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Model Risk Analysis of Multiplier Technology Applied at Stock Valuation of Russian Companies

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ABSTRACT

This work is a new direction in the authors' previous study on applying the market multipliers in assessing the value of oil and gas companies. The work is based on the findings of statistical studies of multipliers calculated for the industry, as well as their volatility over a 12-year period — from 2006 to 2017 inclusively, as exemplified by 46 companies from nine sectors of the economy of the Russian Federation. The analysis of the risk measures Value-at-Risk (hereinafter VaR) and Expected Shortfall (hereinafter ES) was conducted by means of volatility calculated in different ways. In particular, the multiplier volatility was introduced by V.B. Minasyan. It was established that for all nine sectors of the Russian economy, calculated with conventional stock volatility statistics (when possible), risk valuation measures VaR and ES led to lower calculated risk values compared to those calculated using multiplier volatility. The results of the study are of interest to evaluators, investors and other interested parties, as it allows to analyze the general behavior of the stock value in Russian companies and to compare the change in indicators of various economic sectors in terms of multiplier technology.

Keywords: company valuation; multiplier P/E; multiplier P/B; stock value; stock volatility; multiplier volatility; risk measure VaR; risk measure ES

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INTRODUCTION

Speaking about company valuation, it is important to mention various approaches, models with their own advantages and disadvantages (see, for example, [1]). Today, experts note an increasing number of mergers and acquisitions1 [2], which emphasizes the additional interest in quick and efficient company valuation with minimum resources.

The data necessary for a qualitative company valuation, especially if they are not public, are not always available. Moreover, required indicators often change due to the high market volatility. What values should be used in a particular valuation model?

To evaluate stocks by the multiplier technology, the expected value estimated statistically often replaces their value.

Based on the example of 46 Russian companies, the results of multiplier behavior study by D.G. Ivko [3–5] show that multipliers have very high volatility both in industries and in specific companies. Therefore, the realized multiplier value will not necessarily be close to the expected value or to the value at the selected

[1] M&A market in Russia. Overview by KPMG. February 2019. URL: https://assets.kpmg/content/dam/kpmg/ru/pdf/2019/02/ru-ru-ma-survey-feb-2018.pdf (accessed on 27.09.2019).

moment. This may lead to a significant deviation of the real stock value from its valuation results when the multiplier method is applied.

Company valuation is mainly associated with decisions on purchase or sale of an asset, a merger and acquisition transaction. In such cases, incorrect valuation of a company or asset can affect the yield or contribute to loss of a deal for a potential investor.

The subject of this study is the risks associated with using multiplier technology in its various versions.

MULTIPLIER TECHNOLOGY FOR STOCK VALUATION AND THE RELEVANT RISKS. DESCRIPTION OF THE SAMPLE OF COMPANIES

In the Russian Federation, a market (comparative) approach is widely used for company stock valuation. The approach is based on the market multiplier method. The valuation considers the information about the company compared to similar companies within the industry by other key performance indicators (see, for example, [1]), or compared to the industry indicators.

This approach suggests that these companies should be quoted at the same multiplier values.

There is a number of studies by European and American companies. However, the Russian stock market is relatively young and a series of minor shock news can increase the volatility of stock value indicators, etc. [6–9].

The "relative youth" of the mechanisms is an additional factor to be considered when using conclusions based on statistics from Western companies.

It is important that when applying the multiplier calculated for the industry, its real (fair) value for a particular company can deviate greatly from the corresponding estimate, since it is an average indicator for companies in the target industry. When using a multiplier of a public company, similar within the industry or in terms of operating activity, business structure or other key indicators, often they use either a statistical estimate of its expected value, or it is determined at a certain moment of time (for example, at the current moment of valuation). The result of applying the multiplier method described above depends on the choice of a similar company. In particular, the expected value of the multiplier of a similar company, as well as its value at a selected moment, can deviate greatly from the value at the time of the quote or deal. Obviously, the valuation quality is low.

The study examines how significant this deviation can be and how this will affect the valuation risk of companies from nine leading sectors of the Russian economy.

Table 1 presents a list of the Russian economic sectors and the result of a sample of industry companies included in the MICEX index as of December 31, 2016.

Some works, for example, the one by V.A. Cherkasova [2], explore methods to select the so-called peer companies for valuation and describe the application of certain models to calculate corrective indicators. The approach using corrective indicators requires certain parameters and resources for the calculation. In practice, many evaluators use the multiplier technology due to its simplicity and speed of obtaining the stock valuation to make appropriate decisions.

A lot of research is devoted to this method and its application. A significant work by J. Liu, N. Doron and T. Jacob [10] is one of them. Other authors (S. Seghal, A. Pandey [11], C. Cheng and R. McNamara [6], E.F. Fama, and K.R. French [8]) have studied various aspects of the relationship of company multipliers with their profitability and value indicators.

R. Barnes [7] and D. Koutmos [9] have investigated the connection between the volatility of stock prices of companies and their individual indicators.

Following is the work by D.G. Ivko [4, 5], that studied the volatility of the multipliers P/E and P/B and their influence on the volatility of stock prices of Russian companies. We provide the volatility calculations for nine sectors of the Russian economy and the selected companies from the respective sectors for 2006–2017 inclusively.

Table 1

Result of a sample of industry companies for research

No.	Name of industry / sector of the economy	Number of companies listed on the MICEX / RTS, pcs.	Number of companies selected for the portfolio*	Share of selected companies (coverage),%
1	Energy sector			
2	Metallurgy and mining			
3	Oil and gas			
4	Consumer sector			
5	Financial sector			
6	Chemical and petrochemical industry			
7	Telecommunications industry			
8	Engineering industry			
9	Transport			
	Total	93	46	–

* Based on common stocks of Russian companies.

