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Introduction

One of the fastest growing areas in the economic sciences is broadly defined area of finance, with particular emphasis on the financial markets, financial institutions and risk management. Real world challenges stimulate the development of new theories and methods. A large part of the theoretical research concerns the analysis of the risk of not only economic entities, but also households.

The first Wrocław Conference in Finance WROFIN was held in Wrocław between 22nd and 24th of September 2015. The participants of the conference were the leading representatives of academia, practitioners at corporate finance, financial and insurance markets. The conference is a continuation of the two long-standing conferences: INVEST (Financial Investments and Insurance) and ZAFIN (Financial Management – Theory and Practice).

The Conference constitutes a vibrant forum for presenting scientific ideas and results of new research in the areas of investment theory, financial markets, banking, corporate finance, insurance and risk management. Much emphasis is put on practical issues within the fields of finance and insurance. The conference was organized by Finance Management Institute of the Wrocław University of Economics. Scientific Committee of the conference consisted of prof. Diarmuid Bradley, prof. dr hab. Jan Czekaj, prof. dr hab. Andrzej Gospodarowicz, prof. dr hab. Krzysztof Jajuga, prof. dr hab. Adam Kopiński, prof. dr. Hermann Locarek-Junge, prof. dr hab. Monika Marcinkowska, prof. dr hab. Paweł Miłobędzki, prof. dr hab. Jan Monkiewicz, prof. dr Lucjan T. Orłowski, prof. dr hab. Stanisław Owsiak, prof. dr hab. Wanda Ronka-Chmielowiec, prof. dr hab. Jerzy Różański, prof. dr hab. Andrzej Sławiński, dr hab. Tomasz Słoński, prof. Karsten Staehr, prof. dr hab. Jerzy Węcławski, prof. dr hab. Małgorzata Zaleska and prof. dr hab. Dariusz Zarzecki. The Committee on Financial Sciences of Polish Academy of Sciences held the patronage of content and the Rector of the University of Economics in Wroclaw, Prof. Andrzej Gospodarowicz, held the honorary patronage.

The conference was attended by about 120 persons representing the academic, financial and insurance sector, including several people from abroad. During the conference 45 papers on finance and insurance, all in English, were presented. There were also 26 posters.

This publication contains 27 articles. They are listed in alphabetical order. The editors of the book on behalf of the authors and themselves express their deep gratitude to the reviewers of articles – Professors: Jacek Batóg, Joanna Bruzda, Katarzyna Byrka-Kita, Jerzy Dzieża, Teresa Famulska, Piotr Fiszeder, Jerzy Gajdka, Marek Gruszczyński, Magdalena Jerzemowska, Jarosław Kubiak, Tadeusz Kufel, Jacek Li-

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Wanda Ronka-Chmielowiec, Krzysztof Jajuga

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MARKET FUNDAMENTAL EFFICIENCY: DO PRICES REALLY TRACK FUNDAMENTAL VALUE?

EFEKTYWNOŚĆ FUNDAMENTALNA RYNKU: CZY CENY NAPRAWDĘ PODĄŻAJĄ ZA WARTOŚCIĄ FUNDAMENTALNĄ?

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Abstract: This paper provides an evidence supporting the hypothesis that under certain assumptions capital market prices track securities fundamental values. Examining market fundamental efficiency using ex ante and ex post analysis of S&P 500 quotations from 1960--2013, it was documented that since 1974 prices follow two series of fundamental values obtained with actual data. Research provides an evidence that under certain assumptions investors correctly predict future values of dividends and expected rates of return. Moreover, unlike fundamental value which may be considered theoretically a very useful tool, as long as certain assumptions are made, fundamental value determined on the basis of historical data has, from investors' point of view, no tangible economic value at all.

Keywords: market, efficiency, fundamental value, stock valuation.

Streszczenie: W artykule przedstawiono wyniki badań potwierdzające hipotezę, że przy pewnych założeniach ceny na rynku kapitałowym naśladują wartości fundamentale uzyskiwane za pomocą prostych modeli kalkulacyjnych. Badanie przeprowadzono, używając analizy *ex ante* i *ex post* notowań indeksu S&P 500 z 1960-2013. Uzyskane rezultaty wskazały, że od 1974 indeks dość dobrze naśladuje dwie serie wartości fudamentalnych ustalonych na podstawie rzeczywistych danych. Pokazano również, że przy pewnych założeniach inwestorzy prawidłowo przewidywują przyszłe wartości dywidend i oczekiwane stopy zwrotu. Co więcej, w przeciwieństwie do wartości fundamentalnej, która jest pojęciem abstrakcyjnym, wartości fundamentalne badanego indeksu ustalone na podstawie danych historycznych, mają z punktu widzenia inwestorów niewielką wartość poznawczą.

Słowa kluczowe: rynek, efektwyność informacyjna, wartości fundamentalne.

1. Introduction

The academic discussion on the functioning of capital markets has been dominated by the issue of their informational efficiency over the last few decades. However, emerging stock market bubbles, including the most actual and painful for investors: the internet bubble, urges us to consider whether the problem is virtually properly defined. At the end of the last century, many individuals and professionals surrendered to large scale pressure by acquiring dot-com stocks whose prices skyrocketed, reaching absurd levels. Less than three years later the bubble burst, and the S&P 500 index value dropped from the year 2000 to 2002 by more than 33%. The stocks that were meant to bring fortune left many, who had bought securities at prices they could not and probably did not understand, losers drowned in disappointment. The most basic question that arises is whether there were any reasonable grounds for buying stocks at such unreasonable prices? Or, more broadly, whether at a given moment in time, investors are able to assess whether they purchase securities at a fair price.

