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Hedging the investment portfolio with derivatives present on the Polish market

1. Introduction

If we were to try to describe the capital market of the second and third decades of the 21st century, one of its distinguishing features would undoubtedly be its mass character. The popularization of investments, whether purely speculative or not, is clearly discernible to the naked eye. As a result, the capital market has evolved in a direction where it is not the exclusive domain of financial institutions but a space in which a single individual investor also finds themself. These investors, driven by the lust for profit and often needing the appropriate knowledge, make investment decisions that do not comply with the accepted standards, seem devoid of common sense, break the basic principles of investment hygiene, and ultimately bring difficult losses.

Apart from the previously mentioned bravado, several options on the market allow one to minimize these losses. We are talking about simple tools and techniques, such as the skillful use of stop loss orders and complex strategies for which derivatives are used. Although the indicated methods of hedging positions seem to be an effective solution to the problem of incurring losses, they are not so everywhere. Investors wishing to invest their capital in the Polish capital market have to contend with a shortage of derivatives, which, in contrast to more developed foreign markets, is present there. This state of affairs significantly ties your hands and complicates securing positions accepted on the market. This is an essential issue as it contributes to the inhibition of investments made on the

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Polish stock exchange, thus contributing to the inhibition of the Polish economy. Therefore, the purpose of this publication is to indicate how to minimize the risk on the capital markets in a practical way, using the financial opportunities and instruments present in the Polish realities.

The article presents considerations regarding models and strategies for optimizing investment processes. For the study, an investment portfolio was constructed and tested, the sensitivity of which to unfavorable price movements is minimal. The construction of the portfolio mentioned above is based on the theory of investment portfolio construction presented by H. Markowitz, while the attempt to hedge it was carried out by the strategy indicated by J. Hull.

The main research hypothesis of the presented article assumes that, in Polish conditions and with the use of available investment tools, it is possible to construct an investment portfolio to a large extent resistant to unfavorable price movements on the market.

2. Literature review

According to the commonly accepted definition, investment is the renunciation of current consumption in favor of increased consumption in the future. Its implementation is held to be possible thanks to the capital increase over time. Therefore, investments are also defined as investing capital in ventures or assets designed to multiply it. This multiplication of capital is accounted for as a success/profit. Its decrease is interpreted as a failure/loss. The specified success or failure is usually measured by the rate of return, the forms, and the types of which there are many variations in the literature (Reilly, Brown, 2001). While the rate of return and the effects of the investments made are intuitive and easy to define, a problem arises when explaining investment risk. It can be interpreted as the probability of harm or uncertainty about the effects of the investments made (Knight, 1921). Risk can also be perceived as subjective and objective. The first approach refers to the predispositions, skills, and disposition of people implementing investments, and the second to the nature of financial instruments and factors influencing their prices (Podlewski, 2021). In the context of the subject of this publication, the approach within which investment risk should be described is an objective approach, with tools helpful in the investment portfolio management process (Markowitz, 1952). The given tools include such indicators as, for example, the variance of the rate of return or the standard deviation of the rate of return (Hayes, 2021).

One of the precursors of the diversification process and portfolio analysis was H. Markowitz, who developed a model optimizing the diversification process,

where his task was to determine the appropriate proportions of assets in the portfolio so as to minimize its exposure to risk measured by the standard deviation (Markowitz, 1959). The effectiveness of this model has been tested many times over the years, and its use indeed reduces the returns of the portfolio compared to alternative portfolios of a similar class, and the application of a given model is relatively simple, and its concept is easy to understand (Amu, Millegård, 2009). Other studies, however, indicate that the reduced standard deviation of the rate of return is not large enough compared to alternative portfolios to significantly translate into investment results. In addition, the expected rate of return of the research portfolio shows disproportionately lower values than those characterizing alternative portfolios with a higher reading of the standard deviation of the rate of return (Širůček, Křen, 2015). Researchers also note that the standard deviation, variance, and covariance of the rate of return are not the only factors determining the risk of the investment portfolio, and the model proposed by H. Markowitz does not take into account extraordinary situations (Marling, Emanuelsson, 2012). What follows, and what has also been empirically demonstrated, is that the optimal construction of the investment portfolio is insufficient in the face of the threats present on the market to effectively protect it against profound fluctuations in the capital markets, which can be leveled with derivatives (Castellano, Giacometti, 2001).

