OTC market during COVID-19 pandemic and impact on its further development

Veronika Machová[1] , *Jiří* Kučera[2,*], and *Michaela* Juhaňáková[1]

[1]Institute of Technology and Business in České Budějovice, School of Expertness and Valuation, Okružní 517/10, 370 01 České Budějovice, Czech Republic

[2]University of Žilina, Faculty of Operation and Economics of Transport and Communications, Department of Economics, Univerzitná 1, 010 26 Žilina, Slovakia

Abstract

Research background: The onset of the COVID-19 pandemic strongly affected the development of the volume of trade on the OTC market. The volume was below its normal level due to the uncertainty and fear in the society.
Purpose of the article: The objective of the paper was to explain the differences between the period before the pandemic, during the pandemic, and to determine the predictions of further development until the year 2025
Methods: Using the method of neural networks, the prediction of the closing exchange rate until 2025 was determined based on the data from the past years, according to which the RM index value will be higher in December this year, with a subsequent slight decrease and fluctuations.
Findings & Value added: The results showed that the volume of trades was lower in the past compared to the period just before the pandemic, i.e. the year 2020, when the RM index was clearly highest. Investors should postpone investments until the value of the RM index is stable and trading on the OTC market is advantageous again. However, if they are willing to risk, investments can be made, although the return on investment will be unreasonably long.

Keywords: OTC market (RM System); RM index; method of neural networks; correlation coefficient; COVID-19 pandemic

JEL Classification: G01; G12

1 Introduction

As a result of the third wave of coupon privatization, there are countless securities owners who cannot trade on the Prague Stock Exchange (Mejstřík, 1997). Therefore, due to the OTC market control, with the permission of the Ministry of Finance of the Czech Republic, RM-System enters the organized capital market (Zeman, 2014). According to Machová et al. (2020), the OTC System uses very similar functions as the stock exchange; however, it

* Corresponding author: kuceraj@mail.vstecb.cz

includes also securities, such as bonds or shares etc., which do not meet the conditions for entering the stock exchange. Many small and medium-sized enterprises do not have any experience with trading on the OTC market because of their low awareness; they believe that it is too complicated and very risky (Dias et al., 2020). In fact, investing in the capital market is the easiest way to increase the value of their unused capital (Valášková, 2020).

Unfortunately, on the other hand, investing in securities is very risky, which is clearly described by the indexes. In 1993, when the RM-System started to be operated, the Czech National Bank with other organizers and large financial institutions created a number of indexes, which have been created by measuring changes in the market value of a representative portfolio of shares until now (Cvengroš, 1995).

Specifically, the ČEZ or Philip Morris ČR shares on the OTC market are currently very unstable, precisely due to the COVID-19 pandemic, which has influenced both people and all small, medium-sized, and large enterprises, surprised and scared them, which had an impact on all capital markets (RM-System, 2021; Šuleř et al., 2020). Although the third quarter of 2020 brought economic recovery, even after one year, the pandemic still affects the operation of various enterprises all over the world, as well as the supply and demand for the produced or offered goods or services, which are nearly minimal (Cieslar, 2020).

The objective of the paper is to evaluate the impacts of the COVID-19 pandemic on the development of RM-System stores.

In order to achieve the objective, the following research questions are formulated:

RQ1: How did the volume of trades develop before the COVID-19 pandemic?

RQ2: How did the volume of trades develop during the COVID-19 pandemic?

RQ3: What is the expected development of the volume of trades until 2025?

2 Literature research

Based on research, the author aimed to detect the development of volume of trade before the COVID-19 pandemic. Stock exchanges are considered the key institutions which provide capital to enterprises and help them to gain competitive advantage through economies of scale (Vychytilová, 2018). The efficient functioning of municipal bond market is essential for providing public services, since it is the biggest capital market for state and municipal issuers (Cestau et al., 2019). Recent regulatory initiatives to improve transparency made detailed business data available to researchers, making the market with municipal bonds a natural laboratory for studying financial intermediation, asset valuation on decentralized markets, and local public finance (Cestau et al., 2019). Hendershott et al. (2020) analysed the network of business relationship between insurance companies and traders on the OTC corporate bond market. Regulatory data show that one third of insurance companies use one dealer only, while other insurance companies have large dealer networks (Hendershott et al. 2020).

