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Assessment of portfolio investment effectiveness during the covid-19 pandemic – multivariate fundamental approach¹

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Abstract

Making long-term investment decisions is possible using the portfolio approach. In this respect, there are classical (e.g., Markowitz model) and non-classical (e.g., fundamental model) approaches. The key element in the construction of models is not only the measurement of risk and rate of return, but also the method of selecting assets (companies) to the portfolio. The method of selecting assets often determines the direction of the investor’s investment strategy. The portfolio construction and asset selection processes remain an open question. The aim of the study is to assess the effectiveness of portfolio investment using the concept of fundamental strength. The results of the study indicate that the fundamental approach, depending on the portfolio construction procedure used, gives different effects, but allows for risk diversification in times of crisis.

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1. Introduction

Investing in the capital market may take place with the use of technical, fundamental or portfolio analysis methods. The choice of investment method is individual and depends on individual investment preferences [1]. The

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issue of investment risk tolerance is also important [2]. By focusing only on the methods of portfolio analysis, various approaches can be observed both in the process of constructing securities portfolios, e.g., Markowitz model [3], Sharpe model [4], fundamental model [5], modified fundamental model [6], and in terms of the concept of selecting assets for portfolios [7]. The approaches to building portfolios can be divided into classical (e.g., Markowitz and Sharpe model) and non-classical (e.g., fundamental portfolio, modified fundamental portfolio).

In the classical approach to building portfolios, the key elements that the investor pays attention to are the rate of return and risk of the securities that are to be included in the portfolio. Shares with low risk and a positive rate of return are preferred. The development of capital markets made the concept of classical risk diversification in the sense of Markowitz insufficient. Investors noticed that the emphasis on the "quality" of the portfolio components can significantly increase the investment effects achieved over time and protect the investment against risk. In this area, it is already possible to speak of a non-classical approach, where the selection of assets for the portfolio has become increasingly important [8]. Consequently, the entire process of activities in this area concerns the application of the concept of horizontal risk diversification [9]. Risk management has adopted the direction of linking the technical side of the portfolio structure, e.g., Markowitz, with the built database that meets the criteria of long-term investment. By definition, horizontal diversification assumes that assets that may potentially be included in the portfolio are to be of the so-called "good quality". In this respect, aspects from the area of fundamental analysis are of particular importance.

Research on the diversification of the horizontal risk contributed to the development and emphasis of the importance of the fundamental strength of companies in the portfolio investing process. The "quality" of the components of investment portfolios has already been noticed by Graham [10], who was guided in investing by a special approach to the company's value and the use of fundamental analysis methods in assessing the investment quality. On this basis, many investment strategies have been developed based on the company's value or investing in value. Of course, each of the concepts required a defined understanding of "value" first".

Referring to the category of fundamental strength, it is possible to speak of its definition and areas of its formation as well as the problem of its measurement [11]. Fundamental strength is a complex category and should be treated as a product of the company's performance assessment. On the other hand, the question of measuring the fundamental strength relates to its quantification and expressing the fundamental strength numerically. In this regard, the Fundamental Power Index (FPI) may be applicable.

The modification of securities portfolios and the construction of investment concepts, despite many works, did not allow for the development of a universal investment method [12,13,14]. Such a situation means that research on new or alternative concepts is still valid and allows to fill the existing research gap. The research that has already been conducted also shows that when it comes to risk diversification, the combination of elements of fundamental analysis with portfolio analysis works well [15]. On the other hand, in the field of database construction, methods allowing for the aggregation of information, e.g., multidimensional methods, are well adapted [16]. Research into existing portfolio building methods also leads to alternative approaches that may give better results in reducing risk and maximizing rate of return.

The aim of the proposed study is to assess the effectiveness of portfolio investment with the use of the concept of fundamental strength in the period of a bear market on the stock market. In the measurement of the fundamental strength, the fundamental power indices were used, built on the basis of a synthetic measure and a vector measure. In the field of securities portfolios, the following model concepts were used: Markowitz, fundamental portfolio with imposed shares and a modified fundamental portfolio. The analysis period covered the years of the COVID-19 pandemic, which was not neutral for the stock market

2. Research methodology

Fundamental strength is a category assigned to the fundamental analysis, and its formation results from the areas of the company's operation. In the study, fundamental strength is understood as a category of assessment of an entity (company, enterprise) only through the prism of its economic and financial condition, which results from the effects of the entity's operation. It is impossible to achieve a good financial standing if other factors and areas of activity do not function properly. It is also one of the definitions of fundamental power.
The fundamental strength is built by a set of quantitative (e.g., financial indicators) and qualitative (e.g., market position, quality of management) factors. In general, fundamental strength is not a directly measurable category, but the introduction of certain generalizations enables its measurement. The fundamental power index is the measure that was created for the purpose of measuring the fundamental strength. The methodology of assessing the fundamental strength of enterprises and its measurement is discussed in detail in the work of Tarczyńska-Luniewska M. Methodology for assessing the fundamental strength of (listed and non-listed) companies [17]. The fundamental power index belongs to the group of multidimensional measures. For its determination, it is possible to use the methods that allow for a synthetic assessment of the enterprise (object) from the perspective of many criteria that create the fundamental strength. It is a measure that allows to assess the fundamental strength of the enterprise in a summary manner, using one number.

