCTURE THEORIES

If we use the CAPM formula for a company without leverage, then we can use this return value as k_0. If we use the CAPM formula for a leveraged company (Hamada formula), then we should "clear" this formula from leverage and only after that can you use the resulting return value as k_0.

The company's profitability k_i is taken from the company's financial statements either for the year, or for the quarter, or for the month, or for a day. If you need to find out the profitability for several periods, you need to use the following formula:

$$k_i = \prod_{k=1}^{n} (1 + k_{ik}) - 1. \quad (20)$$

Although in the CAPM it is declared that the company profitability k_e is for an unleveraged company, since it is taken from the company's financial statements, it is clear that it is defined for a leveraged company.

Since both theories of capital structure (BFO and MM) use non-leveraged cost of equity as a seed value for the cost of equity, it is necessary to remove k_i from leverage.

The simplest way to do this is to use the MM formula for the cost of equity

$$k_i = k_0 + L(k_0 - k_d)(1 - t), \quad (21)$$

$$k_0 = \frac{k_i + Lk_d(1 - t)}{1 + L(1 - t)}. \quad (22)$$

Table 1

Cost of Equity with Non-Zero Leverage and Its Cleaned Value k_0 (GAZP)

Indicator	2021	2020	2019	2018
k_0	3.529%	6.106%	5.587%	4.542%
Leverage level, L	0.500	0.538	0.448	0.486
Debt cost, k_d	0.017	0.021	0.017	0.020
GAZP, average profitability	4.26%	7.83%	6.98%	5.53%
GAZP, standard deviation	0.945%	0.840%	0.415%	0.310%

Source: Compiled by the authors.

Here k_0 is k_i value, cleaned from leverage.

To clean k_f value used BFO theory, one should use formula

$$k_e = WACC(1+L) - k_d L(1-t), \tag{23}$$

but you need to know the value of *WACC* at a specific value of the leverage level *L*.

We could include a business risk premium at two levels: (1) at market level or (2) at industry level.

To include a market risk premium, one needs to add to k_0 the following term

$$\beta_{im}(k_m - k_F). \tag{24}$$

To include an industry risk premium, one needs to add to k_0 the following term

$$\beta_{iI}(k_I - k_F). \tag{25}$$

To include effects, described by Fama-French model, we should add the following terms:

either two terms within Fama-French three — factor Model

$$s \cdot SMB + h \cdot HML, \tag{26}$$

or four terms within Fama-French Five-factor Model

$$s \cdot SMB + h \cdot HML + r \cdot RMW + c \cdot CMA. \tag{27}$$

As result we get

$$\begin{gathered} k_0 = k_f + \beta_U(k_m - k_f) + s \cdot SMB + h \cdot HML = \\ = \frac{k_f + Lk_d(1-t)}{1+L(1-t)} + \beta_U(k_m - k_f) + s \cdot SMB + h \cdot HML \end{gathered} \tag{28}$$

$$\begin{gathered} k_0 = k_f + \beta_U(k_m - k_f) + s \cdot SMB + \\ + h \cdot HML + r \cdot RMW + c \cdot CMA = \\ = \frac{k_f + Lk_d(1-t)}{1+L(1-t)} + \beta_U(k_m - k_f) + \\ + s \cdot SMB + h \cdot HML + r \cdot RMW + c \cdot CMA. \end{gathered} \tag{29}$$

We use this value k_0 to study the dependence of the company's main financial indicators on debt financing, the cost of debt, taxation, the age of the company etc.

$$\begin{gathered} k_0 = k_f + s \cdot SMB + h \cdot HML = \\ = \frac{k_f + \beta_U(k_m - k_f) + Lk_d(1-t)}{1+L(1-t)} + s \cdot SMB + h \cdot HML, \end{gathered} \tag{30}$$

$$\begin{gathered} k_0 = k_f + s \cdot SMB + h \cdot HML + r \cdot RMW + c \cdot CMA = \\ = \frac{k_f + \beta_U(k_m - k_f) + Lk_d(1-t)}{1+L(1-t)} + s \cdot SMB + \\ + h \cdot HML + r \cdot RMW + c \cdot CMA. \end{gathered} \tag{31}$$

The algorithm for Using this Innovative Technique

1. Take the average return on the asset for the year from statistical data.

2. Clean of it from leverage using equation (9) for k_e.

It can be seen from *Table 1*, that the values of k_0 are always lower than the cost of equity with non-zero leverage, as it should be, given that the cost of equity increases with leverage.

Add a Market Business Risk Premium, or an Industry One

Let us give an example for GAZP company for 2018.

To find premium to k_0, let us calculate Δk_0 within market CAPM approach:

$\beta = 1.16$;

$k_m - k_f = 12.3\% - 7.75\% = 4.55\%$;

$\Delta k_0 = 1.16 \cdot 4.55\% = 5.278\%$.

Finally, one gets

$$\hat{k}_0 = k_0 + \Delta k_0 = 1.16 \cdot 4.55\% = \\ = 4.542\% + 5.278\% = 9.82\%.$$

It is easy to see, that account of business risk within market CAPM approach change k_0 from 4.542% to $\hat{k}_0 = 9.82\%$.

It is seen, that the use of $\hat{k}_0$, which takes into account the business risk, will significantly change the results of calculation of the financial indicators of the GAZP.

Add Fama-French corrections (use either three factor Fama-French model or five factor Fama-French model.

Now we are ready to use the obtained k_0 value to calculate the main financial parameters of the company: the cost of raising capital, *WACC*, company value, etc. The theory of Brusov-Filatova-Orekhova (BFO) and its eternal limit — the theory of Modigliani-Miller (MM) — have recently been generalized to the established practice of the functioning of companies. This generalization took into account the real conditions of the company's activities, such as variable income, frequent income tax payments, advance income tax payments, etc. This made it possible to investigate the impact of these conditions on its main financial indicators (see Review [14]).

A few practical calculations have been made for real companies (see below in sections 6, 7). They focus on:

(1) applying two versions of CAPM (market or industry) to real companies (PJSC Polymetal and PJSC Severstal);

(2) application to Apple company of a new methodology developed by us for assessing the financial performance of a company, taking into account both business (market or industry) and financial risks.

WACC FORMULAS FOR BRUSOV-FILATOVA-OREKHOVA (BFO) — THEORY AND FOR MODIGLIANI–MILLER (MM) — THEORY

Below we give a summary of the WACC formulas for Brusov-Filatova-Orekhova (BFO) — theory as well as for Modigliani-Miller (MM) — theory (see Review [14]).

Variable Income Case

Income tax payments at the ends of periods

BFO:

$$\frac{1-\left(\frac{1+g}{1+WACC}\right)^n}{WACC-g} = \frac{1-\left(\frac{1+g}{1+k_0}\right)^n}{(k_0-g)\cdot\left(1-w_d t\left[1-(1+k_d)^{-n}\right]\right)}, \quad (32)$$

$$\text{MM: } WACC = (k_0 - g)\cdot(1 - w_d t) + g. \quad (33)$$

Advance Income Tax Payments

BFO:

$$\frac{1-\left(\frac{1+g}{1+WACC}\right)^n}{WACC-g} = \frac{1-\left(\frac{1+g}{1+k_0}\right)^n}{(k_0-g)\cdot\left(1-w_d t\left[1-(1+k_d)^{-n}\right]\cdot(1+k_d)\right)}. \quad (34)$$

$$\text{MM: } WACC = (k_0 - g)\cdot\left(1 - w_d t\cdot(1+k_d)\right) + g. \quad (35)$$

Frequent Income Tax Payments

Income Tax Payments at the Ends of Periods

BFO:

$$\frac{1-(1+WACC)^{-n}}{WACC} = \frac{1-(1+k_0)^{-n}}{k_0\cdot\left(1-\frac{k_d w_d t}{p}\frac{\left[1-(1+k_d)^{-n}\right]}{(1+k_d)^{1/p}-1}\right)}, \quad (36)$$

$$\text{MM: } WACC = k_0 \cdot \left(1 - \frac{k_d w_d t}{p \cdot \left[\left(1+k_d\right)^{1/p} - 1\right]}\right). \quad (37)$$

Advance Income Tax Payments

BFO:

$$\frac{1-\left(1+WACC\right)^{-n}}{WACC} = \frac{1-\left(1+k_0\right)^{-n}}{k_0 \cdot \left(1 - \frac{k_d w_d t}{p} \frac{\left[1-\left(1+k_d\right)^{-n}\right] \cdot \left(1+k_d\right)^{1/p}}{\left(1+k_d\right)^{1/p} - 1}\right)}, \quad (38)$$

$$\text{MM: } WACC = k_0 \cdot \left(1 - \frac{k_d w_d t \cdot \left(1+k_d\right)^{1/p}}{p \cdot \left[\left(1+k_d\right)^{1/p} - 1\right]}\right). \quad (39)$$