Van Bavel studied the cycles of growth, imbalance and decrease on several economic markets over the last 1500 years. However, his arguments are built on a confusion between finance and capital goods (Hodgson, 2021). The development of share prices is a dynamic and non-linear processes influenced by several factors. An interesting fact is the unpredictability of share prices as a result of the global financial crisis (Vochozka et al. 2020). Disclosing the terms of a transaction provides information the seller has on the asset quality and reduces the dealer´s rent when they dispose of the inventory in the second transaction. It shows that costly signalling in a transparent market is beneficial for investors through lower spread and higher volume (Back et al., 2020). Unique data at the level of transactions and identity, Cenedese et al. (2020) provide the first systematic study of interest swaps traded over the counter (OTC). The authors thus identified a significant and permanent heterogeneity of the derivative prices consistent with a pass-through of regulatory costs on

market prices by means of the so-called valuation adjustments (XVA). Clients thus pay higher price for buying interest-rate protection from dealers, i.e. clients pay a higher fixed rate, if the contract is not cleared by means of a central counterparty. This OTC premium decreases with disclosing initial margins and higher creditworthiness of a buyer (Cenedese et al., 2020). In his work, Weill (2020) formulates and solves a simple model to demonstrate typical prerequisites and economic forces at play.

The Covid-19 pandemic has had a strong impact on the economy and capital market. In times of crisis, it is important for investors to be able to diversify their investment portfolio in order to reduce the risk. During the Covid-19 pandemic, research on financial integration began to develop, especially on the main global capital markets. Therefore, it is important to extend the research to other capital markets. The results also show that the majority of significant structural turns occurred in March 2020. The analysis of the relationship between the markets in the short term shows positive / negative co-movements with a statistical significance and persistence longer than one week (Pardal et al., 2020).

The marginal expected deficit measure is based on the well-known concept of expected deficit. More precisely, it can be considered a conditional version of expected deficit, where the global revenues exceed a given market decline (Hendrych and Cipra, 2017).

The specific objectives of Nasseri et al. (2020) consisted in using the stochastic dominance criterion to evaluate the performance of over-the-counter (OTC) companies in a developing countries and their analysis using a hybrid model including the particle swarm optimization and artificial neural networks. Optimization of investment portfolios must enable correlations between the revenues in a considered period of financial maintenance, if there is an asymmetric distribution of revenues.

Neklyudov (2019) develops a model of basic search and matching model, which generates robust central discount expendable lower supply and demand offered by more central sellers. If traders are allowed to move sufficient amount of trading capital between their idiosyncratic states, the same model parameters might produce a centrality premium.

Arseneau et al. (2020) prove that trading frictions on the OTC markets leads to inefficient provision of private liquidity. They developed a dynamic model of market financial intermediation with a two-way interaction between the primary credit markets and secondary OTC markets. In contrast, Lester and Weill (2020) developed a solution technique which enables full applicability of the model and enables derivation of theoretical formulas for key statistics analyzed by empirical studies of the intermediation process on the OTC markets.

The analysis and possible prediction were made using the method of neural networks. Accurate stock price forecasting is currently very difficult in today´s economy. Accurate prediction plays an important role in helping investors to improve the return on capital. Logically, in recent years, a number of new approaches and technologies have been proposed, which are able to predict stock prices. One of them is the method of artificial neural networks, which have a number of advantages compared to the traditional methods (Horák and Krulický, 2019). Time series smoothing is carried out using artificial neural networks, which is followed by exponential smoothing of time series and subsequent comparison of predicted time series of the future stock price trends predicted using the most successful neural network. Finally, predicted prices are calculated by means of exponential smoothing of time series (Horák and Krulický, 2019). Traditional methods are no longer sufficient for predicting the development of stock prices. Over-reliance on prediction data can lead to losses in the case of software failures. Vochozka et al. (2020) aim to innovate the management of predictions when predicting the development of stock prices over time using neural networks.

