The efficiency of an investing in investment funds in the context of a longevity

Monika Mościbrodzka
Department of Statistics and Operations Research
Faculty of Law, Administration and Economics
University of Wrocław, Wrocław, Poland
monika.moscibrodzka@uwr.edu.pl

Magdalena Homa
Department of Statistics and Operations Research
Faculty of Law, Administration and Economics
University of Wrocław, Poland
magdalena.homa@uwr.edu.pl

Abstract

Aim/purpose – The aim of this paper is to evaluate the efficiency of an investing in investment funds with different risk levels in times of a future life expectancy increase. For this purpose, it was analysed how future prices of the investment funds’ entities behave, depending on the window function and the age of the investors, in particular people of retirement age, for whom an investment income may be a supplementary way of raising additional capital.

Design/methodology/approach – Based on the historical data of the funds chosen from the different risk groups, a simulation of their price behaviour in the window function was carried out covering investor’s further life expectancy. Then, based on the result, the distribution of prices was analysed and the efficiency of investing in investment funds according to risk exposure was evaluated.

Findings – According to the conducted analyses, the funds with the lowest efficiency were share funds. The best funds, in terms of efficiency, were bond and money funds.

Research implications/limitations – The study was conducted on a limited number of funds, but this analysis can help take investment decisions.

Originality/value/contribution – In this study, the investment in investment funds is treated as a long-term project which expires after 25-30 years, and therefore it may be problematic to use standard methods of evaluation for the purpose of this paper. As a result, the NPV (Net Present Value) method was applied as a measure of the investment’s efficiency. In the literature, this approach to the evaluation of investment funds is unique.

Cite as: Mościbrodzka, M., & Homa, M. (2019). The efficiency of an investing in investment funds in the context of a longevity. Journal of Economics & Management, 38(4), 107-128. https://doi.org/10.22367/jem.2019.38.06
Keywords: efficiency, longevity, investment funds, simulation methods.
JEL Classification: C15, G23, E22.

1. Introduction

Longevity risk is one of the main risks related to the increasing life expectancy of future pensioners (Trzpiot, 2015a). It indicates that the average value of life expectancy is increasing, which on the one hand, may lead to problems with an insolvency of the pension plans and insurance agencies, whilst on the other, may cause a radical decline in the amount of paid annuities in the future (Trzpiot, 2015b). Hence, it becomes an issue of the quality of life in case of arising limits that are related to the age of people exceeding the life expectancy threshold. Each additional year of life for such a person requires an additional year of monies necessary to sustain it. Therefore, a future pensioner should not wait for their imminent income’s decline, but choose an investment strategy that will guarantee the adequate level of the future pension. This kind of rational thinking should be applied long before reaching the upper limit of the productive age, as only in this way may the higher longevity risk be balanced and the financial security be provided (Trzpiot, 2015a).

One of the possible investment methods available on the market are investment funds. It needs to be highlighted that they are perceived as one of the most secure methods of a raising capital (Jawdosiuk & Rożko, 2010). According to experts, the basic rule of a investing in such funds is that the riskier investing strategy a fund has, the longer the investment holding time should be (Harris, 2014). Hence, as an illustration of share fund brochures, the recommended minimum duration of the investment is in most cases 5 years. By comparison for bond funds, the suggested investment is a period of at least 2 years. Choosing the right fund is not a simple task. Therefore, experts recommend firstly defining how much risk we are willing to take and for how long we are able to wait for the profits (Jajuga, 2009). Namely, those investors who are prepared to risk more in return for the prospects of higher results, should take advantage of the potential of the stock market, whereas individuals who value safety, should probably consider bond or cash fund investments.

---

3 Retrieved December 31, 2018 from https://www.analizy.pl/fundusze/; https://www.gpw.pl/biblioteka-gpw-wiecej?gpwl_id=14&title=Fundusze+inwestycyjne
4 Retrieved December 31, 2018 from https://www.analizy.pl/fundusze/edukacja/jak-inwestowac/19107/ile-tak-naprawde-mozemy-zarobic-na-funduszach-inwestycyjnych.html
ing additional money means that the investors, i.e. future pensioners, face tough decisions regarding the way of investing, since they alone bear the investment risk, and are fully responsible for any negative effects of their choices. Therefore, it is necessary to conduct an analysis, focusing on the efficiency of the investment funds, which are the basis for choosing a suitable investment strategy. There are multiple analyses of this kind, not only for the Polish investment fund market (e.g. Jurek-Wasilewska, 2014), but also for foreign ones (Grinblatt & Titman, 1989; Kon & Jen, 1979). However, these analyses employed classical and alternative measures of efficiency, based on a standard deviation, a risk premium and an additional rate of return. It should be remembered that this evaluation is of a relative nature; in other words, the rates of return of one fund are compared to the results of other funds. Consequently, the fund with negative, lower than other fund’s rates of return may be perceived as the more effective one (Miziołek & Trzebiński, 2017). Additionally, these analyses assumed the time horizon of maximum 10 years (Miziołek, 2000; Stanimir, 2001). There is currently no literature concentrating on the analysis of an investment efficiency in the context of a longevity. The measures commonly reported were usually employed for a short investment period with no reflections of the time value of money. That is why, it is necessary to search for such instruments which could be the basis for the investment evaluation in any window function, including long time horizon.

