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# STOCK PRICE PREDICTION OF THE LARGEST AUTOMOTIVE COMPETITORS BASED ON THE MONTE CARLO METHOD

**Bojana Novićević Čečević**

*University of Niš, Faculty of Economics, Republic of Serbia*

✉ *bojana.novicevic@eknfak.ni.ac.rs*

**Ljilja Antić**

*University of Niš, Faculty of Economics, Republic of Serbia*

✉ *ljilja.antic@eknfak.ni.ac.rs*

**Andrijana Jevtić**

*University of Belgrade, Technical faculty in Bor, Republic of Serbia*
*Department for Engineering Management*

✉ *ajevtic@tfbor.bg.ac.rs*

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Review paper

**Abstract:** The transition to electric vehicles would be a great improvement for the population. On the other hand, this transition will make a great pressure for companies in the automotive industry, since they would have to develop such vehicles and make them better than traditional ones. Moreover, the transition period can last a long time. In the meantime, fossil fuel car sale rates are still dominant in the world. In this paper, the stock price prediction is made for two of the world's largest competitors in automotive industry - Toyota and General Motors. The prediction covers one year, based on historical data of stock price trends using Monte Carlo simulation in two possible cases: the first, with 1,000 outcomes, and the second, with 10,000 outcomes. After price simulation, a comparative analysis of the results obtained for these two companies follows. The results show that the greater the number of outcomes specified in the prediction, the greater the variability of the results compared to the variability of historical data. In other words, the transition of General Motors to the leading position is not impossible.

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## 1. Introduction

Early 2020s have been marked by intense propaganda about environmental protection, which imposed numerous changes in the way companies do business around the world. Requirements for reducing the emission of harmful gases represent one of the most important activities for achieving a cleaner environment. These requirements particularly affect the automotive industry, which is considered one of the biggest $CO_2$ emitters. One of the main UN (United Nations) goals for slowing down climate change is Net Zero, i.e. to keep global warming to no more than 1.5°C – as called for in the Paris Agreement – emissions need to be reduced by 45% by 2030 and reach net zero by 2050 (United Nations).

According to the *10 Important Auto Industry Trends (2022-2024)* report, Howarth (2022) indicates that only the most developed world countries follow the UN recommendations. The Scandinavia and Western Europe countries have set targets for reducing emissions of harmful gases until 2030, while Canada and several states of the USA set 2040 as the target year.

As it is a matter of time when fossil fuel cars will be completely banned, companies within the automotive industry have had to find a global solution – electric vehicles. Many of the world's largest car manufacturers have been developing various models of electric vehicles for a long time. Although there is intense worldwide propaganda about switching to electric vehicles, they still cannot completely replace classic fossil fuel cars. In its report *Five trends transforming the Automotive Industry*, PWC predicts that by 2030 electric vehicles will account for at least 55% of all new car sales (PWC). Also, one should not ignore the fact that consumers differ in the speed of accepting new products, which also makes this transition difficult. Because of all of the above, it is obvious that fossil fuel cars will be in use for at least some time to come.

In addition to environmental impacts, numerous world market crises affect the automotive industry as well. The current crisis in Ukraine is shaking the world economy. It started while the world had not yet recovered from the previous COVID-19 crisis. The impact of the crisis on car production on the US market is seen in significantly lower share in GDP (Samaddar & Bachman, 2022).

Economic factors constitute another group of elements influencing the automotive industry. June 2022 recorded a global decline in demand for cars, under the influence of the following factors: price rise, interest rate rise and economic instability (Basaline, 2022). The automotive industry generates about 3% of global economic output. In certain countries, known for car production (Germany, Mexico, Japan, South Korea and some states of the USA), this percentage is significantly higher. This means that any disruption on the car market, even a small one, would have major consequences for the economies of this country (Ewing & Cohen, 2021).

The history of the automotive industry says that two companies stand out as long-term leaders in car production and sale. General Motors has been dominant on the world market for decades, especially on the US market. However, in 2021, it lost its ninety-year-long position when Toyota took over the leading position (Carlogos, 2022). For years, Toyota has been recognized for the exceptional sales of its cars in the world.

According to Factorywarrantylist reports, Toyota has been ranked as the largest car seller for the last two years (approximately 19 million cars in 2020 and 2021 in total), which is also true from the point of view of operating income ($238.6 Billion with a growth of 5% compared to 2020). According to this report, General Motors achieved sales volume by one third lower and half the operating income compared to Toyota. The competitive situation between the two observed companies is slightly different when looking only at the US market. For the first three quarters of 2022, GM sold approximately 1.65 million cars on the US market, making it the best-selling company, while the second-ranked Toyota sold 1.57 million cars.

Based on the above, it is clear that Toyota and General Motors have been rivals for many years on the world market and are constantly at the top. Toyota, a company from the East, applies various methods in its production process developed in Japan, while General Motors applies the Western school methods. In this paper, the stock sales price of the mentioned companies is predicted for a period of one year using the Monte Carlo method. Given that the value of companies on the market is formed, among other things, based on their operating income, the aim of this paper is to review the position of these companies on the stock market over the previous period, determine future price trends based on forecasts, as well as make a comparative presentation of the analyzed values.

After reviewing the literature, the paper further explains the methodology used in this research. The final part of the paper refers to the interpretation of the obtained results, as well as their comparative analysis.

## 2. Literature review

The products of the automotive industry, cars, are considered one of the most owned products in the world. The car is considered the most common means of transportation, so it can be said that millions use it every day.

Due to the specifics that characterize the products themselves, the automotive industry is one of the most analyzed areas from both a theoretical and a practical point of view. Numerous world experts analyze the automotive industry and its products, primarily cars, from various points of view. So engineers look at technological, environmental, energy, etc. aspects of this product, while economists and managers analyze these companies from the point of view of finance, logistics,

management, marketing, etc. As cars are very complex products, made up of a huge number of different parts, it is obvious that automotive companies have a large number of business partners. Therefore, literature offers various papers including analyses by a large number of authors from different fields. Here the focus will be only on those authors who analyze economic and financial aspects of automotive companies.