3 Data and methods

The development of the volume of trades is analysed on the example of several years before and after the COVID-19 pandemic. As for the period before the COVID-19 pandemic, the data from the period between 2 January 2017 and 31 March 2021 are considered. The data from the period during the COVID-19 pandemic include the period of 1 April 2020 – 1 April 2020; the prediction considers the date from the period of 1 April 2021 – 31 December 2025.

The data on the development of volume of trades will be obtained from the official websites of the RM-System, Czech stock exchange (RM-SYSTÉM, Czech Stock Exchange, 2008), in the Results tab, where it is possible to enter individual periods and find out about the RM index in a given period. RM index is shown as a weighted average of 9 main titles (for more details, see Table 1).

Table 1. RM index structure

Name	BIC	ISIN	Number (pcs)	Weight (%)
ČEZ, a. s.	BAACEZ	CZ0051123	215,195,904	26.42
Erste Group Bank AG	BAAERBA	AT00006520	317,012,763	22.06
O2 Czech Republic	BAATELEC	CZ00090932	322,089,890	21.26
Komerční banka	BAAKOMB	CZ00080191	30,407,882	12.41
Deutsche Telekom AG	BAADETEL	DE00055575	218,066,000	8.99
Unipetrol	BAAUNIPE	CZ00090915	181,334,764	3.70
CETV	BAACETV	BMG200452	36,024,273	1.90
Philip Morris Czech Republic	BAATABA	CS00084188	1,913,698	1.71
CPI FIM	BAAORCO	LU01226247	65,663,196	1.54

Source: RM-System (2021)

The development of the volume of trades is calculated using the method of neural networks in the programme TIBCO, Statistica, version 135.0.17. After starting the programme, we will select the file from which the programme uses all data, and the icon of time series (regression). Next, we will select the data to examine and consider; in this case, it will be the data on the closing rate (9) on the left; on the right, it will be the date (1), day of the month (2), day of the week (3), month (4), and year (5). In the field "Random selection", we will choose 70% for training, 15% for test, and 15% for validation; for sampling, we will choose the value 1,000. The next step is to check off all activation functions in the training algorithm in the right and left part of the table, i.e. identity, logistic, hyperbolic tangent, exponential, and sine. In the tab "Speed", for the MLP networks, we will select 3 for minimum and 11 for maximum, for the RBF networks, we will select 21 for minimum and 30 for maximum, in the tab "Networks for training", we will select 1,000, and "Retain networks" 5. For spreading of the signal, the following activation functions will be selected:

$$\text{Identity: } 2ab + b^2 \tag{1}$$

$$\text{Logistic: } \sigma(\xi) = \frac{1}{1+e^{\xi}} \tag{2}$$

$$\text{Hyperbolic tangent: } \sigma(\xi) = \frac{1-e^{-\xi}}{1+e^{-\xi}} \tag{3}$$

$$\text{Exponential: } y = f(x) = a^x \tag{4}$$

$$\text{Sine: } sin\,\alpha = \frac{a}{c} \tag{5}$$

To find out the prediction, the data are changed so that they correspond with the date for which the prediction is made.

The results answering the RQ1, RQ2 and RQ3 are presented in the form of the following graphs and tables:

1. Overview of retained neural networks (Table 2).
2. Graph of residuals (Figure 1).
3. Graph of smoothed time series (Figure 2).
4. Graph of predictions until the year 2025 (Figure 3).

4 Results

There was presented the development of individual closing rates for the period under review (i.e. 2021-2025).

The predicted closing rate of the first degree is between 513.01 and 491.35 and reaches its maximum at the beginning of the period under review (i.e. until the year 2021) and its minimum in the year 2025. Its curve drops sharply every day from the end of the first quarter of the year 2021 until its end, where the curve slows down and declines slightly until September 2022; until 2023, it stagnates and remains at the same level every day, in the range of the minimum decimal difference until the year 2025.