Simultaneous Accounting of Variable Income in Case of Frequent Income Tax Payments

Income Tax Payments at the Ends of Periods

BFO:

$$\frac{1-\left(\frac{1+g}{1+WACC}\right)^{n}}{WACC-g} = \frac{1-\left(\frac{1+g}{1+k_0}\right)^{n}}{\left(k_0-g\right) \cdot \left(1 - \frac{k_d w_d t}{p} \frac{\left[1-\left(1+k_d\right)^{-n}\right]}{\left(1+k_d\right)^{1/p} - 1}\right)}, \quad (40)$$

$$\text{MM: } WACC - g = \left(k_0 - g\right) \cdot \left(1 - \frac{k_d w_d t}{p \cdot \left(1+k_d\right)^{1/p} - 1}\right) \quad (41)$$

Advance Income Tax Payments

BFO:

$$\frac{1-\left(\frac{1+g}{1+WACC}\right)^{n}}{WACC-g} = \frac{1-\left(\frac{1+g}{1+k_0}\right)^{n}}{\left(k_0-g\right) \cdot \left(1 - \frac{k_d w_d t}{p} \frac{\left[1-\left(1+k_d\right)^{-n}\right] \cdot \left(1+k_d\right)^{1/p}}{\left[\left(1+k_d\right)^{1/p} - 1\right]}\right)}, \quad (42)$$

$$\text{MM: } WACC - g = \left(k_0 - g\right) \cdot \left(1 - \frac{k_d w_d t \cdot \left(1+k_d\right)^{1/p}}{p \cdot \left(1+k_d\right)^{1/p} - 1}\right). \quad (43)$$

APPLICATION OF TWO VERSION OF CAPM (MARKET AND INDUSTRY) TO REAL COMPANIES

Estimation of the Cost of Equity of PJSC Polymetal for the Period 2018–2022 by CAPM Capital Asset Pricing Model (Ticker PJSC Polymetal on the Moscow Exchange is POLY)

In *Table 2* below the summary of indicators for Polymetal shares, the RTS mining and metal index and the MICEX index in the period 2018–2022 are shown

This *Table 3* gives:

(1) the company's average annual return;

(2) the company's profitability with an industry risk premium;

(3) profitability of a company with a market risk premium

Estimation of the Cost of Equity of PJSC Severstal for the Period 2018–2022 by CAPM Capital Asset Pricing Model (Ticker PJSC Severstal on the Moscow Exchange is CHMF)

The last three lines in *Table 4* give:

(1) the company's average annual return;

(2) the company's profitability with an industry risk premium;

(3) profitability of a company with a market risk premium

APPLICATION OF NEW METHODOLOGY FOR ASSESSING THE COMPANY'S FINANCIAL PERFORMANCE

Below we apply the developed by us new methodology for assessing the company's financial performance, taking into account both business (market and industry) and financial risks to the Apple company in 2019–2021.

As Market we take S&P 500; as Industry (sector): S&P500 Information Technology and we consider period 2019–2021.

The Collection and Processing of Statistical Data About the Company, Industry and Market and Two Versions of CAPM (Market and Industry)

Below in *Table 5* the collection and processing of statistical data about the company, industry and market and two versions of CAPM (market and industry) are shown.

Comments

The following formulas were used to calculate the company's profitability using the CAPM model:

For calculation by industry (sector): $\mu_i = \mu_F - \beta_{iI}\left(\mu_I - \mu_F\right)$, where μ_i — average annual return per share; μ_F — US market risk free rate; β_{iI}

Table 2

Summary Table of Indicators for Polymetal Shares, the RTS Mining and Metal Index and the MICEX Index in the Period 2018–2022

Year	2018	2019	2020	2021	2022
Company level (Polymetal)					
Profitability actual	3.48%	32.80%	78.71%	–24.39%	–71.71%
Standard deviation	0.304	0.242	0.454	0.264	0.705
Average debt cost	3.52%	4.89%	4.00%	2.88%	3.28%
Leverage level	4.78	3.41	1.57	0.54	1.6
Industry level (RTS mining and metal index)					
Profitability actual	2.11%	40.20%	56.08%	12.37%	–9.80%
Standard deviation	0.233	0.144	0.390	0.230	0.580
Average leverage level	0.408	0.370	0.351	1.128	0.818
Beta with Polymetal	0.208	0.107	0.436	0.349	0.250
Profitability (industry CAPM)	6.79%	11.07%	27.97%	9.10%	4.96%
Correlation with Polymetal	0.27	0.18	0.51	0.40	0.30
Market level (Moscow Exchange index MICEX)					
Profitability actual	18.15%	36.24%	22.57%	3.25%	–16.78%
Standard deviation	0.167	0.120	0.271	0.163	0.497
Beta with Poly	0.443	0.189	0.516	0.307	0.508
Profitability (market CAPM)	12.51%	12.99%	14.67%	6.09%	–3.68%
Correlation with Polymetal	0.24	0.09	0.31	0.19	0.36

Source: Compiled by the authors.

Table 3

Actual and Projected Returns Based on CAPM Models for Polymetal Shares in the Period 2018–2022

Profitability actual	3.48%	32.80%	78.71%	–24.39%	–71.71%
Profitability (industry CAPM)	2.11%	40.20%	56.08%	12.37%	–9.80%
Profitability (market CAPM)	12.51%	12.99%	14.67%	6.09%	–3.68%

Source: Compiled by the authors.

Table 4

Estimation of the Cost of Equity of PJSC Severstal for the Period 2018–2022 by CAPM

Indicators		2018	2019	2020	2021	2022
μ_F		8.02%	7.59%	6.27%	7.34%	9.87%
Company PJSC	μ_i	6.23%	–0.53%	41.01%	21.27%	–43.66%
	L	1.21	1.75	1.51	1.37	–
	k_d	3.77%	3.98%	3.38%	3.36%	–
	σ_i	0.24	0.19	0.26	0.28	0.53
Industry	μ_I	8.71%	10.68%	47.75%	7.37%	–46.96%
	L	0.41	0.81	0.66	0.68	0.64
	σ_I	0.19	0.11	0.24	0.17	0.45
	$\beta_{i,I}$	0.40	–0.19	0.91	1.42	1.10
Market	μ_m	12.20%	28.58%	8.06%	15.08%	–43.10%
	σ_m	0.17	0.11	0.26	0.16	0.52
	β_{im}	0.77	–0.73	0.69	0.85	0.94
μ_i		**6.23%**	**–0.53%**	**41.01%**	**21.27%**	**–43.66%**
μ_i **CAPM (Industry)**		**8.29%**	**6.99%**	**44.22%**	**7.38%**	**–52.55%**
μ_i **CAPM (market)**		**11.22%**	**–7.64%**	**7.51%**	**13.93%**	**–40.11%**

Source: Compiled by the authors.

industry beta (sector); μ_I – average annual return of the sector (S&P500 Information Technology)

For calculation by market: $\mu_i = \mu_F + \beta_{im}\left(\mu_m - \mu_F\right)$, where μ_i — average annual return per share; μ_F — US market risk free rate; β_{im} — market beta; μ_m — average annual market return in the market (S&P500)

The average yield of 10-year US Treasury boxes was taken as the risk-free rate in the US market.

Data on daily market quotes, as well as daily quotes of the S&P500 index and the S&P500 Information Technology sector are taken from a specialized Internet resource https://ru.investing.com/.

For calculations, μ_i was taken — the average annual return on shares. To calculate the average annual return, it was first necessary to find the average daily return. The average daily return was calculated using the logarithmic return formula:

$\mu_d = \ln \frac{P_t}{P_{t-1}}$, where μ_d — daily yield; P_t — share price on date t; $P_{(t-1)}$ — share price on date $t-1$.