Some authors aim to analyze the impact of the globalization process on operations in the automotive industry (Hartungi, 2006; Sturgeon et al., 2009; Chandak et al.; 2014). There are also authors who analyze the impact of globalization on the automotive industry with a focus on specific economies, i.e. countries and areas (Belcet & Enrietti, 2002; Kädtler & Sperling, 2002; Bouare et al., 2003; Black & Bhanisi, 2006; Tan & Perrons, 2009; Schaede, 2010; Wang et al., 2010; Frigant & Zumpe, 2017; Krzywdzinski, 2019).

Literature also offers studies of trends in the automotive industry globally or in individual economies (Truett & Truett, 2007; Salihoglu & Salihoglu, 2016; Saidani et al., 2018; Russo-Spena et al., 2018; Masondo, 2018; Albulescu et al., 2021).

One of the most popular topics in the field of the automotive industry is the relationship between environmental and economic issues, aimed at determining the direct relationship between the two mutually exclusive categories and sustainability development (Liu et al., 2018; Rovinaru et al., 2019; García-Machado & Martínez-Ávila, 2019; Meckling & Nahm, 2019; Gohoungodji et al., 2020; Haas, 2021; Hu et al., 2021; Szász et al., 2021; Palea & Santhià, 2022; Beier et al., 2022; Lukin et al., 2022).

Some authors perform comparative analysis of companies in the field of the automotive industry (Scavarda et al., 2009; Shah & Regassa, 2010; Studeny, 2015; Lui et al., 2018; Gorgoni et al., 2018; Mordue & Sweeney, 2020; Lukin et al., 2022).

Given that Toyota is a company that has been at the top of the world car market for decades, it is expected to find studies analyzing this company in particular. They are most often available in the form of various case studies. They focus both on the global market and the individual markets where this company operates, analyzing it in various terms (Li, 2018; Madoh et al., 2019; Priyadi, 2019; Khan, 2019; Soviar et al., 2019; Schulz, 2020; Ishigame, 2020; Arsy, 2021). General Motors has been somewhat less analyzed in recent literature. Available analyses of this company as well are also based on case studies (Mladjan & Markovic, 2019; Chuang & Zhao, 2019; Dmytriiev et al., 2019; Saranga et al., 2019; Meckling & Nahm, 2019; Kirca et al., 2020).

In recent literature, there are authors who deal with stock price prediction of automotive companies using different methodologies or their combination (Nguyen et al., 2019; Yu & Yan, 2020; Anand, 2021; Rakhra et al., 2021).

Based on the given literature review, it can be concluded that there is no paper dealing with the prediction of Toyota and General Motors stock prices using the

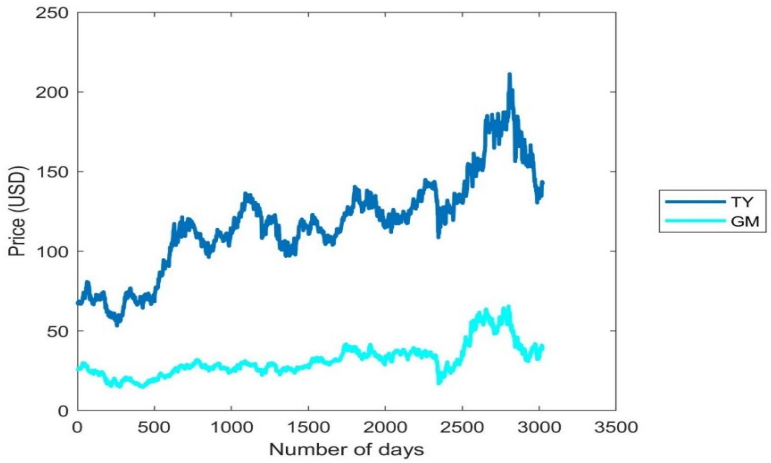
Monte Carlo method. In this regard, the contribution of this paper is the different approach and methodology used.

The starting hypothesis in this paper is that the number of simulations carried out in the analysis does not affect the results, i.e. the level of the expected stock prices.

## 3. Data and methodology

Historical price data taken from the Yahoo Finance website (https://finance.yahoo.com/) is used to predict future stock prices for Toyota and General Motors. Both companies list their shares on various world stock exchange markets, such as the Tokyo Stock Exchange, the London Stock Exchange and some European stock exchange markets; however, the largest trading volume takes place on the New York Stock Exchange (NYSE). It is interesting to note that Toyota, a company from the East, has been listing its shares on the stock exchange since the 1970s, while General Motors has been doing so for just over a decade. This is why the price trends are analyzed from the moment of data availability for both companies, in order to achieve full comparability of the data.

**Figure 1. Stock price trends for Toyota and General Motors on the NYSE for 10 years**




*Source:* Authors based on data taken fromhttps://finance.yahoo.com/

Stock trading data is publicly available for all companies on a single stock exchange market. This data is displayed on a daily, monthly, quarterly basis, for different time ranges, but also by different prices. Given that the trading of securities, including shares, on the stock exchange is a very dynamic process, hence the availability of data on different prices for each day that the stock exchange is open. So there is a difference between the opening price, the closing price, as well as the data on the highest and lowest daily price. Data on daily trading volume, as well as

current changes in trading, is also available. As studies mostly use the Adj. Price, i.e. adjusted closing price, to analyze companies on the stock exchange (from the point of view of stock price), this research will also take this price as the basic data for analysis. Monte Carlo analysis focuses on stochastic data, so before starting the simulation process, it is necessary to determine the nature of the included data. Figure 1 shows the price trend of observed companies on the NYSE for a period of 10 years (21 November 2012 – 21 November 2022).

Figure 1 shows that data on the stock prices of the two companies are of a stochastic character, i.e. that it cannot clearly point to price trends. This is exactly the character that data suitable for conducting Monte Carlo simulation should have. The blue color in the figure represents the price of Toyota stocks (TY), while the cyan color shows the stock price trend of General Motors (GM). Given that Toyota is the company whose car models are the most sold in the world, it is expected that its stock prices are at a slightly higher level. GM is the second largest company in the automotive industry by car sales over the long term.

The figure also shows that these companies' price trends have an approximate character, i.e. that there is consistency between all significant price changes (spikes and falls) in the same time period. So it can be concluded that the value of the two observed companies, based on their stock value, is balanced on the market. More precisely, the market affects the prices of the observed companies' stocks in the same way. Considering that, it can be stated that the main difference between the observed companies is their historical value.

