JOURNAL OF SECURITY AND SUSTAINABILITY ISSUES
ISSN 2029-7017 print/ISSN 2029-7025 online
2023 Volume 13
https://doi.org/10.47459/jssi.2023.13.13

TOWARDS ECONOMIC SECURITY VIA FORECASTING OF COSTS

Bartosz Kozicki[1], Kacper Kumor[2], Jarosław Zelkowski[3], Andrzej Glen[4], Dariusz Latosiewicz[5]

[1, 2,3]Military University of Technology, Poland
[4]Siedlce University of Natural Sciences and Humanities, Poland
[5]Ministry of National Defence, Poland

E-mails: [1]bartosz.kozicki@wat.edu.pl; [2]kacper.kumor@student.wat.edu.pl;
[3]jaroslaw.zelkowski@wat.edu.pl; [4]andrzej.glen@uph.edu.pl; *[5]dlatosiewicz@mon.gov.pl*

Received 25 January 2023; accepted 15 June 2023; published 30 July 2023

Abstract. The study attempts to forecast the total costs of a company in Poland. The first stage of the research was analyzing and evaluating the time series of total costs. It detected: trends, seasonality and a random factor. This became a premise for the application of two methods for forecasting: Holt-Winters' multiplicative and additive. The research shows that the Holt-Winters' multiplicative model proved to be better in forecasting total costs in the research subject. The forecasted total costs from July to December 2022 will reach PLN 45 395 685, while from January to December 2023, their value will amount to PLN 85 948 927.

Keywords: costs; economic security; forecasting; COVID-19; planning

Reference to this paper should be made as follows: Kozicki, B., Kumor, K., Zelkowski, J., Glen, A., Latosiewicz, D. 2023. Towards economic security via forecasting of costs. *Journal of Security and Sustainability Issues*, 13, 133-142.
https://doi.org/10.47459/jssi.2023.13.13

JEL Classifications: D24, E17

1. Introduction

The economic security of any entity is closely related to many factors, including its economic viability (Ivančík, Andrassy, 2023). During globalization and increasing competitiveness, enterprises are constantly pressured to innovate and introduce new products to the market. In addition to searching for new markets or growing expenditures on brand building, they also compete at the level of reducing production costs - analyzing them and basing business decisions on reliable forecasts. Therefore, the issue of the appropriate selection of forecasting methods that will enable obtaining results as close to reality as possible using scientific methods is gaining more and more importance.

This became a premise for outlining the main research problem of the study: what regularities can be found in the time series of the total costs of the research subject, and will it be possible to choose two methods to forecast these costs in the future?

The article presents the primary goal. It is an attempt to forecast total costs for eighteen subsequent periods using two forecasting methods and then their evaluation to choose the best economic security. The central hypothesis of the research is as follows: it is assumed that the best method of forecasting the total costs of the research subject, obtained as a result of the evaluation, will have the average absolute forecast error below the significance level and, thus, reflect on the correct selection of the forecasting model of the research subject in terms of economic security.

The research subject is a company in Poland - an independent producer of video games known for their difficulties and requiring rivalry; the research subject is total costs.

To conduct the research process, the following research methods were adopted: analysis, comparison, generalization, and synthesis. The research techniques were: forecasting, autocorrelation and partial autocorrelation. The research tools are a Microsoft Excel spreadsheet for the initial data processing and the Statistica statistical package.

2. Analysis of the literature on the research subject

In the literature on the subject of economic sciences and in other sources, many definitions of management as a process can be found (Jokiel, 2009; Jurgilewicz et al., 2022). Management consists of four basic functions: planning, organizing, motivating and controlling (Ober, 2013, pp. 258-260; Wudarzewski, 2007, pp. 270-272). Planning begins a sequence of activities aimed at improving enterprise processes and optimizing resource use (Gliński, 1996, p. 37; Mamokhere, J. 2023).

It is a strategic process that allows setting goals and strategies for their implementation (Griffin, 2016, p. 67). It is a decision-making process based on data analysis that allows one to make the right choices and an action plan (Griffin, 2013, pp. 175-176). P.F. Drucker defines planning as a continuous process of making current, risky decisions systematically with an awareness of their future, organizing the efforts systematically necessary to implement those decisions, and measuring their results against expectations through structured, systematic feedback (Drucker, Maciarello, 2008, p. 125). According to R.W. Griffin, planning is a process that takes place in an environmental context. He also argues that effective goal-setting fosters good planning, which facilitates the setting of future goals (Griffin, 2013, pp. 176-177). According to A. Zawiślak, "planning is a set of activities that include:
– defining the tasks that can be conducted;
– identifying variables that must and can be manipulated;
– identifying variables that the planner does not control;
– establishing mutual relations between the variables of both sets;
– designing activities, taking into account the mutual relationships between variables, to implement the intended action" (Zawiślak, 1979, p. 220).