Therefore, this paper analyses the efficiency of the investments in long-term investment funds on the Polish market, assuming an investor’s passive approach, i.e. the investor does not change the fund during the whole period of analysis. The purpose is to evaluate the efficiency of an investing in the investment funds with different risk levels in times of increased life expectancy. It was assumed that the investor is a future pensioner who contributes money to investment fund entities with the aim of long-term investments, and that the 5-year investment will be completed in their lifetime. The results of the investments provided basis for the evaluation of the efficiency of individual’s investment funds with regards to their risk exposure and independently of the results of other analysed instruments. As an instrument for the analysis, a widely known measure was employed – namely Net Present Value (NPV). However, it needs to be highlighted that this measure has not been employed before in this type of analysis. In other words, using NPV method bridges the gap, as it is an alternative method to classical measures commonly used and described in the literature (Carhart, 1997; Cogneau & Hubner, 2009; Jensen, 1967). The results enabled the evaluation of
individual investment funds, applicable to the Polish market only. Hence, future analyses will need to involve other markets, in order to confirm the hypothesis, according to which funds with high-risk exposure, although recommended by experts as highly effective long-term instruments, are less effective than funds with low-risk exposure.

The literature review covering the analysis of the efficiency of Polish investment funds is presented in this paper. The question of measuring the efficiency, including NPV and the simulating methods, is introduced to the reader. Empirical research forms the basis for drawing conclusions and verifying stated theses.

2. Literature review

Most commonly used methods for evaluating the efficiency of the investment funds are those which employ both the rates of return and the risk involved. The evaluation is based on rankings in which the position represents the value level of applied efficiency measures (Miziołek & Trzebiński, 2017). The top positions indicate outstanding results, whereas the low positions – insignificant ones. However, the main weakness of building and comparing rankings is that the fund efficiency is defined only in correlation to other funds or market portfolios (Miziołek & Trzebiński, 2017). Therefore, it may be concluded that the evaluation of the investment funds’ efficiency is limited to defining the type and the level of the risk involved as well as the rate-of-return values and the relation to the market portfolio (Reilly & Brown, 2001). When applying this method, it is worth bearing in mind that the reference point, i.e. a benchmark, may not be represented by the benchmark of the portfolio, but by the ‘zero’ value. Another possible result is that the fund with the minor loss within the examined group is the best one (Cogneau & Hubner, 2009ab).

In practice, these methods are divided into two groups – traditional and modern ones. The surveys on the efficiency of the Polish investment funds clearly indicate two research streams. The first one employs the Sharpe ratio (Sharpe, 1966), the Treynor ratio (Treynor, 1965), and the Jensen’s alpha (Jensen, 1967), as well as their modifications, such as the Sharpe alpha ratio, Information Ratio (IR), and the Modigliani ratio. These methods put emphasis both on the total and the market risk as well as the managers’ competence regarding the selection of financial instruments. Characteristic of these methods is the assumption of a neutral approach to the risks.
The three above-mentioned efficiency measures were applied in pioneer analyses regarding the efficiency of the national investment funds, carried out in the works of Miziołek (2000, 2001), in which all the funds between 1997 and 1998, as well as the share funds and the balanced funds of the year 2000 were taken under analysis. What is more, this set of measures became the basis for the works of other authors (e.g. Jamróz, 2013; Jurek-Wasilewska, 2014; Sekuła, 2011; Stanimir, 2001). Other classical measures were applied by Czekaj, Woś & Żarnowski (2001) who, in addition to the Sharpe ratio, the Treynor ratio, and the Jensen’s alpha, employed in their studies the Sharpe alpha ratio. However, in the paper of Zatoń (2001), the Modigliani ratio was applied, i.e. the ratio which enables defining the fund’s rate of return, based on the total portfolio’s market risk.

The second approach to the evaluation of the investment funds’ efficiency employs the modern types of measures which do not require an additional assumption regarding the symmetry in the distribution of the rates of return. Here mainly applied are: the Omega ratio (Shadwick & Keating, 2002), the Sortino ratio (Sortino & Price, 1994), or the Carhart four-factor model (Carhart, 1997). These analyses consider the impact of other risk types, such as the size and the value of listed companies, a value exposed to risk, and a negative risk concept. For the Polish fund market analyses, the new efficiency measures, such as tracking error, the generic Sharpe ratio, the Sortino ratio, and the Sharpe–Israelsen ratio, were applied in the papers of Dawidowicz (2007). However, in the paper of Zamojska (2008), the Sortino and Omega ratios were applied as well as the return on VaR and other measures which included the capital loss – the Burke, the Sterling and the Calmar ratios. In 2011, Perez (2011) added additional measures – the Sharp–Omega ratio and the incremental rate of return ratio.

Alternatively, the fund efficiency evaluation may be conducted as well by using methods which consider the abilities of the management. In this case, no investment rankings should be made – the funds are divided into those with positive and negative rates of return. These methods were applied in the research papers of Olbryś (2010), Homa & Mościbrodzka (2016b) and Perez (2012), to name a few, and they employed, e.g. the Jensen’s four-factor alpha from the Carhart model and the three-factor alpha from Fama–French model as well as modified market-timing models.

Nevertheless, the presented approaches are not equal. In the first method, the results of managers’ decisions are evaluated, whereas in the second one, the abilities of the managers are the key factor for the evaluation. Only a blend of these two approaches provides a complete assessment of the investment fund results (Miziołek & Trzebiński, 2017).
However, it is worth mentioning the attempts of introducing other methods to research as well, such as: the taxonomic (Homa & Mościbrodzka, 2016a), the Bayes’ theorem (Sikora, 2010) or the wavelet analysis (Zamojska, 2015).