Academics generally agree that in the developed and liquid stock markets the prices should track fundamental value. Any deviations from fundamentals are adjusted by the market through purchasing of undervalued stocks or selling overvalued ones. Such a market can be called fundamentally efficient, which is to some extent associated with the concept of informational efficiency, but these terms are definitely not identical. In contrast to the informational efficiency, which commonly means that there is no possibility of achieving abnormal returns by investors, fundamental efficiency means only that the prices follow securities fundamental value.

In this study the concept of fundamental value from the theoretical as well as practical point of view was examined. In the first case, it was showed that under certain assumptions the concept of fundamental value, on the theoretical side, works perfectly, and that prices in the stock market do track such values. In the second case, research showed that the practical use of this concept is of little importance to investors and should not be the basis for investment decisions.

In order to perform the analyses, firstly the fundamental value of S&P 500 index unit over the period of 1960-2013 with Gordon Growth Model was reconstructed using the data that was available to investors at a certain point in time. For the calculation of the expected rate of return, both risk premiums obtained by arithmetic and geometric means, as well as risk-free rates based on T-Bills rate and T-Bonds rate, were used. By doing so four series of fundamental values were obtained which in result did not force us to decide on which data might have been taken into account by investors for their own calculations.

Subsequently, it was examined whether the S&P 500 quotations track any obtained series of model fundamental values. In the next step, scopes of risk premiums for the market, reported in literature, were used in order to obtain a range of model fundamental value results based on the extreme values of risk premiums within these scopes for each year from 1960 to 2013. This is due to impossibility of

determining whether investors calculate risk premiums according to a certain model or perhaps in some other manner.

The application of the risk premium scopes given in literature eliminates some of this uncertainty. Subsequently, it was examined whether the S&P 500 quotations track the ranges of model fundamental value obtained in such way. In the next analysis, it was examined whether the market follows the series of "real" fundamental values of S&P 500 unit. For the calculation we used the actual data, such as dividends, risk rates, risk-free rates from 1960 to 2013 period (the data related to the period beyond the year 2013 was obtained by applying the Gordon Growth Model and CAPM). At the end, it was examined what levels of dividend growth rate and expected rate of return bring the model fundamentals and S&P 500 quotations the closest to each other.

This paper is most closely related to the previous studies that test whether the stock market prices are related to their fundamental value (e.g., Shiller [1981], Marsh and Merton [1986], LeRoy and Porter [1981], Campbell and Shiller [1988]). Using this approach, the authors examined the stability of the present value through time that suggests there is excess volatility in the aggregate stock market, relative to the present value implied by the efficient markets model. In this paper, in contrast, the stock market fundamental efficiency was examined, as well as the answer, whether prices accurately track asset's fundamental value, was looked for.

Using the S&P 500 quotations from 1960 to 2013 and the Gordon Growth Model, it was first documented that investors are unable to obtain economically useful fundamental value of the index unit. Regardless of dividends growth rate, risk premium and risk-free rate, and different calculation models, current S&P 500 quotes in the period from 1960 to 2007 significantly outweigh the obtained fundamental values. What is more, even the use of the risk premium value given in the literature still makes the concept of fundamental value useless for investors. The results also show that using historical data under some specific assumptions makes it possible to properly estimate the future average dividends growth rate and the risk premium with an acceptable standard error.

The main cause of model fundamental value being consecutively undervalued was an inability to estimate the future value of T-Bonds rate or T-Bills rate which fluctuated significantly in 1960-2013 period. In contrast, the ex post analysis indicates that from a theoretical perspective, the concept of fundamental value is a very useful tool. Under some specific assumptions, S&P 500 quotations do track series of model fundamental value obtained by using real data from 1960-2013 period and estimated data beyond 2013.

In one case, the average difference, between the market quotes and series of "real" fundamental values, comes close to 23.2% for the whole analysed period and even to 12.3% for the 1974-1995 period. Second ex-post analysis showed that, under assumption that the applied Gordon Growth Model is a correct method of obtaining stocks fundamental value, it is possible to optimize the fixed value of dividend

growth rate and expected rate of return which give a series of fundamental values being tracked by S&P 500 quotations. In this case, the average difference between the market quotes and the series of fundamental values obtained with optimized fixed parameters, come close to 24.4% for the whole analysed period.

The remainder of the paper is organized as follows. Section 2 describes the data and research methods. Section 3 provides results regarding the market fundamental efficiency. Section 4 discusses and concludes.

2. Data and research methods

The principal data for this study comes from the Board of Governors of the Federal Reserve System (3-Month Treasury Bill: Secondary Market Rate) and Federal Reserve of St. Louis (US treasury 10-year bond at end of each year and S&P 500 quotes at end of each year). In order to calculate the risk premiums for each year from 1927 to 2013, the annual returns on investments in S&P 500 including dividends, 3-month Treasury Bills and 10-year Treasury Bonds were obtained. To compute the return on a constant maturity bond, two components were added: the promised coupon at the start of the year and the price change due to interest rate changes. In order to estimate the fundamental value of S&P 500 unit for each year from 1960 to 2013, a dividend value per unit was obtained and T-Bills and T-Bonds rates were used as well as the risk premiums determined in the manner described below.