The values obtained using this formula were averaged for each study period (year). The average daily returns were then converted to annual averages

Table 5

Results for Parameters of Company, Industry (Sector) and Market

Index	Unit	Source	2019	2020	2021
Average annual return per share (Apple)	**%**	**Authors's calculation**	**90.04**	**71.87**	**37.36**
Average annual market return (S&P 500)	%	Authors's calculation	28.86	16.18	26.88
10-year US Treasuries	%	Investing.com	3.75	3.75	3.75
Standard deviation of stock return (Apple)	%	Authors's calculation	1.66	2.94	1.58
Standard Deviation of Market Returns (S&P 500)	%	Authors's calculation	0.79	2.19	0.83
Beta	x	Authors's calculation	1.57	1.12	1.31
Expected stock return	**%**	**Authors's calculation**	**43.13**	**17.68**	**34.07**
Average annual return of the sector (S&P500 Information Technology)	%	Authors's calculation	48.00	41.98	33.33
10-year US Treasuries	%	Investing.com	3.75	3.75	3.75
Standard deviation of stock return (Apple)	%	Authors's calculation	1.66	2.94	1.58
Sector Return Standard Deviation (S&P500 Information Technology)	%	Authors's calculation	1.14	2.57	1.23
Beta	x	Authors's calculation	1.22	1.04	1.06
Expected stock return	**%**	**Authors's calculation**	**57.57**	**43.65**	**35.00**
Interest expenses	mln $	Apple Annual Report 2019 Apple Annual Report 2020 Apple Annual Report 2021	3.58	2.87	2.65
Total debt	mln $	Apple Annual Report 2019 Apple Annual Report 2020 Apple Annual Report 2021	102.07	107.44	118.72
Debt cost	**%**	**Authors's calculation**	**3.50**	**2.67**	**2.23**
Total debt	mln $	Apple Annual Report 2019 Apple Annual Report 2020 Apple Annual Report 2021	102.07	107.44	118.72
Equity value	mln $	Apple Annual Report 2019 Apple Annual Report 2020 Apple Annual Report 2021	90.49	65.34	63.09
Leverage level	**x**	**Authors's calculation**	**1.13**	**1.64**	**1.88**

Source: Compiled by the authors.

Table 6

Results for Three Values of k_0

Indicator	Unit	2019	2020	2021
μ_i	%	85.99	80.21	33.80
μ_0	%	46.86	36.16	14.83
k_0 (1st value)	%	46.86	36.16	14.83
k_0 (2nd value)	%	100.69	76.06	46.08
k_0 (3 rd value)	%	86.24	50.09	45.15

Source: Compiled by the authors.

using the following formula: $\mu_i = (1 + \mu_d)^n - 1$, where n — number of trading days on the exchange.

The beta coefficient was found using the following formulas:

For the industry (sector): $\beta_{iI} = \frac{\text{cov}_{iI}}{\sigma_I^2}$, where cov_{iI} — covariance between returns on stocks and returns on the industry (sector) under study; σ_I^2 — sector variance.

For market: $\beta_{im} = \frac{\text{cov}_{im}}{\sigma_m^2}$, where cov_{im} — covariance between stock returns and market returns; σ_m^2 — market variance.

Also, the beta coefficient was calculated using the standard deviation, the results agreed with the previous calculations (for more details, see the Excel table).

For Apple, the cost of debt and financial leverage ratio were also calculated.

The cost of debt was calculated using the formula:

$k_d = \frac{IE}{D}$, where I is the cost of debt, IE is the interest expense for the period, D is the debt value, on which interest is charged.

The leverage level was calculated as the ratio of debt (total liabilities) to the company's equity capital.

The data for the calculations above were taken from Apple's annual reports for 2019–2021.

CALCULATIONS

Comparing the average annual return of the Apple stock with the average annual returns of the market (S&P500) and the sector (S&P500 Information Technology), we can say that the company's shares show more profitability, but at the same time more volatility, and therefore riskiness.

Table 7

Dependence of *WACC* on Leverage Level L, *WACC* (*L*) for 2019–2021 Years

	2019			2020			2021		
L	*WACC1*	*WACC2*	*WACC3*	*WACC1*	*WACC2*	*WACC3*	*WACC1*	*WACC2*	*WACC3*
0	46.86%	100.69%	86.24%	36.16%	76.06%	50.09%	14.83%	46.08%	45.15%
1	42.18%	90.62%	77.62%	32.54%	68.46%	45.08%	13.35%	41.47%	40.63%
2	40.61%	87.26%	74.74%	31.34%	65.92%	43.41%	12.85%	39.94%	39.13%
3	39.83%	85.58%	73.30%	30.73%	64.65%	42.57%	12.61%	39.17%	38.38%
4	39.36%	84.58%	72.44%	30.37%	63.89%	42.07%	12.46%	38.71%	37.92%
5	39.05%	83.91%	71.87%	30.13%	63.39%	41.74%	12.36%	38.40%	37.62%
6	38.83%	83.43%	71.46%	29.96%	63.02%	41.50%	12.29%	38.18%	37.41%
7	38.66%	83.07%	71.15%	29.83%	62.75%	41.32%	12.23%	38.02%	37.25%
8	38.53%	82.79%	70.91%	29.73%	62.54%	41.18%	12.19%	37.89%	37.12%
9	38.43%	82.56%	70.72%	29.65%	62.37%	41.07%	12.16%	37.79%	37.02%
10	38.34%	82.38%	70.56%	29.58%	62.23%	40.98%	12.13%	37.70%	36.94%

Source: Compiled by the authors.

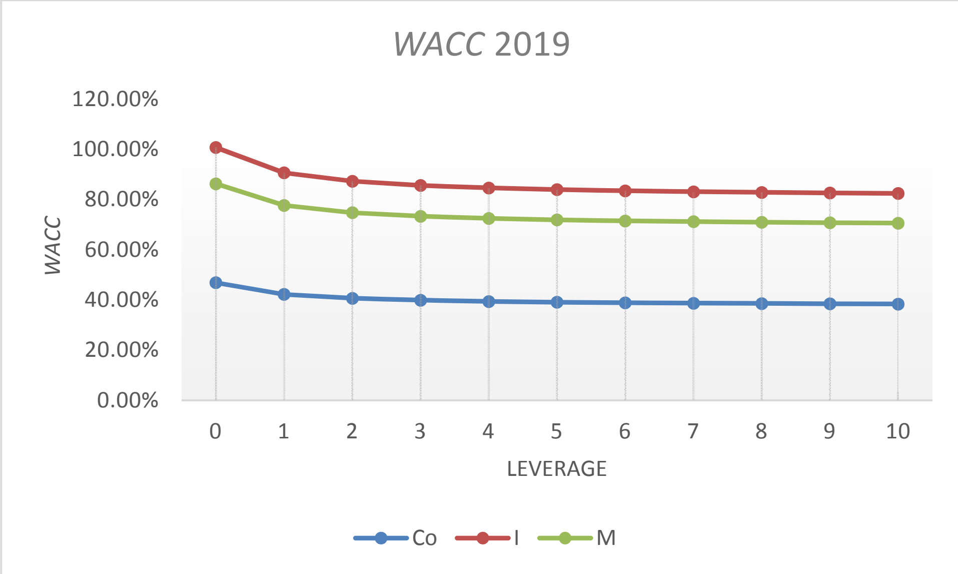

Fig. 1. **Dependence of *WACC* on Leverage Level *L*, *WACC* (*L*) for 2019 Year**

Source: Compiled by the authors.

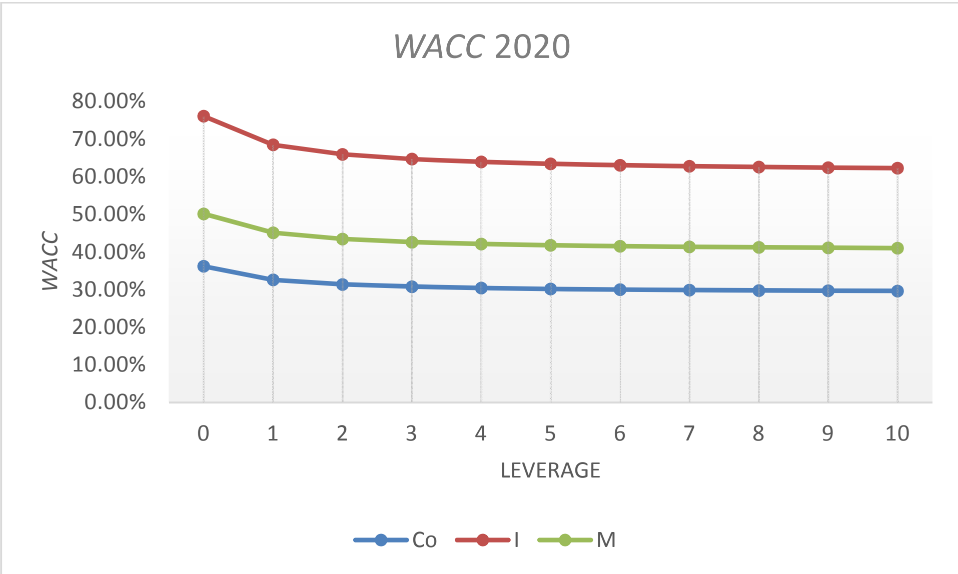

Fig. 2. **Dependence of *WACC* on Leverage Level *L*, *WACC* (*L*) for 2020 Year**

Source: Compiled by the authors.