** In terms of capitalization, 7 companies cover 75% of all 24 listed companies in the industry.

Source: designed and compiled by the authors.

Table 2 shows the data from the telecommunications industry and PJSC "ROSTELECOM". *Appendix 1* presents the results for the other sectors — the input data, on which only calculation results will be presented below.

Table 2 shows the expected values and standard deviations of both absolute and relative values of the multipliers P/E and P/B at the industry and company level. The values of the multipliers and their volatility are quite high. Thus, using the multiplier calculated for the industry as part of valuation of the selected company at the moment, one can make a serious mistake due to the possible deviation of the multiplier calculated for the industry from the multiplier of the selected company and due to the significant volatility of the multiplier calculated for industry.

For example, replacing the multiplier P/B calculated for the industry with a multiplier of a similar company is even worse. Thus, ROSTELECOM, which is a public company, is the best similar company for itself. However, in this case, the significant volatility of its multiplier is obvious.

Therefore, the value of the company multiplier — both its expected value and the data at any particular moment (for example, during the valuation) — can significantly differ from the real value of the company multiplier at the time of a quote/deal. For non-public companies, there will also be a difference between the selected and the similar company. Obviously, there are significant risks in stock valuation of Russian companies as part of the multiplier method.

Following the study by D.G. Ivko on the presence and significance of the correlation of stock price volatility with the volatility of the considered multipliers [3, 4], the current study was

Table 2

The results of calculations of indicators: the mathematical expectation and standard deviation based on data for 2006–2017

Indicator	Mathematical expectation of indicators		Standard deviation of indicators (daily value)	
	Industry	PJSC "ROSTELEKOM"	Industry	PJSC "ROSTELEKOM"
For absolute values				
Multiplier P/E	16.14	34.48	40.79	16.14
Multiplier P/B	3.13	1.45	1.6	1.03
Annual profit, rub.	38 522 142 143	19 445 523 384	32 740 012 166	16 038 104 257
Annual profit per 1 share, rub.	20.69	8.91	13.97	6.37
Book value, rub.	434 978 343 567	156 013 716 041	224 183 681 052	98 070 503 443
Book value per 1 share, rub.	41.01	77.11	19.98	39.55
Share price, rub.	293.34	143.93	163.23	66.33
For relative values				
Return on multiplier P/E	–0.00064	–0.00001	0.05399	0.0396
Return on multiplier P/B	–0.00027	–0.00007	0.09926	1.02606
Share price, rub.	0	–0.00001	0.01625	0.0176

Source: designed and compiled by the authors.

conducted for nine industries for the periods of 2006–2011, 2012–2017 and 2006–2017.

Table 3 presents the values of the correlation coefficients between the volatility of returns and the multipliers calculated for the industry. They show a periodically different, but significant statistical relationship between relative changes in the index calculated for the industry and the corresponding multipliers in seven out of nine industries.

The result makes us think about the quality of the valuations by the multiplier technology as applied to Russian companies.

In general, for the entire period from 2006 to 2017, for the telecommunications industry, the correlation coefficients between the volatility indicators of the portfolio index returns and the P/E portfolio volatility indicators and between the indicators of the portfolio index return volatility and the P/B portfolio volatility returns are

Table 3

Results of the calculated values of correlation coefficients for the period from 2006 to 2017

Industry	Period	Results of correlation coefficients	
		Between the volatility of returns on the portfolio's index and the volatility of returns on P/E portfolio	Between the volatility of returns on the portfolio's index and the volatility of returns on P/B portfolio
Oil and gas	2006–2017	–0.1068	0.7219
	2006–2011	0.6205	0.6048
	2012–2017	–0.5374	0.5801
Financial	2006–2017	0.5924	0.1793
	2006–2011	0.5275	0.1056
	2012–2017	0.7652	–0.0457
Consumer sector	2006–2017	–0.239	–0.2471
	2006–2011	0.7851	–0.073
	2012–2017	–0.6232	–0.5877
Transport	2006–2017	0.2658	0
	2006–2011	0.6511	0
	2012–2017	–0.2467	0
Chemical	2006–2017	–0.1941	0.1886
	2006–2011	0.3649	0.3752
	2012–2017	–0.4388	–0.1612
Engineering	2006–2017	0.045	–0.2972
	2006–2011	0.5555	0.8894
	2012–2017	–0.2879	0.0687
Metallurgical and mining	2006–2017	0.4879	0.7029
	2006–2011	0.581	0.6476
	2012–2017	0.223	0.03
Energy	2006–2017	0.7007	0.7176
	2006–2011	0.8627	0.8681
	2012–2017	0.7523	–0.0247
Telecommunications	2006–2017	0.0061	0.0255
	2006–2011	0.4062	–0.104
	2012–2017	–0.4108	–0.0259

Source: designed and compiled by the authors.

Table 4

Results of the calculated values of the correlation coefficients by years in the telecommunications industry for the period from 2006 to 2017

Correlation coefficient	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2006–2017	2006–2011	2012–2017
Between the volatility of returns on the portfolio's index and the volatility of returns on P/E portfolio	0.90	0.38	0.71	0.38	0.87	0.97	0.99	–0.14	–0.03	–0.30	0.77	0.72	0.01	0.41	–0.41
Between the volatility of returns on the portfolio's index and the volatility of returns on P/B portfolio	0.92	0.07	0.92	0.99	0.98	0.92	–0.18	0.31	0.68	0.98	0.41	0.77	0.03	–0.10	–0.03

Source: designed and compiled by the authors. High level of connection with coefficient values over 0.49.

close to zero. Now, the "behavior" of the indicators by year within the studied period should be considered in more detail.

