Share portfolio on the Polish Capital Market in Conditions of Financial Crisis
Adrianna Mastalerz-Kodzis, Ewa Pośpiech 1

Abstract
Investing is one of the basic activities in economy. Selected elements of investment strategies are considered in the research. The work consists of two parts where the first one focuses on brief descriptions of investment strategies and the other concentrates on given data analyses methods, methods which may be useful in risk analysis and building investment strategies. In the second part, basing on data taken from Stock Exchange in Warsaw selected measures and investment portfolio components were calculated with the use of presented formulae. There is a summary at the end of article.

Key words
Investment strategies, portfolio theory, share risk measures, portfolio risk measures

1  Introduction

Analysis of financial data is one of the fastest developing fields of econometrics and theory of finances. The increase of market risk and the necessity to protect against it are the main stimuli development methods on financial data analyses. The dynamic development of Polish financial market causes that there is a need for better and better tools for analyses and financial phenomena descriptions. More and more efficient class models are the result of looking for combined modeling financial variables of time rows and dependencies between them.

Recently, capital markets have been exposed to big risk resulting from financial crisis. The question is whether there is a chance to generate some positive profit investing on the stock market during crisis and what elements should a portfolio share consist of so that it would generate a positive rate of return at least risk.

Pension scheme in Poland is based on 3 structures in which the Poles gather money for their pensions. The first one is obligatory for everyone and the money are collected in Social Insurance Board (ZUS) which is administered by government. The second one is also obligatory, based on the capital market and is administered by Open Retirement Funds (OFE). The third one is voluntary, also based on the capital market and administered by private investors (objects). Open Retirement Funds (OFE), which have been investing /among others/ on the Polish market in recent years show losses, which will result in little pensions for the Poles. The question is whether the losses of OFE are due to decreasing stock prices, or whether the costs of running retirement funds are too high. Therefore, the aim of this research was to build an effective portfolio of shares based on data obtained from Warsaw Stock Exchange. It is obvious that there are many investment strategies and many ways of building up the components of portfolio. The article focuses on selected strategies.

1 Adrianna Mastalerz-Kodzis, Ph.D., University of Economics in Katowice, adamast@ae.katowice.pl
Ewa Pośpiech, Eng., Ph.D., University of Economics in Katowice, posp@ae.katowice.pl
2 Basic notion of portfolio theory

In 1965, Jack Hirshleifer stated that “An investment is actually a current recantation for future profit. However, the present is relatively well known while the future is a mystery. Therefore, an investment is a recantation of the certain profit for the uncertain one”.

Investment strategy is a set of concrete rules and behavior patterns used by the investor to realize their decisions on buying and selling on a given market. Different kinds of investment techniques are used for different strategies. The idea of investment pyramid well reflects the following levels, going downwards:

- Investment strategy
- Investment system
- Investment style (discipline in investing)
- Knowledge of market (education, knowledge about the market)

Investment style can be described as an individual feature of each investor. Psychology of financial markets advises that the investor should work on their development and use a certain investment style, which will help to eliminate the two crucial problems each investor faces: uncertainty and inconsistency.

In this article, we should like to concentrate on the structure of portfolio basing on data from Warsaw Stock Exchange. In the classical theory of portfolio created by Harry Markowitz, two characteristics of securities are used: expected rate of return and rate of return variance. Let us mark share price as \( P_t \) in period (moment) \( t \) (look \([1, 4]\)).

- Rate of return from share during period \( t \) is a value
  \[
  R_t = \frac{P_t - P_{t-1}}{P_{t-1}} \tag{1}
  \]

By using historical data like rates of return realized in \( n \) past periods, an estimated expected rate of return can be calculated as an arithmetic mean.

- The expected rate of return from share is a value
  \[
  R = \frac{1}{n} \sum_{i=1}^{n} R_i \tag{2}
  \]

If the distribution of rate of return is unknown but the value of \( R_t \) have been observed in the past, it may be assumed that changes in rates of return in the future will be close to those in the past, and will be oscillating around the expected rate of return. The arithmetic mean of rate of return on a sample is the best estimator of unknown expected rate of return.

While using historical data, one should ask the question about the number of periods taken into account to calculate the expected rate of return. The higher the number of periods, the more stable arithmetic mean is (stable with regard to little sensitivity to extreme values in row). However, it is the current value of rate of return together with recent values that have the biggest influence on the future rate of return value. Therefore, too long historical periods should not be taken into consideration. This research covers the period of financial crisis so data taken from May, 2008 up to August, 2010.