Derivatives allow us to effectively reduce the total risk of a portfolio, regardless of whether the losses stem from a systematic or specific risk. Precisely because of this, it is reasonable to use derivatives to hedge positions taken on the capital market (Hull, 1999). When choosing specific instruments to hedge positions, it is worth paying particular attention to options that, using appropriate speculative strategies, such as *strangles* or *straddles*, can bring outstanding results at a relatively small cost (Kownatzki et al. 2021). However, apart from the issues of stock market speculation, one of the basic strategies protecting the portfolio against price collapses is the so-called **protective put** consisting of the purchase of put options for assets requiring protection, which generates positive cash flows when the price of the protected assets falls below predetermined values, compensating for the losses (McMillan, 2002). **Protective put**, otherwise known as **hold stock, buy put**. However, it does not work in speculative strategies aimed at achieving above-average profits, and ensures portfolio stability in terms of protecting assets (Dash et al. 2008).

Considering all of the above, an attempt to build a portfolio with minimal risk will be carried out by constructing an effective portfolio with the lowest possible standard deviation of the rate of return and hedging it with derivatives, using the protective put strategy.

3. Research methodology

The purpose of this paper is to attempt to build a portfolio with minimal risk, which is to verify the hypothesis that it is possible in Polish conditions to construct an investment portfolio which is to a large extent resistant to unfavorable price movements on the market and that hedging an investment portfolio with the use of the derivatives market is compelling. As one can easily guess, building an investment portfolio is a complicated process with many successive stages. One of them is the tactical allocation of assets, finally ending with portfolio analysis, serving the purpose of appropriately diversifying the constructed portfolio. The person who was one of the first to notice the importance of diversification in the investment process was H. Markowitz, who not only made the observation above but also developed a model that allows the diversification of selected assets in an optimal way. A given model is the foundation of portfolio analysis.

The study's main hypothesis assumes that it is possible to construct an investment portfolio in Polish conditions which is to a large extent resistant to unfavorable price movements on the market. Therefore the construction of the research portfolio will be based on the theories of H. Markowitz, the application of which will increase the probability of the assumption adopted. The aim of one of the first stages of the study was, therefore, an attempt to construct an effective portfolio, which is such a portfolio, which, with the expected rate of return, is characterized by the lowest possible risk or, for the selected risk level, maximizes the potential rate of return. The constructed portfolio had a one-year investment horizon and included equity instruments issued by five selected companies whose shares are included in the WIG20 index. The selection consisted of companies with the highest capitalization on February 1, 2022, whose stock exchange debut took place in 2007 at the latest.

The conditions mentioned above were met by the following companies: **Powszechna Kasa Oszczędności Bank Polski, Santander Bank Polski, Bank Polska Kasa Opieki, Polskie Górnictwo Naftowe i Gazownictwo, KGHM Miedź Polska.**

The next step after the selection was the estimated annual rates of return achieved by the companies on February 1, starting from the first year in which the shares of all selected companies were traded and ending with the current year. What follows the research period of the conducted study was seventeen years. If February 1 fell on a non-trading day, i.e., Saturday or Sunday, the closing prices from the last session were used to estimate. On the basis of the calculated returns, the variance and standard deviation of the rates of return of selected instruments were estimated because the risk of the examined portfolio is defined by the value of the standard deviation it assumed.

The next step was to examine the interdependence of companies, measured by the correlation of rates of return. And all this is to use the given ratios and

values to carry out a portfolio analysis to build an effective portfolio according to H. Markowitz's multi-company portfolio theory, with an initial value of one million zlotys.

After constructing the portfolio, its expected rate of return and standard deviation were determined. Then, it was assessed by comparing it to other six portfolios with the same expected rate of return but different, randomly selected shares of assets forming it. The comparison consisted in juxtaposing the standard deviation, the Sharpe index, and the coefficient of volatility characterizing the described portfolios.

Unfortunately, obtaining a portfolio with the minimum standard deviation value while maintaining the highest investment potential measured by the rate of return does not exhaust the topic of building a portfolio with minimal risk. The design of an efficient portfolio reduces specific risks with little or no impact on systematic risk. Fortunately, the development of financial markets, especially the derivatives market, allows one to effectively reduce the total risk of a portfolio, regardless of whether the losses resulting from the impact of systematic or specific risk. Therefore, the next research stage focused on using derivatives on the Polish stock exchange, designed to protect the portfolio against the loss of its value in the event of unfavorable price movements on the market. This procedure verified the study's hypothesis, indicating that hedging the investment portfolio using derivatives present in the Polish market is effective.