B. Kozicki writes about planning: "Planning is management's first and most important function. It is the beginning and basis of all activities of the organization, including the armed forces. The need for planning results from many reasons related to the functioning of any organization" (Kozicki, 2022, p. 20).

R. Krupski defines a plan as a product of the planning process (Krupski, 2004, p. 51). The plan is an essential part of this process. It is a document describing the goals, strategies, and specific actions to be implemented. The plan may collect information about costs, schedules, or information about required resources. There are three basic types of planning in the literature (Łęgowik-Świącik, 2012, p. 49):
- operational planning,
- tactical planning,
- strategic planning.

An essential element of the planning process is forecasting, often referred to as prediction. The Dictionary of the Polish Language defines prediction as: "what someone predicts, supposes, expects, guesses" (Dictionary of the Polish language, 2023). N. Cesa-Bianchi and G. Lugosi understand prediction as a short-term guessing of the evolution of certain phenomena (Cesa-Bianchi, Lugosi, 2006, p. 1). It is, therefore, a process of concluding future events based on past information. Only unknown events that belong to the past or the future can be predicted. Predicting the future, according to the quoted definitions, consists in predicting unknown events belonging to the future based on known events belonging to the past (Cieślak, 2005, p. 18). A forecast is a scientifically

based judgment about the situation at a certain time in the future. M. Cieślak understands it as a judgment with the following characteristics (Cieślak, 2005, p. 20):
- outlined with the use of scientific achievements,
- referring to a specific future,
- empirically verifiable,
- uncertain but acceptable.

According to M. Kupiszewski and J. Bijak, forecasts make it possible to confront the current goals with the expected changes, using the best possible knowledge and statistical information and using a recognized forecasting methodology (Kupiszewski, Bijak, 2006, p. 68). P. Dittmann defines this concept: "A forecast is a judgment concerning the future of the forecasted phenomenon – precise and uncertain. The forecast should be outlined precisely, i.e. in a way that enables its empirical verifiability and evaluation of its accuracy. A forecast whose degree of uncertainty is acceptable to its recipient is called a good forecast" (Dittman et al., 2016, p. 17). The forecast construction follows the established algorithm of conduct (Kozicki, 2020). It begins with the first stage, which is constructing a forecasting task. Its main tasks are (Dittman et al., 2016, p. 23):
- defining the object of the forecast;
- defining the phenomenon which the forecast will concern;
- defining the purpose of the forecast;
– setting the time horizon of the forecast;
- defining its accuracy.

Defining the accuracy of the forecast is understood as determining the maximum forecast error and the costs associated with it accepted by the company. Increasing the budget usually results in improved forecast accuracy. However, it should be remembered that no matter how multidimensional and expensive the method used for forecasting is, it is impossible to eliminate uncertainty factors and the associated risks (Dittman et al., 2016, p. 28). The costs of using such methods may also exceed the potential savings the company would gain by implementing the forecast results into its business strategy. The cost is "the necessary use of resources of an economic unit expressed in value to achieve a specific useful effect" (Matuszek, Kołosowski, Krokosz-Krynke, 2011, p. 32). Costs are a multifaceted economic category that includes numerous elements and can be divided and classified in many ways, but no such categorization can be considered objective or universal (Nowak, 2016, p. 45). When analyzing the company's costs, it is necessary to penetrate its internal structure. The correct valuation of the company's operating costs requires identifying these components. In addition, information on the development of respective cost components allows for making the right financial decisions, and the division of the total cost into detailed points creates conditions for evaluating responsible people at their level.

To sum up, planning using forecasting is essential in terms of the precise allocation of financial resources in the future to ensure economic security for enterprises dynamically.

When discussing the subject of economic security (Piwowarski et al., 2021), J. Marszałek-Kawa and G. Kinelski define it as "a state of being without risk and uncertainty" (Marszałek-Kawa, Kinelski, 2020, p. 5). They also point out that "the economic security status of the country is understood mainly as the state of the economy. It consists of the condition of public finances and trends in the domestic economy. In this case, the size of public debt is of significant importance" (Marszałek-Kawa, Kinelski, 2020, p. 5).

2. Analysis and evaluation of total costs of the research subject

The research began with the outline of a line graph of the total costs of the research subject from January 2016 to June 2022.