Determining the proposed fundamental power index requires the use of selected factors of fundamental strength. In terms of these factors, financial indicators are most often used. Due to the different groups of enterprises (non-financial, financial or insurance enterprises), appropriate financial indicators for these groups of enterprises should be used to build the FPI. Such a division results from the substantive foundations of the financial analysis itself and financial statements on the basis of which financial indicators are built.

The indicator itself can be determined using a static or dynamic approach to the variables used (financial indicators on the basis of which the indicator is built). For the purposes of the presented study, a dynamic approach was used, consisting in adopting a system of weighting variables over time. Such a system makes it possible to take into account the importance of information that a given financial indicator "contributes" to the fundamental strength in time. This means that the first study period had the lowest weight and the last period the highest. The study was conducted for the period of three years; hence the sequence of periods will be: i=1, 2, 3. Consequently the weights (\(w_i\)) were determined as follows [17]:

\[
w_i = \frac{n_i}{\sum n_i}, \quad \text{where: } i=1, 2, 3 \quad \sum w_i = 1, \quad \sum_1^i n_i = 6;
\]

where:
- \(w_i\) - weight for the i-th period of the study,
- \(n_i\) - number of the i-th period of the examination.

3. **Fundamental Power Index based on SMD**

In the construction of the fundamental power index, the concept of a synthetic measure of development [18] and an approach to assessing the investment attractiveness of companies were used [19]. The following formulas were used in the construction of the measure [20]:

\[
FPI_t = TMAI_t,
\]

where:
- \(i=1,2,\ldots,k; j=1,2,\ldots,l\) and \(t=1,2,\ldots,n\).
- TMAI\(_{t}\) – fundamental strength measured by the use TMAI approach for weights in time financial ratios.

TMAI formula is as follow:

\[
TMAI_i = 1 - \frac{d_i}{d_0}, \quad (i = 1, 2, \ldots, n),
\]

where:
- TMAI\(_i\) – synthetic development measure for the i-th object,
- \(d_i\) – distance between the i-th object and the model object defined with the formula:

\[
d_i = \sqrt{\sum_{j=1}^{k} (z_{ij} - \max_j (z_{ij}))^2}, \quad (i = 1, 2, \ldots, n), (j = 1, 2, \ldots, k),
\]
n – number of objects,
k – number of variables,
d\(_0\) – norm which assures that TMAI\(_i\) values belong to the interval from 0 to 1:

\[
d_0 = \bar{d} + a \cdot S_d.
\]

According to the relation (1) and given \(d_i > 0\), we may find the marginal value for the a constant:

\[
a \geq \frac{d_{i_{\text{max}}} - \bar{q}}{S_d},
\]

where: \(d_{i_{\text{max}}}\) is the maximum \(d_i\) value, \(S_d\) is the standard deviation for \(d_i\), \(\bar{q}\) is mean of \(d_i\).

In this method, the system of standardization of the data was used to assure its comparability: the 0-1 standardization. We calculated \(z_q\) using formula:

\[
z_{ij} = \frac{x_{ij} - \bar{x}_j}{S_j},
\]

where:

\(x_{ij}\) – values of the j-th variable for the i-th object,
\(\bar{x}_j\) – average value of the j-th variable,
\(S_j\) – standard deviation for the j-th variable.

The adoption of the above formulas allows for the normalization of the FPI\(_i = \text{TMAI}_i\) in the \(<0; 1>\) range. Values closer to 1 indicate a higher level of fundamental strength of a given object (enterprise, company).

The context of using synthetic measures of development is wide \([21,22]\), but their construction requires the adoption of methodological foundations of the phenomenon under study.