The standard deviation of the return on Apple stock is at the level of 2–3%. Which is higher than the values for the sector and the market by ~ 1 p.p. At the same time, there is a sharp increase in 2020, which may be due to the COVID-19 pandemic.

It is important to analyze the average annual return of Apple stock with expected returns under the CAPM model. The model is considered relative to the S&P500 market and the S&P500 Information Technology sector.

Beta coefficients were calculated for both models. In all options, the coefficients turned out to be greater than one, which indicates a correlation between the price dynamics of Apple's stock and the dynamics of the market and the sector, but at the same time, the volatility of the shares is higher, which means that the risks are higher. At the same time, it should be noted that the beta calculated for the sector is close to 1, which indicates a higher correlation than for the market (the company's shares follow the sector's trend, the company's risks are almost equivalent to the sector-wide ones).

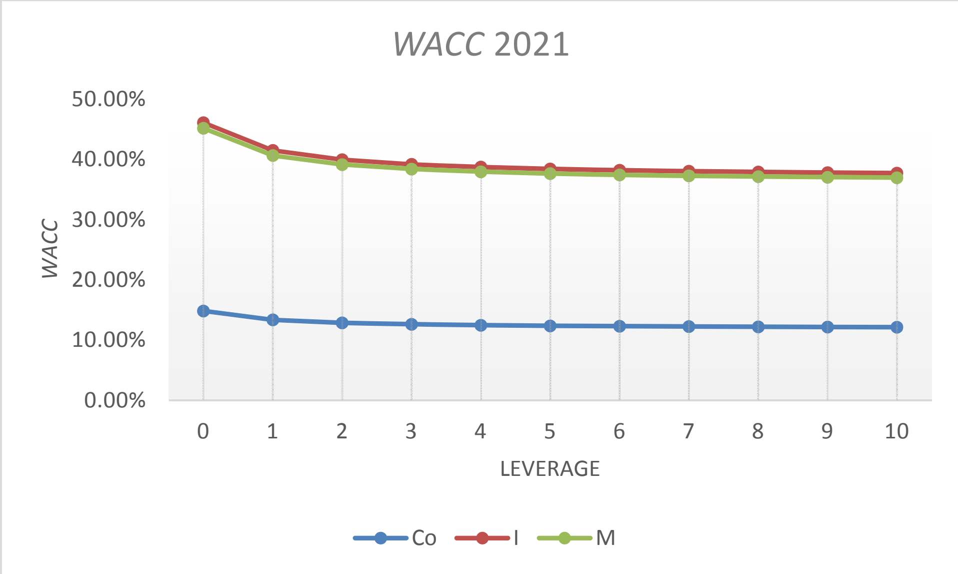

Fig. 3. **Dependence of *WACC* on Leverage Level *L*, *WACC* (*L*) for 2021 Year**

Source: Compiled by the authors.

Table 8

Dependence of Company Value, V on Leverage Level L, V(L) for 2019–2021 Years

	2019			2020			2021		
L	*V1*	*V2*	*V3*	*V1*	*V2*	*V3*	*V1*	*V2*	*V3*
0	166.70	77.59	90.58	235.52	111.96	170.02	864.59	278.25	284.00
1	185.22	86.21	100.65	261.69	124.40	188.92	960.66	309.16	315.55
2	192.35	89.52	104.52	271.75	129.18	196.18	997.61	321.05	327.69
3	196.12	91.28	106.57	277.08	131.72	200.03	1017.17	327.35	334.11
4	198.45	92.37	107.84	280.38	133.29	202.41	1029.28	331.25	338.09
5	200.04	93.11	108.70	282.62	134.35	204.03	1037.51	333.90	340.79
6	201.19	93.64	109.33	284.25	135.12	205.20	1043.47	335.82	342.75
7	202.06	94.05	109.80	285.48	135.71	206.09	1047.99	337.27	344.24
8	202.75	94.36	110.17	286.44	136.17	206.79	1051.53	338.41	345.40
9	203.30	94.62	110.47	287.22	136.54	207.35	1054.38	339.33	346.34
10	203.75	94.83	110.71	287.86	136.84	207.81	1056.73	340.08	347.11

Source: Compiled by the authors.

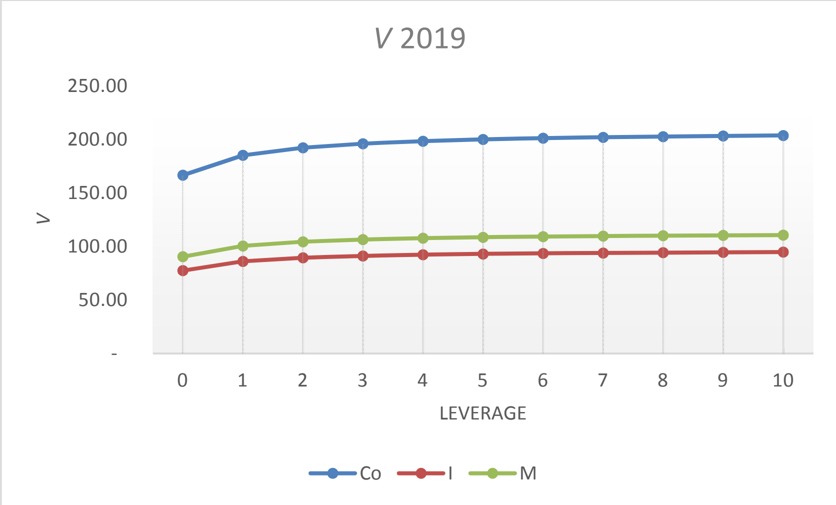

Fig. 4. **Dependence of Company Value, *V* on Leverage Level *L*, *V*(*L*) for 2019 Year**

Source: Compiled by the authors.

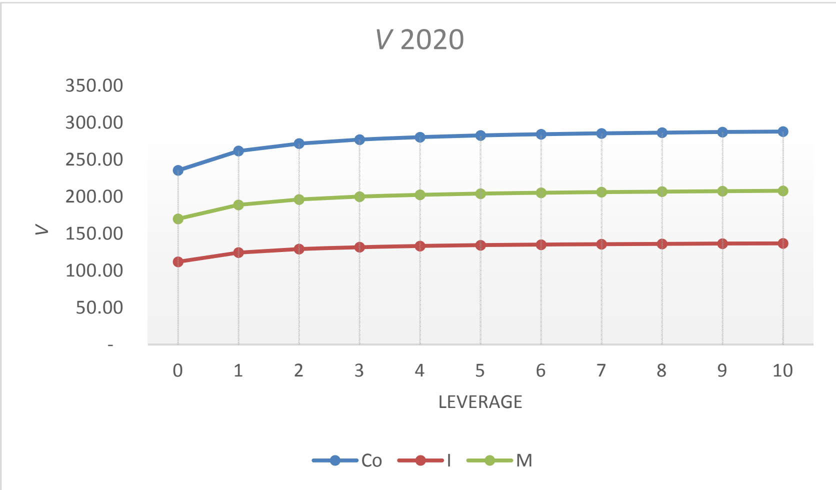

Fig. 5. **Dependence of Company Value, *V* on Leverage Level *L*, *V*(*L*) for 2020 Year**

Source: Compiled by the authors.

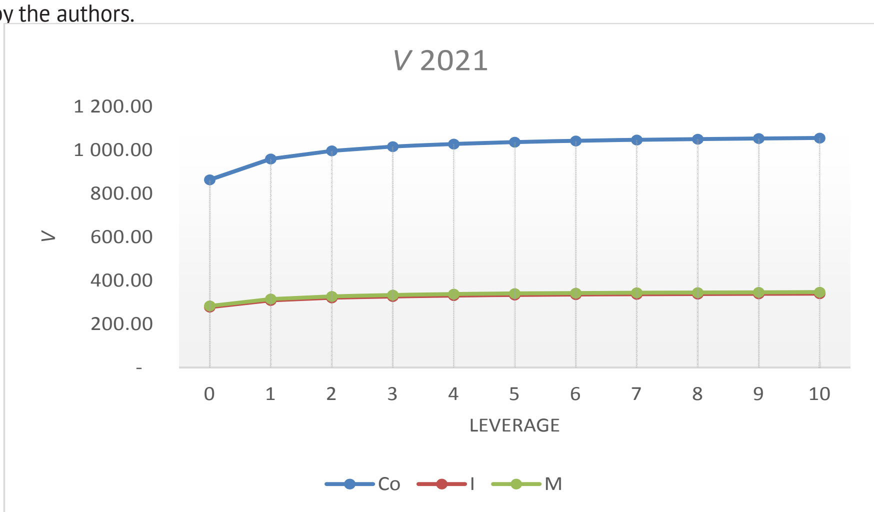

Fig. 6. **Dependence of Company Value, *V* on Leverage Level *L*, *V*(*L*) for 2021 Year**

Source: Compiled by the authors.