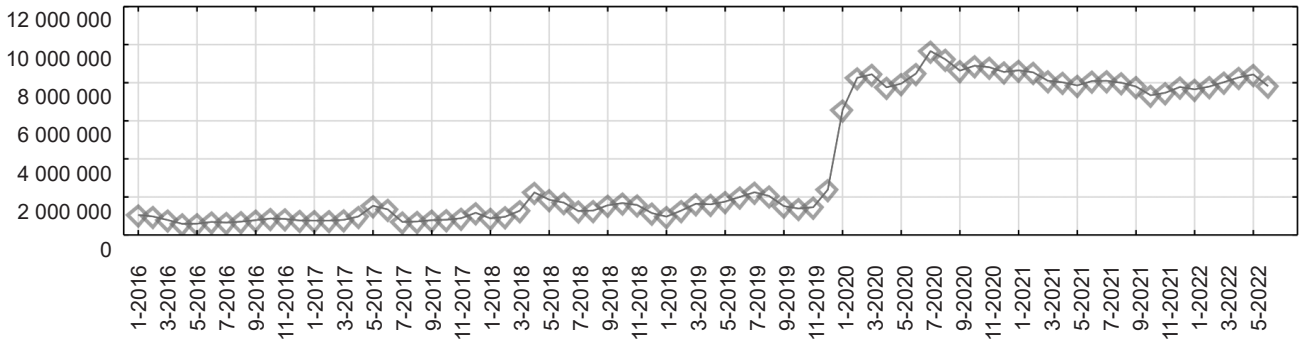

Figure 1. Line graph of total costs from January 2016 to June 2022

Source: own study

Figure 1 shows a substantial increase in the value of total costs between the fourth quarter of 2019 and the first quarter of 2020. This phenomenon is due to the impact of the COVID-19 pandemic. Between 2016-2019, the total costs of the research subject were below PLN 2 000 000 and between 2021-2022 they reached the level of approximately PLN 8 000 000.

Then, in Figure 2, a can graph of the total costs of the research subject was made from January 2016 to June 2022.

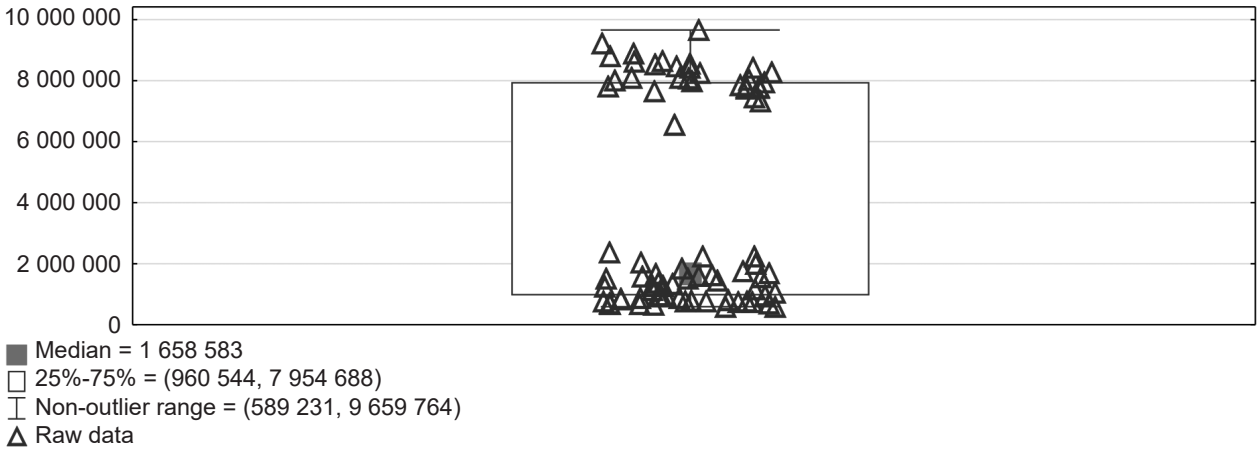

Figure 2. Can graph of total costs of the research subject from January 2016 to June 2022

Source: own study

The data in Figure 2 shows that the two variables are distant. One is focused on the median, which is less than PLN 2 000 000. The second one oscillates around the third quartile.

To measure the level of the median of the second group of variables oscillating around the third quartile, Figure 3 shows a can graph of total costs from January 2021 to June 2022.