As described earlier, the portfolio was hedged against impairment using derivatives listed on the Polish market, specifically options. Since the only options existing in Poland are those based on the WIG20 index, the constructed portfolio was hedged with these options after examining the relationship between the concerned portfolio and the WIG20 index. After the protection was made, a simulation showed its method and effectiveness.

The methodology of the entire study is presented in the Figure 1.

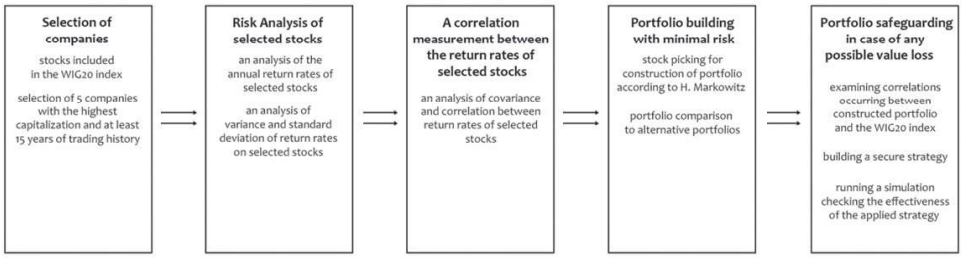

Figure 1. Scheme presenting the methods of the conducted research

Source: own elaboration

4. Research outcome

To start constructing a portfolio with minimal risk, it is essential to determine the risk of the assets included in the portfolio at the beginning. According to H. Markowitz's multi-company portfolio theory, the risk of investment instruments that make up a portfolio is determined by their standard deviations. To know these, one must make a series of calculations enabling a given estimate. Therefore, the arithmetic average of the rates of return of all instruments included in the portfolio from February 1, 2006, to February 1, 2022 should be calculated first, and then the variances characterizing the rates of return. The obtained results are worth interpreting. The following tables (Tabs 1, 2) present the results of the estimates and their interpretation.

Table 1

Risk of selected investment instruments

No.	Symbol	Arithmetic mean rate of return [%]	Return variance [%]	The standard deviation of the rate of return [%]
1	PKO	6.474	8.846	29.741
2	SPL	13.765	19.365	44.006
3	PEO	4.162	14.330	37.854
4	PGN	5.891	6.024	24.544
5	KGH	23.043	54.981	74.149

Source: own elaboration

Table 2

Research outcome interpretation

No.	Symbol	Lowest rate of return expected [%]	Expected highest rate of return [%]
1	PKO	−23.267	36.216
2	SPL	−30.241	57.770
3	PEO	−33.692	42.017
4	PGN	−18.653	30.435
5	KGH	−51.106	97.192

Source: own elaboration

The next stage of the conducted research is the recognition of the interdependence of the rates of return of selected investment instruments. This is important because the given instruments will create one portfolio which will be determined by the price reaction of some assets to the change in the prices of others. Therefore, the estimation of the level and type of interdependence will allow the selection of individual shares to minimize the risk of the optimally constructed portfolio.

The determination of the relationship described above will be carried out by using the indicator, which is the Pearson linear correlation. The calculation results for all pairs of companies in the portfolio are presented in Table 3.

Table 3

Measurement of the relationship between the rates of return of selected stocks

No.	Pair	Covariance	Correlation
1	PKO & SPL	0.117	0.892
2	PKO & PEO	0.096	0.849
3	PKO & PGN	0.001	0.016
4	PKO & KGH	0.071	0.324
5	SPL & PEO	0.148	0.885
6	SPL & PGN	−0.008	−0.075
7	SPL & KGH	0.140	0.428
8	PEO & PGN	−0.016	−0.176
9	PEO & KGH	0.052	0.186
10	PGN & KGH	0.050	0.277

Source: own elaboration

After calculating the correlation coefficient, it must be interpreted. The interpretation is two-part. The sign before the result is evaluated first, then its absolute value. For example, the result obtained for the PKO/SPL pair shows a very high correlation between the two companies share prices. This allows us to conclude that the given assets show almost identical price movements. Table 4 presents the interpretation for all pairs.