The closing rate of the second degree ranges between 551.22 and 431.79, reaching its maximum in the year 2021 and minimum in the year 2025. Similarly, the values of the closing rate of the fifth degree range between 504.61 and 475.45, reaching its maximum in 2021 and minimum in 2025. Its curve declines slightly for the whole period under review, its value being a minimum of a decimal lower each day. Also, it shows that in this degree of the closing rate, the difference between the minimum and maximum is very small for the whole monitored period.

Table 2. Retained neural networks.

Index	Net. Name	Training perf.	Test perf.	Validation per.	Training error	Test error	Validation error	Training algorithm	Eror function	Hidden activation	Output activation
1	MLP 5-10-1	0.994641	0.9955	0.995944	637.303	590.1123	514.2679	B FGS 238	SOS	Logistic	Identity
2	MLP 5-6-1	0.994346	0.99573	0.995908	672.4303	546.0771	517.0932	B FGS 438	SOS	Tanth	Tanth
3	MLP 5-7-1	0.993774	0.99519	0.995685	741.456	612.9076	551.6924	B FGS 140	SOS	Tanth	Logistic
4	MLP 5-11-1	0.995564	0.996340	0.996240	527.704	496.9397	475.9248	B FGS 283	SOS	Tanth	Identity
5	MLP 5-9-1	0.994277	0.9954	0.995940	681.557	599.5794	514.6642	B FGS 120	SOS	Logistic	Logistic

Source: authors (2021).

The network structure is the multilayer perceptron network (MLP), with 5 data at the input (date, month, year, day of the week and day of the month), 10 or other number of neurons in the hidden layer, and 1 output, which is the RM index in this case. The network performance in the training, test, and validation dataset is given by the correlation coefficient, whose ideal value is as close to zero as possible, which means higher accuracy of the network. Training and test errors presented in the table are acceptable. The selected training algorithm is BFGS (see Table 2).

In this table, the samples are divided into training, test and validation datasets and presented with the statistical characteristics of the input data. The table also presents the training minimum, maximum, means, and standard deviations. The ideal outputs are very similar or approximately the same data in the individual datasets. The output is the closing rate as it really was in reality.

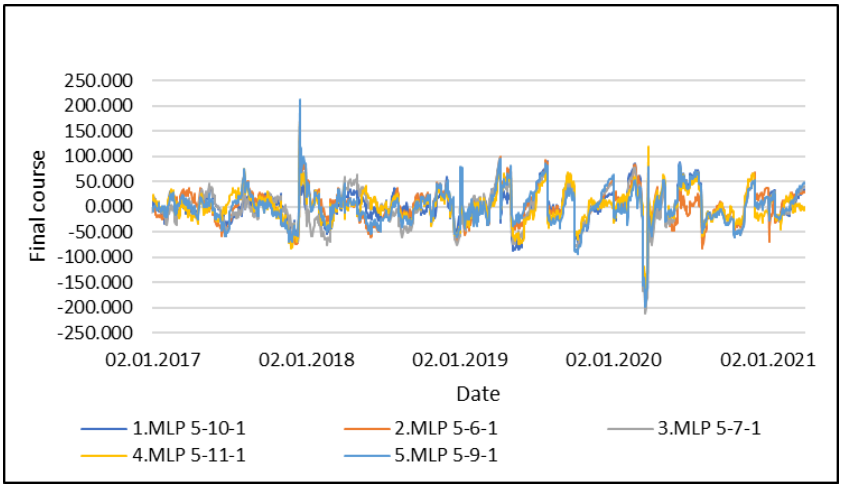

Figure 1. Graph of residuals

Source: authors (2021)

Figure 1 shows the data concerning dates, more specifically, the period between 2 January 2017 and 31 March 2021, i.e. the dates from the period when the COVID-19 pandemic did not influence the priorities of the society and the period when the influence was already occurring. There are also included the data on the deviations from training and testing individual neural networks, which is clearly presented in the Graph. The data in the Graph provide answers to RQ1 and RQ2.