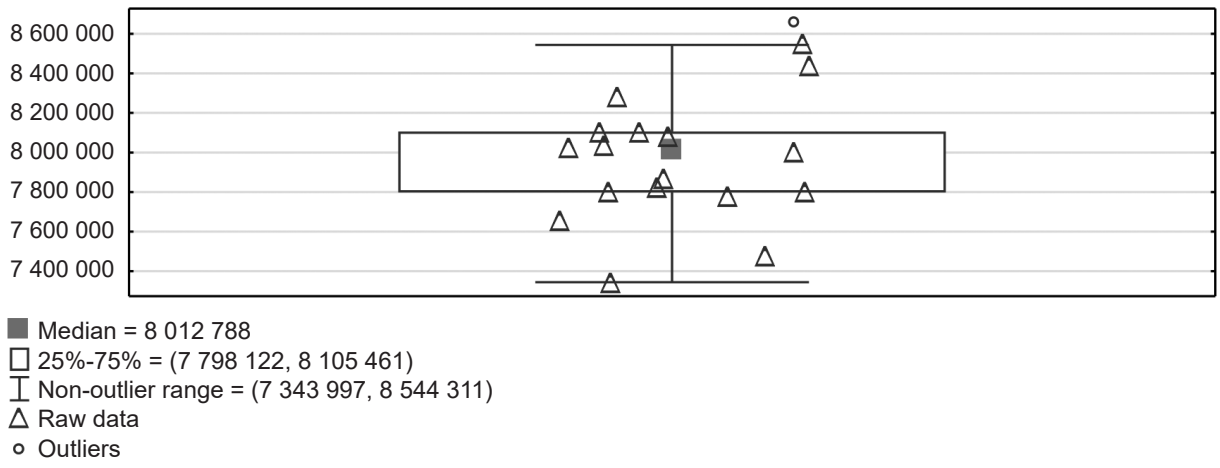

Figure 3. Can graph of total costs from January 2021 to June 2022

Source: own study

Based on the analysis of the data presented in Figure 3, it can be concluded that the median value for the data from January 2021 to June 2022 oscillates around PLN 8 012 788.

The total costs of the research subject in 2020, due to the impact of the COVID-19 pandemic, were considered a random phenomenon. Their increase led to the situation that since 2021, the variance of the total costs of the research subject has increased by PLN 6 000 000. In terms of forecasting the total costs of the research subject, this became a premise to increase the variance by PLN 6 000 000 for each month from January 2016 to December 2019. To build a model for data forecasting, it was assumed that the values of the total costs of the research subject from January to December 2020 were the same as in the same periods in 2019 after increasing the variance by the amount indicated above. The line graph of the company's costs after the correction from January 2016 to June 2022 is presented in Figure 4.

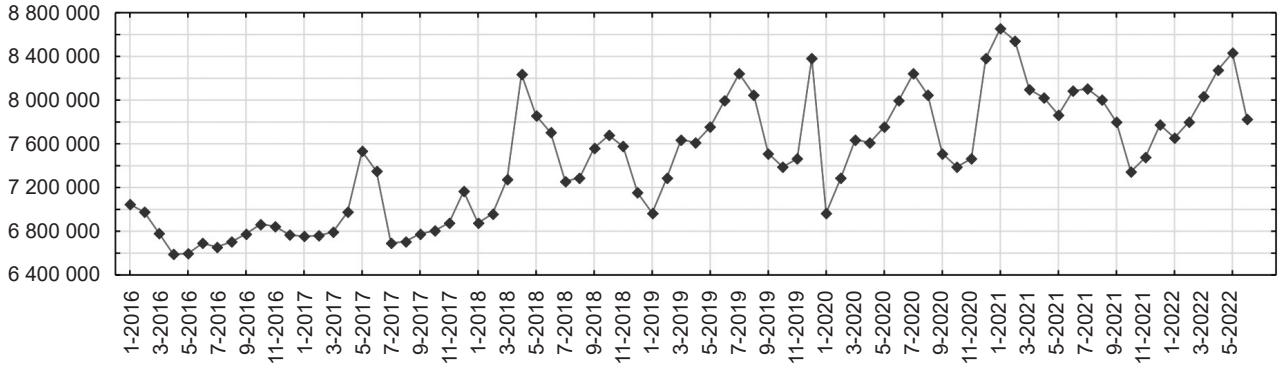

Figure 4. Line graph of costs of the enterprise after the correction from January 2016 to June 2022

Source: own study

The data summarized in Figure 4 indicates a random factor, seasonality and an upward trend.

The box plot of total costs in the group of the same months is shown in Figure 5.