Table 4

Interpretation of the obtained results

No.	Pair	Correla-tion	Interpretation of the sign	Value interpretation
1	PKO & SPL	0.892	Positive sign. As one company grows, the other also grows. When one goes down, the other goes down as well	Very strong relation, price movements of the examined assets are almost identical
2	PKO & PEO	0.849	Positive sign. As one company grows, the other also grows. When one goes down, the other goes down as well	Very strong relation, price movements of the examined assets are almost identical
3	PKO & PGN	0.016	Positive sign. As one company grows, the other also grows. When one goes down, the other goes down as well	Very weak relation, price movements of the examined assets are practically unrelated
4	PKO & KGH	0.324	Positive sign. As one company grows, the other also grows. When one goes down, the other goes down as well	Weak relation, price movements of the examined assets show little connection
5	SPL & PEO	0.885	Positive sign. As one company grows, the other also grows. When one goes down, the other goes down as well	Very strong relation, price movements of the examined assets are almost identical
6	SPL & PGN	−0.075	Negative sign. When one company goes up, the other goes down. When the first decreases, the second increases	Very weak relation, price movements of the examined assets are practically unrelated
7	SPL & KGH	0.428	Negative sign. When one company goes up, the other goes down. When the first decreases, the second increases	The relation is moderate, the price movements of the examined assets are insignificantly related to each other

Table 4 cont.

8	PEO & PGN	−0.176	Negative sign. When one company goes up, the other goes down. When the first decreases, the second increases	Very weak relation, price movements of the examined assets are practically unrelated
9	PEO & KGH	0.186	Positive sign. As one company grows, the other also grows. When one goes down, the other goes down as well	Very weak relation, price movements of the examined assets are practically unrelated
10	PGN & KGH	0.277	Positive sign. As one company grows, the other also grows. When one goes down, the other goes down as well	Weak relation, price movements of the examined assets show little connection

Source: own elaboration

The obtained results show that the level of dependence between the share prices of selected companies is ambiguous. The portfolio will be built of both assets closely related to each other and those for which there is no correlation.

Based on the results obtained, an attempt will be made to construct an effective portfolio with minimal risk. All the ratios calculated so far will be merged to create a kind of "resultant" of their characteristics, allowing to minimize the risk of investing in selected assets while maximizing the investment potential measured by the rate of return. The merge above will be obtained by combining the estimated data in the matrix proposed by H. Markowitz. Its transcript is presented below:

	PKO	**SPL**	**PEO**	**PGN**	**KGH**	
PKO	0.177	0.233	0.191	0.002	0.143	1
SPL	0.233	0.387	0.295	−0.016	0.279	1
PEO	0.191	0.295	0.287	−0.033	0.105	1
PGN	0.002	−0.016	−0.033	0.120	0.101	1
KGH	0.143	0.279	0.105	0.101	1.100	1
	0.177	0.233	0.191	0.002	0.143	1

After constructing the matrix above, create an inverse matrix to multiply it by a vector with $n+1$ components, where the first n components are zero, and the last one is unity. This will create a vector with dimension $n+1$, where the first n components are shared in the constructed portfolio. In the case of the wallet, the construction of which is the subject of this article, the vector appears as follows:

$$\begin{vmatrix} 0.377 \\ -0.310 \\ 0.356 \\ 0.576 \\ 0.001 \\ -0.064 \end{vmatrix}$$

Taking into account the fact that the initial value of the portfolio assumed in the assumptions should be 1 million PLN, the shares of the companies selected for its construction, both in percentage and amount terms, are presented in the Table 5.

Table 5

Shares of selected companies in the investment portfolio

No.	Symbol	Percentage share [%]	Amount Share [zł]
1	PKO	37.7	377 194.08
2	SPL	−31.0	−310 312.39
3	PEO	35.5	355 826.33
4	PGN	57.6	576 286.77
5	KGH	0.1	1 005.21
Sum		100.000	1 000 000.00

Source: own elaboration

The obtained results may be difficult to interpret due to the negative values appearing with the shares of Santander Bank Polska. The outstanding reading should be interpreted so that it is recommended to make the so-called short sale in the case of the indicated assets.

It is also worth explaining that the above shares are only theoretical values that may differ from the actual shares. The given situation's determinants are selected companies' share prices on February 1, 2022. To estimate the number of shares of a specific company that should be purchased for the constructed portfolio, the share shown above should be divided by their price. The result obtained may cause consternation because with a high degree of probability, it will not be an integer. Therefore, it should be rounded down, which will result in determining the previously searched value. In the case of the considered portfolio, the actual shares are as presented in the Table 6.