In this paper, however, the investment in investment funds is treated as a long-term project which expires after 25-30 years, and, therefore, it may be problematic to use standard methods of an evaluation for the purpose of this article. As a result, the NPV method was applied as a measure of the investment’s efficiency. This approach to the evaluation of investment fund is unique in the literature.

3. Research methods

3.1. Investment efficiency – Net Present Value

Efficiency should be understood as a result of the actions taken, and in economics, it is defined as the relation between the effects and incurred expenses, thus as the evaluation whether the achieved financial results were, in the investor’s opinion, commensurate with the incurred expenses.

As for the investment fund market, it is assumed that a high efficiency fund is the one whose manager accurately forecasts the changes in the market prosperity, skilfully matches the financial instruments with the fund type, and consistently achieves the objectives referring to the risk level and the provisions of the fund’s articles (Perez, 2012). The study of the efficiency of the investment portfolios has been a crucial element of research in the financial field for many years. In the literature, there are no clearly outlined instructions that would strictly define which of the efficiency measures should be applied and when.

In the works of Cogneau & Hubner (2009a, 2009b), there are over 100 methods which can be used to measure the efficiency. What is more, many of them have their numerous modifications.

Nevertheless, the majority of these methods measure mainly the results of short-term investments. In the case of long-term investment, the fluctuations of the time value of money should also be considered when analysing the efficiency, and that leads to the conclusion that this type of investment should be treated as a long-term project whose task, in a finite time horizon, is to generate a certain income. Hence, in order to examine the cost-effectiveness of such an investment, other methods should be used which correctly take account of the cash flow throughout the life of the investment. The Net Present Value method is one
of these methods and was constructed in accordance with the requirement of the modern financial management. Its asset is that it correctly takes account of the fluctuations of the time value of money and of the cash flows throughout the life of the investment. Net present value is a sum of discounted cash flows generated by the investment, calculated as investment (Jajuga & Słoński, 1997):

\[ NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+k)^t} \]

where
\( CF_t \) – cashflows achieved during a period \( t \),
\( n \) – the length of investment horizon,
\( k \) – a discount rate.

NPV value informs how much the value of invested capital will increase as a result of the completion of the investment. According to the literature (Jakubczyc, 2008):
- if \( NPV > 0 \), then a project should be conducted (an investment should be started);
- if \( NPV = 0 \), a project is neutral to the investor;
- if \( NPV < 0 \), an investment is not profitable.

The discounted rate used in this method may be defined in many ways. In most cases it is described as:
- the rate of return probable to achieve on a market when investing in other projects with a risk level that is similar to the risk level of our investment;
- the cost of capital necessary to provide funds for a project with a given level of risk.

The most frequently chosen discount rate is WACC (Weight Average Cost of Capital), which may be calculated as:

\[ WACC = \sum_{i=1}^{n} w_i \cdot k_i \]

where:
\( w_i \) – a percentage of a capital from \( i \)-source,
\( k_i \) – a cost of a capital from \( i \)-source in company’s capital structure.
In practice, this formula is presented as:

\[ WACC = w_d k_d (1 - T) + w_p k_p + w_e k_e \]

where:
- \( w_d \) – a percentage of the capital of debt,
- \( w_p \) – a percentage of the capital of preferred shares,
- \( w_e \) – a percentage of equity,
- \( k_d \) – a cost of equity capital,
- \( k_p \) – a cost of preferred capital,
- \( k_e \) – a cost of company’s equity capital,
- \( T \) – an income tax.

As the investment presented in this paper does not include costs of debt and costs related to the issue of other financial instruments, the rate of income may be defined using the cost of equity capital, which may be estimated using the capital valuation model – CAPM. This model was created by Sharpe (1964), Lintner (1965) and Mossin (1969) and combines the expected return-risk relationships with the risk of the market on which the assets are placed. According to its formula:

\[ k_e = k_{RF} + \beta (k_M - k_{RF}) \]

where:
- \( k_{RF} \) – a risk free rate,
- \( k_M \) – a market portfolio rate of return.

### 3.2. Simulating method

The Monte Carlo method (MC) was created during the Second World War by John von Neumann and his team. It has been used to model complex processes in such a way that their results may be forecast through the analytical approach. The key role of this method is based on the stochastic choice of variables describing the process. The sampling is carried out according to the distribution of observations that must be known in advance. The accuracy of the result achieved through this method depends on the quantity of repetition and the quality of the Random-Number Generator (Metropolis, 1987). This method involves in particular (Hull, 2011):
- formulating the stochastic models of processes under analysis (real processes),
- modelling variables of known probability distribution,
- solving a statistic problem using the theory of estimation.
This method is simple in theory but very complex in practice. The basis for any consideration is the assumption of a hypothetical model describing the behaviour of rates of return.

Firstly, to carry out the cash flow valuation and define the pay-out – the value of an investment fund portfolio, one must carry out a pricing simulation (with the assumption of the financial market model). Therefore, this research deals with simulating methods and for investment fund pricing employs the Monte Carlo method. In this method, the distribution of the base instrument value at its expiry date was defined by a stochastic process. Knowing this process in advance and applying the Monte Carlo method, through numerous simulations, leads to the result in the distribution of the base instrument final values. In this paper, it is assumed that the investment market is ideal, and the entities of the chosen fund exist, what is described as:

$$dS_t = \mu_S(t)S_t dt + \sigma_S(t)S_t dW_t$$

where:

- $W_t$ – the Wiener process (standard Brownian motion process),
- $S_t$ – a basic instrument’s future price,
- $S_0$ – a basic instrument real price,
- $\mu_S$ – an expected value of process,
- $\sigma_S$ – a process standard deviation.