Table 9

Dependence of Cost of Equity k_e on Leverage Level L, $k_e(L)$ for 2019–2021 Years

	2019			2020			2021		
L	k_e 1	k_e 2	k_e 3	k_e 1	k_e 2	k_e 3	k_e 1	k_e 2	k_e 3
0	46.86%	100.69%	86.24%	36.16%	76.06%	50.09%	14.83%	46.08%	45.15%
1	81.55%	178.43%	152.43%	62.95%	134.77%	88.02%	24.91%	81.16%	79.48%
2	116.24%	256.18%	218.62%	89.73%	193.48%	125.95%	34.99%	116.24%	113.82%
3	150.92%	333.93%	284.81%	116.52%	252.19%	163.88%	45.07%	151.33%	148.16%
4	185.61%	411.67%	351.00%	143.31%	310.90%	201.81%	55.16%	186.41%	182.49%
5	220.30%	489.42%	417.19%	170.09%	369.61%	239.74%	65.24%	221.49%	216.83%
6	254.99%	567.17%	483.38%	196.88%	428.32%	277.67%	75.32%	256.57%	251.16%
7	289.67%	644.91%	549.57%	223.67%	487.03%	315.60%	85.40%	291.65%	285.50%
8	324.36%	722.66%	615.76%	250.46%	545.74%	353.53%	95.48%	326.74%	319.84%
9	359.05%	800.40%	681.95%	277.24%	604.46%	391.46%	105.56%	361.82%	354.17%
10	393.74%	878.15%	748.14%	304.03%	663.17%	429.39%	115.65%	396.90%	388.51%

Source: Compiled by the authors.

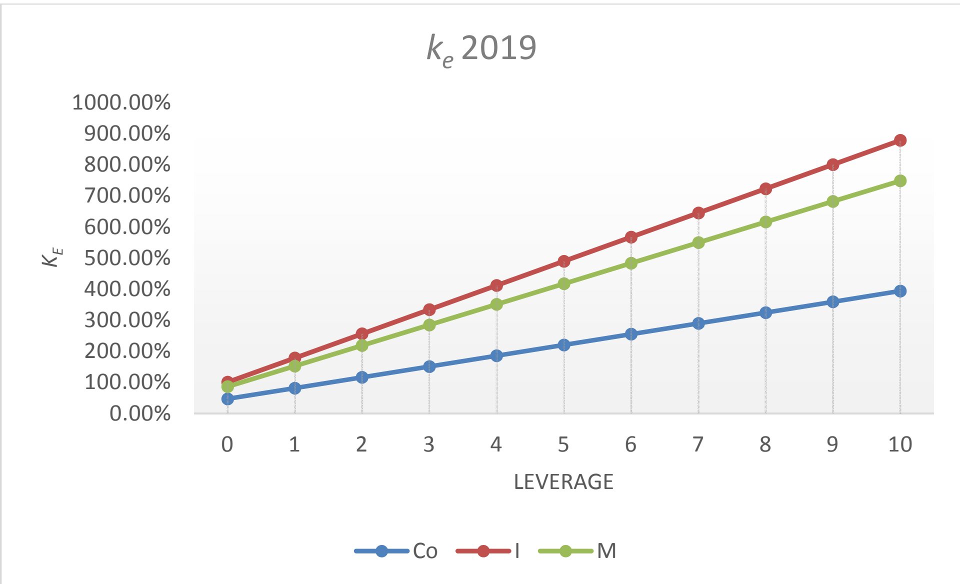

Fig. 7. **Dependence of Cost of Equity ke on Leverage Level L, ke (L) for 2019 Year**

Source: Compiled by the authors.

This can be explained by the fact that only companies from the IT sector are represented in the S&P500 Information Technology sector, while several industries are represented in the S&P500 market.

In general, comparing the expected returns under the CAPM model and the real average annual return of the Apple stock for the period 2019–2021, it can be observed that the forecast indicators for the sectoral CAPM model are closer to real values

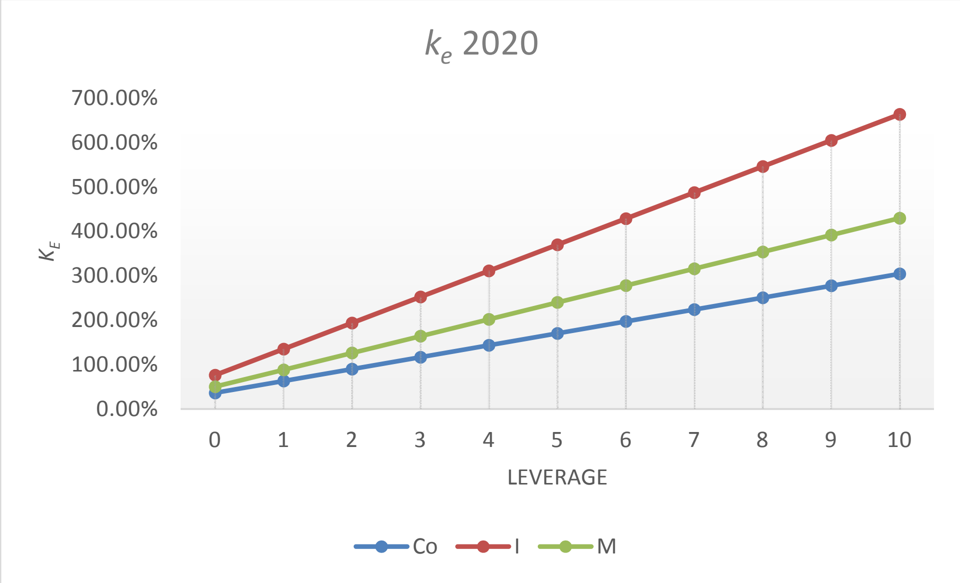

Fig. 8. **Dependence of Cost of Equity ke on Leverage Level *L*, k_e (*L*) for 2020 Year**

Source: Compiled by the authors.

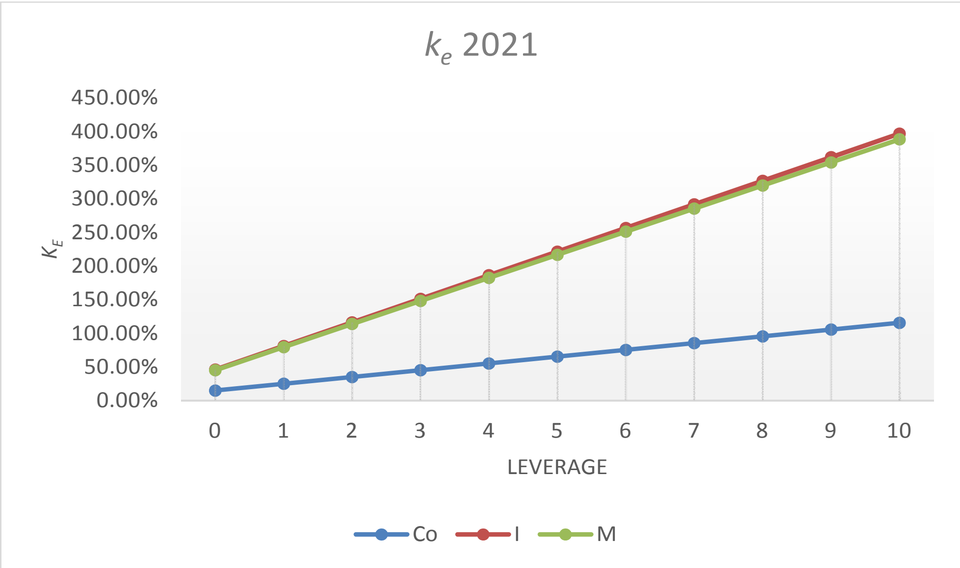

Fig. 9. **Dependence of Cost of Equity k_e on Leverage Level *L*, k_e (*L*) for 2021 Year**

Source: Compiled by the authors.

than for the market model, which is explained by a higher correlation. At the same time, the real values of Apple's average annual return are higher with positive values and lower with negative ones, which indicates increased volatility and riskiness of the security. Apple's leverage ratio is below 2, which may indicate that the company is funded largely by equity.