4. Fundamental Power Index based on Vectorial Measure

The values of the variables of the examined objects in the vector space are interpreted as vector coordinates. Each object therefore determines a specific direction in space. The pattern and anti-pattern difference is also a vector which determines a certain direction in space. Along this direction, the aggregate measure value for each object is calculated. This difference can be treated as a monodimensional coordinate system, in which the coordinates are calculated based on the formula \([23]\):

\[
c = \left(\frac{\vec{A}, \vec{B}}{\vec{B}, \vec{B}}\right)
\]

In turn, \(\vec{A}\) and \(\vec{B}\) are vectors, and \(\left(\vec{A}, \vec{B}\right)\) is the scalar product, which can be defined as follows:

\[
\left(\vec{A}, \vec{B}\right) = \sum_{k=1}^{n} a_k b_k
\]

where:

\(a_k\), \(b_k\) – coordinates of the appropriate vector \(\vec{A}\) i \(\vec{B}\).

We consider the \(\vec{B}\) vector as the monodimensional coordinates system, thus it represents a difference between the pattern and anti-pattern. By entering coordinates of the pattern and anti-pattern as well as the object into the formula (8) the result is as follows:

\[
m_{j}^{m} = \frac{\sum_{i=1}^{m} (x_{ij}' - x_{ij}')^2 (x_{ij}' - x_{ij}')}{\sum_{i=1}^{m} (x_{ij}' - x_{ij}')^2}.
\]
For a synthetic measure so constructed, all objects that are better than the anti-pattern and worse than the pattern will have the measure value in the range from zero to one. The pattern will have the value equal to one and anti-pattern equal to zero. It is also possible to specify the value of the objects’ measure better than the pattern. They will have values greater than one. Objects that are worse than the anti-pattern will have a negative value of measure. Thanks to this, the position of the object in the ranking in relation to the pattern and anti-pattern will be easy to determine. The values of the aggregate measure allow for ranking objects, thus it is possible to determine which of them are "better" and which are "worse", which can also be used in terms of fundamental strength.

5. Securities portfolios

In the construction of securities portfolios, the classical approach may be used – the Markowitz model, or the non-classical approach, the fundamental model or the modified fundamental model may be used. The detailed procedure of building the portfolios is widely described in the literature on the subject [3,5,6]. The table (Table 1) presents the formulas used in the study to determine the parameters of the securities portfolios.

Table 1. Formulas for the securities portfolios used.

| Portfolio Type                | Formula                                                                 |
|-------------------------------|-------------------------------------------------------------------------|
| Markowitz model (MM)          | \[ S_p^2 = \sum_{i=1}^{N} \sum_{j=1}^{N} x_i \cdot x_j \cdot \text{cov}(x_i, x_j) \rightarrow \min, \] |
|                               | \[ R_p = R_{op} \sum_{i=1}^{N} x_i = 1, \quad x_i \geq 0, \] |
|                               | \[ S_p \rightarrow \min \] |
|                               | where \( S_p \) – portfolio variation, \( S_p \) – portfolio’s expected risk, |
|                               | \( R_p \) – portfolio’s expected rate of return, \( R_{op} \) – a desired rate of return, \( n \) – number of assets in a portfolio, \( x_i \) – asset i’s share in the portfolio (necessary to determine \( R_p \) and \( S_p \)). |
| Modified fundamental portfolio (MFP) | \[ S_p^2 = \sum_{i=1}^{N} \sum_{j=1}^{N} x_i \cdot x_j \cdot \text{cov}(x_i, x_j) \cdot (1 - TMAI_i) \cdot (1 - TMAI_j) \rightarrow \min, \] |
|                               | \[ R_p = R_{op} \sum_{i=1}^{N} x_i = 1, \quad x_i \geq 0, \] |
|                               | \[ S_p \rightarrow \min \] |
|                               | where symbols are the same as in previous formulas. |
| Portfolios with shares according to FPI, TMAI, and VM | portfolio formulas as in Markowitz model but \( x_i \) are given as follows: |
|                               | \( x_i \) – asset i’s share in the portfolio (necessary to determine \( R_p \) and \( S_p \)) described by formula as follow: |
|                               | for TMAI \( x_i = \frac{TMAI_i}{\sum_{i=1}^{N} TMAI_i} \) for VM (Vectoral measure) \( x_i = \frac{VM_i}{\sum_{i=1}^{N} VM_i} \). |

6. Data and Research Concept

The study was conducted for listed companies from the main market that were part of the WIG20 in 2014-2018. The index includes companies with the highest capitalization and liquidity on the market. Fundamental power indices were built on the basis of financial data from the Notoria Serwis 2021 database (financial statements data). These data included sets of indicators for non-financial and financial companies (Table 2.).