Significant differences in stock prices of the observed companies can already be seen in the figure itself. However, the range of price trends, as well as the average price for the observed time period, cannot be seen in the figure. That is why table 1 shows individual values of descriptive statistics for the observed historical data.

**Table 1. Values of descriptive statistics for the observed historical data for Toyota and General Motors**

| Company | Average Price | Minimum Price | Maximum Price | Standard Deviation |
|---|---|---|---|---|
| Toyota | 117.4648 | 53.0895 | 211.3700 | 30.7282 |
| General Motors | 31.4175 | 14.4973 | 65.5902 | 10.1601 |

*Source:* Authors' calculation

Data shown in table 1 shows that the most common price of Toyota stocks for the observed period is $117.4648, and it ranges from $53.0895 to $211.3700. The average deviation from the mean is $30.7282. Although it is a long period of time, a high level of volatility in stock prices can be noted. When it comes to GM, the average stock price on the stock exchange for the observed period is $31.4175, which

is almost three times less in relation to the Toyota stock price. As for the volatility of the General Motors stock price, it is at a slightly lower level and ranges from a minimum of $14.4973 to a maximum of $65.5902 per share for the observed period. The average deviation from the mean is $10.1601.

Monte Carlo simulation i.e. stock price prediction for the future period of one year (the average number of trading days on the stock exchange is 252, so that value is considered representative) is performed using the Matlab software. The prediction is made individually for the selected companies. Based on the corresponding code, the normalized daily rise in the stock price is first calculated, as well as the mean value and standard deviation for this data. As this prediction method is based on probability, the next step involves generating random numbers. To generate random numbers, a function that realizes their normal distribution is used. These random numbers represent the simulated price increments for the future period on the basis of which the price prediction for the future period is made.

For each company, a prediction in two cases is made: the first, when 1,000 possible outcomes are calculated, and the second, where the prediction is based on 10,000 possible outcomes. The number of outcomes indicates how many times the code (prediction) will be executed based on the input data (historical data), the set methodology and the randomly generated, different probabilities. Therefore, in the first case, when 1,000 possible outcomes are set, the stock price is simulated 1,000 times with differently generated random probabilities. The code is designed to predict the stock price trend for each of the total number of prediction days. As the final result, in this case, 1,000 different possible prices are obtained for the entire observed period of 252 days. In the second case, when 10,000 outcomes are set, the code is executed exactly that many times, and the result is based on 10,000 potential prices for each day of the prediction period. As the aim of the paper is to predict the stock price for one year, i.e. after 252 working days of the stock market from the moment of the last data, the results will be reviewed and analyzed in more detail with a focus on the last prediction day.

Figures are created based on simulated prices, the interpretation of which will be given in the rest of this paper.

## 4. Results and discussion

Stock price prediction will be discussed for Toyota and General Motors by simulating values based on 1,000 possible outcomes and 10,000 possible outcomes.

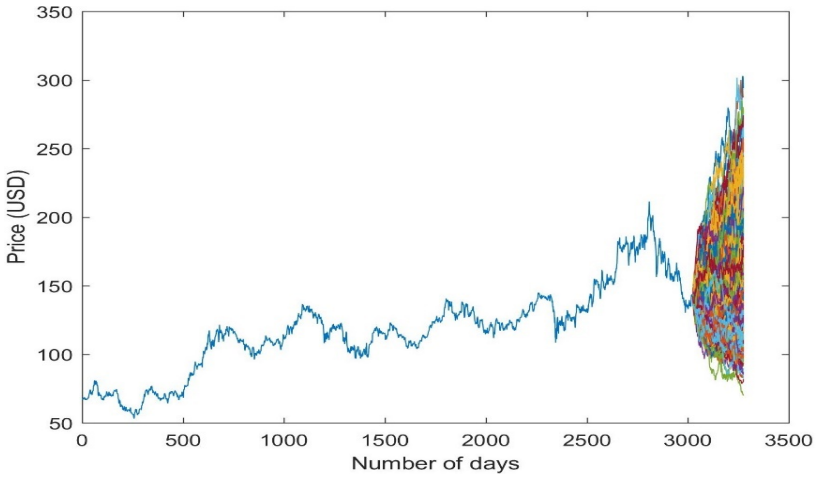
### *4.1. Stock price prediction for Toyota*

In this part will be presented stock price prediction for simulated values based on 1,000 possible outcomes and 10,000 possible outcomes for Toyota.

### 4.1.1. *Simulated values based on 1,000 possible outcomes*

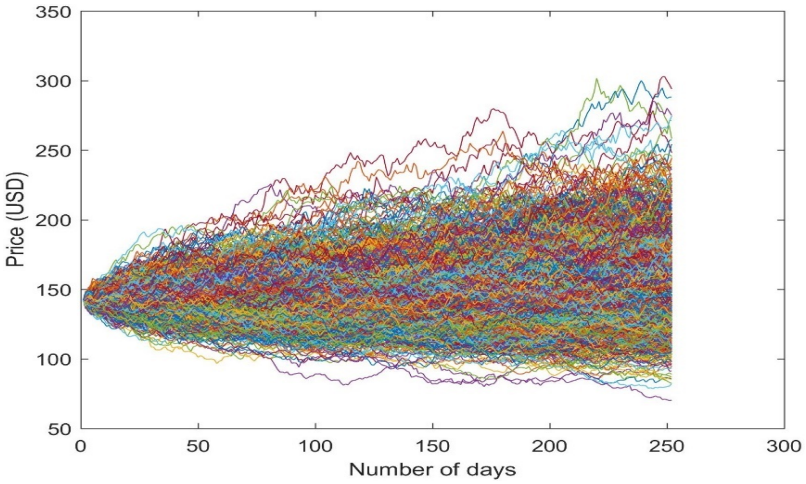
In order to achieve data comparability, Figure 2 summarizes historical data and predicted prices for the observed period. Taking into account the high volatility of the stock price in the previous period and the use of different probabilities for price prediction, the expected outcomes also indicate high volatility i.e. show 1,000 possible outcomes (prices).