Table 4 makes it clear that only in two cases out of 12 none of the indicators "showed" a high level of connection (in 2007 and 2013). Over a number of years, the coefficient generally changes the sign from "+" to "–". In this industry, one should consider not only the impact of the financial crisis in the economy in 2008–2010 and in 2014, but also the features of the industry itself, the specifics of the telecommunications company. Thus, in 2006–2011 and 2012–2017, this group does not fully reflect the situation on the market and one should consider the annual calculation results.

The multipliers P/E and P/B were chosen as the most common and basic indicators that evaluators often check first. This study can additionally be conducted for other equally important multipliers: EV/EBITDA (company value / profit before taxes, interest and depreciation), P/CF (price / cash flow) or P/DIV (price / dividends) and others.

Further, to assess the model risk (multiplier technology), we used the method of model risk analysis in stock valuation proposed by V. B. Minasyan [12].

On the example of the method by V. B. Minasyan, it is expedient to conduct calculations for the telecommunications industry, thereby showing that the method is accessible and requires minimal knowledge of statistics and econometrics to be applied. The results are explained below.

ASSESSMENT OF RISK MEASURES VAR AND ES USING MULTIPLIER VOLATILITY FROM VARIOUS SECTORS OF THE RUSSIAN ECONOMY

The stock price in the next time period depends not only on factors such as the current level of development and the situation in the company, industry, sector and region, but also on the perception of information about the company

by its external consumers: investors, regulatory authorities and other market participants. Thus, the price behaves as a random variable. Of course, the stock price volatility is also significantly affected by speculative operations, sometimes not related to the fundamental characteristics of a company's financial performance, but more related to the ability to use specific information that has a short-term effect or its specific perception. Following assessment risks are of particular interest for the study. The importance of stock price volatility is increasing for potential investors.

In his work [12], V.B. Minasyan first introduced the term "multiplier" stock volatility, i.e. proposed a method to express stock price volatility through the volatility of company multipliers. This interpretation of stock volatility became possible due to the dependence of stock volatility on the volatility of the multipliers P/E and P/B for Russian companies.

The "multiplier" volatility of stocks is a new method to estimate their volatility based on the volatility of the multipliers P/E and P/B considered in the study. In this paper, the multiplier estimates of expected prices and their volatility will be denoted by $E_{M,E}(P)$ and $\sigma_{M,E}(P)$ or by $E_{M,B}(P)$ and $\sigma_{M,B}(P)$, respectively, depending on whether the multipliers P/E and P/B were used. In our opinion, this method will be especially relevant for non-public companies for which there is no available stock price quotation data.

Thus, the following statements are true for the multipliers P/E and P/B [12]:

$$E_{M,E}(P) = E(E) \cdot E\left(\frac{P}{E}\right); \quad (1)$$

$$\sigma^2_{M,E}(P) = \sigma^2(E) \cdot \sigma^2\left(\frac{P}{E}\right) + \sigma^2(E)\left(E\left(\frac{P}{E}\right)\right)^2 + \left(E(E)\right)^2 \cdot \sigma^2\left(\frac{P}{E}\right). \quad (2)$$

(For details related to the idea of multiplier volatility and the derivation of formulas, see [12]).

VaR_p (Value at Risk) indicator is often used to determine the risk of stock investment. VaR_p is the maximum possible deviation for the worse from the company's stock price from its expected value in a set time period T with a given confidence probability p [12–15].

The formula to calculate Value at Risk is:

$$VaR_p = k_p^{0.1} \cdot \sigma(P) \cdot \sqrt{\frac{T}{\tau}}, \quad (3)$$

where $\sigma(P)$ — is the price volatility (here, calculated as its standard deviation for the period τ (days);

T — is the investment horizon (days); $k_p^{0.1}$ — is the quantile of standardized stock price distribution with the confidence probability p [12–15].

In addition to VaR, it is necessary to calculate the Expected Shortfall with the confidence probability p, ES_p, reflecting the average value of price deviations from its expected value, which could potentially occur in the worst-case scenarios implemented with a probability of $1 - p$ [12–15].

The formula to calculate the Expected Shortfall is:

$$ES_p = \sigma(P) \cdot \sqrt{\frac{T}{\tau}} \cdot \frac{1}{\sqrt{2\pi}} \cdot \frac{\exp(-0{,}5\left(k_p^{0.1}\right)^2}{1-p}, \quad (4)$$

where $\pi \approx 3.14$, and the standard notation for the exponential function is applied $\exp(x) = e^x$, where $e \approx 2.71$.

In these VaR and ES formulas, volatility values are usually provided by the statistical estimates from a sample of the company's stock price quotations. Since it is now possibile to determine multiplier estimates of the stock price volatility $\sigma_M(P)$ and $\sigma_B(P)$, we will calculate the VaR and ES multiplier values, which we denote by VaR_p^M и ES_p^M $\left(VaR_p^B \text{ и } ES_p^B\right)$ according to the above formulas:

$$VaR_p^M = k_p^{0.1} \cdot \sigma_M(P) \cdot \sqrt{\frac{T}{\tau}},$$

$$ES_p^M = \sigma_M(P) \cdot \sqrt{\frac{T}{\tau}} \cdot \frac{1}{\sqrt{2\pi}} \cdot \frac{\exp(-0{,}5\left(k_p^{0.1}\right)^2}{1-p}. \quad (5)$$

Formula (5) will look similar both for VaR_p^B and for ES_p^B.

In the example below, these risk measures will be calculated with the confidence probabilities of 0.95. However, depending on the mission, another confidence probability, different from 0.95, may be chosen.