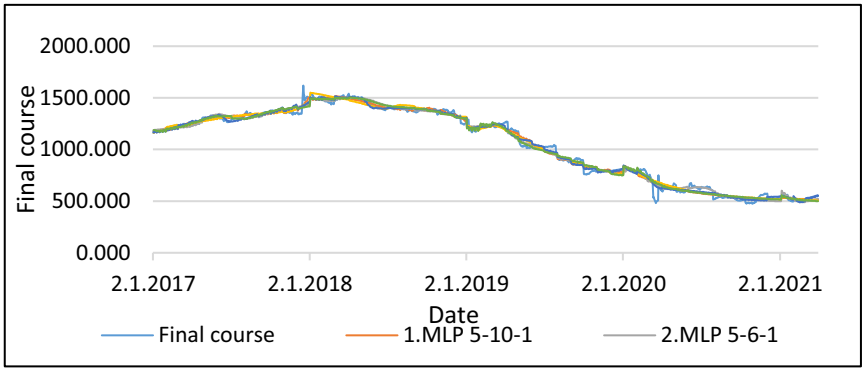

Figure 2. Smoothed time series

Source: authors (2021)

Figure 2 shows the curve of results of training and testing individual neural networks. It includes the data from the year 2017 until the end of March 2021 and the level of the RM index closing rate, which, as it clearly shows, changes and fluctuates every day. The Graph provides answers to RQ1 and RQ2.

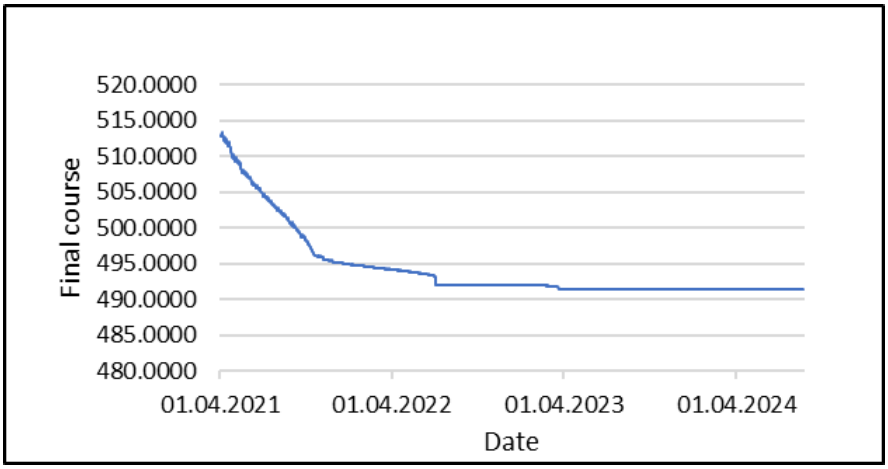

Figure 3. Graph of predictions until 2025.

Source: authors (2021)

Five different graphs were created based on the results of training and testing individual neural networks. For the prediction until the year 2025, the ideal one was selected, which slightly decreases gradually. The graph includes the data from April 2021 to the year 2025 and the resulting predicted data on the RM index. This Graph provides answers to the RQ3 and shows the prediction of the RM index closing rate until the year 2025 (see Graph 3).

5 Discussion of results

Based on the results obtained, it is possible to answer the formulated research questions as follows:

How did the volume of trades develop before the COVID-19 pandemic?

The closing rate was different every day in the orders of tenths or hundredths; yet the deviation was clear. The fluctuation of the RM index was natural, as there is no market on which the values at the end of the day and at the beginning of the following day were the same; it is thus the same on the OTC market. Contrary to the value of the RM index in 2017, its closing rate at the end of March 2021 differed significantly (by 1,143.77).

The closing rate on the OTC market was smooth and slightly fluctuating at the same time, developing over the years, with the volume of data slightly growing, since the awareness and interest in OTC markets has been growing.

How did the volume of trades develop during the COVID-19 pandemic?