Table 2. A set of variables for FPI determination.

| Non-financial companies | Financial companies |
|-------------------------|---------------------|
| ROE, ROA                | ROE, ROA            |
| Current Ratio (1.2-2.0)  | Capital adequacy ratio |
| Receivables turnover    | IMF liquidity       |
| Inventory turnover      | Tier 1 Ratio        |
| Rotation commitments    |                     |
| Rotation assets         |                     |
| Debt ratio              |                     |
Basic descriptive statistic like average, standard deviation (S(x)), volatility coefficient (Vs), quartile deviation (Q), quartile volatility coefficient (VQ) was used in the assessment of financial indicators.

Based on stock market data on share prices, logarithmic weekly rollover rates of return (5 business day interval) were estimated. The rates of return were used in the construction of the securities portfolios. For the purpose of comparison and effectiveness assessment, the following portfolios were selected (the designations of selected portfolios are given in brackets):

1. portfolios that meet the condition of the number of shares from 5 to 10:
   - Markowitz portfolios: MM_8, MM_6,
   - modified fundamental portfolios: MFP_9, MFP_7_H (H – means a higher Vs coefficient for a portfolio of 7 shares), MFP_7_L (L – means a lower Vs coefficient for a portfolio of 7 shares).

2. portfolios with imposed shares, where the number of companies was determined in proportion to the total number of non-financial (15 companies) and financial (5 companies) companies, e.g., with the assumed composition of 10 companies, 7 came from the non-financial group and 3 from the financial group.
   - portfolios with shares according to the vector measure: P_VM_10, P_VM_7, P_VM_5,
   - portfolios with shares according to FPI = TMAI: P_FPI_10, P_FPI_7, P_FPI_5,

3. the lowest Vs for the considered portfolio variant, without the condition of the number of shares:
   - Markowitz portfolio: MM_minVs,
   - modified fundamental portfolio: MFP_4.

A preliminary assessment of the quality of the portfolios was conducted in terms of the expected rates of return, risk and coefficient of variation obtained by the portfolios. In the next step, the effectiveness of the portfolios was assessed during the period of the COVID-19 pandemic. The assessment procedure consisted in simulating the purchase of portfolios at the end of 2018 and then their sale in three periods: at the end of 2019, 2020 and 2021. The analysis covered the years 2016-2021.

7. Research results

A synthetic presentation of the level of financial indicators for non-financial and financial companies is presented in Table 3 and Table 4.

| Descriptive statistics | ROE | ROA | Current ratio | Receivables turnover | Inventory turnover | Rotation commitments | Rotation assets | Debt ratio |
|------------------------|-----|-----|---------------|----------------------|--------------------|---------------------|----------------|-----------|
| mean                   | 0.083 | 0.047 | 1.550 | 67,322 | 28,908 | 52,422 | 1192,015 | 0.410 |
| st. deviation.         | 0.115 | 0.059 | 0.991 | 71,237 | 27,891 | 23,983 | 4029,580 | 0.173 |
| Vs [in%]               | 138.2% | 125.2% | 63.9% | 105.8% | 96.5% | 45.7% | 338.0% | 42.3% |
| median                 | 0.079 | 0.043 | 1.267 | 40,615 | 18,061 | 51,100 | 115,898 | 0.427 |
| Q                      | 0.054 | 0.028 | 0.481 | 22,173 | 19,046 | 17,019 | 39,355 | 0.110 |
| VQ [in %]              | 64.5% | 59.0% | 31.0% | 32.9% | 65.9% | 32.5% | 3.3% | 26.9% |
| min                    | -0.226 | -0.129 | 0.410 | 2,299 | 0.000 | 8,774 | 56,241 | 0.069 |
| max                    | 0.467 | 0.206 | 5.154 | 344,469 | 107,914 | 114,058 | 17388,764 | 0.812 |

The data in the table (Table 3) shows that the examined non-financial companies in the analyzed years 2016-2018 are highly diversified in terms of the obtained financial indicators. This is confirmed by the obtained levels of the coefficients of variation (Vs and VQ), significantly exceeding the statistically recognized range of low variability from 0 to 10%. The examined companies obtain diversified financial results describing their activities in a synthetic way. It is also worth emphasizing the range, represented by the difference between the minimum and maximum level of indicators. A very large disproportion is visible between the minimum and maximum values of the indicators, which consequently affects the size of the obtained statistical measures, including the coefficients of variation (Vs and VQ). At the same time, it should be noted that the levels of the indicators make it possible to assess the financial condition of the examined companies. Taking into account their value, it can be concluded that this condition is also diversified. As the financial indicators presented in Table 3 constitute the basis for the construction of the fundamental power index (FPI) and the vector measure (VM), it should be expected that these indicators will also be diversified, and their levels will be low.