Three Values of k_0 (see *Table 6*).

For further calculations, μ_i was taken — the average annual return on shares. To calculate the average annual return, it was first necessary to find the average daily return. The average daily return was calculated using the logarithmic return formula:

$$\mu_d = \ln\frac{P_t}{P_{t-1}},$$ where μ_d — daily yield; P_t — share price on the date t; P_{t-1} — share price on the date $t-1$.

The values obtained using this formula were averaged for each study period (year). The average

Table 10

Dependence of WACC on Leverage Level L, *WACC* (*L*) for 2019–2021 Years

	2019			2020			2021		
L	*WACC1*	*WACC2*	*WACC3*	*WACC1*	*WACC2*	*WACC3*	*WACC1*	*WACC2*	*WACC3*
0	46.86%	100.69%	86.24%	36.16%	76.06%	50.09%	14.83%	46.08%	45.15%
1	43.24%	92.91%	79.58%	33.67%	70.84%	46.65%	13.88%	43.18%	42.31%
2	42.04%	90.32%	77.36%	32.85%	69.10%	45.50%	13.57%	42.22%	41.36%
3	41.43%	89.02%	76.25%	32.43%	68.23%	44.93%	13.41%	41.73%	40.89%
4	41.07%	88.24%	75.58%	32.18%	67.70%	44.58%	13.32%	41.44%	40.60%
5	40.83%	87.72%	75.14%	32.02%	67.35%	44.35%	13.25%	41.25%	40.41%
6	40.66%	87.35%	74.82%	31.90%	67.11%	44.19%	13.21%	41.11%	40.28%
7	40.53%	87.07%	74.58%	31.81%	66.92%	44.07%	13.17%	41.01%	40.18%
8	40.43%	86.86%	74.40%	31.74%	66.77%	43.97%	13.15%	40.93%	40.10%
9	40.35%	86.69%	74.25%	31.69%	66.66%	43.89%	13.13%	40.86%	40.04%
10	40.28%	86.54%	74.13%	31.64%	66.56%	43.83%	13.11%	40.81%	39.98%

Source: Compiled by the authors.

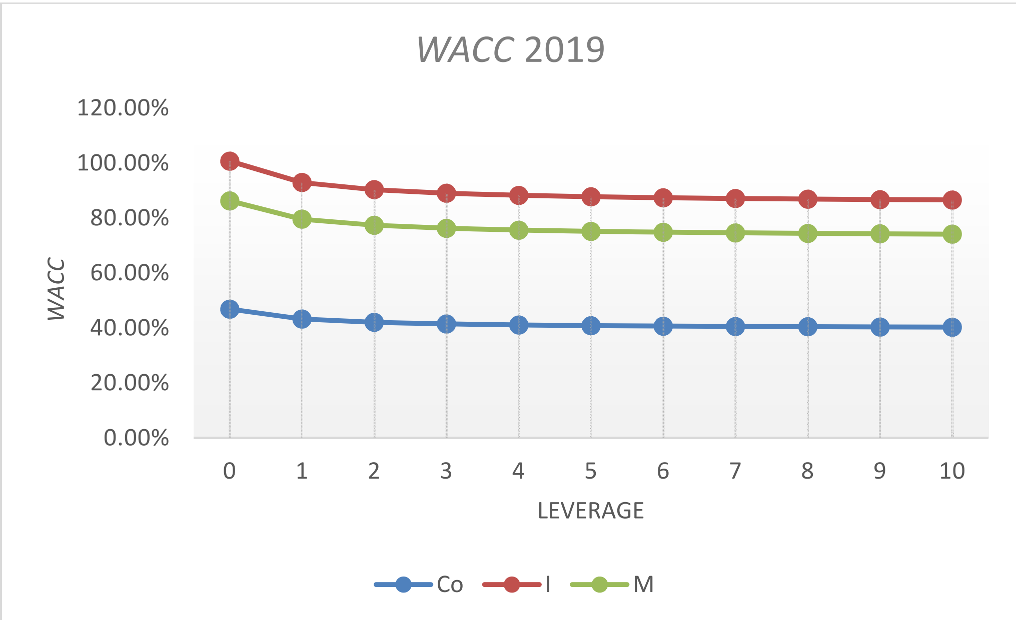

Fig. 10. **Dependence of *WACC* on Leverage Level *L*, *WACC*(*L*) for 2019 Year**

Source: Compiled by the authors.

daily returns were then converted to annual averages using the following formula: $\mu_i = (1 + \mu_d)^n - 1$, where n — number of trading days on the exchange.

Next, μ_0 was found by the formula:

$$\mu_0 = \frac{\mu_i + L k_d (1-t)}{1 + L(1-t)},$$ where L — leverage level; t — income tax rate). After that, k_0 was calculated according to three conditions:

$$k_0(1) = \mu_0, \quad (44)$$

$$k_0(2) = \mu_0 + \beta_{iI} (\mu_I - \mu_F) \text{ for industry}, \quad (45)$$

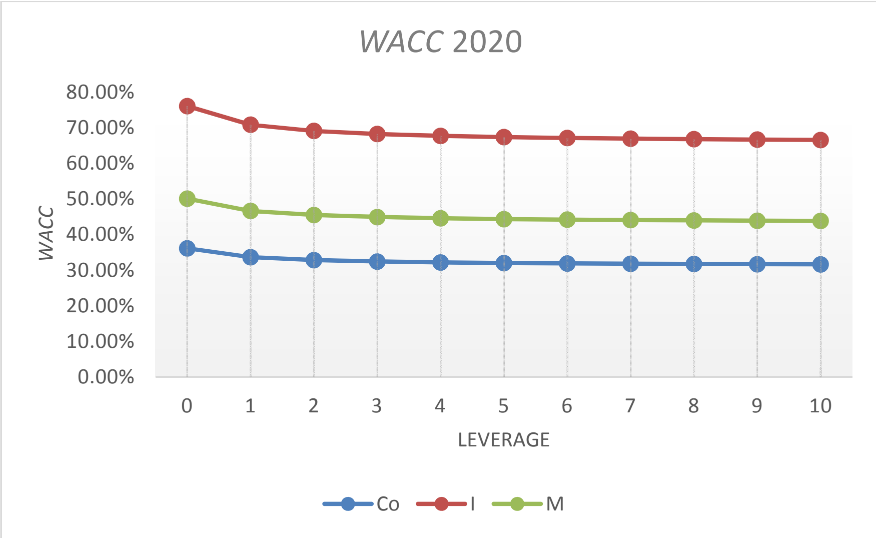

Fig. 11. **Dependence of *WACC* on Leverage Level *L*, *WACC* (*L*) for 2020 Year**

Source: Compiled by the authors.

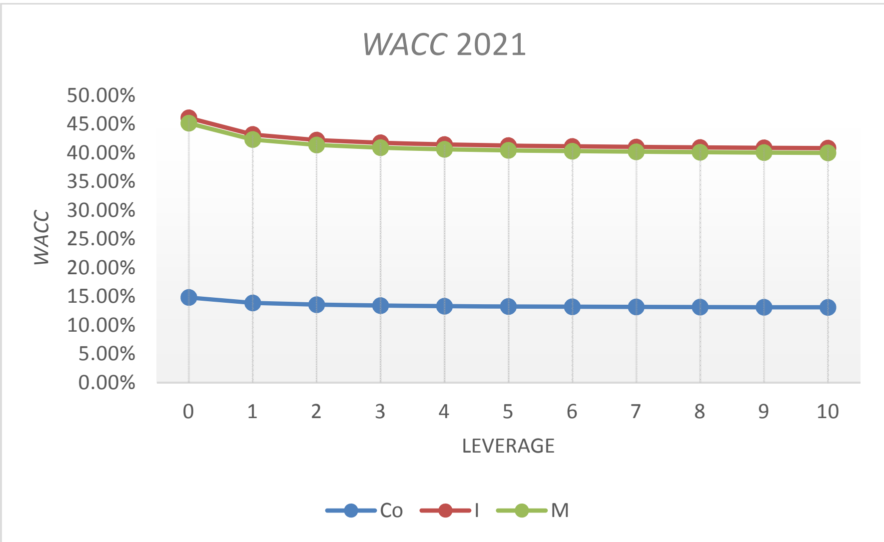

Fig. 12. **Dependence of *WACC* on Leverage Level *L*, *WACC*(*L*) for 2021 Year**

Source: Compiled by the authors.

$$k_0(3) = \mu_0 + \beta_{iM}\ (\mu_M - \mu_F) \text{ for market.} \quad (46)$$

Based on the data obtained, indicators were calculated for two models: the Modigliani-Miller and the Brusov-Filatova-Orekhova theories.