The only answer to this differential equation is:

$$S_t = S_0 \exp\left(\sigma W_t + \left(\mu - \frac{1}{2} \sigma^2\right) \cdot t\right)$$

This paper uses the simplest pricing model named the standard Brownian motion process, hence the price of the investment fund entity – $S_t$, is described by it, including an accurate drift ratio which may be defined using the Euler method (Weron & Weron, 2018). Employing this mathematic method, the pricing simulation of investment fund entities in finite number of moments was conducted.

4. Research findings

A survey was conducted on 42 investment fund entities with the longest window function (20 years), quoted in the period of 11.1998-11.2018, including: 11 share investment funds (A), 17 mixed funds (along with 8 stable growth funds (SW), 1 asset allocation fund (MAA), 8 balanced funds (Z), 6 bond funds
(including 4 treasury bonds (OS) and 2 universal funds) and 6 investment funds of the money market (PU). The investment fund values were taken from the website stooq.pl.

In this paper, it is assumed that the investor contributes the amount of PLN 100,000 to the chosen investment fund entities, using five types of investment scenarios. Namely: W1 – according to which the investor will contribute the whole sum at the beginning of the research period, W2 – the investor will be regularly investing their capital as annuities every week for 5 years and the capital discounted amount at the beginning is PLN 100,000, W3 – the investor will be regularly investing their capital as annuities every week for 10 years and the capital discounted amount at the beginning is PLN 100,000, W4 – the investor will be regularly investing their capital as annuities every week for 15 years and the capital discounted amount at the beginning is PLN 100,000, W5 – the investor will be regularly investing their capital as annuities every week for 20 years and the capital discounted amount at the beginning is PLN 100,000. At the end of the investment period (after 20 years) the number of entities purchased by the investor within the whole research period was defined (Table 1).

Table 1. The number of entities purchased by the investor in using five types of investment scenarios

| Scenario | PU41 | PU36 | PU34 | PU20 | PU14 | PU10 | MA46 | OU25 | OU26 | OS21 |
|----------|------|------|------|------|------|------|------|------|------|------|
| W1       | 1334 | 7968 | 6716 | 943  | 984  | 908  | 894  | 978  | 93   | 987  |
| W2       | 1093 | 6681 | 5616 | 755  | 793  | 734  | 813  | 804  | 73   | 778  |
| W3       | 1015 | 6310 | 5288 | 707  | 746  | 691  | 697  | 751  | 68   | 705  |
| W4       | 960  | 6087 | 5086 | 682  | 729  | 670  | 672  | 702  | 62   | 650  |
| W5       | 936  | 6031 | 5046 | 676  | 725  | 664  | 687  | 684  | 60   | 626  |
| Scenario | OS15 | OS13 | OS5  | Z13  | Z12  | Z10  | Z7   | Z6   | Z5   | Z4   |
| Z3       | 616  | 1990 | 10000| 10173| 1565 | 741  | 975  | 9921 | 2325 |      |
| W1       | 520  | 1569 | 8238 | 11088| 1565 | 1312 | 688  | 825  | 8099 | 1672 |
| W2       | 471  | 1352 | 7061 | 10612| 1390 | 1188 | 652  | 752  | 7272 | 1303 |
| W3       | 463  | 1278 | 6563 | 10204| 1337 | 1169 | 679  | 740  | 7013 | 1162 |
| W4       | 445  | 1241 | 6384 | 10167| 1331 | 1158 | 712  | 760  | 6766 | 1105 |
| W5       | 1173 | 10091| 988  | 1896 | 5008 | 883  | 1039 | 563  | 1251 | 881  |
| Scenario | A47  | A44  | A42  | A38  | A35  | A32  | A30  | A24  | A23  | A19  |
| A47      | 1981 | 4769 | 932  | 1137 | 928  | 9452 | 1541 | 1088 | 912  | 892  |
| A44      | 1580 | 4031 | 754  | 874  | 753  | 8399 | 1383 | 996  | 823  | 756  |
| A42      | 1452 | 3735 | 705  | 734  | 641  | 6902 | 1227 | 908  | 716  | 656  |
| A38      | 1366 | 3516 | 677  | 676  | 614  | 6469 | 1236 | 973  | 722  | 629  |
| A35      | 1316 | 3430 | 665  | 654  | 607  | 6341 | 1242 | 1052 | 764  | 616  |
| A32      | 985  | 8397 | 789  | 1824 | 5045 | 902  | 846  | 501  | 1151 | 882  |
| A30      | 763  | 6331 | 634  | 1527 | 4319 | 751  | 687  | 433  | 935  | 694  |
| A24      | 697  | 5762 | 600  | 1489 | 4714 | 730  | 653  | 425  | 915  | 618  |
| A23      | 678  | 5645 | 597  | 1530 | 5235 | 763  | 639  | 427  | 876  | 593  |
The efficiency of an investing in investment funds in the context...

In the next step of every scenario, based on historical values of the analysed investment fund entities, a simulation of the portfolio values (100,000 implementations) was made, in two window functions, depending on the duration of life (T1-5 and T2-10 years – resulting from the adjustment of the anticipated life expectancy).