Table 6

The actual shares of selected companies in the investment portfolio

No.	Symbol	Number of shares	Real share [zł]	Percentage share [%]
1	PKO	7858	377 184.00	37.718
2	SPL	−880	−310024.00	−31.002
3	PEO	2598	355 796.10	35.580
4	PGN	108 324	576 283.68	57.628
5	KGH	7	999.25	0.100
Total:		117 907	1 000 239.03	100.024

Source: own elaboration

To evaluate the constructed portfolio, four indicators characterizing it should be calculated and compared to other portfolios with similar investment potential. Indicator data include the expected rate of return, standard deviation, coefficient of volatility, and Sharpe ratio. The Table 7 presents a list of six portfolios with a given expected rate of return of 3.074% (the expected rate of return obtained by the research portfolio), with randomly selected shares of selected companies totaling nearly 100%. It allows you to evaluate the constructed portfolio against others of the same class.

As one can see, the Table 7 clearly shows that the constructed portfolio is of the highest quality compared to the other six portfolios. This is supported by the lowest value of the standard deviation, the coefficient of variation, and the Sharpe index's highest value.

Table 7

Comparison and evaluation of portfolios of the same class

No.	Portfolio under review	Share of PKO [%]	Share of SPL [%]	Share of PEO [%]	Share of PGN [%]	Share of KGH [%]	Expected rate of return [%]	Standard deviation [%]	Coef-ficient of variation	Sharpe index
1	Research portfolio	37.718	−31.002	35.580	57.628	0.100	3.074	17.861	5.810	0.064
2	Portfolio A	29.124	35.874	27.978	36.754	−30.724	3.074	32.259	10.500	0.035
3	Portfolio B	39.965	−77.783	56.846	55.890	24.016	3.074	23.477	7.640	0.049
4	Portfolio C	7.890	−46.869	38.876	91.611	8.675	3.074	24.406	7.940	0.047
5	Portfolio D	6.069	43.875	44.967	35.899	−31.876	3.074	35.174	11.440	0.033
6	Portfolio E	−19.876	22.872	99.097	8.234	−14.745	3.074	40.070	13.040	0.029
7	Portfolio F	22.334	35.765	39.340	30.879	−29.301	3.074	34.039	11.070	0.034
8	WIG20						1.084	21.899	20.200	−0.039

Source: own elaboration

According to the theory of H. Markowitz, a constructed portfolio is a portfolio for which it is impossible to create another one, which with the same risk could achieve a higher expected rate of return or lower risk for a given rate of return. In addition, a portfolio built with the same assets but with a more minor standard deviation will have a disproportionately low rate of return compared to a constructed portfolio. Thus, its investment potential would be zero and devoid of any attractiveness.

Despite achieving the set goal, the range in which the rate of return on investment in a given portfolio may be found oscillates between −14.788% and 20.935%. It is worth noting that the mentioned range is only a theoretical outline because it is impossible to predict the market behavior that may affect selected assets so that the actual annual rate of return will reach a result outside the established limits. The situation would be acceptable if it were a result higher than 20.935%, and it would be different if the ongoing market slump led to losses significantly exceeding the designated range. To prevent this, the portfolio will be hedged with derivatives.

As one can see, the table above clearly shows that the constructed portfolio is of the highest quality compared to the other six portfolios. This is supported by the lowest value of the standard deviation, the coefficient of variation, and the Sharpe index's highest value. According to the theory of H. Markowitz, a constructed portfolio is a portfolio for which it is impossible to create another one, which with the same risk could achieve a higher expected rate of return or lower risk for a given rate of return. In addition, a portfolio built with the same assets but with a more minor standard deviation will have a disproportionately low rate of return compared to a constructed portfolio. Thus, its investment potential would be zero and devoid of any attractiveness.

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Considering the prevailing conditions in the Polish market, options are the best derivatives used to protect the portfolio against the loss of value. This hedging can be performed using the protective put strategy, a typical portfolio hedging strategy that takes a long position in put options for the indicated assets. Unfortunately, the problem with the Polish capital market is that it has

a significantly limited derivatives market, which allows you to take positions only in options based on the WIG20 index. This situation makes it much more difficult to hedge, as taking any position in options that directly protect the assets used to create the portfolio is impossible. As a result, hedging should be done indirectly, using options on the WIG20 index. In a given situation, the WIG20 index should be considered a market portfolio in which the hypothetical portfolio constructed in this publication operates. This is necessary to determine the mutual influence of the instruments studied, which will allow us to build an appropriate strategy. After estimation, the impact was measured using the beta coefficient, a final value of −1.352.

