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Република Северна Македонија
SS. CYRIL AND METHODIUS UNIVERSITY IN SKOPJE
Republic of North Macedonia

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ARIMA FORECASTING FOR NEW COVID-19 CASES IN NORTH MACEDONIA

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Abstract

One of the most serious challenges on global level in the past year and a half was the COVID-19 pandemic. Having severe impact on almost every segment of the society, pandemic has made difficult downward changes: weakening of the economy, placing enormous burden on the public health service providers, putting limitations on free movement and travel, reducing the education to online lectures etc. One complicated aspect of the pandemic is its turbulence with three waves of rise in infections and now the begging of the fourth wave as results of the new Delta variant.

While the world hopes for the day when the pandemic will end, rising numbers of new COVID-19 infections seem to postpone the end of the crisis. This paper aims to test the ARIMA model whether it can be used as a good forecasting model of the new daily COVID-19 cases in North Macedonia. If the results are proven to be acceptable, the model can be used for forecast that can be used as valuable input for policy makers and their decisions on the new and current restrictions.

JEL classification: I18, C22, C53

Keywords: COVID-19, ARIMA model, Forecasting

Introduction

Global COVID-19 pandemic has taken the world by storm and caught many nations unprepared and in disbelief of the vast impact it has brought. The effects of this disease are numerous, and it could not be foreseen. Unlike the other pandemics of the 20th century (Spanish flu in 1918, Asian flu in

1957, HIV/AIDS in 1981 and SARS in 2003), the COVID-19 pandemic was introduced in a highly technological world with incredible movement and travel of the population. While some governments reacted promptly, others lagged behind. The race for vaccine brought results and after less than a year it was available. Economy suffered, health systems were on a verge of collapsing, and governments tend to balance between restrictions measures and keeping the economy alive, particularly in sectors such as tourism and hospitality. By August 2021, there were total of 207 million cases worldwide, with 4.36 million deaths.

North Macedonia was also hit hard by the pandemics. After the initial COVID-19 wave, government put heavy restrictions in the spring and summer of 2020, and thus keeping the number of infections relatively low (below 200 new cases per day). Second wave hit in November 2020, where the peak reached 1,079 new cases per day. Another set of restrictions was given; however, it was not sufficient to stop the British variant of the virus that started the third wave. Situation stabilized in the spring and summer of 2021 with significantly low number of new cases, and many of the restrictions were lifted. With people travelling in the summer without any national restrictions and the new Delta variant started to take effect rapidly increasing the number of new cases, and introducing the fourth wave. An estimated percent of 35% - 55% of population is vaccinated, which reduces the number of fatal incomes, but not the number of infections. In August 2021 total number of cases in North Macedonia is 162,000 with total of 5,552 deaths.

The pandemic has serious impact on the global and national economy, health systems, educational systems, poverty, labor markets, with variety of psychological effects onto the population. While waiting and hoping for the pandemic to end, new variants arise, and new waves extend the crisis. This paper tends to examine the ARIMA model and its performance in forecasting the new cases on the national level in the upcoming period. Concise prediction will give valuable input for further decisions in managing of the crisis.

Literature review

Using statistical models to predict the COVID-19 pandemic is not a novelty. Many statistical approaches were applied, by different authors, to find which performs the best. ARIMA models are found to be as one of the most successful in predicting the number of new COVID-19 cases, deaths, recoveries, even the vaccination rate. They find their application in different

analysis for different countries, since the current epidemic situation varies from one nation to another, due to the restrictive measure undertaken by the government and the percentage of vaccinated population.

By using ARIMA (1,2,0) model Kufel (2020) forecasted the dynamics of COVID-19 cases for selected European countries in each stage of the epidemic as a manner of evaluation of the implemented non-pharmaceutical countermeasures on the dynamics of the epidemic.

Tandon et al. (2020) emphasize the importance of the prediction of the future infected cases to support prevention of the disease and aid in the healthcare service preparation. They used data for countries with highest confirm infections (US, Spain, Italy, France, Germany, China and Iran) and countries in South-Asia region (India, Indonesia, Thailand, Bangladesh, Shri Lanka, Maldives, Nepal, Bhutan and Timor-Leste). They applied different forecasting techniques (ARIMA model, Single exponential smoothing, Double exponential smoothing, Moving average, S-Curve trend model, Quadrating trend model and Linear trend model). They conclude that for forecasting ARIMA modeling is one of the best modeling techniques.

Paper from Sengupta (2020) investigates the possible time required for India before the numbers of daily infected people could start declining and what could the peak value hit by then. ARIMA model, SAR epidemical model, and ML regression model are used for the initial predication and then the results are fit into a stacked LSTM model which makes the final prediction.

ARIMA models are used not only to predict the daily new cases. Using the Machine Learning approach based on ARIMA models Maitre et al. (2020) manage to forecast the probable increase or decrease in vaccination rates for developed, developing and undeveloped countries, to understand which country needs more attention in terms of vaccine supply and/or creating awareness amongst its citizens. Their conclusion is that vaccination rate for developing countries is increasing at fast pace, or 50 – 80 people per hundred are getting vaccinated in the next month, while in the developing countries 30 -60 people per hundred are being vaccinated in the following month. For underdeveloped countries not all data for vaccination is available, and thus the forecast is 10 – 50 people per hundred to be vaccinated in the following 30 days.