Based on the results, for every generated portfolio value, the NPV was calculated. To calculate the discounted value of cash flows, the discount rate was determined, using the beta of investment and market interest rates (benchmarks) characteristic for the stock, mixed, bond and cash markets.

Table 2. Basic distribution parameters for investment funds – T1

| T1 | mean | median | min    | max    | standard deviation | variability | asymmetry | kurtosis |
|----|------|--------|--------|--------|--------------------|-------------|-----------|----------|
| 1  |      |        |        |        |                    |             |           |          |
| 2  | 67264| 49138  | −48838 | 334960 | 80709              | 1.1999      | 0.9538    | 0.4467   |
| PU36| 37028| 27306  | −6955  | 204030 | 53486              | 1.4445      | 0.7802    | 0.1091   |
| PU34| 27462| 18221  | −50157 | 183100 | 49641              | 1.8076      | 0.7897    | 0.1109   |
| PU20| 41209| 31396  | −45031 | 211720 | 54632              | 1.3258      | 0.7763    | 0.1070   |
| PU14| 43865| 34582  | −40168 | 203050 | 52389              | 1.1943      | 0.7300    | −0.0124  |
| PU10| 42290| 32751  | −43257 | 208600 | 53926              | 1.2751      | 0.7462    | 0.0190   |
| OU25| 60788| 43623  | −51606 | 324320 | 78363              | 1.2891      | 0.9729    | 0.5200   |
| OU26| 82385| 58499  | −52045 | 424620 | 98694              | 1.1980      | 1.0726    | 0.7566   |
In the next step, the distribution of the results was analysed by the group of a fund and investment scenarios. Since the quantity of bought entities was the biggest in W1, the results of the simulation will be represented for this particular scenario (Table 2). The results of simulations in other scenarios were similar in terms of received correlations.\(^5\)

Figure 1 presents the behaviour of the distribution of the NPV in several investment fund groups. It may be observed that the bond fund and money market fund groups were the most homogeneous in terms of risk and efficiency, as the values of NPV and standard deviations were similar. The share fund investments were the second group in terms of NPV homogeneity, but the effectiveness of these investments was the lowest and always negative with the volatility not exceeding 150%.

The mixed investment funds turned out to be the least homogeneous portfolio group in terms of efficiency, as the average NPV had the biggest volatility in their case. However, in terms of risk, it may be observed that this group has the biggest risk exposure. Nevertheless, the average efficiency measured by the average NPV was higher than in the case of share investment funds.

---

\(^5\) Due to limitations, full results can be made available on request.
When the investment period extended over 10 years, there were no changes in trends of the results achieved. Namely, the most efficient funds, in terms of average NPV, were those with the lowest risk exposure. Even though their average efficiency declined (Table 3), it was still in plus, contrarily to the results of share funds for which the NPV did not exceed the point of PLN –80 000. However, the investment volatility increased in each case. The biggest fluctuation of these results may be observed among the bond and money market investment funds. These changes can be seen in Figure 2, in which the behaviour of the NPV for each and every representative of individual fund subgroup is presented.
Table 3. Basic distribution parameters for investment funds – T2