The value of expected rate of return does not include differentiation of rates of return in historical periods taken into account. Information on differentiation can be obtained by calculating rate of return variance and its root – standard deviation. The bigger the value of expected rate of return and lower standard deviation is, the lower the risk of investing in shares is. The bigger the differentiation of rate of return is, the bigger the risk is. The measure
of share risk is the rate of return variance. With the use of historical rates of return from \( n \)-periods the value of variance can be calculated.

- Rate of return variance

\[
Var(R) = \frac{1}{n-1} \sum_{i=1}^{n} (R_i - R)^2
\]

Non-negative values are used for variance of rates of return. Variance is equal to zero when, and only when all taken into account rates of return equal the values of expected \( R \). The bigger the historical deviation of rates of return is from expected values \( R \), the bigger the variance is. The measure that is more frequently used in risk analyses for securities is the square root of variance, called standard deviation.

- Standard deviation of rate of return is the value

\[
s(R) = \left( Var(R) \right)^{1/2} = \left( \frac{1}{n-1} \sum_{i=1}^{n} (R_i - R)^2 \right)^{1/2}
\]

The standard deviation of rate of return presents the average deviation of possible rate of returns with regard to expected rate of return. Standard deviation uses non-negative values, therefore, the bigger deviation value is, the bigger the risk is.

The investor, bearing in mind the rule of maximal income and minimal risk should buy shares at highest expected income rate and the lowest standard deviation. By analogy, the presented above characteristics can be used to define for share portfolio.

- Expected portfolio rate of return has been presented as

\[
r_p = \sum_{i=1}^{n} w_i E(r_i)
\]

where: \( r_p \) – expected portfolio rate of return

\( w_i \) – participation of \( i \)-company in portfolio

\( E(r_i) \) – expected share rate of return for \( i \)-company

- Variance of portfolio rate of return is presented as

\[
V_p = \sum_{i=1}^{n} w_i^2 \sigma_i^2 + 2 \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} w_i w_j \sigma_i \sigma_j \rho_{ij}
\]

where: \( V_p \) – variance of portfolio rate of return

\( \sigma_i \) – standard deviation of share rate of return for \( i \)-company

\( \rho_{ij} \) – correlation coefficient of share rate of return for \( i \)-company and \( j \)-company

- Portfolio standard deviation is presented as

\[
\sigma_p = \sqrt{ \sum_{i=1}^{n} w_i^2 \sigma_i^2 + 2 \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} w_i w_j \sigma_i \sigma_j \rho_{ij}}
\]

Portfolio risk depends not only on the risks of portfolio components but also on correlation coefficients of portfolio component rates of return, where the more negative or slightly positive correlation coefficients of rates of return are, the lower the risk of portfolio is.
In case of two companies in portfolio, the portfolio of minimal variance risk (MVP) consists of following shares:

\[
\begin{align*}
    w_1 &= \frac{\sigma_2^2 - \sigma_1 \sigma_2 \rho_{12}}{\sigma_1^2 + \sigma_2^2 - 2\sigma_1 \sigma_2 \rho_{12}}, \\
    w_2 &= \frac{\sigma_1^2 - \sigma_1 \sigma_2 \rho_{12}}{\sigma_1^2 + \sigma_2^2 - 2\sigma_1 \sigma_2 \rho_{12}}
\end{align*}
\]

The efficient portfolio is such a portfolio which:

- For the given expected rate of return (but higher than expected portfolio rate of return a minimal risk) minimizes risk (standard deviation).
- For given risk (standard deviation) maximizes expected rate of return.

Efficient portfolios are attractive for investor who follows the rule of obtaining the highest possible expected rate of return and lowest standard deviation of rate of return. Other portfolios are dominated by efficient portfolios.

2.1 Working out portfolio of minimal risk

Participation of shares in a portfolio of minimal risk can be presented as:

\[ w = C^{-1}I \]  

where: 
- \( w \) – vector of \( n+1 \) components whose first \( n \)-components are shares in a portfolio of minimal risk
- \( I \) – vector of \( n+1 \) components whose first \( n \)-components are zeros and the last one is 1
- \( C^{-1} \) – a matrix which is reverse to matrix \( C \)
- \( C \) – a matrix of dimensions \( (n+1) \times (n+1) \) whose elements are marked as:
  - \( c_{ii} = 2\sigma_i^2, \ i = 1, \ldots, n \);
  - \( c_{ij} = 2\sigma_i \sigma_j \rho_{ij}, \ i, j = 1, \ldots, n, \ i \neq j \);
  - \( c_{i,n+1} = c_{n+1,i} = 1, \ i = 1, \ldots, n \);
  - \( c_{n+1,n+1} = 0 \).