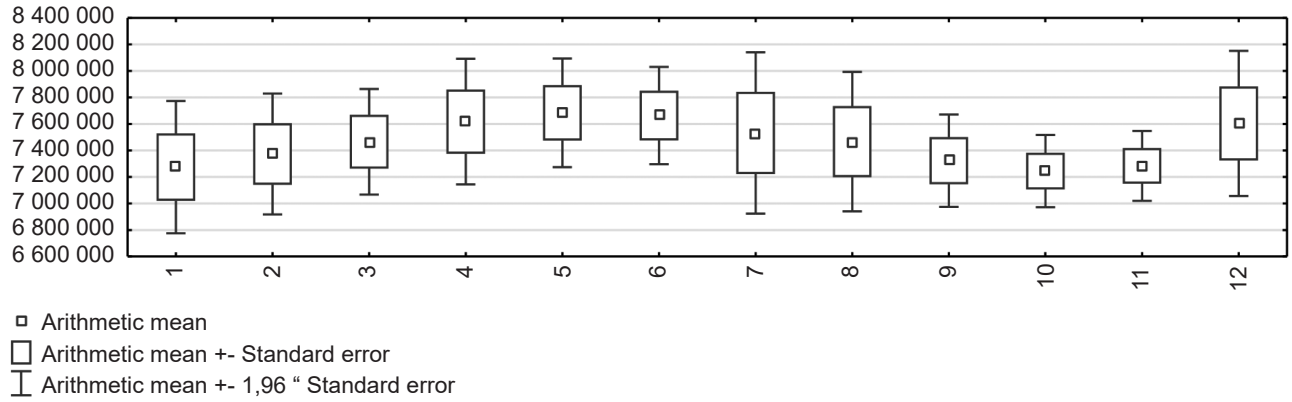

Figure 5. Box plot of total costs in a group of the same months

Source: own study

Total costs presented in the same months as arithmetic means indicate the phenomenon of seasonality. The observed seasonality, the growing trend and the random factor are the factors that recommend the use of the Holt-Winters' exponential smoothing method to forecast the total costs of the research subject for eighteen future periods (Kozicki, Sowa, 2021, pp. 26-27). Analyzing Figure 5, it was noticed that the highest values of the arithmetic means of total costs were in May–June and the lowest amount in October.

The box plot of total costs in the group of the same years is shown in Figure 6. It offers a strong, close-to-linear increase in average total costs in the research subject between 2016 and 2022.

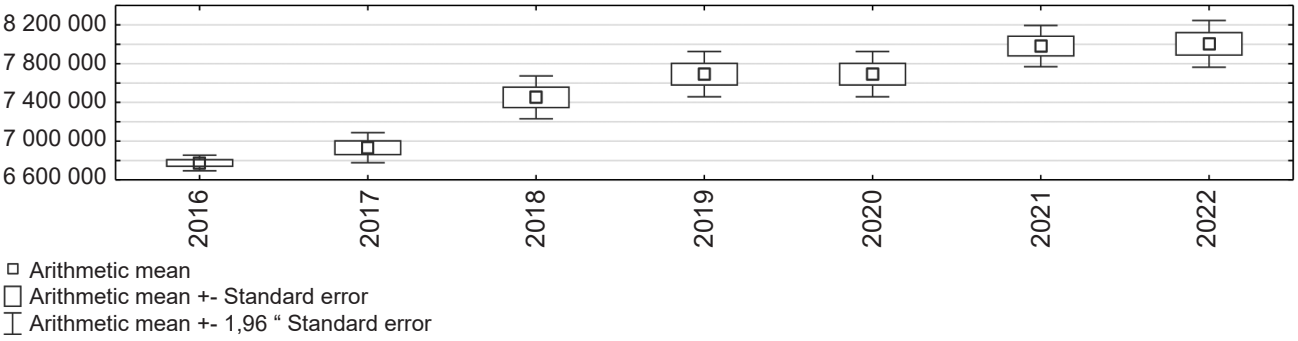

Figure 6. Box plot of total costs in a group of the same years

Source: own study

In the time series of total costs, three regularities were distinguished after its correction obtained from the research subject: trend, seasonality and a random factor. The observed regularities allow the forecasting of the analyzed total costs. The following substantive point will be devoted to the forecasting of the total costs of the research subject.

3. Total cost forecasting

The multiplicative and additive Holt-Winters' method was selected to forecast total costs in the research subject. This results from the evaluation of the literature analysis in terms of three regularities observed and mentioned above in the time series (Szmit, Szmit, 2012, p. 2). The selected methods are the most frequently used during these regularities (Szmuksta-Zawadzka, Zawadzki, 2009, p. 85). Charles Holt and Peter Winters developed the Holt-Winters forecasting algorithm. It is a tool commonly used for time series forecasting. Exponential smoothing is a time series method that assigns exponentially decreasing scales to values relative to historical data to

reduce the significance of more distant data (Panda, 2020, p. 5).
Then, in Figure 7, the forecast of total costs using the Holt-Winters' multiplicative model for the period from July 2022 to December 2023 was outlined.