| T2 | mean  | median | min   | max   | standard deviation | variability | asymmetry | kurtosis |
|----|-------|--------|-------|-------|--------------------|-------------|-----------|----------|
| PU41 | 30152 | 11114  | −87878 | 555350 | 119790             | 3.9727      | 1.7700    | 3.1615   |
| PU36 | 12438 | 12759  | −83040 | 344650 | 83585              | 6.7200      | 1.4626    | 1.9885   |
| PU34 | 9585  | 30031  | −86095 | 258440 | 67161              | 7.0068      | 1.4625    | 1.9553   |
| PU20 | 13107 | 10814  | −82727 | 343920 | 83360              | 6.3599      | 1.4552    | 1.9640   |
| PU14 | 25521 | 67     | −78039 | 356900 | 86890              | 3.4046      | 1.3542    | 1.5664   |
| PU10 | 19662 | 5837   | −80800 | 356310 | 86137              | 4.3809      | 1.3968    | 1.7295   |
| OU25 | 11180 | −24424 | −90125 | 473530 | 103960             | 9.2982      | 1.8140    | 3.3794   |
| OU26 | 24980 | −22165 | −91685 | 630580 | 130100             | 5.2081      | 1.9897    | 4.1477   |
| OS21 | 45693 | −13575 | −91720 | 813630 | 160160             | 3.5052      | 2.0973    | 4.6738   |
| OS15 | 57425 | −3716  | −90145 | 843200 | 166600             | 2.9012      | 2.0207    | 4.2951   |
| OS13 | 59889 | 9113   | −85160 | 715760 | 148550             | 2.4804      | 1.8074    | 3.3525   |
| OS5  | 61140 | 6828   | −86339 | 755360 | 154610             | 2.5288      | 1.8474    | 3.5147   |
| MAA6 | −92242| −94057 | −98875 | −68418 | 5921               | 0.0642      | 1.5037    | 2.1204   |
| Z13  | −79157| −87665 | −98861 | 32120  | 23009              | 0.2907      | 2.1169    | 4.8144   |
| Z12  | −87357| −91069 | −8673 | −39632 | 11125              | 0.1274      | 1.7145    | 2.9205   |
| Z10  | −83233| −89623 | −98931 | −732   | 17605              | 0.2115      | 2.0019    | 4.2265   |
| Z7   | −83319| −86814 | −97193 | −38243 | 11793              | 0.1415      | 1.3779    | 1.6496   |
| Z6   | −93415| −94765 | −98885 | −75532 | 4611               | 0.0494      | 1.3865    | 1.7145   |
| Z5   | −93617| −95066 | −99041 | −74564 | 4788               | 0.0511      | 1.4840    | 2.0463   |
| Z4   | −83487| −88745 | −98478 | −6480  | 15346              | 0.1838      | 1.7897    | 3.2226   |
| Z3   | −63212| −79130 | −98240 | 146640 | 42273              | 0.6688      | 2.1788    | 5.1302   |
| SW28 | −73948| −83091 | −97980 | 43743  | 25741              | 0.3481      | 1.9073    | 3.7975   |
| SW26 | −72073| −82285 | −97995 | 58808  | 28373              | 0.3937      | 1.9450    | 3.9413   |
| SW24 | −91577| −93385 | −98650 | −67891 | 6080               | 0.0664      | 1.4108    | 1.7821   |
| SW22 | −78560| −83780 | −97012 | −10714 | 16704              | 0.2126      | 1.5281    | 2.2154   |
| SW21 | −67502| −74935 | −95140 | 30049  | 24471              | 0.3625      | 1.4763    | 2.0074   |
| SW20 | −87299| −88358 | −95426 | −70179 | 5348               | 0.0613      | 0.8518    | 0.2406   |
| SW17 | −83765| −86406 | −96361 | −48293 | 9792               | 0.1169      | 1.1954    | 1.0984   |
| SW12 | −46824| −66491 | −96323 | 211860 | 55016              | 1.1749      | 2.0199    | 4.3408   |
| A52  | −93499| −96956 | −99832 | −45722 | 8814               | 0.0943      | 2.5385    | 7.1550   |
| A47  | −96256| −98008 | −99855 | −72859 | 4586               | 0.0476      | 2.3118    | 5.8352   |
| A44  | −94201| −97212 | −99836 | −52315 | 7729               | 0.0820      | 2.5025    | 6.9561   |
| A42  | −96227| −97777 | −99792 | −76055 | 4178               | 0.0434      | 2.0998    | 4.7021   |
| A38  | −98839| −99254 | −99915 | −93534 | 1164               | 0.0118      | 1.9119    | 3.7907   |
| A35  | −98365| −99187 | −99948 | −87296 | 2117               | 0.0215      | 2.4247    | 6.4591   |
| A32  | −97558| −98482 | −99839 | −85952 | 2543               | 0.0261      | 1.9977    | 4.2226   |
| A30  | −94234| −96717 | −99717 | −61495 | 6619               | 0.0702      | 2.1782    | 5.1175   |
| A24  | −86311| −90561 | −98717 | −32091 | 12501              | 0.1448      | 1.7580    | 3.1030   |
| A23  | −95664| −98089 | −99893 | −66139 | 5482               | 0.0571      | 2.5583    | 7.2995   |
| A19  | −94749| −97490 | −99855 | −57166 | 7023               | 0.0741      | 2.4810    | 6.7604   |
Subsequently, from every investment fund group, the funds with the highest efficiency were chosen. The distribution of their NPV with the box plots are illustrated in Figure 3. It may be observed that, in terms of the NPV achieved, the leaders were the funds which on the investment fund market are perceived as those with minimum risk, namely the money market and bond funds. For those funds, the average NPV reached from PLN 61,000 in W1 to PLN 14,000 in W5 and from PLN 79,000 in W1 to PLN 28,400 in W5 (and was always positive), with the variability from 120% (in W1) to 375% (in W5) for money market IF and from 110% (in W1) to 220% (in W5).

What is more, it may be observed that in these scenarios which prolong payments, the efficiency of all the investment fund groups declined, both in the case of funds with the highest and the lowest efficiency. This means for the investor that contributing their money at the very beginning would be a better solution with more effective results.
When the investment period extended over 10 years, there were no changes in trends of the results achieved (Figure 4). Only the variability of NPV increased.
The efficiency of an investing in investment funds in the context…

Figure 4. Box plots of NPV values in scenario W1-W5 for funds with the highest efficiency in the group (T2)

5. Conclusions

The results of the analysis are the extension of the existing research on the use of NPV in an investment evaluation from the investor’s point of view. Thereby, these results indicate the best and the worst investment methods:

1) The funds with the lowest efficiency are share funds. Their average efficiency in the group in the shortest investment period was at PLN –58,310, with the risk measured by the standard deviation of PLN 22,500. While the investment period was exceeding, the efficiency of these types of instruments was declining (up to PLN –95,100), and the risk was decreasing up to PLN 5,700.

2) The best funds, in terms of efficiency, were the bond and money funds, for which the average efficiency in the group in the shortest investment period exceeded PLN 83,300 and PLN 43,100, respectively, with the risk measured by the standard deviation at PLN 96,000 and PLN 57,000.
As a result, it may be stated that the efficiency of investment funds on the Polish market has declined along with the investment period increase, but the average NPV was still positive. Hence, the research shows that along with the investment period increase, the funds with high-risk exposure may not serve their function of capital multiplication and, what is more, their efficiency in long window function declines. This may suggest that in the case of ‘passive’ investments investors should opt for investments with lower risk as they may guarantee higher income over a long-time horizon. Hence, the results of this analysis do not confirm the experts’ opinion, according to which the riskier an investment fund strategy is, the longer the time horizon should be.