It is widely agreed among academics that, for practical purposes, the most appropriate evaluation of fundamental value of a stock or index unit is the present value of future dividends through infinity. In this study a well-known Gordon Growth Model was used, as dividends of S&P 500 companies increase in value with time. The model fundamental value is defined as follows:

$$Fundamental\ Value = \frac{D_0(1+g)}{r_e - g}$$

where D_0 is the value of dividends per index unit that have been recently paid, r_e is investors annual required rate of return and g is dividends constant growth rate.

In order to calculate investors' expected rate of return, the Capital Asset Pricing Model was used with the beta coefficient equal to one, as it concerns an expected rate of return on broad index. It is expressed formulaically as follows:

$$r_e = r_f + RP$$

where, r_f is risk-free rate and RP is the risk premium. In the first analysis covering years 1960-2013, the historical average dividend growth rate was used in order to determine the fundamental value of the model, always starting from 1928 and ceasing with the observation of the year for which the current model fundamental value was calculated. This gives a fairly reliable, long-term average growth rate of dividends

even for the first year of the analysed period. Without getting into an argument about what kind of measure should be used to determine the growth rates of dividends, both the arithmetic mean recommended by Cooper [1996] and the geometric mean recommended by Dimson et al. [2002] were used. There is also some discussion whether to use T-Bonds or T-Bills rate as a risk-free rate. Thus, for practical reasons, both of these variables were used.

Risk premiums in a given year were obtained by subtracting annual return on T-Bonds and T-Bills from the S&P 500 annual return, including paid dividends, as recommended by Dimson et al. [2002]. Then, for each year of the analysis, the arithmetic or geometric mean of historical risk premiums were determined, each time starting from 1928. Similarly, to the dividend growth rate calculation model, such proceeding gives a rather reliable, long-term average risk premium rate, even for the first analysed year. Such an approach is recommended, inter alia, by Damodaran [2011]. As a result, eight series of S&P 500 model fundamental value were obtained. Theyarise from the use of different methodologies for determining the following parameters: the growth rate of dividends (arithmetic and geometric mean), the risk-free rate (T-Bonds rate and T-Bills rate) and the risk premium (arithmetic and geometric mean). Such broad spectrum of fundamentals was compared with the series of S&P 500 quotations.

Since there are many issues related to the concept of risk premium, as well as methods of its calculation which are mentioned, among others, by Ibbotson [2011], in the second group of analyses the risk premium rates reported in literature, were used. Of course, these values vary depending on the considered period as well as on the method used.

Jorion and Goetzmann [1999] report that in the period of 1921-1998 the risk premium equalled 3.84% on average. Fama and French [2002] estimate this value at 2.55% to 4.32% for the years 1951-2000. Dimson et al. [2002] suggest that global historical risk premium is of about 6%. Ibbotson [2011] argues, in contrast, that for years 1926 to 2010 it ranged from 4.4% to 8.2%. Fernandez [2009] and Fernandez, Aguirremalloa and Corres [2011] estimate the mean value at 5.5% which is the average of 1436 risk premium estimates given by professors, analysts and financial companies' staff. If we consider the standard deviation of this prediction to be equal to 1.7%, we obtain the risk premium ranging from 3.8% to 7.2%. Welch [2000] set the rate of risk premium at 6.8% -7.0% for the last 30 years' period (arithmetic mean) on the basis of surveys collected from 226 financial economists. Brealey and Myers [1996] suggest that the premium historically oscillates around the value of 8.2% to 8.5%.

In the analysis, a range of risk premium rates suggested by Ibbotson [2011] was adopted because it is wide enough to include the figures given by most of the other mentioned authors. For practical reasons, the T-Bonds rates were used as the risk-free rate, as applying the T-Bills rate would cause the expected rate of return to be lower than the dividends growth rate in some periods. As a result, four series of

model fundamental value were received. Two series for the lower extreme value of the risk premium (4.4%) provided by Ibbotson, were obtained with the arithmetic and geometric mean of historical dividends growth rates. Similarly, two series of data were obtained for the upper extreme value of the risk premium (8.2%). All four series of model fundamental value were compared with the S&P 500 market quotations.

In subsequent analysis, the actual value of dividends per S&P 500 unit from the period of 1960-2013 were used. For each year from the specified time range, investor's expected rate of return was determined in accordance with the formula given earlier. Both the T-Bills rate and the T-Bond rate from a given year as the risk-free rate were used. Also, the risk premium for a given year using the arithmetic and geometric mean of differences between annual returns on the S&P 500 (including the dividends paid) and the returns on investments in T-Bills and T-Bonds for the years preceding the year of calculation (starting from the year 1928) was calculated. Thus, the determined annual expected rates of return that were employed to create foldable expected rates of return which allowed for discounting the dividends actually paid in the years 1960 to 2013.