Table 4. Descriptive statistics for financial companies (2016-2018).
Descriptive statistics

|            | ROE    | ROA    | Capital adequacy ratio | IMF liquidity ratio | Tier 1 Ratio |
|------------|--------|--------|------------------------|--------------------|--------------|
| mean       | 0.096  | 0.012  | 19.001                 | 0.082              | 17.021       |
| Standard deviation | 0.012  | 0.002  | 3.286                  | 0.037              | 3.055        |
| Vs [in %]  | 12.8%  | 20.0%  | 17.3%                  | 45.0%              | 17.9%        |
| Median     | 0.096  | 0.012  | 18.400                 | 0.075              | 17.300       |
| Q          | 0.007  | 0.002  | 1.803                  | 0.032              | 1.685        |
| VQ [in %]  | 7.0%   | 13.0%  | 9.8%                   | 42.8%              | 9.7%         |
| Minimum    | 0.077  | 0.008  | 13.670                 | 0.030              | 11.320       |
| Maximum    | 0.121  | 0.016  | 24.620                 | 0.143              | 21.510       |

The data in Table 4 show that financial companies (banks) are much less diversified in terms of their financial results. This is evidenced by the levels of the coefficients of variation: classical (Vs) and positional (VQ). It is worth noting that the VQ measures of location are much more favorable. In three cases (for the indicators: ROE, Capital adequacy and Tier 1 Ratio) the variability was on a low level. Generally, average lower levels of the coefficients of variation (both Vs and VQ) indicate smaller differentiation and disproportions in the obtained indicators for the examined entities. When assessing the indicators presented in Table 4, it should also be taken into account that banks, as financial entities, have pre-imposed guidelines as to the levels of financial indicators obtained. The upward and/or downward excess of the financial indicators for this group of companies entails legal consequences on the part of the Banking Supervision Authority. Banks are thus obliged to comply with the established requirements. Table 5 presents the determined fundamental power indices \( FPI_{16/18} \). Due to the measure construction procedure, it was possible to perform a synthetic and general assessment of the fundamental strength of the examined companies.

**Table 5. Level of FPI\(_{16/18}\) index for all analyzed companies**

| ASSECOPOL | 0.249 |
| CCC | 0.199 |
| CYFRPLSAT | 0.254 |
| ENEA | 0.289 |
| ENERGA | 0.187 |
| EUROCASH | 0.00 |
| ORANGEPL | 0.002 |
| PGE | 0.294 |
| PGNIG | 0.353 |
| PKNORLEN | 0.354 |
| TAURONPE | 0.092 |
| PGE | 0.294 |
| MBANK | 0.407 |
| PEKAO | 0.473 |
| PKOBP | 0.417 |
| ALIOR | 0.00 |
| BZWBK | 0.436 |

Fundamental power indices for the surveyed companies presented in Table 5 are on average low levels. The average \( FPI_{16/18} \) for non-financial and financial companies is 0.215 and 0.347, respectively. It should be noted that the index takes values in the \(<0; 1>\) range, the closer to 1 the value of the index, the higher the level of the fundamental strength of the examined entity. The obtained results in the context of fundamental strength are not positive. The fundamental strength of non-financial companies should be assessed as weak on average. On the other hand, banks have rather moderate fundamental strength, excluding Alior. Due to the level of the \( FPI_{16/18} \), this company should be assessed negatively. It is worth noting that the examined companies in 2014-2018 were part of the WIG20, which means that they had to meet the conditions for inclusion in the index – they had to, among others, be characterized by high capitalization or market liquidity and positive results in terms of fundamental analysis. In these circumstances, the FPI levels are even less optimistic.

The following tables (Table 6, Table 7, Table 8, Table 9) present the results of the construction of the securities portfolios. Among the analyzed portfolio variants, only those for which a solution had been obtained were included. The portfolios that were subject to the investment effectiveness assessment in the next steps of the analysis were indicated in the tables in bold.

**Table 6. Markowitz portfolios for the examined companies**

| Name of companies | share of stock in portfolio |
|-------------------|----------------------------|
| ASSECOPOL | 15% 16% 18% 17% 8% |
The results in Table 6 indicate that positive expected rates of return were obtained for all analyzed portfolio variants. The risk of the portfolios, on the other hand, is very high. This is also confirmed by high values of the coefficients of variation (Vs). The share of risk in the rate of return is very high. It is worth noting that there are no financial companies in the portfolio structure.