With the onset of the COVID-19 pandemic and the related anti-pandemic measures, the volume of trades on the OTC market dropped sharply. It can be said that it happened suddenly, between 16 – 23 March 2020, when the value fell to 199.425, as the Czech government announced that due to the pandemic, there would be a closure of all types of schools. After a few days, however, the value of the RM index unexpectedly returned to normal, when the curve fluctuates every day. It can be said that the curve remained at normal but since March 2020, it decreased steadily, which can also be seen in Graph 2. This is also confirmed by the statement that "the results also show that most structural turns occurred in March 2020. The analysis of the relationship between the markets in the short term showed positive / negative co-movements with a statistical significance and persistence longer than one week" (Pardal et al., 2020).

The pandemic is strongly affecting all trades due to the fear and uncertainty that emerge in the society. Therefore, the volume of trades fell suddenly and decreased steadily for several weeks.

And finally, what is the expected development of the volume of trades until 2025?

Unfortunately, according to the prediction, the development of the volume of trades in the next 5 years will not differ significantly from the development during the COVID-19 pandemic. As Vochozka et al. (2020) argue, the development of stock price is a dynamic and non-linear process influenced by several factors. An interesting fact is the unpredictability of stock prices as a result of the global financial crisis, which the author fully agrees with, and which is confirmed in practice in the event of the COVID-19 pandemic. According to the prediction made using the Statistica programme, the curve of the RM index values will slightly decrease till the point where the value of the closing rate is stable and balanced for several days in a row, which is expected to happen in December 2021.

The closing rate in the next 5 years was predicted at the same value as during the pandemic. As known from the past, the unpredictability of stock prices due to the global financial crisis is notable, which has been confirmed in this case.

The results of this study could be useful for investor who are willing to invest further without any limitations, as well as for investors who are new to the OTC market and anybody else who is interested in the development of the RM index and market development as such.

6 Conclusion

The objective of the paper was to compare the development of the volume of trades on the OTC market before the COVID-19 pandemic, starting from the year 2017 to March 2020, when the first cases of coronavirus disease appeared in the Czech Republic and the Czech government started to adopt first anti-pandemic measures. The data from this period were compared with the data on the volume of trades during the pandemic until the year 2021, when the method of neural networks was used to make the prediction for the period after the COVID-19 pandemic until the year 2025. Using the method of neural networks, the curve of the RM index values was predicted, which means that the objective was achieved.

The predicted closing rate of the RM index does not correspond to its real development between the year 2017 and 2020. It can thus be concluded that the difference is caused by the impacts of the pandemic, which has influenced both the social life and purchasing behaviour of the whole country. This, however, had been expected, given the hysterical fear concerning the future and further critical development that was about to take place. The predicted RM index shows a downward trend; however, this is a satisfactory result given the crisis has lasted for a year. The market as well as the society need time to get back to normal. The fact that the COVID-19 pandemic is still ongoing and not all its effects on the economy and OTC markets have been identified is the limitation of the research. Therefore, the authors would recommend enterprises that want to invest to postpone the investments until the value of the RM index stabilizes and trading on the OTC market is advantageous again. If enterprises are willing to risk, the investments can be made; however, it should be considered that the return could be unreasonably long.

The above results providing the answers to the research questions provoke other questions, such as “When will the RM index achieves its initial or better values than those achieved as a result of the pandemic?” “Will the effects of the pandemic be predictable only or can its effects on the OTC market be much worse?” “Is it advantageous invest in corporate shares when the period of the pandemic crisis is difficult for keeping businesses or companies still capable of operating in the market?” and many others, which cannot be answered on the basis of the data obtained. Therefore, it is necessary to conduct further research to answer these questions and obtain clear data that would help understand better the relationship

between the effects of the COVID-19 pandemic and the development of the volume of trades on the OTC market.