**Figure 2. Historical and predicted stock prices for Toyota, 1,000 outcomes**




*Source:* Authors

**Figure 3. Predicted stock prices for Toyota, 1,000 outcomes**

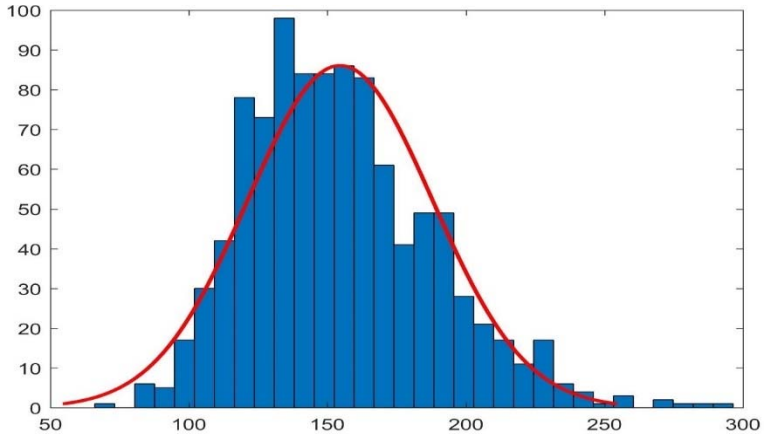



*Source:* Authors

A more detailed presentation of price movements can be seen in Figure 3. A large number of outcomes also generates a large amount of data, and only some of them can be seen in the figure, because the outcomes are similar and overlap. Each of these lines represents one possible outcome of the stock price trend in the future period. The initial value of the stock price, which is actually the last available historical data, can be seen in the figure, and is $142.16. Also, based on the obtained values, the average predicted stock price for the entire observed period is $148.2243, and it is obtained as the average value of the average prices for each day. According to the same principle, the minimum and maximum prices for the entire observed period are determined, and they amount to $69.9789 and $302.8726, respectively.

The following figure (Figure 4) shows the price simulation values for the last analyzed day. This figure shows the distribution of simulated stock prices on day 252. The x-axis shows the most common values of simulated stock prices, while the y-axis reflects the number of times each price is repeated. Also, the figure shows the normality of distribution of the obtained data. More detailed data on stock price values for the 252$^{nd}$ day is given in Table 2 (values are in USD).

**Figure 4. Histogram of predicted stock prices for Toyota on 252nd day, 1,000 outcomes**




*Source:* Authors

**Table 2. Values of descriptive statistics for predicted prices on 252nd day, 1,000 outcomes**

| 252nd prediction day | Minimum Price | Maximum Price | Average Price (mean) | Standard Deviation | Standard Error |
|---|---|---|---|---|---|
| Value | 70.3044 | 293.9690 | 154.5522 | 33.3597 | 1.0549 |

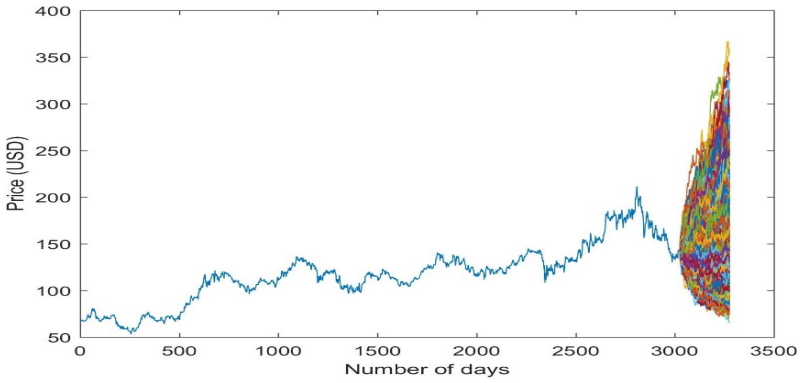
*Source:* Authors' calculation

Based on the values shown in Table 2, it can be seen that the stock price volatility in the case with 1,000 possible outcomes ranges from $70.3044 to $293.9690. The median expected price for one year is $154.5522. The table also shows that the average deviation from the mean price is $33.3597, and the standard error level is 1.0549.

### 4.1.2. *Simulated values based on 10.000 possible outcomes*

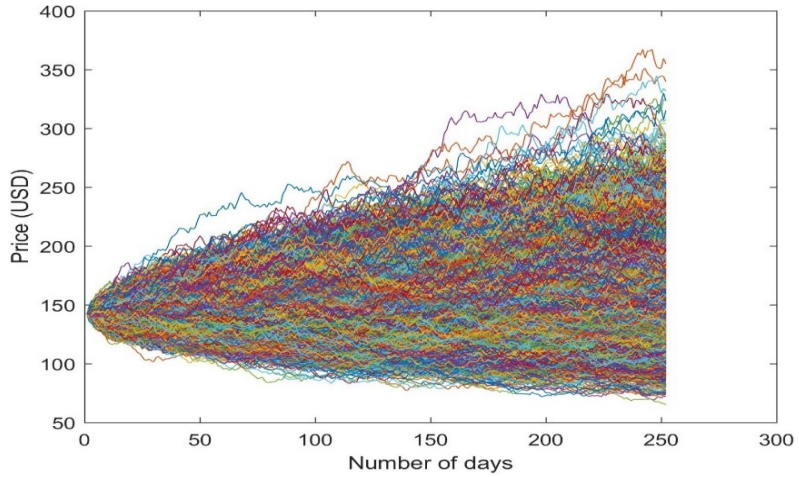
Another case of predicting Toyota's stock price includes 10,000 possible outcomes. Figure 5 summarizes historical and predicted stock price data. In this figure, one can also see the high volatility of predicted prices. Also, it can be seen that the volatility is within the limits of the previously established minimum and maximum prices for the previous period.