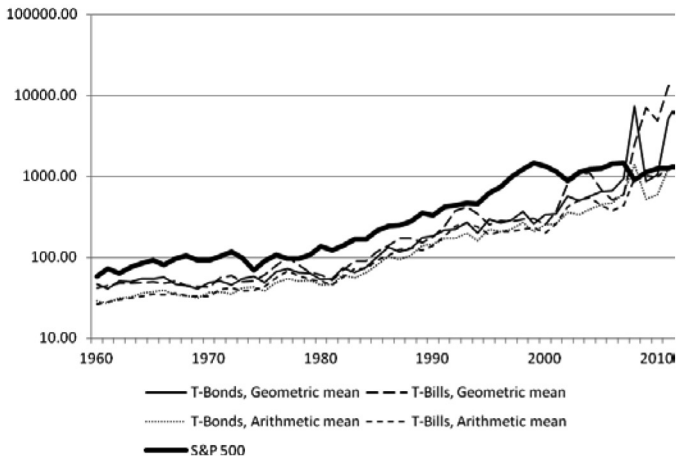
In order to determine the value of future dividends per S&P 500 for the period beyond 2013, an average dividends growth rate from the years 1928-2013 was used. For calculating their present value in 2013 an annual expected rate of return from 2013 was applied, which then, using foldable expected rates of return, was reduced to the present value for a given year. Thus, adding up the discounted dividends paid and the expected dividends from beyond 2013 resulted in four series of model fundamental value that are as close as possible to the "real" fundamentals of S&P 500 unit obtained with different means (arithmetic or geometric) and risk-free rates (T-Bills rate or T Bonds rate).

In the next step these values were compared to the actual S&P 500 quotations. In the final analysis, Monte Carlo simulation was used to determine the fixed dividends' growth rate and the expected rate of return for which fundamental value obtained with the Gordon Growth Model differs from the actual S&P 500 quotations the least.

3. Results

In the first analysis it was examined whether the S&P 500 quotations reflect model fundamental value obtained by using historical dividends growth rate means and historical risk premium rate means. Figure 1 shows four series of results determined with use of arithmetic mean of dividends growth rate per S&P 500 unit in 1960-2013 period.

The data clearly shows that in the period of 1960-2007 market quotations of S&P 500 were continuously exceeding the fundamental value of index units determined with the Gordon model. In the years 2008-2013 these values were unreasonably high as compared to the index market quotations. The results presented in Table 1 show



Note: The chart presents S&P 500 quotations against fundamental value obtained by using the arithmetic mean of dividends growth rate. Four series of data represent the use of T-Bills and T-Bonds as risk-free rates and arithmetic or geometric mean of historical risk premiums.

Figure 1. Model fundamental values obtained with arithmetic mean of historical dividends' growth rate vs. S&P 500 quotations

Source: Author's own study.

Table 1. Percentage differences between S&P500 quotations and model fundamental values for arithmetic mean of historical risk premiums

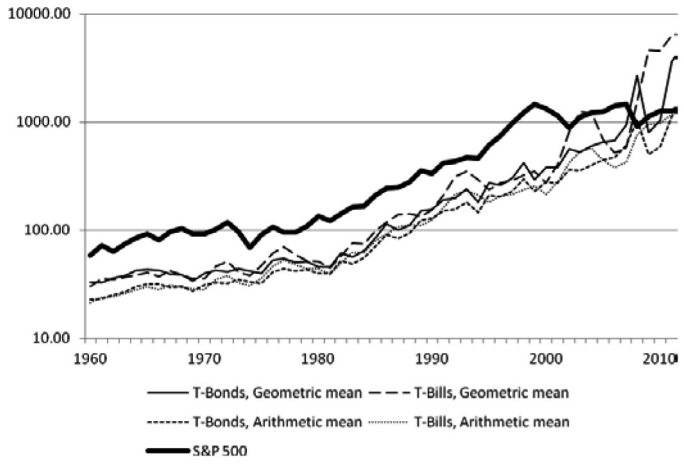
Risk free rate	T-Bonds	T-Bonds	T-Bills	T-Bills
Mean historical risk premium	Geometric	Geometric	Arithmetic	Arithmetic
Average	72.8%	101.5%	59.0%	54.1%
Median	49.8%	46.0%	60.7%	57.2%
Maximum	715.7%	1049.4%	85.8%	85.1%
Minimum	6.9%	3.6%	0.9%	3.5%

Source: Author's own study.

that the mean difference between the S&P 500 values and index model fundamental value range between 54.06% and 101.50%, and the maximum reaches up to more than 1000%.

Figure 2 shows four series of fundamental values obtained by using the geometric mean of historical dividends' growth rate in the period of 1960-2013. Data are presented in an identical arrangement as in the previous graph.

Over the whole analysed period, S&P 500 market quotations constantly outweigh the model fundamental value of index unit obtained by applying the geometric mean value of the historical risk premiums. Similarly, as in the data presented in



Note: The chart presents S&P 500 quotations against fundamental value obtained by using the geometric mean dividends' growth rate. Four series of data represent the use of T-Bills and T-Bonds as risk-free rates and arithmetic or geometric mean of historical risk premiums.

Figure 2. Model fundamental value obtained with geometric mean of historical dividends' growth rate vs. S&P 500 quotations

Source: Author's own study.