In terms of the proposed technology, we will now provide the detailed calculations of ROSTELECOM's stocks valuation and the risks of investing in it in three ways:

1. Risk assessment of investing in the company's stocks by usual stock volatility values.

2. Risk assessment of investing in the company's stocks by values of the multiplier P/E and the multiplier valuation of stock volatility.

3. Risk assessment of investing in the company's stocks by values of the multiplier P/B and the multiplier valuation of stock volatility.

Suppose, the management of the company that invested in ROSTELECOM's stocks knows that this company will face serious financial difficulties if the stock price falls below 15 rubles in a year (in 2018). The investor wants to be sure that a probability of difficulties is no more than 5%. It is important to understand whether this scenario is reliable. What will the average stock price be after 5% of the worst-case scenarios are implemented? We expect normal distribution of the stock price within the calculations provided below.

1. Risk assessment of investing in the company's stocks by usual stock volatility values.

Statistical estimates of the expected ROSTELECOM stock price and its standard deviation based on a sample of quotes for 2006–2017, amount to 143.93 and 66.33 rubles respectively. VaR calculation:

$$VaR_{0,95} = 1.65 \cdot 66.33 = 109.44 \text{ rubles.}$$

This result suggests that with a probability of 5% the company's stock price may become 109.44 rubles less than expected. Thus, with a probability of 95%, the company can expect the stock price to be no less than 143.93 – 109.44 = = 34.48 rubles > 15 rubles. Therefore, a probability of serious difficulties is no more than 5%. To estimate the company's average stock price, which may occur in 5% of the worst-case scenarios, we calculate ES for the coming year.

$$ES_{0.95} = 66.33 \cdot \frac{1}{\sqrt{2\pi}} \cdot \frac{\exp(-0,5(1.65)^2}{1-0.95} = 135.66.$$

Despite the fact that at the end of 2018, the company expects the stock price to be143.93 rubles, in the worst-case scenarios, implemented with a probability of 5%, the average expected price can be 143.93 – 135.66 = 8.26 rubles <15 rubles. On average, in 5% of the worst-case scenarios, the investors in ROSTELECOM expect serious financial difficulties.

2. Risk assessment of investing in the company's stocks by values of the multiplier P/E and the multiplier valuation of stock volatility.

To calculate the expected value of ROSTELECOM at the end of 2018, we first apply industry estimates of the expected value and volatility of the multiplier P/E and the expected profits and profit volatility of ROSTELECOM, provided in *Table 2*:

$$E_{M,E}(P) = E(E) \cdot E\left(\frac{P}{E}\right) = 8.91 \cdot 16.14 =$$

$$= 143.77 \text{ руб.}$$

$$\sigma_{M,E}(P) = (\sigma^2(E) \cdot \sigma^2\left(\frac{P}{E}\right) + \sigma^2(E) \left(\begin{array}{c} E\left(\frac{P}{E}\right)^2 + \\ + \left(E(E)\right)^2 \cdot \sigma^2\left(\frac{P}{E}\right) \end{array} \right)^{\frac{1}{2}} =$$

$$= 6.37^2 \cdot 40.79^2 + 6.37^2 \cdot 16.14^2 + 8.91^2 \cdot 40.79^2)^{\frac{1}{2}} = 458.41 \text{ руб.}$$

Next, we calculate $VaR_{0.95}^{M,E}$:

$$VaR_{0.95}^{M,E} = 1.65 \cdot 458.41 = 756.37 \text{ rub.}$$

With a probability of 5%, the company's stock price may become less than expected by 756.37 rubles compared to the expected value. Thus, when using the multiplier P/E with a probability of 95%, we can expect the stock price to be no less than

143.77 – 756.37 = –612.60 rubles. Given that the stock liability is limited by the stock price, we understand that the stock price cannot be negative. The model claims that in the worst-case scenario, the expected stock price will be zero with a probability of 95%. According to the multiplier model, the company's stock will cost nothing with a probability of more than 5%.

To estimate the average stock price, which may occur in 5% of the worst-case scenarios, we will calculate $ES_{0,95}^{M,E}$ for 2018:

$$ES_{0.95}^{M,E} = 458.41 \cdot \frac{1}{\sqrt{2\pi}} \cdot \frac{\exp(-0.5(1.65)^2}{1-0.95} = 937.58 \text{ rub.}$$

Despite the fact that the company expects the stock price to be 143.77 rubles by the end of 2018, in the worst-case scenarios, implemented with a probability of 5%, the average expected price can be 143.77–937.58 = –793.80 rubles. On average, in 5% of the worst-case scenarios, the investors in ROSTELECOM expect serious financial difficulties associated with a complete loss of the value of the acquired stocks.

In some cases, using the multiplier valuation of a specific stock in calculations, the comparative method does not use the expected value of the multiplier calculated for the industry, but the expected value of the multiplier of a similar company.

ROSTELECOM is a public company and may act as a similar company itself. Let us recalculate, applying the expected value and standard deviation of ROSTELECOM's multiplier P/E. We get the following results:

$$E_{M,E}(P) = 8.91 \cdot 15.37 = 136.88 \text{ rub.}$$

$$\sigma_{M,E}(P) = 6.37^2 \cdot 16.14^2 + 6.37^2 \cdot 15.37^2 + 8.91^2 \cdot 16.14^2)^{\frac{1}{2}} = 202.10 \text{ rub.}$$

Next, we calculate $VaR_{0.95}^{M,E}$:

$$VaR_{0.95}^{M,E} = 1.65 \cdot 202.10 = 333.47 \text{ rub.}$$

With a probability of 5%, the company's stock price may become 333.47 rubles less than expected. Thus, when using the multiplier P/E with a probability of 95%, we expect the stock price to be no less than 136.88 – 333.47 = = –196.59 rubles. Given that the stock liability is limited by the stock price, we understand that the stock price cannot be negative. The model claims that in the worst-case scenario, the expected stock price will be zero with a probability of 95%. According to the multiplier model, the company's stock will cost nothing with a probability of more than 5%.