A negative value of the obtained result indicates that the rate of return of the examined portfolio reacts inversely to the rate of return resulting from changes in the WIG20 index price. This means that when the index's return increases, the portfolio's return decreases, and vice versa. In addition, the absolute value of the beta coefficient higher than one means that changes in the value of the examined portfolio over time are more rapid than those resulting from the change in the WIG20 index price.

Having all the information gathered so far, it is possible to establish a portfolio hedging strategy. To do this, you need to perform a few simple mathematical operations. Because this strategy will be an indirect strategy, you should start with an attempt to hedge a market portfolio with an initial value of one million zlotys. The collateral will be exercised with options whose redemption date will be closest on February 1, 2022, to the end of the investment horizon of the hypothetical portfolio, i.e., February 1, 2023. Options meet this requirement with a redemption date of December 2022. Taking into account the fact that on February 1, 2022, the closing price of the WIG20 index was 2,224.28, the "closest" out-of-money option that can be used to implement a hedging strategy is OW20X222100 with the strike price 2100. Notably, the options using which hedging strategy should be implemented should be out of the money or at the money at the time of constructing the strategy, as it is associated with a negative and zero cash flow from the exercise of given options, and thus the amount the premium for their acquisition is small. The phrase "closest" option used earlier means that its exercise price should be close to the current price of the hedged asset so that the hedge starts to work even with tiny fluctuations in stock exchange rates.

Another crucial step in constructing a strategy for hedging the hypothetical portfolio is determining the multiplier that characterizes the options on the Polish market. In the case of options on the WIG20 index, the multiplier is 10. Thus, each decrease or increase of the index by one point changes the value of the contract by 10 PLN. When a given value is known, it should be multiplied by the WIG20

index price from 01/02/2022 to determine the value of one option contract. In the case of the WIG20 index, the value of one contract is 22,242.8 PLN.

Consequently, entering into a single contract protects such a portfolio value. To find out how many options to hedge the entire portfolio, divide the portfolio's initial value by the result obtained above. In the case of the examined portfolio, the estimated effect is close to 45. As a result, to hedge a market portfolio with an initial value of 1,000,000 PLN, one should take a long position in 45 put options with an exercise price of 2,100.

Knowing how many options contracts are needed to hedge the market portfolio, this knowledge can be translated into a previously constructed hypothetical portfolio. To see the number of options that can hedge a given portfolio, one should multiply the number obtained above by the estimated beta coefficient of the portfolio. This practice is based on the assumption that each change in the value of the market portfolio by one point affects the change in the value of the hypothetical portfolio precisely by the value of its beta coefficient, in this case, by −1.352. The mathematical operation described above should give a result of −61.

So, to hedge the hypothetical portfolio, you need to take positions in 61 options. Due to the negative sign before the obtained result, it is known that the position taken should be opposite to the originally intended one. So it would be best to take a long position in call options. Revising the above assumptions, the option that will be used to achieve the set goal will be the call option OW20L222300, with an exercise price of 2300. It was selected for hedging because it is an out-the-money option, the exercise price is close to the current one on a given day, and the level of the WIG20 index. The premium for a given option is 101.36 PLN. Thus, taking a position in 61 options will incur costs of 6,161.66 PLN.

Is the developed strategy effective? The answer to this question is provided by the simulation presented below in the Table 8, which, depending on the level of the WIG20 index price, illustrates the behavior of the hypothetical portfolio, cash inflows from taking a position on the derivatives market, and the consequences of given inflows on the final value of the portfolio under the study of this article.

As shown in the table above, the applied strategy brings the expected results, reducing the risk of the hypothetical portfolio from the desired level of −14.788% to the maximum possible loss of −5.219%. It is also worth noting that implementing this strategy lowers the rate of return when the prices of purchased shares increase and the portfolio's value increases. This is the execution price of the option hedge, related to incurring costs generated by paying a premium for taking a position in 61 call options.