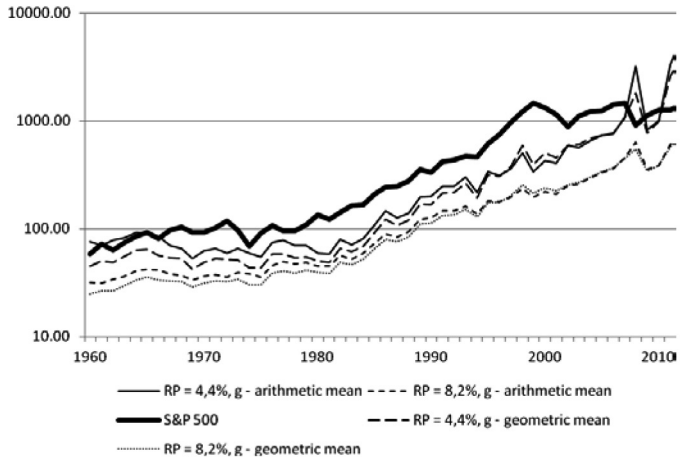
Figure 1, the fundamental value calculated with the arithmetic mean of historical risk premiums for the period of 2008-2013 exceeds the index stock market quotations by several hundred percent. The results presented in Table 2 show that the average difference between the S&P 500 market value and model fundamental value range between 58.6% and 77.0%, whereas the maximum deviation decreased to 398.8%.

Table 2. Percentage differences between S&P500 quotations and model fundamental value for the geometric mean of historical risk premiums

Risk free rate	T-Bonds	T-Bonds	T-Bills	T-Bills
Mean historical risk premium	Geometric	Geometric	Arithmetic	Arithmetic
Average	62.1%	77.0%	62.0%	58.6%
Median	55.1%	55.2%	64.8%	63.1%
Maximum	251.4%	398.8%	84.4%	84.0%
Minimum	1.2%	0.8%	1.3%	3.7%

Source: Author's own study.

Within the next analysis, it was examined whether the S&P 500 quotations track series of model fundamental value determined by using the values of risk premiums given in the literature. Figure 3 shows the results obtained for the two extreme values of this parameter provided by [Ibbotson 2011] which are 4.4% and 8.2%.



Note: The chart presents S&P 500 quotations against fundamental value obtained by using the extreme rates of risk premium given in the literature. Four series of data represent the use of risk premium of 4.4% (the lower limit of the range) and one of 8.2% (the upper limit of the range), as well as the arithmetic and geometric mean used to determine the growth rate of dividends based on historical data.

Figure 3. Model fundamental value for extreme rates of risk premium range (RP) vs. S&P 500 quotations

Source: Author's own study.

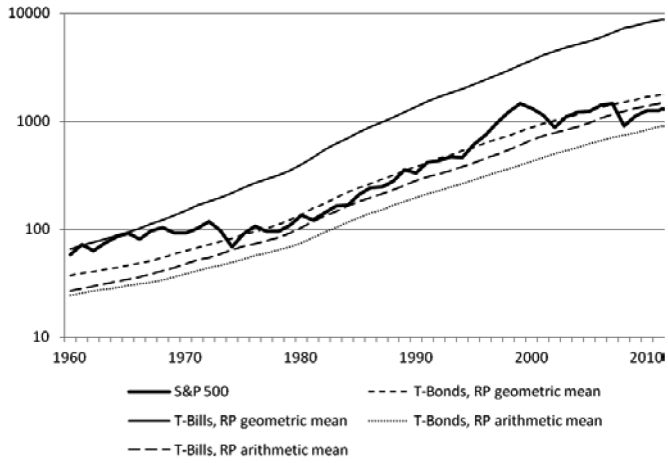
Similarly, as in the earlier analyses, in the 1960-2007 period, the S&P 500 quotations significantly and in a continuous manner exceeded model fundamental value obtained with the extreme range of the risk premiums given in the literature, except for the period of 1961-1967 (for one of the series). The years 2008-2013 show, on the other hand, high fluctuations in model fundamental value which, with the exception of those obtained with the use of the lower risk premium extreme value (4.4%), oscillating around S&P 500 market value. However, these oscillations reach the level of even several hundred percent. The use of the fixed risk premium rates decreased the average differences between the S&P 500 quotations and the model fundamental value. Detailed statistics are given in Table 3.

Table 3. Percentage differences between the S&P500 quotations and model fundamental value obtained with extreme values of risk premiums reported in the literature

Risk premium	4,4%	4,4%	8,2%	8,2%
Mean historical dividend growth rate	Arithmetic	Geometric	Arithmetic	Geometric
Average	49.7%	50.2%	63.4%	67.3%
Median	41.3%	49.1%	64.6%	68.5%
Maximum	305.9%	169.0%	86.7%	85.4%
Minimum	1.6%	10.3%	29.7%	39.3%

Source: Author's own study.

In the subsequent ex-post analysis, it was examined whether the S&P 500 quotations track model fundamental value obtained by using real amount of dividends per index unit over the period of 1960-2013. The present value for 2013 of estimated dividends which go beyond this year has been determined by using the Gordon Growth Model. Figure 4 presents the results obtained against the S&P 500 quotations.



Note: The chart presents the S&P 500 "real" fundamental value obtained by using the actual dividends per index unit against the S&P 500 market quotations over the period of 1960-2013. Four series of data represent the use of different risk-free rates, which are T-Bonds rate and T-Bills rate respectively, as well as the use of arithmetic and geometric mean applied to determine the risk premium in a given year of analysis on the basis of historical data.