Reference

1. Arseneau, D. M., Rappoport, W. D. E., & Vardoulakis, A. P. (2020). Private and public liquidity provision in over-the-counter markets. *Theoretical Economics*, 15(4), 1669-1712.
2. Back, K., Liu, R. M., & Teguia, A. (2020). Signalling in OTC markets: benefits and costs of transparency. *Journal of Financial and Quantitative Analysis*, 55(1), 47-75.
3. Cenedese, G., Ranaldo, A., & Vasios, M. (2020). OTC premio. *Journal of Financial Economics*, 136(1), 86-105.
4. Cestau, D., Hollifield, B., Li, D., & Schurhoff, N. (2019). Municipal bond markets. *Annual Review of Financial Economics*, 11, 65-84.
5. Cieslar, J. (2020, December 17). *Třetí čtvrtletí přineslo ekonomické oživení [The third quarter brought an economic recovery]*. Český statistický úřad [Czech Statistical Office]. https://www.czso.cz/csu/czso/treti-ctvrtleti-prineslo-ekonomicke-oziveni
6. Cvengroš, F. (1995) Indexy kapitálového trhu v ČR [Capital market indices in the Czech Republic]. *Finance a Úvěr [Finance and credit]*, 45(6), 304-316.
7. Dias, R., Alexandre, P., & Heliodoro, P. (2020). Contagion in the LAC financial markets: The impact of stock crises of 2008 and 2010. *Littera Scripta*, 13(1), 32-45.
8. Hendershott, T., Li, D., Livdan, D., & Schurhoff, N. (2020). Relationship trading in over-the-counter markets. *Journal of Finance*, 75(2), 683-734.
9. Hendrych, R., & Cipra, T. (2017). Marginal expected shortfall: The Czech px index case study. *11th International Days of Statistics and Economics*, *Czech Republic* (pp. 459-468).
10. Hodgson, G. M. (2021). On the limits of markets. *Journal of Institutional Economics*, 17(1), 153-170.
11. Horák, J., & Krulický, T. (2019). Comparison of exponential time series alignment and time series alignment using artificial neural networks by example of prediction of future development of stock prices of a specific company. *Innovative Economic Symposium - Milestones and Trends of World Economy (IES)*, China, 61.
12. Machová, V., Krulický, T., & Horák, J. (2020). Comparison of neural networks and regression time series in estimating the development of the afternoon price of gold on the New York stock exchange. *Social and Economic Revue*, 1, 61-72.
13. Mejstřík, M. (1997). Evolution process of Czech privatization. *Politická Ekonomie*.
14. Nasseri, A., Jamshidi, S., Yazdifar, H., Percy, D., & Alam, M. A. (2020). Evaluating the performances of over-the-counter companies in developing countries using a stochastic dominance criterion and a PSO-ANN hybrid optimization model. *Journal of Applied Accounting Research*, 21(3), 563-582.
15. Neklyudov, A. (2019). Bid-ask spreads and the over-the-counter interdealer markets: core and peripheral dealers. *Review of Economic Dynamics*, 33, 57-84.
16. Pardal, P., Dias, R., Šuleř, P., Teixeira, N., & Krulický, T. (2020). Integration in Central European capital markets in the context of the global COVID-19 pandemic. *Equilibrium-Quarterly Journal of Economics and Economic Policy*, 15(4), 627-650.

17. RM-Systém [RM SYSTEM]. (2021, September 23). *Souhrnné statistiky [Summary statistics]*. https://www.rmsystem.cz/vysledky/historie-obchodovani/souhrnne-statistiky
18. Šuleř, P., Horák, J., & Krulický, T. (2020). Validation of the prediction of ČEZ stock prices. *Littera Scripta*, 13(1), 194-210.
19. Valášková, K. (2020). Coronavirus and the economy: a crisis like never before or just a temporary trip. *Journal of Economic Info,* 7(3), 152-154.
20. Vochozka, M., Horák, J., & Krulický, T. (2020). Innovations in management forecast: time development of stock prices with neural networks. *Marketing and Management of Innovations*, 2, 324-339.
21. Vychytilová. J. (2018). Stock market development beyond the GFC: the case of V4 countries. *Journal of Competitiveness*, 10(2), 149-163.
22. Weill, P. O. (2020). The search theory of over-the-counter markets. *Annual Review of Economics*, 12, 747-773.
23. Zeman, K. (2014). *Analýza privatizačního procesu v České republice [Analysis of the privatization process in the Czech Republic]*. Karolinum.