**Figure 5. Historical and predicted stock prices for Toyota, 10,000 outcomes**




*Source:* Authors

**Figure 6. Predicted stock prices for Toyota, 10,000 outcomes**

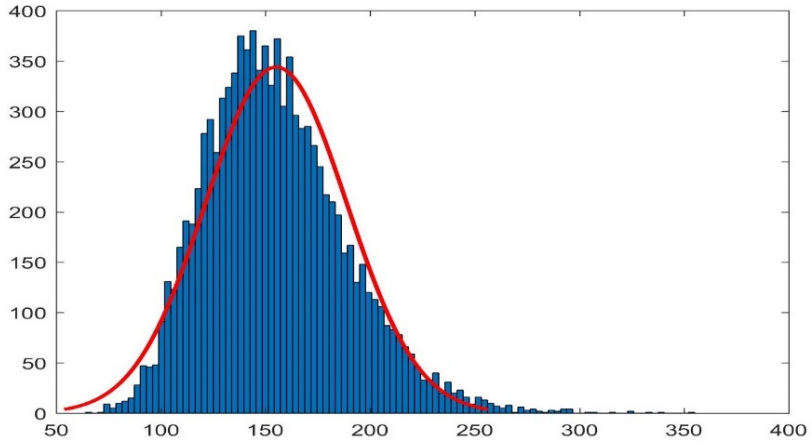



*Source:* Authors

Figure 6 represents the trend of simulated stock prices for 10,000 thousand possible outcomes. This figure shows an even larger amount of data, which can be seen based on the density of the lines (simulated situations). In this case as well, the simulation starts with the last available price, i.e. $142.16. Based on the performed 10,000 simulations, the average predicted stock price in the future is $148.4196 and it differs very little from the average price calculated on the basis of 1,000 simulations. The calculated minimum and maximum prices for the entire prediction period are $65,2045 and $367,1420, respectively. On the basis of the obtained values, a slightly higher fluctuation in the stock price trend can be noted.

In this case as well (10,000 outcomes), an analysis of simulated prices is performed on the last analyzed day. Figure 7 shows the distribution of simulated stock prices on day 252. The values on the x-axis show the most common values of the simulated stock prices, while the y-axis reflects the number of times each price is repeated. Also, the figure shows the normality of the distribution of the obtained data. More detailed data on stock price values for the 252nd day are given in Table 3 (values are in USD).

**Figure 7. Histogram of predicted stock prices for Toyota on 252nd day, 10,000 outcomes**




*Source*: Authors

**Table 3. Values of descriptive statistics for predicted prices on 252nd day, 10,000 outcomes**

| 252nd prediction day | Minimum Price | Maximum Price | Average Price (mean) | Standard Deviation | Standard Error |
|---|---|---|---|---|---|
| Value | 65.2045 | 354.9069 | 155.0612 | 33.7515 | 0.3375 |

Based on the values shown in Table 3, the stock price volatility is higher compared to the case with 1,000 possible outcomes. Volatility ranges from $65.2045

to $354.9069. The average expected price for one year is $155.0612 and it differs significantly from the average price calculated based on historical data, but it is close to the average price calculated based on 1,000 simulations. The average deviation from the mean price is $33.7515. It is approximately equal to the average deviation for a case with 1,000 outcomes. When it comes to the standard error level, there is a significant difference in the calculated value in this case, when it is 0.3375.

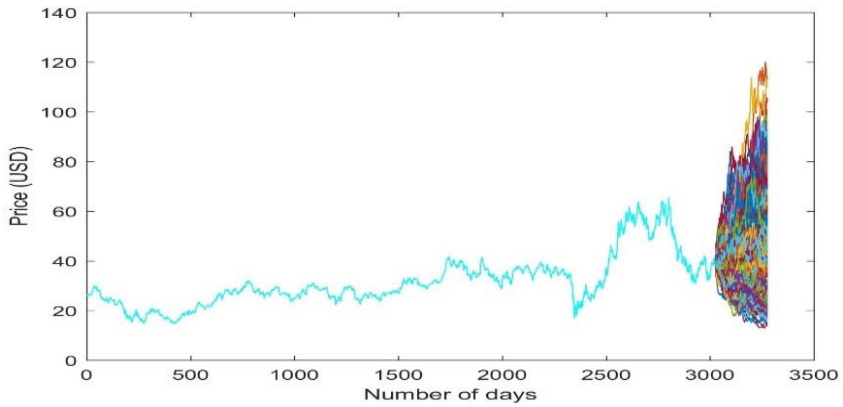
### *4.2. Stock price prediction for General Motors*

Stock price prediction for General Motors will be discussed for simulated values based on 1,000 possible outcomes and 10,000 possible outcomes.

#### *4.2.1. Simulated values based on 1,000 possible outcomes*

In the case of General Motors, as is the case with Toyota, Figure 8 highlights the relationship between historical and simulated stock price data for 1,000 outcomes. In this case, the volatility of predicted stock prices exceeds the range of price trends based on historical data.

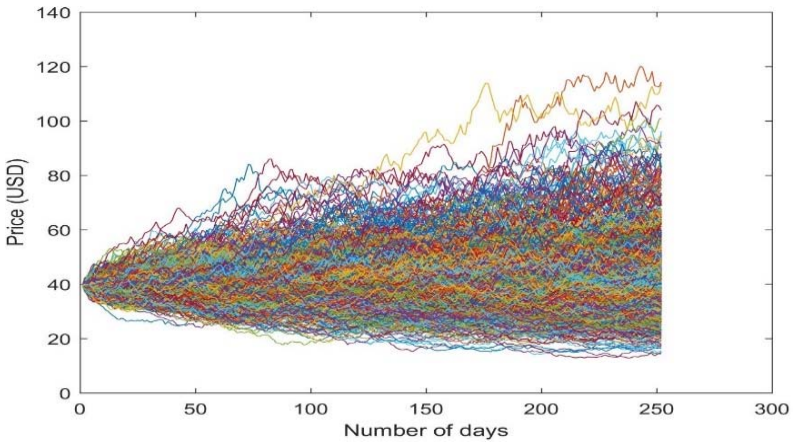
**Figure 8. Historical and predicted stock prices for General Motors, 1,000 outcomes**




*Source:* Authors

Figure 9 shows the trend of predicted stock prices for General Motors, for a period of one year (252 working days on the stock market) and with 1,000 outcomes. The starting value for the prediction is also the last price within the historical data set. For General Motors, it amounts to $39.52. Looking at the value of all predicted prices for the entire analyzed period, an average price is $41.51 and is calculated on the same principle as with Toyota. The predicted price trend ranges from $12.8104, as the minimum price, to $120.1992, as the maximum predicted price for the entire observed period.