Figure 4. "Real" fundamental value vs. the S&P 500 quotations

Source: Author's own study.

The results show two cases where the S&P 500 quotations tracked the "real" fundamental value obtained for the ex-post data since 1974. In the examined period, the series of fundamental value determined by the T-Bonds rate as the risk free rate and the geometric mean of risk premium historical value, as well as by the T-Bills rate and the arithmetic mean, all showed insignificant deviations from the current quotations. They amounted to 23.2% and 31.0% respectively.

For the years 1974-1995, the average deviations of the S&P 500 quotations from these two series of "real" fundamental value were even lower and amounted to 12.3% and 17.8% respectively. Moreover, it is worth noting that since 1974, the index has been deviating from the calculated "real" fundamental value, but every time it returned to this value after time.

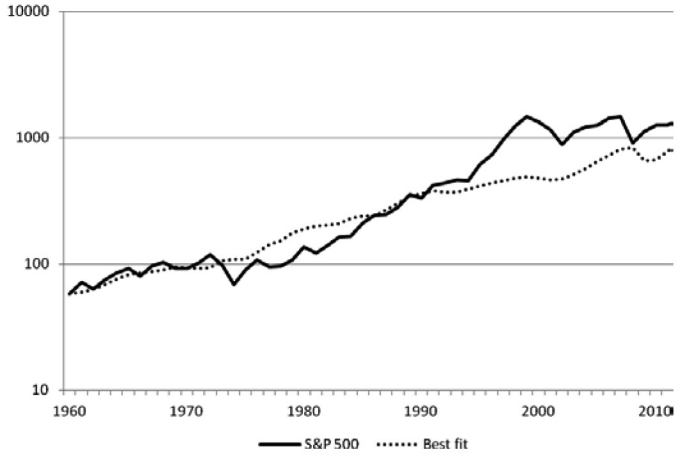
In the last analysis, using Monte Carlo simulation, the possibility of optimizing fixed parameters for the Gordon Growth Model which would allow obtaining the

Table 4. Percentage differences between the S&P500 quotations and the "real" fundamental value obtained with the ex-post data

Risk free rate	T-Bonds	T-Bills	T-Bonds	T-Bills
Mean historical risk premium	Geometric	Geometric	Arithmetic	Arithmetic
Average	23.2%	267.6%	45.1%	31.0%
Median	19.4%	291.0%	44.9%	25.0%
Maximum	66.0%	758.2%	70.8%	62.9%
Minimum	0.3%	5.9%	12.8%	2.3%

Source: Author's own study.

series of model fundamental value most closely fitting the current S&P 500 quotations was re-examined. The "best fit" was obtained for the dividends fixed growth rate of 7.11%, and the investors' expected return fixed rate of 12.33%.



Note: The graph presents model fundamental value obtained by using the Gordon Growth Model with optimized parameters against the S&P 500 quotations.

Figure 5. "Best fit" Gordon Growth Model fundamental value vs. the S&P 500 quotations

Source: Author's own study.

Results show that the use of long-term fixed parameters which control model fundamental value calculation does not represent any major practical advantages. The average difference between the S&P 500 quotations and the model fundamental value, set in the manner described above, amounts to 24.37% and the maximum deviation can be as high as 59.8%.

4. Discussion and conclusions

The discussion of the obtained results of the research requires an introduction and highlighting of certain important factors affecting their evaluation. Firstly, the fundamental value is not an observable measure in contrast to market prices. Therefore, no one, knows if it is true value at a given time. Secondly, the commonly used securities' valuation models do not necessarily adequately define their fundamental value. One should bear in mind though, that even if investors would have full access to information of fundamental nature and the mechanisms which reflect this information in securities' prices would operate faultlessly, these investors might resort to asset pricing models other than they are commonly expected to use.

There are two possible explanations for such circumstances. One is that the market is wrong, and the academics are right and the other, that we may not really understand what and how investors value, which implies the market is right. The discussion of the presented results requires the assumption that fundamental valuation model adopted in this study is suitable for this purpose, otherwise, we face a joint hypothesis problem.

Finally, the accepted model of securities valuation is driven by control parameters whose true value is also unknown. Neither academics, nor researchers, nor investors are unanimous about what approximate values of these parameters shall be regarded as real and appropriate, if we consider the present value of future cash flows associated with the security to be the best approach for fundamental valuation. Since there is no way to eliminate this problem, a discussion on the obtained results shall develop in two directions. On the one hand, using ex-ante data, we examined whether model fundamental values have any practical application for investors. On the other hand, using ex-post data, whether the capital market represented by the S&P 500 index is fundamentally efficient and so, whether the prices accurately track the fundamental value obtained using adopted valuation model.

Within the first analysis we examined the concept of fundamental value in terms of its usefulness for investors. Academics generally agree that on developed stock markets prices should return to the fundamental value in the long term, whenever they deflect from it because of, for example, behavioural biases. Theoretically, the calculation of stocks' or index units' fundamental value should provide investors with information on whether the securities are overvalued or undervalued at a given time, and thus influence their investment decisions. But the question rather comes down to whether the investors using public information are able to determine a fundamental value which would be close enough to the unknown true fundamental value to make economic sense.