To predict the growth of COVID-19 in Spain, Carrión-García et al. (2021) apply ARIMA models with accurate predictions. ARIMA models are also used to analysis of COVID-19 case series in Peru. The results obtained with the ARIMA model show adequate adjustment of the values and finds the model as a simple and immediate tool to approximate the number of

cases Sotomayor and Carlos (2021). Another application of ARIMA models was made to forecast COVID-19 confirmed cases, deaths and recoveries in Pakistan. The fitted forecasting models revealed high exponential growth in the number of confirmed cases, deaths and recoveries (Yousaf et al., 2020).

Lucic et al., (2021) test ARIMA and Seasonal Trend Random Walk forecasts to determine which is more appropriate for modeling the spread and lethality of COVID-19 and then utilize the superior ARIMA models to forecast future COVID-19 trends in the clusters and present the areas in the United States which have the highest COVID-19 related risk heading into the winter of 2020.

ARIMA models were also used by Yonar et al., (2020) to forecast the number of new daily cases in G8 countries. In the Balkan countries, a combination of techniques including ARIMA models was used to track the COVID-19 epidemic in Greece which was successful paradigm of resistance against the virus (Katris, 2021). Using pandemic data for Bulgaria and divide them into two categories: Sofia city data and the province data, several different models, including ARIMA, were used and the analysis shows their successful implementation for analysis of the pandemic (Gurova, 2021). Predictions of COVID-19 cases in North Macedonia using ARIMA models was not discovered by the author in time of writing of this article. Thus, it would be a valuable contribution to policy makers if the model generates satisfying results.

Development of COVID-19 in North Macedonia

Data for new COVID-19 daily confirmed cases were used in this analysis. Observed period is September 1st, 2020, to August 11th, 2021, with total of 396 daily observations calculated as seven day rolling average. The dynamics of new cases in North Macedonia are presented in Figure 1.

Figure 1. Daily new confirmed COVID-19 cases in RoNM

Source: ourworldindata.org

From the presented data it is evident that the country has gone through three COVID-19 waves, the initial at the beginning of the pandemic, second wave hitting its peak in November 2021 and the third wave reaching its peak in April 2021. The situation has stabilized in the begging of the summer of 2021; however, a new rise is on the horizon. The numbers in August are constantly increasing, mostly due to relaxed measures, increased frequency of national and international travel and mass gatherings as weddings and other celebrations. With 439.048 fully vaccinated citizens and 104.549 partly vaccinated by August 9th, 2021, total of vaccinated people reaches 543.597. This number can be increased by the unaccounted citizens that were vaccinated in the neighboring countries (mostly Serbia and Bulgaria). Vaccination prevents serious complications from the virus and reduces the death outcomes; however the Delta variant is galloping with 2.7 effective reproduction rate on August 9th and rising. The reproduction rate represents the average number of new infections caused by a single infected individual. If the rate is greater than 1, the infection is able to spread in the population. If it is below 1, the number of cases occurring in the population will gradually decrease to zero (Arroyo-Marioli et al., 2021). All conditions are in place for a new, fourth wave of COVID-19 in North Macedonia and European Region before the autumn. World Health Organization has issued a warning of possible new wave due to three conditions: new variants, deficit in vaccine uptake and increased social mixing (World Health Organization, 2021). Possibility of new wave in North Macedonia is very high, and it will very likely bring new restrictions, slowing down of the economy, loss of working positions, heavy burden on the health system, online schooling, and other difficult repercussions.

The aim of this paper is to examine if the ARIMA model is suitable for forecasting the trend of new daily cases in the country, and if it is so, what is the most likely scenario for development of the COVID-19 curve.

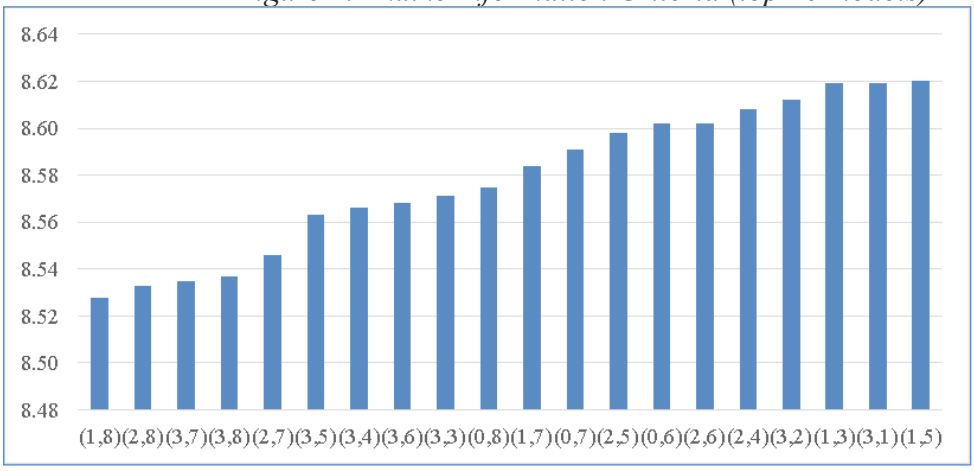
Research Methodology and Empirical Results