Table 8

Simulation of the effectiveness of the applied strategy

Simulation of payments related to taking positions in 61 options on the WIG20 with an exercise price of 2300							
An exemplary value of the WIG20 index	2100	2200	2300	2400	2500	2600	2700
Profit/loss on options [zł]	−6 161.66	−6 161.66	−6 161.66	54 838.34	115 838.34	176 838.34	237 838.34
Simulation of the change in the value of the portfolio after applying the option strategy							
The value of the portfolio resulting from changes in stock prices in the market [zł]	1 075 549.60	1 014 759.77	953 969.94	893 180.11	832 390.28	771 600.45	710 810.62
Rate of return before using the option strategy [%]	7.555	1.476	−4.603	−10.682	−16.761	−22.840	−28.919
Value of the portfolio after using the option strategy [zł]	1 069 387.94	1 008 598.11	947 808.28	948 018.45	948 228.62	948 438.79	948 648.96
The rate of return after using the option strategy [%]	6.939	0.860	−5.219	−5.198	−5.177	−5.156	−5.135

Source: own elaboration

5. Summary

This paper aims to answer whether an individual investor operating in Polish conditions can construct an investment portfolio, optimizing the investment process while reducing the total risk to a minimum. The main emphasis in creating the publication was on pragmatism and practice so that the tools available in the Polish market; could be used most effectively. As the study results showed, the goal set at the beginning was achieved, and the implementation itself leaves no illusions that the portfolio constructed during the research fulfills its tasks and the options strategy securing it. Diversified according to the model proposed by H. Markowitz, the portfolio has the highest possible investment potential, measured by the rate of return, which makes investments optimal in generating profits and defending against current market slumps. To summarize the above argument, this work is a model that allows for the implementation of stock exchange investments in a responsible, safe, and conscious manner, presented step by step.

Despite the achievement of the adopted objectives, it is worth explaining a few things that took place during the study and may need clarification about the reliability of its conduct. The first of these issues is selecting companies that comprise the research portfolio. Building an investment portfolio is a complicated process consisting of consecutive steps. The choice of investment instruments needed to construct a specific portfolio begins with an attempt to determine the individual profile of the investor. It ends with the tactical allocation of assets. Focusing on the subject of this work and not wanting to lose it, the method of selecting investment instruments has been simplified and reduced to selecting shares of five companies included in the WIG20 index, with the highest capitalization on February 1, 2022, whose stock exchange debut took place in 2007 at the latest.

An issue that raises doubts may be the period selected for the selection, assuming at least fifteen years of trading in equity instruments on the capital market. Why is it at least fifteen years and not ten or twenty? A longer time series provides a more extensive series of statistical data to validate the results of the calculations. Therefore, the history of stock trading must be well-spent. On the other hand, a given interval can only set the selection border a little in the past, as this would narrow down the pool of instruments available for testing. This is due to the relatively short period of operation of the Warsaw Stock Exchange. Therefore, the fifteen-year interval is a compromise, giving credibility to the results obtained in the study.

Another element worth explaining is why the portfolio was built with only five stocks. The number of selected companies must be more relevant for creating and securing the portfolio and its effectiveness. The transparency of estimates and calculations dictates the decision to build a portfolio using a limited number of companies shares.

The last issue needing clarification is the choice of derivatives to implement the hedging strategy. Why were options for this purpose, not futures contracts available on the Polish capital market, for assets building the portfolio? Well, futures contracts would compensate for the losses incurred by the portfolio while generating identical ones when its value increases. As a result, the portfolio would be deprived of its earning potential, maintaining a value close to its original value throughout the investment period, regardless of the prices of the instruments that make it up over time. As a result, there are better choices than the use of futures contracts. It is much more reasonable to use options that, apart from the costs associated with taking the position, will not generate any other expenses while compensating for the potential decline in the portfolio's value at critical moments.

Finally, it is worth noting that, due to the limited choice of derivatives, the portfolio was hedged with options for assets other than those used to construct the portfolio. As a result, the security used in the study is also adequate outside the capital market. It can increase optimization in securing transactions in metals, energy resources, agricultural products, and other goods traded on stock exchanges. Therefore, it makes the analyzed strategy universal and can be used by many recipients.

References

[1] Amu, F. and Millegård, M. (2009) Markowitz portfolio theory, [Online], Available: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.145.90&rep=rep1&type=pdf [4 Oct 2022].
[2] Bąk, I., Markowicz, I., Mojsiewicz, M. and Wawrzyniak, K. (2020) Statystyka opisowa. Przykłady i zadania, Warszawa: Wydawnictwo CeDeWu.
[3] Bernoulli, D. (1954) 'Exposition of a New Theory on the Measurement of Risk', *Econometrica*, vol. 22, No 1 (January), pp. 23–36.
[4] Borowski, K. (2014) Miary ryzyka na rynku akcji i obligacji, Warszawa: Wydawnictwo „Difin".
[5] Castellano, R. and Giacometti, R. (2001) 'Performance of a Hedged Stochastic Portfolio Model in the Presence of Extreme Events', *Computational Economics*, vol. 17, pp. 239–252.
[6] Dash, M., Kavitha, V., Deepa, K.M., and Sindhu, S. (2008) A Study of Optimal Stock & Options Strategies, [Online], Available: https://ssrn.com/abstract=1293203 [4 Oct 2022].
[7] Elton, E.J., Gruber, M.J., Brown, S.J. and Goetzmann, W.N. (2014) Modern Portfolio Theory and Investment Analysis, 9th edition, New York: John Wiley & Sons, Inc.