Table 6. The characteristic of portfolios

| Name of companies | share of stock in portfolio |
|-------------------|-----------------------------|
| CYFRPLSAT         | 31% 30% 23% 8% 0%           |
| ENEA              | 2% 0% 0% 0% 0%              |
| EUROCASH          | 3% 0% 0% 0% 0%              |
| LOTOS             | 22% 29% 46% 67% 92%         |
| LPP               | 10% 9% 0% 0% 0%             |
| PGNIG             | 11% 13% 13% 7% 0%           |
| PKNORLEN          | 6% 2% 0% 0% 0%              |
| Number of securities | 8 6 4 4 2          |
| Name of portfolios | MM_8 MM_6 - - MM_minVs |
| Vp                | 2313% 1219% 696% 552% 498% |
| Rp                | 0,1% 0,2% 0,4% 0,6% 0,8%   |
| Sp                | 2,3% 2,4% 2,8% 3,3% 4,0%   |

Table 7. Modified fundamental portfolios

| Name of companies | share of stock in portfolio |
|-------------------|-----------------------------|
| ASSECOPOL         | 10% 11% 12% 14% 12% 7%      |
| CYFRPLSAT         | 26% 26% 25% 21% 7% 0%       |
| ENEA              | 1% 0% 0% 0% 0% 0%           |
| LOTOS             | 19% 23% 27% 44% 67% 92%     |
| LPP               | 10% 9% 8% 0% 0% 0%          |
| PGNIG             | 18% 19% 20% 21% 14% 1%      |
| PKNORLEN          | 9% 7% 5% 0% 0% 0%           |
| PEKAO             | 1% 0% 0% 0% 0% 0%           |
| PKOBP             | 7% 6% 4% 0% 0% 0%           |
| Number of securities | 9 7 7 4 4 3          |
| Name of portfolios | MFP_9 MFP_7_H MFP_7_L - MFP_4 |
| Vp                | 1620% 1106% 851% 481% 377% 3385% |
| Rp                | 0,10% 0,15% 0,20% 0,40% 0,60% 0,80% |
| Sp                | 1,62% 1,66% 1,70% 1,92% 2,26% 27,08% |

Table 7 presents the results of the modified fundamental portfolios. The structure of the portfolios, expected rates of return, risk and coefficients of variation were taken into account. Similarly to the Markowitz portfolios (Table 6), Rp for this group of portfolios is positive, and the portfolios are characterized by a high level of risk and high variability (Vs levels). The structure of the MFP_9, MFP_7H, MFP_7 portfolios includes both non-financial and financial companies (banks).

Tables 8, 9, 10 and 11 present the results of the portfolios built based on the vector measure and the FPI index.

Table 8. Portfolios with shares according to the vector measure (VM)

| Name of companies | Vector Measure | PKNORLEN | PGE | PGNIG | LOTOS | JSW | LPP | ENEA | BZWBK | MBANK | PEKAO | Number of securities |
|-------------------|----------------|----------|-----|-------|-------|-----|-----|------|-------|-------|-------|----------------------|
| share of stock in portfolio | 0,919 0,87 0,812 0,801 0,696 0,667 0,653 0,78 0,53 0,74 | 12% 12% 11% 11% 9% 9% 9% 10% 7% 10% | 10 | 12% 14% 14% 16% 15% 0% 0% 14% 0% 13% | 7 |

Table 8. Portfolios with shares according to the vector measure (VM)
Due to the adopted construction criteria, the results obtained from portfolios built using the vector measure (Table 8, Table 9) are varied and include both non-financial companies and banks. The portfolios are characterized by a very high variability, representing a significant share of risk in the rate of return. Moreover, assigning shares using the proportion of the vector measure did not hedge the portfolio against shares with a negative rate of return. Consequently, the rate of return on portfolios is negative in two cases (P_VM_10 and P_VM_7).

| Name of portfolios | Portfolio parameters |
|--------------------|----------------------|
| P_VM_10            | 1501% (-0,18%) 2,77% |
| P_VM_7             | 2238% (-0,13%) 2,91% |
| P_VM_5             | 4285% 0,07% 3,00% |

The results of the portfolios in Table 10, Table 11, similarly to the portfolios in Table 8, Table 9, include non-financial and financial companies. All expected portfolio rates of returns (Rp) are negative, which is not favorable from a portfolio risk point of view. The portfolios are also characterized by excessive variability. Compared to the variant with the vector measure, the Vs coefficients are also higher.

| Portfolio sales results |
|-------------------------|
| Portfolio | 2019 | 2020 | 2021 | Portfolio | 2019 | 2020 | 2021 |
| MM_8      | 8.00%| 0.30%| 30.80%| P_VM_10  | -19.40%| -39.70%| -4.70%|
| MM_6      | 7.60%| -0.50%| 30.10%| P_VM_7   | -25.30%| -44.30%| -19.30%|
| MM_minVs  | -2.11%| -1.08%| -21.59%| P_VM_5   | -19.70%| -40.50%| -19.10%|
| MFP_9     | 0.70%| -5.80%| 25.30%| P_FPI_10 | -11.50%| -55.40%| 6.60%|
| MFP_7_H   | 0.80%| -6.20%| 23.60%| P_FPI_7  | -17.40%| -40.70%| -11.70%|
| MFP_7_L   | 1.00%| -7.10%| 21.60%| P_FPI_5  | -17.80%| -39.90%| -13.50%|
| MFP_4     | 0.10%| -30.10%| -7.50%| P_FPI_5  | -17.80%| -39.90%| -13.50%|