It was found the dependence of WACC, V, ke indicators on the level of leverage (change in leverage from 0 to 10).

Calculations of Indicators for the Modigliani-Miller — CAPM Model

The following formulas were used to calculate the indicators:

$$WACC = k_0(1 - w_d t);\ w_d = \frac{L}{L+1};\ V = \frac{CF}{WACC},$$

$$CF = EBITDA;\ k_e = k_0 + L(k_0 - k_d)(1 - t). \quad (47)$$

The results obtained are presented in *Tables 7–9* of dependencies of the values of indicators (*WACC, V,* k_e) on the level of leverage for each year for three values of k_0, as well as in figures.

Here and below in the *Fig. 1–9*: Co means company; I means industry (sector); M stands for market.

Table 11

Dependence of Company Value *V* on Leverage Level *L*, *V*(*L*) for 2019–2021 Years

	2019			2020			2021		
L	*V*1	*V*2	*V*3	*V*1	*V*2	*V*3	*V*1	*V*2	*V*3
0	166.70	77.59	90.58	235.52	111.96	170.02	862.88	278.25	284.00
1	180.66	84.08	98.17	252.89	120.22	182.56	920.80	296.92	303.06
2	185.84	86.50	100.99	259.26	123.25	187.16	941.87	303.72	309.99
3	188.55	87.76	102.46	262.57	124.82	189.55	952.77	307.24	313.58
4	190.21	88.53	103.36	264.60	125.78	191.02	959.44	309.38	315.78
5	191.34	89.05	103.97	265.97	126.43	192.00	963.93	310.83	317.26
6	192.15	89.43	104.41	266.95	126.90	192.72	967.17	311.88	318.32
7	192.76	89.72	104.75	267.70	127.26	193.25	969.61	312.66	319.12
8	193.24	89.94	105.01	268.28	127.53	193.67	971.52	313.28	319.75
9	193.63	90.12	105.22	268.75	127.76	194.01	973.05	313.77	320.26
10	193.94	90.27	105.39	269.13	127.94	194.29	974.30	314.18	320.67

Source: Compiled by the authors.

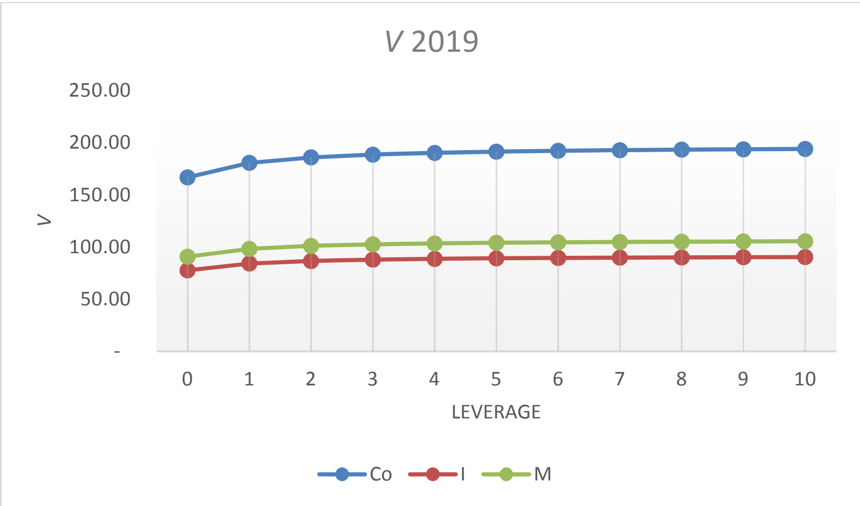

Fig. 13. **Dependence of Company Value *V* on Leverage Level *L*, *V*(*L*) for 2019 Year**

Source: Compiled by the authors.

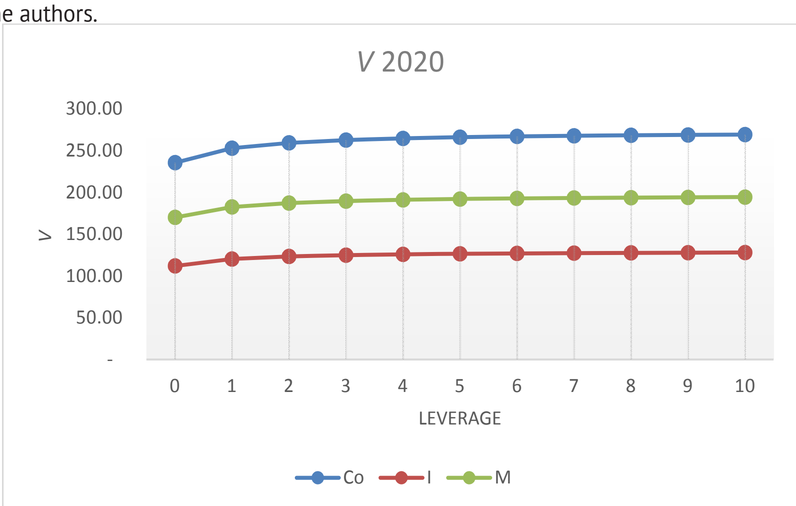

Fig. 14. **Dependence of Company Value *V* on Leverage Level *L*, *V*(*L*) for 2020 Year**

Source: Compiled by the authors.

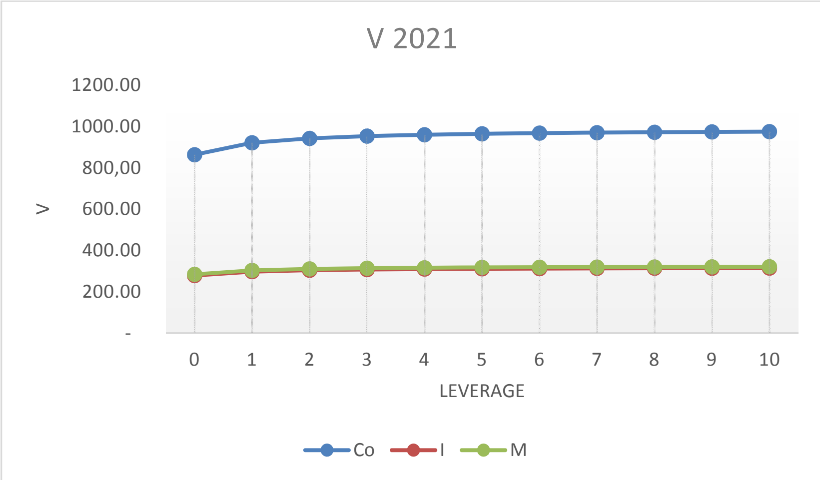

Fig. 15. **Dependence of Company Value *V* on Leverage Level *L*, *V*(*L*) for 2021 Year**

Source: Compiled by the authors.

Table 12

Dependence k_e (*L*); 2019–2021 Years

	2019			2020			2021		
L	k_e 1	k_e 2	k_e 3	k_e 1	k_e 2	k_e 3	k_e 1	k_e 2	k_e 3
0	46.86%	100.69%	86.24%	36.16%	76.06%	50.09%	14.83%	46.08%	45.15%
1	83.68%	183.01%	156.35%	65.21%	139.54%	91.15%	25.99%	84.58%	82.83%
2	120.50%	265.34%	226.47%	94.26%	203.01%	132.22%	37.14%	123.08%	120.52%
3	157.32%	347.67%	296.58%	123.31%	266.48%	173.29%	48.30%	161.58%	158.21%
4	194.14%	429.99%	366.69%	152.36%	329.96%	214.35%	59.45%	200.09%	195.89%
5	230.96%	512.32%	436.81%	181.42%	393.43%	255.42%	70.60%	238.59%	233.58%
6	267.78%	594.65%	506.92%	210.47%	456.91%	296.49%	81.76%	277.09%	271.26%
7	304.60%	676.98%	577.04%	239.52%	520.38%	337.55%	92.91%	315.59%	308.95%
8	341.42%	759.30%	647.15%	268.57%	583.85%	378.62%	104.06%	354.09%	346.63%
9	378.24%	841.63%	717.26%	297.62%	647.33%	419.69%	115.22%	392.59%	384.32%
10	415.05%	923.96%	787.38%	326.67%	710.80%	460.75%	126.37%	431.09%	422.01%

Source: Compiled by the authors.

CALCULATIONS OF INDICATORS FOR THE BRUSOV-FILATOVA-OREKHOVA — CAPM MODEL

To calculate indicators according to the BFO model, it is necessary to take into account the duration of the company's operation

Date Apple was founded: 04/01/1976.