[8] Gajdka, J. and Walińska, E. (2000) Zarządzanie finansowe. Teoria i praktyka, Tom I, 2nd editio, Warszawa: Fundacja Rozwoju Rachunkowości w Polsce.
[9] Hayes, A. (2021) Sensitivity: Overview, Benefits, Examples, [Online], Available: https://www.investopedia.com/terms/s/sensitivity.asp [23 Sep 2021].
[10] Hayes, A. (2021) Volatility: Meaning In Finance and How it Works with Stocks, [Online], Available: https://www.investopedia.com/terms/v/volatility.asp [23 Sep 2021].
[11] Hull, J. (1999) Kontrakty terminowe i opcje. Wprowadzenie, Warszawa: WIG-Press.
[12] Jajuga, K. (2009) Instrumenty pochodne. 3rd edition, Warszawa: Komisja Nadzoru Finansowego.
[13] Jajuga, K. and Jajuga, T. (2015) Inwestycje. Instrumenty finansowe, aktywa niefinansowe, ryzyko finansowe, inżynieria finansowa, Warszawa: Wydawnictwo Naukowe PWN.
[14] Jensen, M.C. (1968) 'The Performance of Mutual Funds in the Period 1945–1964', *Journal of Finance*, vol. 23, May, pp. 389–416.
[15] Knight, F.H. (1921) Risk, Uncertainty and Profit, [Online], Available: https://oll.libertyfund.org/title/knight-risk-uncertainty-and-profit [22 Sep 2021].
[16] Kownatzki, C., Putnam, B. and Yu, A. (2021) 'Case study of event risk management with options strangles and straddles', *Review of Financial Economics*, vol. 40, April, pp. 150–167.
[17] Markowitz, H.M. (1959) Portfolio Selection. Efficient Diversification of Investments, New York: John Wiley & Sons, Inc.
[18] Markowitz, H.M. (1952) 'Portfolio Selection', *Journal of Finance*, vol. 7, March, pp. 77–91.
[19] Marling, H. and Emanuelsson, S. (2012) The Markowitz Portfolio Theory, [Online], Available: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.298.1476&rep=rep1&type=pdf [4 Oct 2022].
[20] McMillan, L.G. (2002) Options as a Strategic Investment, 4th edition, New York: New York Institute of Finance.
[21] Podlewski, J. (2021). Ryzyko gospodarcze. 15 studium przypadku – e-book (PDF), self-publishing.
[22] Reilly, F.K. and Brown, K.C. (2001) Analiza inwestycji i zarządzanie portfelem, Warszawa: Polskie Wydawnictwo Ekonomiczne.
[23] Sharpe, W.F. (1994) 'The Sharpe Ratio', *The Journal of Portfolio Management*, vol. 21, January, pp. 49–58.
[24] Širůček, M. and Křen, L. (2015) 'Application of Markowitz portfolio theory by building optimal portfolio on the us stock market', Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, vol. 63, September, pp. 1375–1386.

[25] Treynor, J.L. (1965) 'How to rate management investment funds', *Harvard Business Review*, vol. 43, January, pp. 63–75.
[26] Zaleśkiewicz, T. (2003) Psychologia inwestora giełdowego. Wprowadzenie do behawioralnych finansów, Gdańsk: Gdańskie Wydawnictwo Psychologiczne.

Summary

This paper explores the evolving nature of the capital market in the second and third decades of the 21st century, characterized by its widespread accessibility to individual investors. However, the emergence of inexperienced investors driven by profit-seeking motives has led to non-conventional investment decisions resulting in significant losses. To address this challenge, the study investigates practical methods to minimize risk, focusing on the limited availability of derivatives in the Polish capital market. The research develops and tests an investment portfolio, drawing on Markowitz's portfolio construction theory and Hull's hedging strategy. The findings support the hypothesis that resilient investment portfolios can be constructed under Polish conditions using available tools and strategies.

JEL codes: G10, G11,

Keywords: *capital market, investment risk, portfolio construction*