2.2 Working out an efficiency portfolio of an inflicted rate of return

Participation of shares in an efficient portfolio (minimal risk at a given rate of return) is presented as:

\[ w = D^{-1}I_0 \]  

where: 
- \( w \) – vector of \( n+2 \) components in which first \( n \)-components are participation of shares in an efficient portfolio
- \( I_0 \) – vector of \( n+2 \) components in which first \( n \)-components are zeros, the one before the last is 1, and the last equals the inflicted expected the portfolio rate of return
- \( D^{-1} \) – matrix reverse to matrix \( D \)
- \( D \) – matrix of dimensions \( (n+2) \times (n+2) \) whose elements are marked as:
  - \( d_{ii} = 2\sigma_i^2, \ i = 1, \ldots, n \);
  - \( d_{ij} = 2\sigma_i \sigma_j \rho_{ij}, \ i, j = 1, \ldots, n, \ i \neq j \);
  - \( d_{i,n+1} = d_{n+1,i} = 1, \ i = 1, \ldots, n \);
Empiric analysis was carried out on the basis of data obtained from selected companies that are in WIG 20 index group (20 biggest companies in Warsaw Stock Exchange) and covered the period from 20th May 2008 to 13th August 2010 (575 observations). During that period 17 out of 20 companies showed complete data. Graph No. 1 presents WIG 20 index values in the research period.

Figure 1: WIG 20 index graph in the research period (source: own work)

Table 1 presents basic characteristics of rate of returns for selected shares. Coefficient \( \beta \) was additionally calculated by the use of Sharp`s single index model [look 2, 5], which shows approximately by how many units will the share rate of return increase if the market rate of return index grows by a unit. The model is presented as:

\[
R = \alpha + \beta \cdot R_M + \epsilon
\]

where:
- \( R \) – rate of return of company share
- \( R_M \) – rate of return of market index (in our work WIG 20 index)
- \( \alpha \) – free element
- \( \beta \) – coefficient \( \beta \)
- \( \epsilon \) – random component

<table>
<thead>
<tr>
<th>Company name</th>
<th>Expected rate of return</th>
<th>Standard deviation of rate of return</th>
<th>Coefficient ( \beta )</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSECOPOL</td>
<td>-0.000128221</td>
<td>0.022365979</td>
<td>0.681084</td>
</tr>
<tr>
<td>BIOTON</td>
<td>-0.00113</td>
<td>0.041782</td>
<td>0.918402</td>
</tr>
<tr>
<td>BRE</td>
<td>-7.8E-05</td>
<td>0.035876</td>
<td>1.33099</td>
</tr>
<tr>
<td>BZWBK</td>
<td>0.00065</td>
<td>0.031749</td>
<td>1.202567</td>
</tr>
<tr>
<td>CEZ</td>
<td>-2.4E-05</td>
<td>0.02474</td>
<td>0.578862</td>
</tr>
<tr>
<td>GETIN</td>
<td>4.46E-05</td>
<td>0.029076</td>
<td>1.016755</td>
</tr>
<tr>
<td>GTC</td>
<td>-0.00029</td>
<td>0.034527</td>
<td>1.06651</td>
</tr>
<tr>
<td>KGHIM</td>
<td>0.000709</td>
<td>0.037203</td>
<td>1.316678</td>
</tr>
<tr>
<td>LOTOS</td>
<td>0.000276</td>
<td>0.028826</td>
<td>0.835997</td>
</tr>
<tr>
<td>PBF</td>
<td>-0.0002</td>
<td>0.023856</td>
<td>0.627482</td>
</tr>
<tr>
<td>PEKO</td>
<td>0.000189</td>
<td>0.033044</td>
<td>1.351966</td>
</tr>
<tr>
<td>PGNIG</td>
<td>-0.00013</td>
<td>0.021258</td>
<td>0.584982</td>
</tr>
<tr>
<td>PKNORLEN</td>
<td>0.000287</td>
<td>0.028597</td>
<td>1.082154</td>
</tr>
</tbody>
</table>
Dependence between rows of rates of return for given companies were examined. Correlation coefficients between companies of positive expected rates of return are presented in table No. 2.