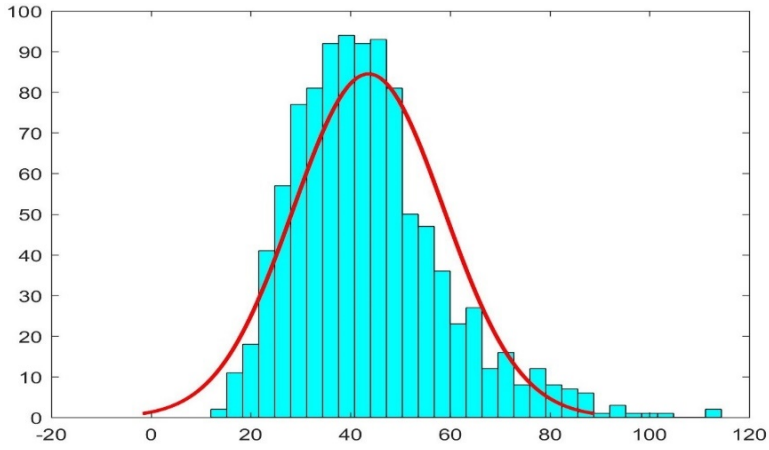
**Figure 9. Predicted stock prices for General Motors, 1,000 outcomes**




*Source:* Authors

The distribution of simulated prices on day 252, one year ahead, is shown in the following figure (Figure 10). The most common values of simulated stock prices are shown on the x-axis, and the number of repetitions for each price is shown on the y-axis. The results obtained by predicting the stock price for 1,000 outcomes have a normal distribution. More detailed data on share price values for the 252nd day is given in Table 4 (values are in USD).

**Figure 10. Histogram of predicted stock prices for General Motors on 252nd day, 1,000 outcomes**




*Source:* Authors

**Table 4. Values of descriptive statistics for predicted prices on 252nd day, 1,000 outcomes**

| 252nd prediction day | Minimum Price | Maximum Price | Average Price (mean) | Standard Deviation | Standard Error |
|---|---|---|---|---|---|
| Value | 14.3535 | 114.2395 | 43.6243 | 15.1017 | 0.4776 |

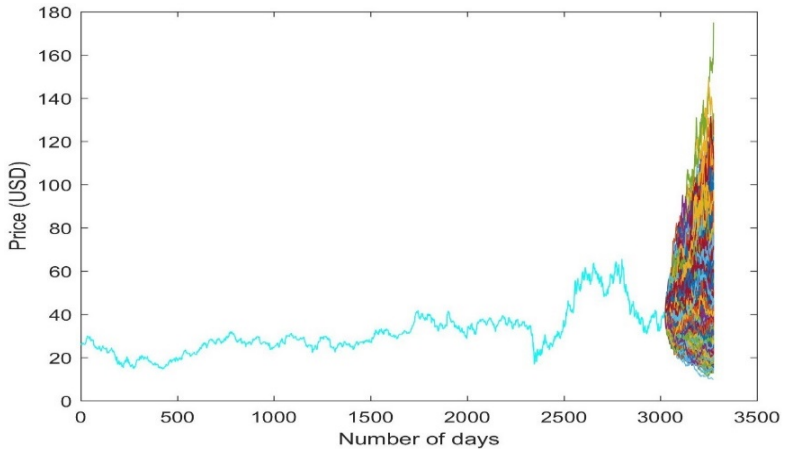
*Source:* Authors' calculation

According to the values shown in table 4, it can be seen that the price of General Motors stocks for one year can range from $14.3535, as the minimum predicted price for one year, up to $114.2395, as the maximum predicted price. The average predicted price is $43.6243, and the average deviation from the mean price is $15.1017. The calculated standard error based on the displayed data in this case is 0.4776.

### 4.2.2. *Simulated values based on 10,000 possible outcomes*

Another case of predicting the price of General Motors stock uses a set of 10,000 possible outcomes. Figure 11 summarizes historical and predicted stock price data. In this figure, one can also see the volatility of the predicted prices in a significantly wider range compared to the previously established minimum and maximum prices for the previous period.

**Figure 11. Historical and predicted stock prices for General Motors, 10,000 outcomes**

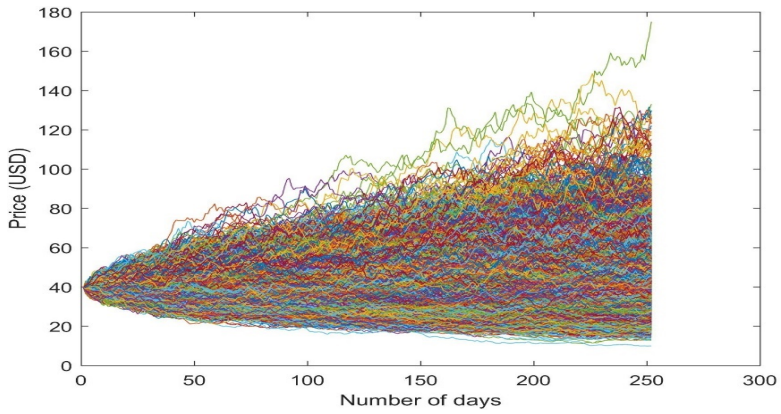



*Source:* Authors

Figure 12 shows the trend of predicted stock prices in the case with 10,000 outcomes. In this case too, the starting price matches the last known price obtained on the basis of historical data, i.e. on 21 November 2022, and amounts to $39.52. After calculating 10,000 potential (future) stock prices for a period of 252 days, an average predicted price is $41.3172. In this figure, quite a large price volatility can

be observed, ranging from the minimum predicted price of $9.7917 to the maximum predicted price of as much as $175.0419.