To estimate the average stock price, which may occur in 5% of the worst-case scenarios, we will calculate $ES_{0.95}^{M,E}$ for the next:

$$ES_{0.95}^{M,E} = 202.10 \cdot \frac{1}{\sqrt{2\pi}} \cdot \frac{\exp(-0.5(1.65)^2}{1-0.95} = 413.36 \text{ rub.}$$

Despite the fact that the company expects the stock price to be 136.88 rubles by the end of the next year, in the worst-case scenarios, implemented with a probability of 5%, the average expected price can be 136.88 – 413.36 = –276.48 rubles. On average, in 5% of the worst-case scenarios, the investors in ROSTELECOM expect serious financial difficulties associated with a complete loss of the value of the acquired stocks.

3. Risk assessment of investing in the company's stocks by values of the multiplier P/B and the multiplier valuation of stock volatility.

To calculate the expected value of ROSTELECOM at the end of 2018, we first apply industry estimates of the expected value and the multiplier P/B volatility and the expected profits and profit volatility of ROSTELECOM, provided in *Table 2*:

$$E_{M,B}(P) = 77.11 \cdot 3.13 = 241.73 \text{ rub.}$$

$$\sigma_{M,B}(P) = 39.55^2 \cdot 1.6^2 + 39.55^2 \cdot 3.13^2 + 77.11^2 \cdot 1.6^2)^{\frac{1}{2}} = 185.78 \text{ rub.}$$

Next, we calculate $VaR_{0,95}^{M,B}$:

$$VaR_{0.95}^{M,B} = 1.65 \cdot 185.78 = 306.54 \text{ rub.}$$

With a probability of 5%, the company's stock price may become less than expected by 306.54 rubles compared to the expected value. Thus, when using the multiplier P/B with a probability of 95%, we can expect the stock price value to be no less than 241.73 – 306.54 = –64.80 rubles < 15 rubles. Thus, a probability of serious difficulties is more than 5%.

To estimate the average stock price, which may occur in 5% of the worst-case scenarios, we will calculate $ES_{0.95}^{M,B}$ for 2018:

$$ES_{0.95}^{M,B} = 185.78 \cdot \frac{1}{\sqrt{2\pi}} \cdot \frac{\exp(-0.5(1.65)^2}{1-0.95} = 379.97 \text{ rub.}$$

Despite the fact that the company expects the stock price to be 241.73 rubles at the end of 2018, in the worst-case scenarios, implemented with a probability of 5%, the average expected price can be 241.73–379.97= –138.24 rubles. On average, in 5% of the worst-case scenarios, the investors expect serious financial difficulties associated with a complete loss of the value of the acquired stocks.

We apply the expected value and ROSTELECOM's multiplier volatility:

$$E_{M,B}(P) = 77.11 \cdot 1.45 = 112.14 \text{ rub.}$$

$$\sigma_{M,B}(P) = (39.55^2 \cdot 1.03^2 + 39.55^2 \cdot 1.45^2 + 77.11^2 \cdot 1.03^2)^{\frac{1}{2}} = 142.12 \text{ rub.}$$

Next, we calculate $VaR_{0.95}^{M,B}$:

$$VaR_{0.95}^{M,B} = 1.65 \cdot 142.12 = 234.49 \text{ rub.}$$

With a probability of 5%, the company's stock price may become less than expected by 234.49 rubles compared to the expected value. Thus, when using the multiplier P/B for company valuation with a probability of 95%, we can expect the stock price to be no less than 112.14 – 234.49 = –122.35 rubles.

Given that the stock liability is limited by the stock price, we understand that the stock price cannot be negative. The model claims that in the worst-case scenario, the expected stock price will be zero with a probability of 95%. According to the multiplier model, the company's stock will cost nothing with a probability of more than 5%.

To estimate the average stock price, which may occur in 5% of the worst-case scenarios, we will calculate $ES_{0.95}^{M,B}$ for 2018:

$$ES_{0.95}^{M,B} = 142.12 \cdot \frac{1}{\sqrt{2\pi}} \cdot \frac{\exp(-0.5(1.65)^2}{1-0.95} = 290.67 \text{ rub.}$$

Despite the fact that the company expects the stock price to be 112.14 rubles at the end of the next year, in the worst-case scenarios, implemented with a probability of 5%, the average expected price can be 112.14–290.67= –178.53 rubles. On average, in 5% of the worst-case scenarios, the investors expect serious financial difficulties associated with a complete loss of the value of the acquired stocks.

This example shows the huge risks for the counterparty in the stock valuation by a comparative method using multipliers that can be applied by the evaluator.

It should be noted that the valuation method using multipliers is most frequently applied in equity valuation of non-public companies. For public companies, market valuation is considered the best. At the same time, it is not possible for non-public companies to obtain an estimate of the expected stock price at the end of the next period based on quotes. Therefore, the estimates obtained by using multipliers have nothing to compare.

It should be noted that only 16 of the 46 companies represented in this study did not have serious problems with indicators of net profit and book value, i.e. these indicators had a positive value from 2006 to 2017. This fact further emphasizes the risks of obtaining high-quality estimates by multiplier technology using P/E and P/B.