The results of such an analysis would serve as a recommendation for practitioners, e.g. fund managers or individual investors, for whom this will be a simple criterion for making decisions according to a chosen investment strategy over a long-time horizon, which is not shown by the classic measures of investment effectiveness.

It needs to be highlighted that the results of this analysis only refer to the Polish investment fund market, and that undoubtedly leads to limits in drawing conclusions. As a result, the question arises if this feature characterises only the individual Polish market or may be typical of other investment fund markets. The crucial aspect is that in order to verify hypothesis which would include foreign markets it is necessary to extend the research, as there are no studies that present similar approach. Hence, future analysis will be focused on verifying hypotheses referring to individual European markets at various stages of development.

References

Carhart, M. M. (1997). On persistence in mutual fund performance. *Journal of Finance*, 52, 57-82. https://doi:10.2307/2329556

Cogneau, P., & Hubner, G. (2009a). The (more than) 100 ways to measure portfolio performance. Part 1: Standardized risk-adjusted measures. *The Journal of Performance Measurement*, 4(13), 56-71. https://doi:10.2139/ssrn.1326076

Cogneau, P., & Hubner, G. (2009b). The (more than) 100 ways to measure portfolio performance. Part 2: Special measures and comparison. *The Journal of Performance Measurement*, 1(14), 56-69. https://doi:10.2139/ssrn.1326076

Czekaj, J., Woś, M., & Żarnowski, J. (2001). *Efektywność giełdowego rynku akcji w Polsce z perspektywy dziesięciolecia* [Effectiveness of the stock exchange market in Poland from the perspective of the decade]. Warszawa: Wydawnictwo Naukowe PWN.
Dawidowicz, D. (2007). Strategie zarządzania funduszami inwestycyjnymi a ich wyniki na przykładzie funduszy inwestycyjnych akcyjnych w 2005 roku [Investment funds’ management strategy and their performances on example of domestic share investment funds in 2005]. Folia Universitatis Agriculturae Stetinensis, Oeconomica, 256(48), 99-107.

Grinblatt, M., & Titman, S. (1989). Mutual fund performance: An analysis of quarterly portfolio holdings. The Journal of Business, 62, 393-416. https://doi:10.1086/296468

Homa, M., & Mościbrodzka, M. (2016a). Application of diagram methods and hierarchical agglomerative procedures to assess the risk of investment funds on the Warsaw Stock Exchange. Nauki o Finansach, 4, 21-34. http://doi:10.15611/of.2016.4.02

Homa, M., & Mościbrodzka, M. (2016b). Dynamiczne wersje hybrydowych modeli market timing oraz weryfikacja ich przydatności w ocenie ryzyka i efektywności funduszy inwestycyjnych [Dynamic versions of the hybrid models of market timing and verification of their usefulness in assessing the risk and the efficiency of the investment funds]. Finanse, Rynki Finansowe, Ubezpieczenia, 1, 73-85. https://doi:10.18276/frfu.2016.79-05

Harris, L. (2014). Chapter 4. Investment vehicles. Charlottesville, VA: CFA Institute. Retrieved from https://www.cfainstitute.org/-/media/documents/support/programs/investment-foundations/14-investment-vehicles.ashx?la=en&hash=5EAC60626C6439B462AED93EBA3D341EAB2E5FE4

Hull, J. (2011). Zarządzanie ryzykiem instytucji finansowych [Risk management of financial institutions]. Warszawa: Wydawnictwo Naukowe PWN.

Jajuga, K. (2009). Zarządzanie ryzykiem [Risk management]. Warszawa: Wydawnictwo Naukowe PWN.

Jajuga, T., & Słoński, T. (1997). Finanse spółek. Długoterminowe decyzje inwestycyjne i finansowe [Finance of companies. Long-term investment and financial decisions]. Wrocław: Wydawnictwo Akademii Ekonomicznej we Wrocławiu.

Jakubczyc, J. (2008). Metody oceny projektu gospodarczego. Podręcznik akademicki [Methods for assessing the economic project. Academic handbook]. Warszawa: Wydawnictwo Naukowe PWN.

Jamróz, P. (2013). Efektywność wybranych FIO rynku akcji w latach 2003-2011 [The efficiency of selected open-end mutual funds in the stock market in years 2003-2011]. Finanse, Rynki Finansowe, Ubezpieczenia, 63, 193-206.

Jawdosiuk, B., & Rożko, K. (2010). ABC inwestowania w fundusze inwestycyjne [ABC of investing in investment funds]. Warszawa: KNF.

Jensen, M. C. (1967). The performance of mutual funds in the period 1945-1964. Journal of Finance, 2(23), 389-416. https://doi:10.2139/ssrn.244153
Jurek-Wasilewska, K. (2014). Efektywność inwestowania w otwartych funduszach inwestycyjnych w Polsce w latach 2001-2010 [The efficiency of investing in open-end mutual funds in Poland in years 2001-2010]. Finanse i Prawo Finansowe, 1, 20-33.

Kon, S. J., & Jen, F. C. (1979). The investment performance of mutual funds: An empirical investigation of timing, selectivity, and market efficiency. The Journal of Business, 52, 263-89. https://doi:10.1086/296046

Lintner, J. (1965). The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets. Review of Economics and Statistics, 47, 13-37. https://doi:10.2307/1926735

Metropolis, N. (1987). The beginning of the Monte Carlo method. Los Alamos Science, Special Issue, 125-130.