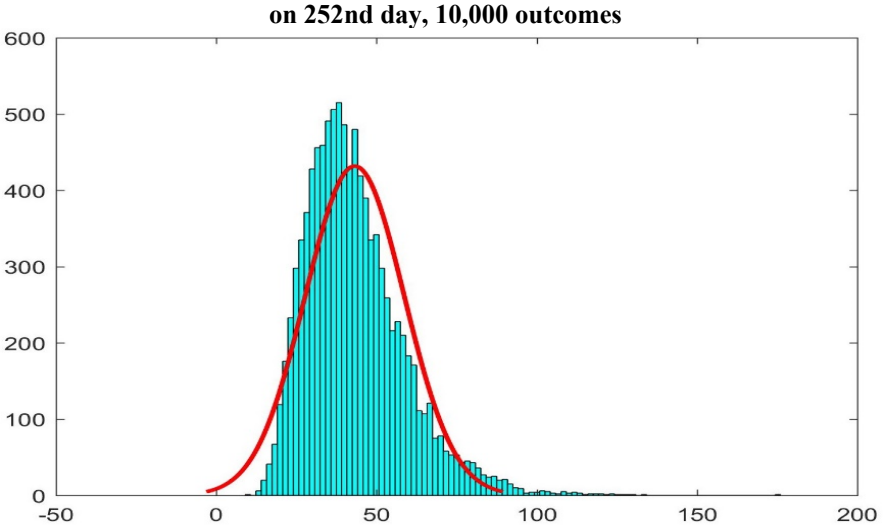
**Figure 12. Predicted stock prices for General Motors, 10,000 outcomes**




*Source:* Authors

A special analysis of the predicted stock prices for the future period is done on the last day, i.e. one year in advance. Figure 13 indicates the normality of distribution of obtained values, where the most common values of simulated stock prices are shown on the x axis, and the number of times of repetition for each price is shown on the y axis. Table 5 shows more detailed data on stock price values for the 252nd day.

**Figure 13. Histogram of predicted stock prices for General Motors on 252nd day, 10,000 outcomes**




*Source:* Authors

**Table 5. Values of descriptive statistics for predicted prices on 252nd day, 10,000 outcomes**

| 252nd prediction day | Minimum Price | Maximum Price | Average Price (mean) | Standard Deviation | Standard Error |
|---|---|---|---|---|---|
| Value | 9.9020 | 175.0419 | 43.1694 | 15.4244 | 0.1542 |

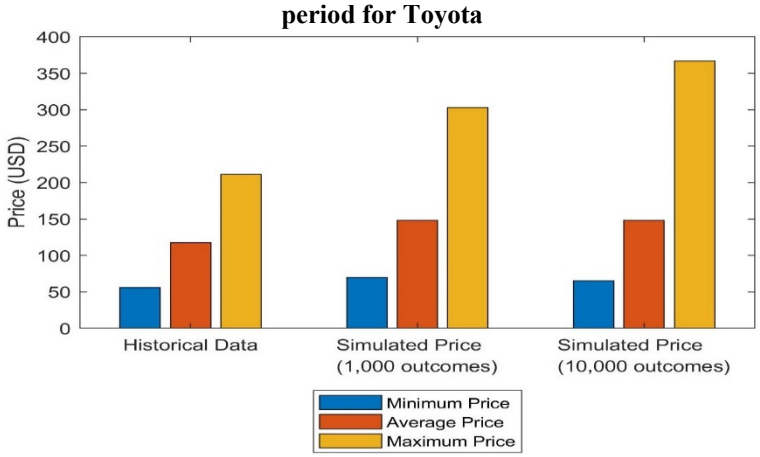
*Source:* Authors' calculation

Table 5 shows more detailed information on the trend of predicted stock prices on the 252nd day. The minimum predicted price is $9.9020, and the maximum is $175.0419. Such a wide range indicates high volatility in the stock price, where it will move between the minimum and maximum predicted, and most likely will be close to the average price of $46.1694. The average deviation from the mean price is $15.4244 and is approximately equal to the average deviation for the case with 1,000 outcomes. When it comes to the level of standard error, in this case it is twice as small compared to 1,000 outcomes and is 0.1542.

### *4.3. Comparative overview of Toyota and General Motors simulated prices*

On the basis of the conducted analysis, the predicted stock prices of Toyota and General Motors for the period of one year are determined. Although it is clear that there is a large difference in prices between these two companies, the analysis of the results of simulations of individual cases points to certain differences in the obtained values . Therefore, a summary overview of the obtained values is created, in order to perform a double comparative analysis: first, comparing the results with a larger and smaller number of outcomes, and second, comparing the differences in the range of price trends of the analyzed companies.

**Figure 14. Comparison of historical and simulated prices for the entire prediction period for Toyota**



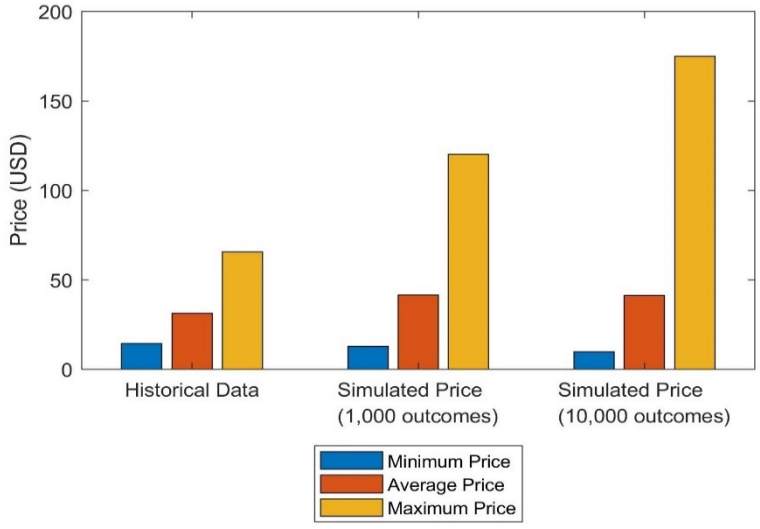

*Source:* Authors

Figure 14 provides a comparative analysis of the minimum, average and maximum price of historical data for Toyota, as well as the corresponding values for the simulated prices for the entire prediction period (prices are in USD).

By comparing the values shown in Figure 14, there is a small difference between the minimum price from the previous period and both predicted prices. The mean of the predicted prices for the two alternatives is approximately equal, but slightly different from the mean price of the historical data. However, from the point of view of the maximum price, the expected maximum price in the future period increases with the number of outcomes.

Figure 15 provides a comparative view of the minimum, average and maximum price of historical data for General Motors, as well as the corresponding values for the simulated prices for the entire prediction period (prices are in USD).