Table 5

Calculation results of the expected value of investments in ROSTELECOM stocks and the risks of these investments based on risk measures VaR and ES

	$E(P)$ (rub.)	$\sigma(P)$ (rub.)	$VAR_{0.95}$ (rub.)	$ES_{0.95}$ (rub.)
Standart statistical estimates	143.93	66.33	109.44	135.66
Estimates using the industry multiplier P/E	143.77	458.41	756.37	937.58
Estimates using the industry multiplier P/E for PJSC "ROSTELEKOM"	136.88	202.1	333.47	413.36
Estimates using the industry multiplier P/B	241.73	185.78	306.54	379.97
Estimates using the industry multiplier P/B for PJSC "ROSTELEKOM "	112.14	142.12	234.49	290.67

Source: the author's calculations.

The example of the public company ROSTELECOM is interesting as it provides estimates of the company's expected stock prices applying quotes and the expected values of the industry multipliers P/E and P/B. Also, the risks of investing in ROSTELECOM stocks were assessed based on risk measures VaR and ES calculated on normal distribution applying the usual statistical estimation of volatility and of the P/E and P/B multiplier volatility. *Table 5* provides the results. *Appendix 2* presents the data on the other sectors where one company, the industry representative, was selected.

The above example makes it clear that the company's expected stock valuation by the multiplier method significantly deviate from its statistical estimation.

The difference in estimating the multiplier volatility of the company's stocks using both multipliers is much altered from the usual statistical volatility estimation. This leads to the fact that both the risk measure VaR and the risk measure for catastrophe ("tail"), calculated using multiplier volatility, ultimately provide higher estimates of the corresponding risks compared to the statistical estimation of volatility. These significant differences in assessing the risks of stock investment are associated both with a high risk of valuation using the multiplier method, as well as with the fact that the usual, historical volatility estimation assumes that the future will be an average repetition of the stock history of a particular company. The multiplier volatil-

ity estimation may contain information about "fundamental" changes in the industry that may not have happened in the company yet, but may affect it in the future. This may be the added value of a multiplicative estimation of the company's stock volatility.

It is worth noting that the normal distribution of stock prices was expected in the example above, which is not quite realistic. As a rule, in a real situation, the distribution has a thicker left tail. For this reason, risks can only be greater than the estimates obtained in our example. Moreover, the purpose of this study was to compare relative values of risk assessments using various assessment methods and constant assumptions about the distribution law.

CONCLUSIONS

The work studied the multiplier method, a classic and commonly used assessment method. The authors calculated the risks of the method use in stock valuation of Russian companies from nine industries. The expected industry average value was used to estimate the multipliers. It is worth revealing how significant the volatility of the applied multipliers is within the industries, i.e. location, distribution by companies within the industry and distribution over time, and how it affects our valuation. The original method of multiplier estimation of stock volatility was used [12]. It clears the estimation of the short-term background and brings it closer to the fundamental industry related to the nature of the business. The risk measures VaR and ES were assessed based on the multiplier volatility estimation. It makes it possible to obtain a different assessment of risk measures to be considered when deciding on long-term investments.

The paper emphasizes the general behavior of the stock value of Russian companies in 2006–2017 depending on the industry. This will help in making decision on the purchase/sale of stocks. It will also provide an opportunity to compare the behavior of indicators between the economic sectors in terms of the multiplier technology for Russian companies' stocks.

The model risk analysis in stock valuation proposed by V. B. Minasyan [12] can be used by any market participant to check estimates of the stock value of Russian companies, both public and non-public, from any industry and any country.

The Russian stock market is relatively young compared to the Western ones (officially, the New York Stock Exchange was founded in 1817, the London Stock Exchange — in 1801, the modern Russian stock market was formed in 1991–1992). Therefore, it is important to apply Western approaches in the stock valuation of Russian companies very carefully.

Appendix 1

Calculation results of the values of mathematical expectation and standard deviation of the indicators for 8 industries according to data for 2006–2017

Indicator	Mathematical expectation of indicators		Standard deviation of indicators (daily value)	
	1			
	Oil and gas industry	The company PJSC LUKOIL	Oil and gas industry	The company PJSC LUKOIL
For absolute values				
Multiplier P/E	8.01	3.62	5.96	3.12
Multiplier P/B	1.33	0.36	0.56	0.22
Annual profit. rub.	1 830 989 337 608.95	756 689 059 530.53	502 810 804 661.20	366 427 607 182.75
Annual profit per 1 share. rub.	80.66	889.63	22.81	430.81
Book value. rub.	14 567 488 976 545.90	6 197 541 987 787.15	6 305 752 644 152.43	2 614 386 471 775.69
Book value per 1 share. rub.	1 214 823.17	7286.40	871 127.12	3073.71
Share price. rub.	557.86	1997.40	183.59	421.63
For relative values				
Return on multiplier P/E	–0.00026	0.00008	0.06546	0.02491
Return on multiplier P/B	–0.00011	0.00008	0.02517	0.02697
Return on shares	0.00002	0.00014	0.02490	0.01929

Appendix 1 (continued)

Показатель / Indicator	Mathematical expectation of indicators		Standard deviation of indicators (daily value)	
	2			
	Finance industry	PJSC VTB	Finance industry	PJSC VTB
For absolute values				
Multiplier P/E	21.18	23.19	1 073.13	1 380.49
Multiplier P/B	1.21	1.20	4.63	10.40
Annual profit, rub.	170 060 170 087.25	32 783 282 318.96	174 052 905 920.02	42 052 442 932.22
Annual profit per 1 share, rub.	232.73	0.00	860.23	0.00
Book value, rub.	2 344 981 714 490.77	627 971 033 410.97	1 500 775 221 050.48	491 819 694 540.61
Book value per 1 share, rub.	252.41	0.06	854.88	0.04
Share price, rub.	4550.27	0.07	19 028.12	0.04
For relative values				
Return on multiplier P/E	–0.00290	–0.00214	0.15560	0.08525
Return on multiplier P/B	–0.00136	–0.00172	0.13273	10.39668
Return on shares	0.00234	–0.00042	0.04339	0.02663