<table>
<thead>
<tr>
<th></th>
<th>BZWBK</th>
<th>GETIN</th>
<th>KGHM</th>
<th>LOTOS</th>
<th>PEKAO</th>
<th>PKN</th>
<th>ORLEN</th>
<th>PKOBP</th>
<th>TVN</th>
</tr>
</thead>
<tbody>
<tr>
<td>BZWBK</td>
<td>1</td>
<td>0.66</td>
<td>0.58</td>
<td>0.46</td>
<td>0.73</td>
<td>0.6</td>
<td>0.71</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>GETIN</td>
<td>1</td>
<td>0.57</td>
<td>0.48</td>
<td>0.63</td>
<td>0.56</td>
<td>0.56</td>
<td>0.63</td>
<td>0.49</td>
<td></td>
</tr>
<tr>
<td>KGHM</td>
<td>1</td>
<td>0.48</td>
<td>0.56</td>
<td>0.57</td>
<td>0.57</td>
<td>0.57</td>
<td>0.61</td>
<td>0.49</td>
<td></td>
</tr>
<tr>
<td>LOTOS</td>
<td>1</td>
<td>0.46</td>
<td>0.61</td>
<td>0.5</td>
<td>0.61</td>
<td>0.61</td>
<td>0.47</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>PEKAO</td>
<td>1</td>
<td>0.62</td>
<td>0.78</td>
<td>0.8</td>
<td>0.78</td>
<td>0.78</td>
<td>0.49</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>PKNORLEN</td>
<td>1</td>
<td>0.64</td>
<td>0.53</td>
<td>0.5</td>
<td>0.53</td>
<td>0.53</td>
<td>0.53</td>
<td>0.53</td>
<td></td>
</tr>
<tr>
<td>PKOBP</td>
<td>1</td>
<td>0.52</td>
<td>0.52</td>
<td>0.52</td>
<td>0.52</td>
<td>0.52</td>
<td>0.52</td>
<td>0.52</td>
<td></td>
</tr>
<tr>
<td>TVN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Table No. 2: Correlation coefficients between companies (source: own work)

The analysis of data presented in the above table allows to draw the conclusion that share rates of return are positively correlated and the dependence is weak, moderate or significant.

Next, a share portfolio consisting of 2 and later 3 selected from above showed shares will be created. For these portfolios the following characteristics will be calculated: expected rate of return from portfolio and portfolio variance. Next, obtained data will be compared. During the analysis of obtained characteristics and correlations between rates of return (only...
companies that had a positive expected rate of return and those whose correlation was below 0.5 were taken into consideration), portfolios consisting of two or three components can be examined (Table No. 3).

<table>
<thead>
<tr>
<th>Portfolio composition</th>
<th>Participation of given companies in portfolio</th>
<th>Expected value of portfolio</th>
<th>Standard deviation of portfolio</th>
<th>β coefficient of portfolio</th>
</tr>
</thead>
<tbody>
<tr>
<td>BZWBK, LOTOS</td>
<td>$W_1$ = 0.411661145, $W_2$ = 0.588338855</td>
<td>0.00043</td>
<td>0.025713</td>
<td>0.986899483</td>
</tr>
<tr>
<td>KGHM, TVN</td>
<td>$W_1$ = 0.344009744, $W_2$ = 0.655990256</td>
<td>0.000271684</td>
<td>0.029058</td>
<td>1.074446512</td>
</tr>
<tr>
<td>TVN, GETIN</td>
<td>$W_1$ = 0.574715331, $W_2$ = 0.425284669</td>
<td>4.33127E-05</td>
<td>0.026022</td>
<td>0.97690563</td>
</tr>
<tr>
<td>TVN, LOTOS</td>
<td>$W_1$ = 0.421168366, $W_2$ = 0.578831634</td>
<td>0.000177608</td>
<td>0.026123</td>
<td>0.882923334</td>
</tr>
<tr>
<td>LOTOS, KGHM</td>
<td>$W_1$ = 0.731413307, $W_2$ = 0.268586693</td>
<td>$\textbf{0.000392309}$</td>
<td>$\textbf{0.017327}$</td>
<td>0.965101219</td>
</tr>
<tr>
<td>LOTOS, GETIN</td>
<td>$W_1$ = 0.508313994, $W_2$ = 0.491686006</td>
<td>0.000162236</td>
<td>0.02491</td>
<td>0.924873152</td>
</tr>
<tr>
<td>LOTOS, PEKAO</td>
<td>$W_1$ = 0.625063941, $W_2$ = 0.374936059</td>
<td>0.000243544</td>
<td>0.026159</td>
<td>1.029451963</td>
</tr>
<tr>
<td>LOTOS, GETIN, TVN</td>
<td>$W_1$ = 0.388247507, $W_2$ = 0.359072707, $W_3$ = 0.252679786</td>
<td>0.000133883</td>
<td>0.023950532</td>
<td>0.92905584</td>
</tr>
<tr>
<td>LOTOS, KGHM, TVN</td>
<td>$W_1$ = 0.512924455, $W_2$ = 0.127255695, $W_3$ = 0.359819849</td>
<td>$\textbf{0.000406858}$</td>
<td>$\textbf{0.025348439}$</td>
<td>0.93725733</td>
</tr>
<tr>
<td>LOTOS, GETIN, TVN</td>
<td>$W_1$ = 0.887826533, $W_2$ = 0.085159309, $W_3$ = 0.027014158</td>
<td>0.00025</td>
<td>0.027295039</td>
<td>0.854399751</td>
</tr>
<tr>
<td>LOTOS, KGHM, TVN</td>
<td>$W_1$ = 0.512503295, $W_2$ = 0.131842767, $W_3$ = 0.355653938</td>
<td>0.00025</td>
<td>0.025348914</td>
<td>0.938998083</td>
</tr>
</tbody>
</table>