The obtained realized rates of return after the sale of the analyzed portfolios (Table 10) indicate that the results in the analyzed period are diversified. Portfolios with a pre-imposed share proved to be the least effective and resulted in losses. Only the P_FPI_10 portfolio achieved a positive rate of return in 2021 (6.6%). However, compared to the Markowitz (MM_8, MM_6) and the modified fundamental (MFP_9, MFP_7_H and MFP_7_L) portfolios, the rate was very low. Overall, Markowitz and the modified fundamental portfolios turned out to be the best.
these portfolios show the effect of the impact of the fundamental strength over time (the best effects in the long term). 2020 was the most intense year in terms of the pandemic stage. At that time, the strongest falls on the stock market and intensified periods of bear market were visible. Markowitz and the modified fundamental portfolios achieved the lowest losses on average. In terms of risk management, such a situation is beneficial for the investor. It is worth noting that one of the portfolios - MM_8 achieved a rate of return of 0.3%.

8. Conclusions

Long-term investment with the use of portfolio analysis methods requires the investor to adopt an action strategy. The investor's actions should be aimed at risk diversification. On the one hand, this requires the adoption of a portfolio building procedure: classical or non-classical approach. On the other hand, it requires a focus on identifying and selecting assets (companies) for the portfolio. Diversification of risk and securing the portfolio against risk become particularly important in times of bear market or crises on the stock markets. The years 2019-2021 (2022) are a special example of this. This period is the period of the COVID-19 pandemic. The aim of the study was to assess the effectiveness of investment during the pandemic. The study used an approach that takes into account aspects of the companies' fundamental strength. This approach was to reduce the risk of portfolios from the very beginning. The assumption that companies with fundamental strength cope much better in times of crisis (such as the period of a pandemic), which is present in the literature on the subject, was used. The identification of "good" companies also took place at the beginning of the definition of the research sample. In this respect, membership in the WIG20 in 2014-2018 was used. The assessment of companies from the point of view of their fundamental strength as measured by the FPI level is quite surprising. Non-financial companies are characterized by relatively low levels of the index, and financial companies by moderate levels. Moreover, the financial indicators on the basis of which the FPI was determined have a high dispersion. This means that the companies are characterized by a large diversification in the level of obtained financial results.

The assessment of efficiency was conducted with the use of different portfolio building approaches. All variants assumed that the companies underlying the construction of the portfolios would be "good" in the sense of long-term investment. The cyclical participation in WIG20 also met this condition. Moreover, in the construction of the portfolios, the condition of the portfolio composition for the Polish market, determined by the range from 5 to 10 shares, was taken into account. A portfolio with this composition is considered to be well diversified in terms of the number of shares. The results of the analysis indicate that the best outcomes in the pandemic period were obtained for portfolios that met the condition of the number of shares – Markowitz portfolios and the modified fundamental ones. Positive effects were also obtained for the modified portfolios, which took into account information on fundamental strength directly in the risk measurement. It is worth noting that in the Markowitz and modified portfolios the fundamental strength effect (a significant increase in the rate of return in the analyzed period) became visible over time. Moreover, these portfolios experienced the lowest average losses in the period of the intensified pandemic. This is a favorable situation in terms of portfolio risk management. The approach of determining the portfolio composition based on the vector measure and FPI did not bring the expected results.

Due to the relatively small number of companies (n=20), the study should be treated as preliminary and should be repeated for a larger sample. The obtained research results, which confirm the validity of the adopted assumptions, also encourage in-depth analyzes. The approach proposed in the article enables the construction of databases focused on highlighting the fundamental strength of companies. It is an advantage of the multi-dimensional methods themselves and the indicators of fundamental strength built on this basis. In addition, the proposed approach to building the portfolio takes into account in the risk measurement not only the risk of individual securities but also their fundamental strength, measured by the level of the FPI indicator. It is an advantage over classical models that do not consider the fundamental aspect. These models are based on the rate and risk for historical data. Delays and comparability of financial data may limit the proposed methods. Data is particularly important in comprehensive research for various groups of companies or different capital markets.
References

[1] Majewski, S. (2019). Could the volatility be a measure of Investors’ optimism? In: K. Nermend & M. Latuszynska (Eds.), Experimental and Quantitative Methods in Contemporary Economics. Computational Methods in Experimental Economics (CMEE) 2018 Conference (pp. 133-142). Cham, Switzerland: Springer Proceedings in Business and Economics.