Miziołek, T. (2000). Zysk, ryzyko i koszty – ranking funduszy inwestycyjnych i powierniczych w 1999 roku [Profit, risk and costs – ranking of investment and trust funds in 1999]. Nasz Rynek Kapitalowy, 3(111), 7-8.

Miziołek, T. (2001). Fundusze akcyjne i zrównoważone – ryzyko i zysk (podsumowanie 2000 roku) [Equity and sustainable funds – risk and profit (summary of the year 2000)]. Profesjonalny Inwestor, 10(2), 71-82.

Miziołek, T., & Trzebiński, A. (2017). Efektywność polskich funduszy inwestycyjnych – przegląd metod i literatury [Effectiveness of Polish investment funds – an overview of methods and literature]. FINANSE. Czasopismo Komitetu Nauk o Finansach PAN, 1(10), 93-119.

Mossin, J. (1969). Security pricing and investment criteria in competitive markets. American Economic, 59, 749-756.

Olbryś, J. (2010). Ocena efektywności zarządzania portfelem funduszu inwestycyjnego z wykorzystaniem wybranych wieloczynnikowych modeli market-timing [Selected multifactor market-timing models for mutual fund performance evaluation]. Optimum. Studia Ekonomiczne, 4(48), 44-61.

Perez, K. (2011). Metody oceny efektywności funduszy inwestycyjnych i ich przydatność dla polskich funduszy akcji [Methods of assessing the effectiveness of investment funds and their usefulness for Polish equity funds]. In W. Przybylska-Kapuścińska (Ed.), Rynek finansowy w okresie zaburzeń [Financial market during disorders] (pp. 94-120). Poznań: Wydawnictwo Uniwersytetu Ekonomicznego w Poznaniu.

Perez, K. (2012). Efektywność funduszy inwestycyjnych. Podejście techniczne i fundamentalne [Effectiveness of investment funds. Technical and fundamental approach]. Warszawa: Difin. https://doi:10.14746/rpeis.2013.75.1.23

Reilly, F. K., & Brown, K. C. (2001). Analiza inwestycji i zarządzanie portfelem [Investment analysis and portfolio management]. Warszawa: PWE.
Sekuła, P. (2011). Analiza stóp zwrotu i ryzyka polskich funduszy akcji [Analysis of returns and risk of Polish equity mutual funds]. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, 158, 1060-1067.

Shadwick, W., & Keating, C. (2002). A universal performance measure. Journal of Performance Measurement, 6(3), 59-84.

Sharpe, W. F. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk. Journal of Finance, 19, 425-442. https://doi:10.2307/2977928

Sharpe, W. F. (1966). Mutual fund performance. Journal of Business, 39, 119-138.

Sikora, T. (2010). Analiza wyników funduszy inwestycyjnych w Polsce z wykorzystaniem wnioskowania bayesowskiego [Analysis of investment fund results in Poland using Bayesian inference]. Materiały i Studia Narodowego Banku Polskiego, 248, 11-74.

Sortino, F., & Price, L. (1994). Performance measurement in a downside risk framework. Journal of Investing, 3(3), 59-64. https://doi:10.3905/joi.3.3.59.

Stanimir, A. (2001). Efektywność i ryzyko funduszy inwestycyjnych [Efficiency and risk of investment funds]. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, 915, 138-146.

Treynor, J. L. (1965). How to rate management of investment funds. Harvard Business Review, 43, 63-75. https://doi:10.1002/9781119196679.ch10

Trzpiot, G. (2015a). Wybrane determinanty ryzyka długowieczności [Selected determinant of longevity risk]. Studia Ekonomiczne. Zeszyty Naukowe Uniwersytetu Ekonomicznego w Katowicach, 223, 225-237.

Trzpiot, G. (2015b). Zarządzanie ryzykiem długowieczności [Longevity risk management]. Finanse, Rynki Finansowe, Ubezpieczenia, 75, 475-486. doi: 10.18276/frfu.2015.75-39

Weron, A., & Weron, R. (2018). Inżynieria finansowa. Wycena instrumentów pochodnych. Symulacje komputerowe. Statystyka rynku [Financial engineering. Valuation of derivatives. Computer simulations. Market statistics]. Warszawa: Wydawnictwo Naukowe PWN.

Zamojska, A. (2008). Ewaluacja wyników funduszy inwestycyjnych na podstawie wskaźników miar efektywności [Evaluation of investment fund performance based on indicator effectiveness measures]. In: S. Buczek & A. Fierla (Eds.), Rynek kapitałowy w Polsce i na świecie – jak mądrze inwestować? [The capital market in Poland and in the world – how to invest wisely?] (pp. 27-35) Warszawa: Szkoła Główna Handlowa w Warszawie.

Zamojska, A. (2015). Zastosowanie analizy falkowej w ocenie efektywności funduszy inwestycyjnych [Mutual funds performance measurement – wavelets analysis approach]. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, 385, 325-333. https://doi:10.15611/pn.2015.385.35
Zatoń, W. (2001). Wyznaczanie stóp zwrotu o jednakowym ryzyku w analizie porównawczej inwestycji, na przykładzie funduszy powierniczych i inwestycyjnych w Polsce [Determination of return rates with the same risk in the comparative analysis of investments, on the example of mutual and investment funds in Poland]. *Prace Naukowe Akademii Ekonomicznej we Wrocławiu, 890*, 68-74.