Appendix 1 (continued)

Indicator	Mathematical expectation of indicators		Standard deviation of indicators (daily value)	
	3			
	Customer industry	The company PJSC MAGNIT	Customer industry	The company PJSC MAGNIT
For absolute values				
Multiplier P/E	2832.91	25.65	67959.31	275.66
Multiplier P/B	243.79	4.71	1584.68	2.79
Annual profit, rub.	17066674356.26	16544704092.27	19561326882.26	20040243188.17
Annual profit per 1 share, rub.	78.99	177.85	126.39	209.81
Book value, rub.	169886504210.69	81322432369.90	126242266173.72	69616797930.15
Book value per 1 share, rub.	113.04	812.07	155.32	732.60
Share price, rub.	1465.50	4374.92	1945.85	4073.63
For relative values				
Return on multiplier P/E	–0.00144	0.00015	0.15816	0.04435
Return on multiplier P/B	–0.00042	–0.00039	0.17372	2.79444
Return on shares	0.00015	0.00042	0.01806	0.01864

Appendix 1 (continued)

Indicator	Mathematical expectation of indicators		Standard deviation of indicators (daily value)	
	4			
	Transportation industry	The company PJSC Aeroflot	Transportation industry	The company PJSC Aeroflot
For absolute values				
Multiplier P/E	5.87	6.65	51.42	79.26
Multiplier P/B	1.86	1.69	21.21	46.38
Annual profit, rub.	6 331 941 468.25	5 109 006 025.93	23 372 206 808.89	12 222 261 643.70
Annual profit per 1 share, rub.	2.26	4.87	7.52	11.58
Book value, rub.	71 916 167 710.24	24 137 965 364.08	55 770 409 229.32	21 605 954 180.08
Book value per 1 share, rub.	4.31	21.24	7.28	20.63
Share price, rub.	35.40	68.77	25.59	37.72
For relative values				
Return on multiplier P/E	0.00086	–0.00039	0.27111	0.09091
Return on multiplier P/B	–0.00084	–0.00041	0.12045	46.37731
Return on shares	0.00026	0.00028	0.01578	0.01938

Appendix 1 (continued)

Indicator	Mathematical expectation of indicators		Standard deviation of indicators (daily value)	
	5			
	Chemical industry	The company PJSC AKRON	Chemical industry	The company PJSC AKRON
The absolute values				
Multiplier P/E	8.78	–1.09	156.70	164.59
Multiplier P/B	3.07	0.91	58.52	0.63
Annual profit, rub.	32 602 971 048.03	7 944 940 916.66	37 489 187 119.99	7 271 191 752.19
Annual profit per 1 share, rub.	70.53	191.10	56.22	178.37
Book value, rub.	231 431 009 826.53	51 876 676 923.79	158 271 296 053.57	35 612 154 229.29
Book value per 1 share, rub.	241.39	1256.09	184.96	888.39
Share price, rub.	969.07	1281.50	1477.45	643.54
For relative values				
Return on multiplier P/E	–0.00052	–0.00135	0.19172	0.03623
Return on multiplier P/B	–0.00017	–0.00006	0.09435	0.63255
Return on shares	0.00004	0.00032	0.02184	0.02050

Appendix 1 (continued)

Indicator	Mathematical expectation of indicators		Standard deviation of indicators (daily value)	
	6			
	Engineering industry	The company PJSC SOLLERS	Engineering industry	The company PJSC SOLLERS
For absolute values				
Multiplier P/E	10.57	31.93	511.89	2 084.20
Multiplier P/B	1.13	1.14	24.51	0.66
Annual profit, rub.	–2 082 613 851.85	1 313 362 122.83	16 049 582 561.59	2 992 985 597.40
Annual profit per 1 share, rub.	40.98	39.26	77.24	91.66
Book value, rub.	33 249 092 257.79	13 915 626 485.91	41 626 486 484.96	5 594 097 713.03
Book value per 1 share, rub.	2.78	379.25	46.91	189.63
Share price, rub.	327.48	579.16	257.01	274.28
For relative values				
Return on multiplier P/E	–0.00081	–0.00093	0.18086	0.10464
Return on multiplier P/B	–0.00006	–0.00002	0.11081	0.66188
Return on shares	0.00005	0.00004	0.02095	0.02248

Appendix 1 (continued)

Показатель / Indicator	Mathematical expectation of indicators		Standard deviation of indicators (daily value)	
	7			
	Energy industry	The company PJSC MOSENERGO	Energy industry	The company PJSC MOSENERGO
For absolute values				
Multiplier P/E	–2.22	–2.27	92.88	739.54
Multiplier P/B	1.17	0.78	1.21	1.20
Annual profit, rub.	54 882 408 818.31	13 167 097 228.27	98 152 809 167.58	18 790 229 575.18
Annual profit per 1 share, rub.	0.11	0.33	0.09	0.47
Book value, rub.	2 250 300 581 879.22	173 591 451 138.96	1 356 430 321 613.57	80 443 372 618.84
Book value per 1 share, rub.	1.39	4.09	0.81	2.23
Share price, rub.	1.92	2.19	1.84	1.84
For relative values				
Return on multiplier P/E	–0.00284	–0.00002	0.20966	0.06864
Return on multiplier P/B	–0.00018	–0.00028	0.06111	1.20330
Return on shares	0.00007	–0.00003	0.02033	0.02044