Informationally efficient markets hypothesis provides a negative answer to this question. However, the same hypothesis understood formally indicates only that on informationally efficient market investors cannot achieve abnormal returns. In contrast, the adopted definition of fundamental efficiency says that in such

a market prices actually track the fundamental value of securities. Theoretically, we can therefore imagine such a market on which it is impossible to generate abnormal returns, but which at the same time does not necessarily track the securities fundamentals and vice versa. Hence the conclusion is that these concepts are not identical and therefore the analysis performed in this paper has a deeper meaning.

At first, we examined whether investors using Gordon Growth Model and the data available at a given time are able to properly determine the fundamental value of S&P 500 index unit that would make economic sense to them. The results presented in a graphical form in Figure 1 and Figure 2 show that so obtained fundamental values have actually no practical economic meaning for investors. No matter which mean they would have used to determine the dividends growth rate and risk premium rate, and which rate they would have used as the risk-free rate: T-Bonds rate or T-Bills rate. The years 1960-2007 show that still the market quotation would significantly outweigh model fundamental values. However, in the period of 2008-2013, the scale of fluctuation of these values was abnormally high, so it is difficult to draw any economically significant conclusions from them. There are two possible explanations for these observations.

If, in accordance with the adopted assumption, the fundamental value calculation model is correct, then, either the market is fundamentally inefficient and regularly recalculates the index, or model parameters determined on the basis of the available data do not allow to properly determine fundamental value. Theoretically, there is also possibility that these two explanations are simultaneously true. At this stage of discussion, it is impossible to examine the first possibility, therefore, the second one needs consideration, which means determining which model parameters, the investors may not have been able to estimate correctly.

Dividend growth rate was calculated as the arithmetic or geometric mean of historical risk premiums from 1928 to the given year of the analysis. The mean growth rate obtained is such way, for the years 1960-2013, was 5.86% and was of identical value as the actual one for the same period. It follows that the value of this parameter has been relatively constant in the long term and it is not its estimation that brings us to economically unsound model of fundamental value. Another possibility may be the incorrect approximation of the expected rate of return that is either a risk premium or / and the risk-free rate. The first of these two variables fluctuates strongly, therefore in this study we used arithmetic and geometric means of data from the year 1928 to current date, for which the value of the risk premium was calculated.

Table 5 presents the differences between the actual and estimated average risk premiums within the framework of the adopted model for the years 1960 to 2013. Differences depending on the method of calculation vary from 1.08 percentage points to 2.65 percentage points. On the one hand, it can be concluded that, having used historical data, investors were not able to calculate the future value of the risk premium rate correctly. On the other, such significant deviations of S&P 500 from model fundamental values cannot be explained only with differences in the risk

premium. This hypothesis is supported by the results of the second analysis, which uses fixed extremes of risk premium range that are presented in Figure 3. Adopted range of 4.4%– 8.2% covers the actual value risk premiums presented in Table 5 with the exception of one (3.67 %), and still S&P 500 quotations outweigh obtained model fundamental value practically through the whole considered period. It can be concluded then, that the lack of a correct model of time-varying risk premiums estimation was not the reason for such significant deviation of actual quotations from model fundamental value.

Table 5. Differences between real risk premiums and estimated risk premiums for the 1960–2013 period

	Real risk premium average		Estimated risk premium average		Difference (estimated – real)	
	Stocks – T. Bills	Stocks – T. Bonds	Stocks – T. Bills	Stocks – T. Bonds	Stocks – T. Bills	Stocks – T. Bonds
Arithmetic mean	6.44%	4.66%	8.33%	7.31%	1.89%	2.65%
Geometric mean	5.10%	3.67%	6.18%	5.30%	1.08%	1.63%

Source: Author's own study.

There are only two explanations for this phenomenon. Either the market is so considerably fundamentally inefficient or variation scale corresponds mainly to the second component of expected rate of return which is the risk-free rate. The model assumed the most current T-Bonds rate or T-Bills rate at a given time which in 1960 amounted to 3.84% and 3.05% respectively. However, during the analyzed period, both variables fluctuated strongly. For example, in the period 1960-2013 T-bonds rate varied from 1.76% to 13.72%. Bearing this in mind, if the estimated dividends growth rate was identical to the actual one and risk premium rate applied in the model just slightly varied from the actual data, then, it is the significant variation in the risk-free rate which may be the main reason for such great differences between the current index quotations and model fundamental value results.

In order to solve this puzzle, third analysis was conducted which employed actual data from the years 1960-2013 to calculate the fundamental value of S&P 500 unit. Still applying the assumption that adopted calculation model is correct, the above undertaking made it possible to establish values that were possibly the closest to the real fundamentals. We still do not know either the value of dividends to be paid after 2013, or the expected returns in the years beyond 2013 which the investors will accept. Despite this, the results obtained, presented graphically in Figure 4, are unusual. Since 1974 S&P 500 quotations have tracked "real" fundamental value obtained with T-Bonds and geometric mean of historical risk premiums as well as with T-Bills and arithmetic mean of historical risk premiums. The differences

between the current quotation values and the two sets of "real" fundamental value equal respectively 23.2% and 31.0% for the whole period. For the years 1974-1995 the average deviation of current S&P 500 quotations from these two series of "real" fundamental values were even lower and amounted to 12.3% and 17.8% respectively.