[2] Kahneman, D., Tversky, A. (1979). Prospect theory: An Analysis of Decision Under Risk. Econometrica Vol. 47(2). 263-29. DOI: 10.2307/1914185

[3] Markowitz, H. M. (1952). Portfolio selection. Journal of Finance 6: 77–91

[4] Sharpe W.F.(1963). A Simplified Model for Portfolio Analysis, Management Science, vol. 19

[5] Tarczyński W.: Fundamentalny portfel papierów wartościowych. Uniwersytet Szczeciński, Rozprawy i studia, Szczecin 1999

[6] Tarczyński W., Tarczyńska-Luniewska M. (2018). The construction of fundamental portfolio with the use of multivariate approach, Procedia Computer Science, Vol. 126, pp. 2085-2096, doi.org/10.1016/j.procs.2018.07.243

[7] Ge S., Weisbach M. S,(2021). The Role of Financial conditions in portfolio choices: The case of insurers, Journal of Financial Economics, Vol. 142, Is. 2, pp. 803-830, doi.org/10.1016/j.jfineco.2021.05.019

[8] Glen A. (2004). Financial Times Guide Investing by Arnold Glen, , Financial Times/Prentice Hall, (First edition).

[9] Tarczynski W, Luniewska M. (2004). Dywersyfikacja ryzyka na polskim rynku kapitałowym, Placet, Warszawa

[10] Graham, B., Dodd, D. L. F., & Cottle, S. (1934). Security Analysis. McGraw Hill, New York, (Fifth edition 2005).

[11] Tarczynska, M. (2013a). Definition and nature of fundamental strengths, Actual Problems of Economics Vol. 2, Nr 1, pp. 15-23.

[12] Huang X. (2008). Portfolio selection with a new definition of risk. European Journal of Operational Research, Vol. 186, Iss. 1, pp. 351-357,doi.org/10.1016/j.ejor.2007.01.045

[13] Theron L., van Vuuren G. (2018).The maximum diversification investment strategy: A portfolio performance comparison. Cogent Economics & Finance, 6: 1427533. https://doi.org/10.1080/23322039.2018.1427533

[14] Zhai J., Bai M. (2018). Mean-risk model for uncertain portfolio selection with background risk. Journal of Computational and Applied Mathematics, Vol. 330, pp. 59-69, doi.org/10.1016/j.cam.2017.07.038.

[15] Silva A., Neves R., Horta N. (2015). A hybrid approach to portfolio composition based on fundamental and technical indicators. Expert Systems with Applications, Vol. 42, Iss. 4, pp. 2036-2048, doi.org/10.1016/j.eswa.2014.09.050.

[16] Kim, W., Kim, Y.M., Kim, T.-H., Bang, S. (2018). Multi-dimensional portfolio risk and its diversification: A note. Global Finance Journal, Vol. 35, pp. 147-156, doi.org/10.1016/j.gfj.2017.10.001.

[17] Tarczyńska-Luniewska, M. (2013b). Metodologia Oceny Siły Fundamentalnej Spółek (Giełdowych i Pozagiełdowych); Zapol: Szczecin.

[18] Hellwig, Z. (1968). Zastosowanie Metody Taksonomicznej Do Typologicznego Podziału Krajów Ze Względu Na Ich Poziom Rozwoju oraz Zasoby i Strukturę Wykwalifikowanych Kadr. Przegląd Statystyczny 1968, 4, 306–327.

[19] Tarczynski W. (1994). Taksonomiczna miara atrakcyjności inwestycji w papiery wartościowe, Przegląd Statystyczny Nr 3.

[20] Tarczyński, W.; Tarczyńska-Luniewska, M.; Majewski, S. The Value of the Company and Its Fundamental Strength. Procedia Computer Science 2020, 176, 2695–2699, doi:10.1016/j.procs.2020.09.331.

[21] Kubiczek, J.; Bieleń, M. The Level of Socio-Economic Development of Regions in Poland. Wiadomości Statystyczne. The Polish Statistician 2021, 66, 27–47, doi:10.5604/01.3001.0015.5130.

[22] Kądziołka, K. Ranking and Classification of Cryptocurrency Exchanges Using the Methods of a Multidimensional Comparative Analysis. Folia Oeconomica Stetinsia 2021, 21, 38–56

[23] Nermend, K. Vector Calculus in Regional Development Analysis; Springer, 2009; Vol. 53, doi:10.2478/foli-2021-0015.