**Figure 15. Comparison of historical and simulated prices for the entire prediction period for General Motors**




*Source:* Authors

Looking at the minimum, average and maximum price of historical data for General Motors (Figure 15), as well as the corresponding value for simulated prices for the entire prediction period, the average price remains almost unchanged. On the other hand, there are differences in the minimum price, which becomes smaller as the number of outcomes increases, while the maximum price in the same case becomes larger.

After a comparative analysis individually for each of the companies, a comparative analysis of the observed indicators between companies is also carried out. Table 6 shows the changes in prices at the company level (the difference

between 1,000 and 10,000 outcomes) from the point of view of the entire price prediction period and from the point of view of the predicted prices at day 252 (after one year). Differences are shown in absolute amounts.

**Table 6. Differences between 1000 and 10000 simulations**

| Price | Toyota | General Motors | Total Difference |
|---|---|---|---|
| Prediction for one year | | | |
| Minimum | 4.7744 | 3.0187 | 1.7557 |
| Average | 0.1953 | 0.1928 | 0.0025 |
| Maximum | 64.2694 | 54.8427 | 9.4267 |
| Prediction on 252nd Day | | | |
| Minimum | 5.0999 | 4.4515 | 0.6484 |
| Average | 0.509 | 0.4549 | 0.0541 |
| Maximum | 60.9379 | 60.8024 | 0.1355 |

*Source:* Authors' calculation

When looking at the values of the total difference column for the prediction of stock prices, which refers to the entire period of one year (a total of 252 stock market working days), it can be seen that for both companies the biggest differences are in the maximum prices, while when calculating the average prices, the differences are almost non-existent. In the last column of Table 6, no big differences between price volatility ranges are observed. The situation is similar with the prediction on the 252nd day.

## 5. Conclusion

In this paper, stock price prediction for a period of one year is made for the two largest competitors in the automotive industry, Toyota and General Motors. The price prediction is made on the basis of the historical data of the stock price of the two companies on the NYSE (a period of 10 years) using the Monte Carlo method for a period of one year. The analysis is performed for both companies in two cases: the first including 1,000 possible outcomes, and the second including 10,000 possible outcomes.

Based on the initial data, there are differences in the price of stocks between Toyota and General Motors, but there is no difference in the influence of the market on the price trend.

Based on the obtained results, there is a small difference between the trend range of the predicted Toyota stock prices when looking at the entire prediction period and the price for exactly one year (252nd day). The biggest difference is observed when comparing the predicted maximum price. The situation is similar with General Motors.

Based on the comparison of the obtained results, there are certain differences in the predicted stock prices in the two observed situations (1,000 and 10,000 outcomes). This difference is particularly noticeable when looking at the maximum predicted prices in both cases. A significant upward trend of the maximum price with increasing number of simulations (outcomes) is observed for both companies. Also, an inversely proportional relationship between the minimum stock price and the number of simulations is observed, which is particularly pronounced in the case of General Motors. Based on that, it can be concluded that the starting hypothesis has been refuted.

The last part of the research indicates the difference in the range of volatility of the predicted stock prices between the two observed companies, as well as the fact that the number of possible outcomes significantly affects the predicted stock prices.

Summarizing all of the above, one general conclusion can be drawn, i.e. that if the average values for both companies are realized, which is most likely, their position on the market will not change. Nevertheless, the simulation shows that General Motors has a chance to take the leading position in case the optimistically predicted (maximum) price is realized for this company, and the pessimistically predicted (minimum) price for Toyota.

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## PREDVIĐANJE CENE AKCIJA NAJVEĆIH AUTOMOBILSKIH KONKURENATA NA OSNOVU MONTE KARLO METODA

**Apstrakt:** Prelazak na električna vozila bio bi veliki napredak za stanovništvo. S druge strane, ova tranzicija će napraviti veliki pritisak za kompanije u automobilskoj industriji, koje bi morale da razvijaju takva vozila i da budu bolja od tradicionalnih. Štaviše, prelazni rok može trajati dugo. U međuvremenu, stope prodaje automobila na fosilna goriva su i dalje dominantne u svetu. U ovom radu je napravljeno predviđanje cene akcija za dva najveća svetska konkurenta u automobilskoj industriji – Tojotu i Dženeral motors. Predviđanje pokriva jednu godinu, na osnovu istorijskih podataka o kretanju cena akcija koristeći Monte Karlo simulaciju u dva moguća slučaja: prvi, sa 1.000 ishoda, i drugi, sa 10.000 ishoda. Nakon simulacije cena sledi uporedna analiza rezultata dobijenih za ove dve kompanije. Rezultati pokazuju da što je veći broj ishoda naveden u predviđanju, to je veća varijabilnost rezultata u poređenju sa varijabilnošću istorijskih podataka. Drugim rečima, prelazak Dženeral motorsa na čelnu poziciju nije nemoguć.

**Ključne reči:** cena akcija, Monte Karlo metod, automobilska industrija.

### Authors' biographies

**Bojana Novićević Čečević**, PhD, Assistant Professor, was born in 1983 in Niš. She graduated from the Faculty of Economics in Nis and successfully defended her master's thesis in the subject of Strategic Management Accounting. She defended her doctoral dissertation entitled Management and Accounting Support to Company Management in a Lean Business Environment in 2016 at the Faculty of Economics in Nis. Since October 2008, she has been working at the Faculty of Economics in Nis. She is the author of a large number of papers published in leading national journals and proceedings of scientific conferences, co-author of the monograph and workbook from Management Accounting and Cost Accounting.

**Ljilja Antić**, PhD, Full Professor, was born in 1968. She defended her doctoral dissertation entitled Calculation of costs by activities in the function of managing a modern company in 2003 at the Faculty of Economics in Nis, where she began her academic career in 1991 as an assistant trainee. Her interests include the field of accounting, with a special emphasis on management accounting and modern methods and concepts of calculation and cost management. She is the author of several monographs and numerous papers published in leading national journals and proceedings of scientific conferences.

**Adrijana Jevtić**, MSc, Teaching Assistant, was born in 1993, in Niš. She is a PhD student at the Faculty of Economics, University of Niš, module Business management. Since December 2019, she has been working at the University of Belgrade, Technical Faculty in Bor on the Department for Engineering Management. She is the author of several papers published in leading national journals and proceedings of scientific conferences.