The other two series of fundamental value are not that close to the current quotations. At this point we should consider which of the four results is the closest to the true fundamental value of S&P 500. The answer, unfortunately, is impossible to give. Fundamental value is not an observable measure as opposed to quotations and their real value is generally unknown. If we assume that the model adopted in this study calculates fundamental value correctly, then it can be concluded that S&P 500 market was fundamentally efficient during 1974-2013 period. However, it is true if an appropriate risk-free rate is T-bonds/T-bills rate and appropriate risk premium is the geometric/arithmetic mean of historical values, respectively. During the abovementioned period, the S&P 500 quotations tracked a series of fundamental value, which is an essential condition for such a finding.

In addition, the current quotations fluctuate, thus obtained fundamental value is consistent with the generally acceptable theoretical premises. Academics agree on the fact that market prices should return to fundamental value whenever they wander off them because of behavioural bias. In the quotations performance from the years 1974-2013 such phenomenon is observed for both series of "real" fundamental value. However, if we assume that the appropriate risk-free rate is T-Bills rate and the appropriate risk premium is the geometric mean of its historical values or the relevant risk-free rate is the T-Bonds rate and appropriate risk premium is the arithmetic mean of its historical value then we should come to the conclusion that S&P 500 index in the years 1960-2013 was not fundamentally efficient. The current quotations do not track the series of fundamental value and the scale of variation is significant and amounts to 267.6% and 45.1%. There is also lack of quotations' fluctuations against series of fundamental value which throughout the period either exceed or fall short of these values.

At this point, it is worth to return to the issue of key parameters calculation in the fundamental valuation model. Previous analyses suggest that inappropriate extrapolation of risk-free rate's future values is the main reason for the presence of significant deviations of S&P 500 quotations from the model fundamental value calculated by using ex ante historical data. However, in ex post analysis based on actual figures which investors could not have known at the time, index quotations have been actually following the two series of fundamental value continuously, since 1974. If we assume that both series are close to real fundamental value, then, investors must have been, somehow, able to predict future risk-free rates correctly. What is more, they certainly could not have been able to apply historical data to their predictions, which practically gave erroneous prognoses for the future. This finding could be the evidence supporting the hypothesis that the performance of stock quotes goes ahead of the actual economic phenomena.

In the last analysis it was examined whether S&P 500 quotations track series of fundamental value estimated using a constant growth rate of dividends and the expected rate of return, which were optimized to give the smallest deviations in the whole study period. The results show that the index does follow so obtained fundamental value, in the long-term and the scale of average deviation is comparable to the one observed for series of "real" fundamental value form previous analyses. However, the index fluctuates around a curve of fundamental value, but crosses it only four times during the entire period of 1960 to 2013.

On the basis of the results of both ex post analyses using actual data from the period 1960-2013, three general observations can be drawn. Firstly, the use of actual time variable Gordon Growth Model parameters resulted in smaller range of deviations from S&P 500 quotations than the use of fixed values of these parameters. Secondly, if we assume again that the market is fundamentally efficient, then, in the period 1960-2013 the long-term dividend growth rate equals 7.11% and the long-term average expected rate of return – 12.33%. Thirdly, the use of fixed control parameters driving the model of fundamental valuation brings us to a rather theoretical than practical value. Periods in which the analysed index quotations would return to the determined curve of fundamental value last for several years on average.

The answer to the question of whether financial markets are fundamentally efficient will never be unequivocal. Securities' fundamental value is not an observable measure, so that any attempt to determine it requires the assumption that both calculation model and methods of determining its key parameters are correct. In exactly the same manner, the results presented in this paper should be interpreted. They suggest that under certain, specified assumptions, fundamental value is theoretically a highly valuable tool for the analysis of price changes in the stock market. The results obtained for the S&P 500 in the ex-post analysis of the years 1960-2013 indicate that the current quotations may follow a series of model fundamental value obtained for both time-varying, as well as fixed, model parameters.

What is more, the results obtained with specific assumptions suggest that index quotations track series of fundamental value as well as oscillate around them. Thus, if the assumptions hold, this observation corroborates the hypothesis that any deviation of prices from fundamental value is adjusted in such manner that prices return back to the fundamentals. This happens for time-varying parameter values, in the short term, and for fixed ones, in the long term. The results of ex-post analysis also suggest that, under certain specific assumptions, market is not fundamentally efficient. The current quotations do not track the series of model fundamental value and consistently exceed or fall short of them. Moreover, the scale of deviations between S&P 500 quotations and obtained model fundamental value is significant and ranges from a few dozens to several hundred percent. The results obtained for the ex-ante analysis suggest that investors using historical data are not able to correctly determine the fundamental value of an index unit that would make economic sense for them.

Regardless of different methods of estimating Gordon Growth Model key parameters, the series of fundamental value obtained this way were consistently below current market value, in the years 1960-2007. For the years 2008-2013, model fundamentals strongly fluctuated and were also of low substantive value to investors. Comparison of the estimated Gordon Growth Model parameters, with their actual value suggests that both the dividends growth rate and the risk premium can be estimated with acceptable accuracy, by using historical data. Deviations between the S&P 500 quotations and series of model fundamental value result either from fundamental inefficiency of the market or incorrect estimation of future risk-free rates. Unlike fundamental value, which may be considered theoretically a very useful tool, as long as certain assumptions are made, model fundamental value determined on the basis of historical data has, from the investors' point of view, no tangible economic value at all.

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