Appendix 1 (continued)

Indicator	Mathematical expectation of indicators		Standard deviation of indicators (daily value)	
	8			
	Metallurgical and mining industry	The company PJSC ALROSA	Metallurgical and mining industry	The company PJSC ALROSA
For absolute values				
Multiplier P/E	9.38	11.77	34.97	402.14
Multiplier P/B	2.53	0.96	1.64	1.17
Annual profit, rub.	94 629 599 320.18	19 210 101 413.21	109 016 056 884.81	32 595 984 754.86
Annual profit per 1 share, rub.	249.87	–2202.27	191.91	31 218.93
Book value, rub.	932 683 531 461.67	103 453 476 277.65	354 802 372 875.56	79 129 858 172.07
Book value per 1 share, rub.	309.55	67 449.84	183.25	133 860.34
Share price, rub.	2 756.38	54.33	2288.27	23.62
For relative values				
Return on multiplier P/E	–0.00082	–0.00074	0.19693	0.06135
Return on multiplier P/B	0.00017	–0.00007	0.04016	1.17394
Return on shares	0.00035	0.00029	0.01929	0.02244

Appendix 2

Results of the assessment of the expected value of investments in companies' stocks and the risks of these investments based on risk measures VaR and ES

Industry		*E*(*P*). rub.	σ(*P*). rub.	$VaR_{0.95}$. rub.	$ES_{0.95}$. rub.
Oil and gas	Standard statistical estimates	1997	422	696	862
	Estimates using the P/E multiplier calculated for the industry	7123	6825	11 262	13 960
	Estimates using the P / E multiplier calculated for Lukoil	3225	3459	5708	7075
	Estimates using the P / B multiplier calculated for the industry	9705	6056	9993	12 387
	Estimates using the P / B multiplier calculated for Lukoil	2654	1632	2693	3339
Financial	Standard statistical estimates	0.07	0.04	0.06	0.07
	Estimates using the P/E multiplier calculated for the industry	0.06	5.32	8.77	10.88
	Estimates using the P / E multiplier calculated for VTB	0.06	6.84	11.29	13.99
	Estimates using the P/B multiplier calculated for the industry	0.07	0.32	0.53	0.65
	Estimates using the P / B multiplier calculated for VTB	0.07	0.70	1.16	1.43

Appendix 2 (continued)

Industry		*E*(*P*). rub.	σ(*P*). rub.	$VaR_{0.95}$. rub.	$ES_{0.95}$. rub.
Consumer sector	Standard statistical estimates	4375	4074	6721	8332
	Estimates using the P / E multiplier calculated for the industry	503 843	18 701 860	30 858 069	38 250 886
	Estimates using the P / E multiplier calculated for MAGNIT	4561	76 011	125 418	155 465
	Estimates using the P / B multiplier calculated for the industry	197 973	1 742 321	2 874 830	3 563 567
	Estimates using the P / B multiplier calculated for MAGNIT	3827	22 432	37 013	45 880
Transport	Standard statistical estimates	69	38	62	77
	Estimates using the P / E multiplier calculated for the industry	29	650	1072	1329
	Estimates using the P / E multiplier calculated for Aeroflot	32	999	1648	2043
	Estimates using the P / B multiplier calculated for the industry	39	629	1038	1287
	Estimates using the P / B multiplier calculated for Aeroflot	36	2009	3315	4109

Appendix 2 (continued)

Industry		*E*(*P*). rub.	σ(*P*). rub.	$VaR_{0.95}$. rub.	$ES_{0.95}$. rub.
Chemical	Standard statistical estimates	1282	644	1062	1316
	Estimates using the P / E multiplier calculated for the industry	1678	40 993	67 638	83 842
	Estimates using the P / E multiplier calculated for AKRON	–209	43 027	70 995	88 003
	Estimates using the P / B multiplier calculated for the industry	3857	90 072	148 619	184 224
	Estimates using the P / B multiplier calculated for AKRON	1149	1069	1765	2187
Machine-building	Standard statistical estimates	579	274	453	561
	Estimates using the P / E multiplier calculated for the industry	415	51 051	84 234	104 414
	Estimates using the P / E multiplier calculated for PJSC SOLLERS	1253	207 840	342 936	425 095
	Estimates using the P / B multiplier calculated for the industry	430	10 394	17 151	21 259
	Estimates using the P / B multiplier calculated for PJSC SOLLERS	433	440	727	901

Appendix 2 (continued)

Industry		*E*(*P*). rub.	σ(*P*). rub.	$VaR_{0.95}$. rub.	$ES_{0.95}$. rub.
Energy	Standard statistical estimates	2	2	3	4
	Estimates using the P / E multiplier calculated for the industry	–1	54	89	110
	Estimates using the P / E multiplier calculated for PJSC MOSENERGO	–1	429	707	877
	Estimates using the P / B multiplier calculated for the industry	5	6	10	13
	Estimates using the P / B multiplier calculated for PJSC MOSENERGO	3	6	9	11
Metallurgy	Standard statistical estimates	54.33	23.62	38.97	48.30
	Estimates using the P / E multiplier calculated for the industry	–20 665	1 132 935	1 869 343	2 317 190
	Estimates using the P / E multiplier calculated for PJSC ALROSA	–25 928	12 590 815	20 774 844	25 751 975
	Estimates using the P / B multiplier calculated for the industry	170 398	417 829	689 419	854 586
	Estimates using the P / B multiplier calculated for PJSC ALROSA	64 992	79 181	130 650	161 950

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