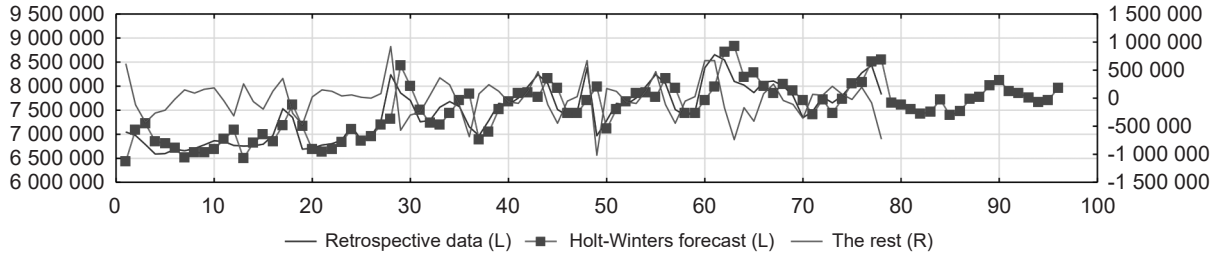

Figure 7. Holt-Winters' forecast of total costs using the multiplicative model for the period from July 2022 to December 2023

Source: own study

Figure 7 shows the historical data, remainder and the forecast of the total costs of the research subject made with the Holt-Winters' method with a multiplicative model. The forecast retained the phenomena visible in the retrospective data. The data analysis in Table 1 shows that from July to October 2022, the amount of costs will decrease from PLN 7 654 605 to PLN 7 422 828. Then, in November 2022, an increase to PLN 7 466 303 will be visible. Similarly, in December 2022, the value of total costs should reach PLN 7 717 714. Then, from January 2023, the total costs will show an upward trend: from PLN 7 389 782 to PLN 8 123 984 in June 2023. Over the next four months, a downward trend will be visible: to PLN 7 658 251 in October 2023. In November and December 2023, an upward trend should be visible. In November, total costs will reach PLN 7 702 481, and in December - PLN 7 961 202.

Then, in Figure 8, the forecast of total costs made with the Holt-Winters' method with the additive model from July 2022 to December 2023 is outlined.

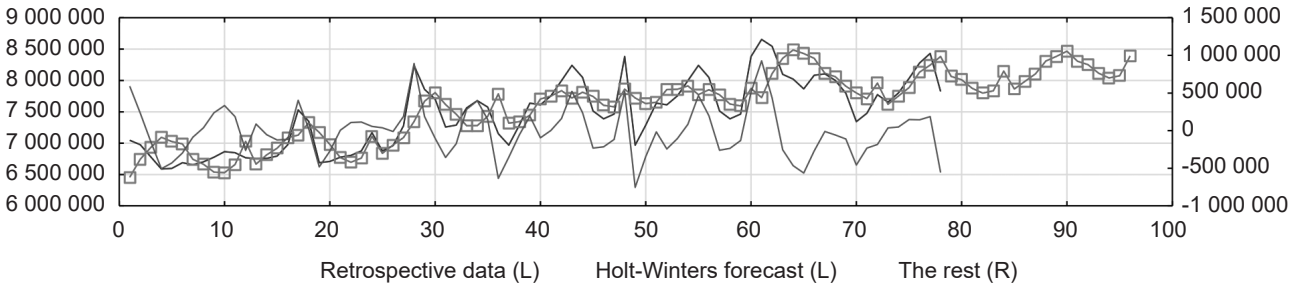

Figure 8. Total cost forecast using the Holt-Winters' method, an additive model for the period from July 2022 to December 2023

Source: own study

Figure 8 presents historical data, the remainder and the forecast of total costs made with the Holt-Winters' method and the additive model. The forecasts retain the regularities visible in the historical data of the total costs of the research subject. From July to October 2022, there is a downward trend in total costs from PLN 8 064 551 to PLN 7 800 049. Then, from November (PLN 7 835 803) to December 2022 (PLN 8 150 884), one can see an upward trend. In January 2023, a decrease to PLN 7 863 352 was observed. Then, an upward trend is visible until June 2023 (PLN 8 466 978). From July to October 2023, there was a decrease in total costs from PLN 8 305 821 to PLN 8 041 318. In November and December 2023, there was an increase in total costs to PLN 8 077 073 and PLN 8 392 154.

Table 1 summarizes the error indices of the obtained forecasts made with the Holt-Winters' method with the multiplicative and additive versions.

Table 1. Comparison of forecast error indices obtained with the Holt-Winters' method with the multiplicative and additive versions

Index	**Result H-W** multiplicative	**Result in H-W** additive
Average error	–10 788,84	–12 861,81
Mean average error	–0,22	–0,30
Mean absolute percentage error	3,17	3,37

Source: own study

The average error of the forecast made with the Holt-Winters' method with the multiplicative version was –10 788,84. Therefore, that was the average difference between the observed and predicted values. The average percentage error was –0,22%. This means that the predicted values were, on average, 0,22% lower than the observed values. On the other hand, the value of 3,17% of the average absolute percentage error means that the forecasted values deviated on average from the observed values by such a value. The average error for the Holt-Winters, the additive forecast was -12 861,81, so this was the difference between the observed and predicted values. The average percentage error is –0,3. This means that the predicted values were, on average, 0,3% lower than the observed values. The average absolute percentage error is 3,37%. Therefore, it can be concluded that the predicted values deviated on average from the observed values by such an amount.