The duration of the company's operation (n) is calculated by the formula: $n = t_1 - t_0$, where t_1 is the current year, t_0 is the year the company was founded.

The following formulas were used in the calculations:

$$\frac{1-(1+WACC)^{-n}}{WACC} = \frac{1-(1+k_0)^{-n}}{k_0\left(1-w_d t\left[1-(1+k_d)^{-n}\right]\right)}, \qquad (48)$$

$$V = \frac{CF}{WACC}\left(1-(1+WACC)^{-n}\right), \qquad (49)$$

$$k_e = WACC(1 + L) - Lk_d(1 - t). \qquad (50)$$

WACC was found using Excel's "Search for Solution" function.

It was considered how the *WACC, V*, k_e indicators change relative to the change in the level of leverage (change in leverage from 0 to 10).

Let's move on to the results: the paper presents *Tables 10–12* of indicator values (*WACC, V*, k_e) for each year in three versions (depending on k_0), as well as *Fig. 10–18* of these indicators.

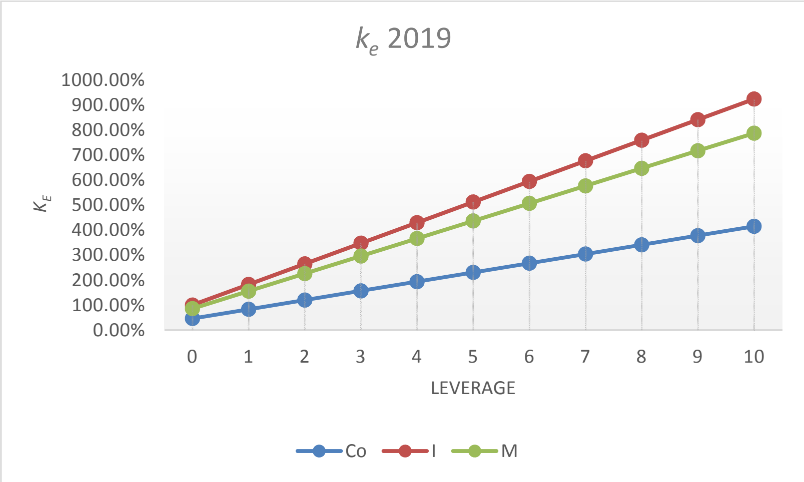

Fig. 16. **Dependence $k_e(L)$; 2019 Year**

Source: Compiled by the authors.

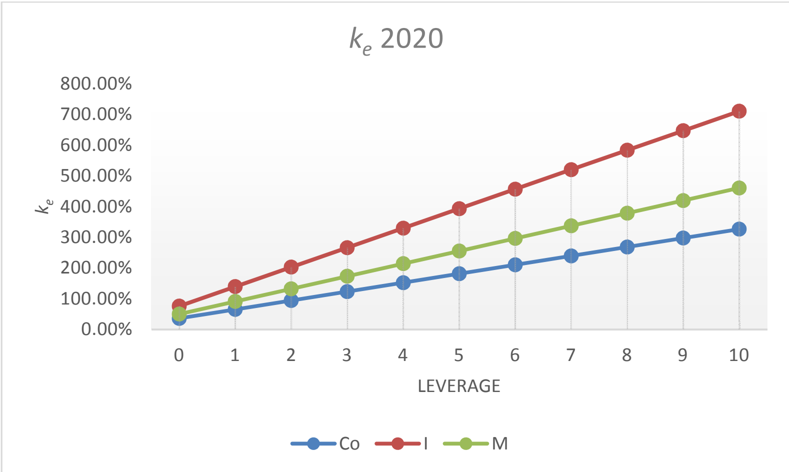

Fig. 17. **Dependence $k_e(L)$; 2020 Year**

Source: Compiled by the authors.

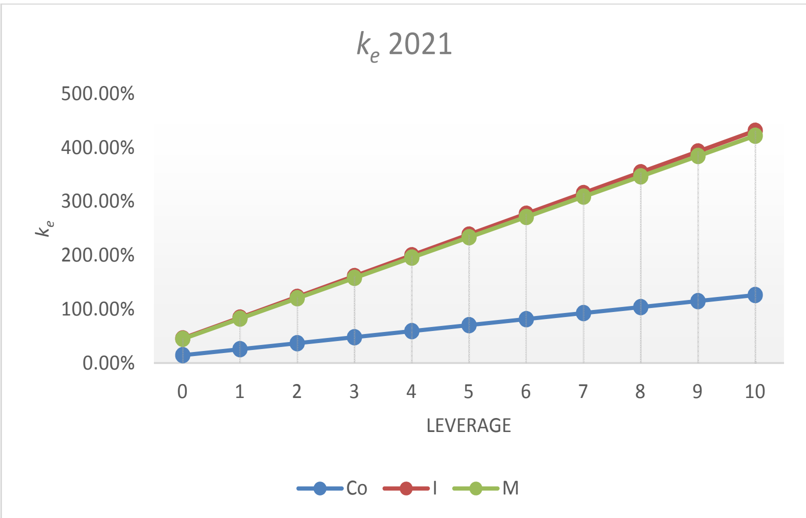

Fig. 18. **Dependence $k_e(L)$; 2021 Year**

Source: Compiled by the authors.

CONCLUSIONS

A fundamentally new approach to assessing the profitability of an asset is proposed. Transition from CAPM, which takes the same risk-free return for all assets as an initial assessment, to a new methodology, in which the average return of an asset, cleared of leverage, with the addition of a premium for business risk (market or industry) is taken as a seed return, significantly improves the accuracy of the estimate. A methodology has been developed for assessing the profitability of assets, taking into account both business (systematic) and financial risks. For this purpose, the CAPM and Fama-French models were incorporated in two main theories of the capital structure — the Brusov-Filatova-Orekhova (BFO) theory and the Modigliani-Miller (MM) theory. The developed approach makes it possible to use the powerful tools of these highly developed theories for the correct assessment of the main financial indicators of the company and their forecasting, taking into account both types of risks. The dependences of these indicators on debt financing, leverage level, taxing, company age, debt cost can be studied. The latest versions of the BFO and MM theories of capital structure, developed by authors and adapted to the established financial practice of the functioning of companies, are used, taking into account the real conditions of their work, such as variable income, frequent income tax payments, advance income tax payments, etc.

The example for GAZP, given by us, shows that account of business risk within market CAPM approach change k_0 from 4.542% to $k_0' = 9.82\%$. This will significantly change the results of calculation of the financial indicators of the GAZP.

Detailed practical calculations for real companies (Apple, Severstal, Polymetal) have been made. They focus on (1) applying two versions of CAPM (market or industry) to real companies; (2) application to real companies of a new methodology developed by us for assessing the financial performance of a company, taking into account both business (market or industry) and financial risks. These calculations show that the financial performance of companies is highly dependent on the type of risks taken into account. Sometimes the difference between market and industry cases is small — sometimes it is significant. However, the difference in financial indicators, while taking into account simultaneously financial and business risks, is always large with respect to accounting for a single risk. This means that taking into account simultaneously both financial and business risks is important for a correct assessment of the financial performance of companies. Three changes to the current methodology significantly improve the accuracy of the estimate: (a) the use of a sectoral approach in CAPM; (b) the use of a new methodology in which the average return on the asset, net of leverage, with (c) the addition of a business risk premium (market or industry), is taken as the initial return. The new methodology opens up new horizons and opportunities in business valuation, corporate finance, investments, ratings, etc.

The significant novelty of the article is as follows: For the first time, we correctly took into account financial and business risks, proving the incorrectness of Hamada's model, and included CAPM in the theories of capital structure (both MM and BFO), which opens up great prospects for assessing the financial performance of companies.

The limitations of the proposed methodology are partly related to the limitations of its components: CAPM, capital structure theories, in particular, with the reliability of the WACC approximation.

In the future, it is planned to (1) improve and clarify the methodology for collecting and processing information about the company, industry, and market; (2) improve the use of MM and BFO models adapted to the real conditions of the functioning of companies.

Abbreviations

CAPM: Capital Asset Pricing Model

MM: the Modigliani-Miller theory;

BFO: Brusov-Filatova-Orekhova theory;

WACC: the weighted average cost of capital;

SMB — the difference between the returns of companies with large and small capitalization;

HML — the difference between the returns of companies with low and high intrinsic value (indicator B/P);

RMW — return on equity; *CMA* — company capital expenditure.

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V.L. Kulik — validation, formal analysis, investigation.

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