Table No. 3: Presentation of selected characteristics of efficient share portfolios (source: own work)

Data presented in Table 3 indicate that from the selected companies it is impossible to build a portfolio at an expected value of over 0.00043. Standard deviations are not lower than 1.7% and not higher than 3%. Therefore, even during financial crisis and basing on portfolios consisting only of shares it is possible to build a portfolio of positive rate of return and little standard deviation.

Figure 3: Profit-risk dependence of rates of return in selected portfolios (source: own work)

Moreover, sensitivity measures can be for example used to protect portfolio value (look [3]). The strategy consists in modifying the portfolio in such a way that the proper sensitivity measure takes the earlier accepted value. For example, it was decided that the considered portfolios had the coefficient $\beta$ equal to 1.

Letter $w$ means participation of KGHM share in the newly established portfolio built up from most profitable efficient portfolios presented in Table 3, and company shares of BZWBK and KGHM (of positive rate of return and $\beta$$>$1).

For example, for the first pair the following equation is to be solved
where \( w \) is an additional share of BZWBK company in the portfolio. Solving the equation gives \( w = 0.060743944 \).

<table>
<thead>
<tr>
<th>X company and its ( \beta )</th>
<th>Share portfolio and its ( \beta )</th>
<th>Participation of share in Company X</th>
<th>Portfolio share</th>
</tr>
</thead>
<tbody>
<tr>
<td>BZWBK 1.202567352</td>
<td>BZWBK+LOTOS 0.986899483</td>
<td>0.060743944</td>
<td>0.939256056</td>
</tr>
<tr>
<td>BZWBK 1.202567352</td>
<td>LOTOS+KGHM 0.965101219</td>
<td>0.146963194</td>
<td>0.853036806</td>
</tr>
<tr>
<td>BZWBK 1.202567352</td>
<td>LOTOS+KGHM+TVN 0.93725733</td>
<td>0.236488125</td>
<td>0.763511875</td>
</tr>
<tr>
<td>KGHM 1.316678209</td>
<td>BZWBK+LOTOS 0.986899483</td>
<td>0.039725173</td>
<td>0.960274827</td>
</tr>
<tr>
<td>KGHM 1.316678209</td>
<td>LOTOS+KGHM 0.965101219</td>
<td>0.099263553</td>
<td>0.900736447</td>
</tr>
<tr>
<td>KGHM 1.316678209</td>
<td>LOTOS+KGHM+TVN 0.93725733</td>
<td>0.165364304</td>
<td>0.834635696</td>
</tr>
</tbody>
</table>

Table No. 4: Presentation of shares of selected efficient portfolios and company shares giving \( \beta \) equal to 1 (source: own work)

## 4 Summary

In conclusion, it may be stated that even in a period of recent big fluctuations and drops on Warsaw Stock Exchange, there is a simple way to build up a portfolio strategy generating positive profit at a relatively low risk. However, it should be stressed that in the research the strategy of building a portfolio was based only on Warsaw Stock Exchange shares. Obviously, a portfolio may also include other stock values like portfolio components free from risk, bonds, options, which additionally differentiate the portfolio and lowers its risk. Nevertheless, as one can clearly see, even a portfolio consisting of only shares brings positive profit. Financial institutions participating in Stock Exchange in an efficient way have a chance for profit. If they, however, generate losses it is probably due to bad investment strategies, incorrect management or too high maintenance costs of conducting financials activities.

## Reference