Bearing that in mind, the multiplicative Holt-Winters' model is better than the additive version, as all analyzed forecast error indices were lower.

6. Summary and conclusions

The study's main research objective was to forecast total costs for eighteen consecutive periods using two forecasting methods and then to evaluate these methods to choose the best one in terms of economic security. This goal has been achieved. Total cost forecasting was conducted using Holt-Winters' exponential smoothing methods with additive and multiplicative models. The conducted analyses show that the multiplicative model worked better. The average error was -10 788,84; in the alternative method, the corresponding error was -12 861,81. In addition, the average percentage error in the multiplicative Holt-Winters' model is -0,22, while in the additive Holt-Winters' model it was -0,3. In addition, the mean absolute percentage error in the multiplicative model was 3,17 and in the additive model 3,37. Thus, the average error in the case of the multiplicative model was lower by PLN 2 072,97 than in the additive model. The average percentage error was lower by 0,08%, while the average absolute percentage error was lower by 0,2%. All analyzed forecast error indices are lower for the multiplicative Holt-Winters' model, so it is the best method for forecasting of total costs in the research subject.

The forecast of total costs from July 2022 to December 2023, made with the Holt-Winters' exponential smoothing method, shows an upward trend. The forecasted total costs from July to December 2022 are PLN 45 395 685, while from January to December 2023 they will amount to PLN 85 948 927.

The total cost planning with the use of forecasting made in the article is a new, so far unused solution in the subject of research, which will improve the entire process in terms of the execution time and reduce the differences between the planned and actual values, and thus in the future will allow for more effective management of financial resources in terms of the economic security.

Literature

Adeniran, A. O., Muraina, J. M., Ilugbami, J. O., Adeniran, A. A. (2023). Government policy: meaning, types, manifestations, theories, and policy cycles. *Insights into Regional Development,* 5(2), 83-99. https://doi.org/10.9770/IRD.2023.5.2(6)

Cesa-Bianchi, N., Lugosi, G. (2006). Prediction, Learning, and Games. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511546921

Cieślak, M. (2005). Prognozowanie gospodarcze – metody i zastosowania, wydanie czwarte zmienione [Economic forecasting - methods and applications, fourth revised edition]. Warszawa: Wydawnictwo Naukowe PWN.

Dittmann, P. (2017). Prognozowanie w przedsiębiorstwie. Metody i ich zastosowanie, wydanie V zmienione i uzupełnione [Forecasting in the enterprise. Methods and their application, 5th edition revised and supplemented]. Warszawa: Wydawnictwo Nieoczywiste.

Dittmann, P., Szabela-Pasierbińska, E., Dittmann, I., Szpulak, A. (2016). Prognozowanie w zarządzaniu przedsiębiorstwem, wydanie II zmienione i uzupełnione [Forecasting in enterprise management, 2nd edition revised and supplemented]. Kraków: Wydawnictwo JAK.

Drucker, P.F., Maciarello, J.A. (2008). Management, revised edition. Nowy Jork: HarperCollins Publishers Inc.

Gliński, B. (1996). Zarządzanie strategiczne. Geneza, rozwój, priorytety [Strategic management. Origin, development, priorities]. Warszawa: Wydawnictwo Key Text.

Griffin, R.W. (2013). Management. Eleventh Edition. College Station: Texas A&M University.

Griffin, R.W. (2016). Fundamentals of Management. Eighth Edition. Boston: CENGAGE Learning.

Ivančík, R., Andrassy, V. (2023). Insights into the development of the security concept. *Entrepreneurship and Sustainability Issues,* 10(4), 26-39. https://doi.org/10.9770/jesi.2023.10.4(2)

Jokiel, G. (2009). Podejście procesowe w zarządzaniu: geneza i kierunki rozwoju koncepcji [Process approach in management: genesis and directions of development of the concept]. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, 52, 15-22.

Jurgilewicz M. et al. (2022). Contemporary challenges for the economic security of enterprises in Poland. *Journal of Security and Sustainability Issues*, (12)1, pp. 71-80. https://doi.org/10.47459/jssi.2022.12.6

Kozicki, B. (2022). Planowanie potrzeb Sił Zbrojnych RP w aspekcie zapewnienia bezpieczeństwa militarnego Polski [Planning the needs of the Polish Armed Forces in terms of ensuring Poland's military security]. Warszawa: Wojskowa Akademia Techniczna.

Kozicki, B., Sowa, B. (2021). Wielomodelowe prognozowanie liczby pasażerów przewożonych krajowym transportem lotniczym w Stanach Zjednoczonych w 2021 r. [Multidimensional forecasting of the number of passengers transported by home air transport in the United States in 2021]. Gospodarka Materiałowa i Logistyka, 7, 23-32. https://doi.org/10.33226/1231-2037.2021.7.3

Kozicki, B. (2020). A New Method for Planning Needs in Terms of Security, [in] 35th International Business Information Management Conference (IBIMA), 1-2 April 2020, Seville, Spain, 2020, 16819-16829.

Krupski, R. (2004). Podstawy organizacji i zarządzania. Wydanie V zmienione [Fundamentals of organization and management. 5th revised edition]. Wrocław: Prace Naukowe Wałbrzyskiej Wyższej Szkoły Zarządzania i Przedsiębiorczości, Wydawnictwo I-BIS.

Kupiszewski, M., Bijak, J. (2006). Ocena prognozy ludności GUS 2003 z perspektywy aglomeracji warszawskiej [Evaluation of the 2003 population forecast of the Central Statistical Office from the perspective of the Warsaw agglomeration]. Studia Demograficzne, 1(149), 68-81.

Łęgowik-Świącik, S. (2012). Planowanie i kontrola w zarządzaniu jednostkami gospodarczymi [Planning and control in the management of economic units]. Częstochowa: Politechnika Częstochowska.

Mamokhere, J. (2023). Sending a message to the top: the influence of service delivery protests on service delivery planning in South African municipalities. *Insights into Regional Development*, 5(2), 60-71. https://doi.org/10.9770/IRD.2023.5.2(4)

Marszałek-Kawa, J., Kinelski, G. (2020). Współczesne bezpieczeństwo regionu Azji i Pacyfiku. Wybrane problem [Contemporary security of the Asia-Pacific region. Selected problems]. Toruń: Wydawnictwo Adam Marszałek.

Matuszek, J., Kołosowski, M., Krokosz-Krynke, Z. (2011). Rachunek kosztów dla inżynierów [Cost accounting for engineers]. Warszawa: Polskie Wydawnictwo Ekonomiczne.

Nowak, E. (2016). Analiza kosztów w ocenie działalności przedsiębiorstwa [Cost analysis in the evaluation of the company and its activity]. Warszawa: Wydawnictwo CeDeWu.

Ober, J. (2013). Funkcja i rola efektywnej komunikacji w zarządzaniu [Function and role of effective communication in management]. Zeszyty Naukowe Politechniki Śląskiej. Organizacja i Zarządzanie, 65, 257-266.

Panda, M. (2020). Application of ARIMA and Holt-Winters forecasting model to predict the spreading of COVID-19 for India and its states. *MedRxiv*, https://doi.org/10.1101/2020.07.14.20153908

Piwowarski, J., Kozicki, B., Jurgilewicz, M., Malec, N. (2021). Managing the Financial Security of Organizations During the Covid-19 Pandemic – Multivariate Analysis. *Journal of Security and Sustainability Issues*, 11(1), 537-546. https://doi.org/10.47459/jssi.2021.11.49

Słownik języka polskiego [Dictionary of the Polish Language], https://sjp.pwn.pl/slowniki/przewidywanie.html (12.02.2023)

Szmit, M., Szmit, A. (2012). Usage of modified Holt-Winters method in the anomaly detection of network traffic: Case studies. *Journal of Computer Networks and Communications*, 5(8), https://doi.org/10.1155/2012/192913

Szmuksta-Zawadzka, M., Zawadzki, J. (2009). O prognozowaniu na podstawie modeli Holta–Wintersa dla pełnych i niepełnych danych [On forecasting based on Holt-Winters models for complete and incomplete data]. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu. Ekonometria, 38, 85-99.

Wudarzewski, G. (2007). Klimat organizacyjny w świetle funkcji zarządzania [Organizational environment in terms of management functions]. *Zeszyty Naukowe Wyższej Szkoły Bankowej we Wrocławiu*, 9(9), 269-278.

Zawiślak, A.M. (1979). Wybór zadań planistycznych w makrosystemie [Selection of planning tasks in the macrosystem]. W: W. Morawski (red.). Kierowanie w społeczeństwie. Analiza socjologiczna [Leadership in society. Sociological analysis]. Warszawa: PWN.

Bartosz KOZICKI - Military University of Technology, PL. Research interests: national security, internal security.
ORCID ID: 0000-0001-6089-952x

Kacper KUMOR - Military University of Technology, PL. Research interests: national security, production management.
ORCID ID: 0009-0004-6727-3721

Jarosław ZELKOWSKI - Military University of Technology, PL. Research interests: national security, internal security.
ORCID ID: 0000-0002-6698-2938

Andrzej GLEN – Siedlce University of Natural Sciences and Humanities, PL. Research interests: national security.
ORCID ID: 0000-0002-7443-2629

Dariusz LATOSIEWICZ – Ministry of National Defence, PL. Research interests: national security, people management.
ORCID ID: 0000-0002-7108-2491