Autoregressive Integrated Moving Average Model (ARIMA) uses the information about the dynamics of one time series to estimate a model that correctly describes the series and uses it for forecasting. The AR part of ARIMA indicates that the evolving variable of interest is regressed on its own lagged (prior) values. The MA part indicates that the regression error is a linear combination of error terms whose values occurred contemporaneously and at various times in the past (Box, 2015). If the data are not stationary and are differenced once or more times to diminish the unit root, then the model is integrated, and this is indicated with the I part of the model. The general $ARMA(p,q)$ is represented as:

$$y_t = \phi_0 + \sum_{i=1}^{p} \phi_i y_{t-i} + e_t - \sum_{i=1}^{q} \theta_1 e_{t-i}$$

where e_t is white noise process, and p and q are nonnegative integers (Risteski et al., 2012).

Figure 2. Akaike Information Criteria (top 20 models)



Source: Author's calculations

If there is no seasonality in the data, the model is denoted as $ARIMA(p, d, q)$, where p is the order of the autoregressive model, d represents the number of times a series was differenced to become stationary and q is the order of the moving average model.

Using the data for daily confirmed COVID-19 cases for North Macedonia, for period September 1st, 2020, to August 11th, 2021, used as seven-day average, $ARIMA(1,1,8)$ was estimated (no regressors were used in the estimation). This specification had the lowest Akaike Information Criteria value, which is an indicator of a good model.

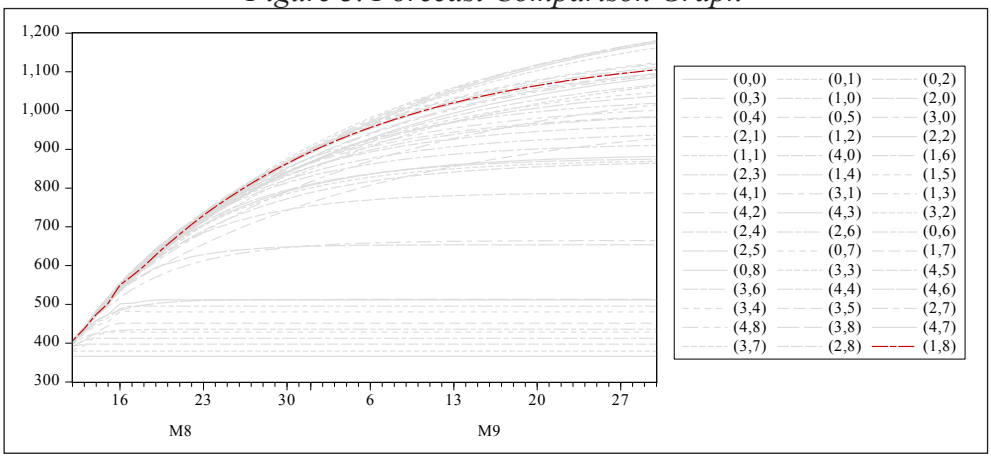
In Figure 2 there is presented a model selection criteria for top 20 model specifications. The $ARIMA(1,1,8)$ estimated coefficients are:

$$\begin{aligned}\Delta covid = {} & 0.949 covid_{t-1} + e_t - (-0.608 e_{t-1}) - (-0.198 e_{t-2}) - 0.144 e_{t-3} - 0.108 e_{t-4} \\ & - (-0.018 e_{t-5}) - 0.158 e_{t-6} - (-0.467 e_{t-7}) - 0.267 e_{t-8} \\ & + 284.13 SIGMASQ\end{aligned}$$

where $\Delta covid$ is the seven-day average of the new daily COVID-19 cases in North Macedonia. Because the time series are not stationary, it has been differenced once, and the model became$ARIMA$. $SIGMASQ$ is the estimate of the error variance presented as one of the estimated coefficients. All estimated coefficients are statistically significant for level 0.01, coefficients $0.144 e_{t-3}$ and $0.108 e_{t-4}$ are statistically significant for level 0.05 and 0.1 respectively, and only the coefficient $-0.018 e_{t-5}$ remains insignificant. Adjusted R – squared is 0.463 and the Durbin – Watson statistic is 2.01.

EViews runs a forecast simulation for different model specification. The period for forecast was until October 1st, 2021. The results are presented in Figure 3, where total of 45 $ARIMA$ models with different specification were estimated and the results from each of their forecasts show possible development of new daily COVID-19 cases in the upcoming period (second half of August and September 2021). Scenarios vary from stagnant trends, trends with slight increase and trends with rapid increase in the new cases. Since the $ARIMA(1,1,8)$ was estimated as the best model, the red forecasted line is followed as most likely scenario.

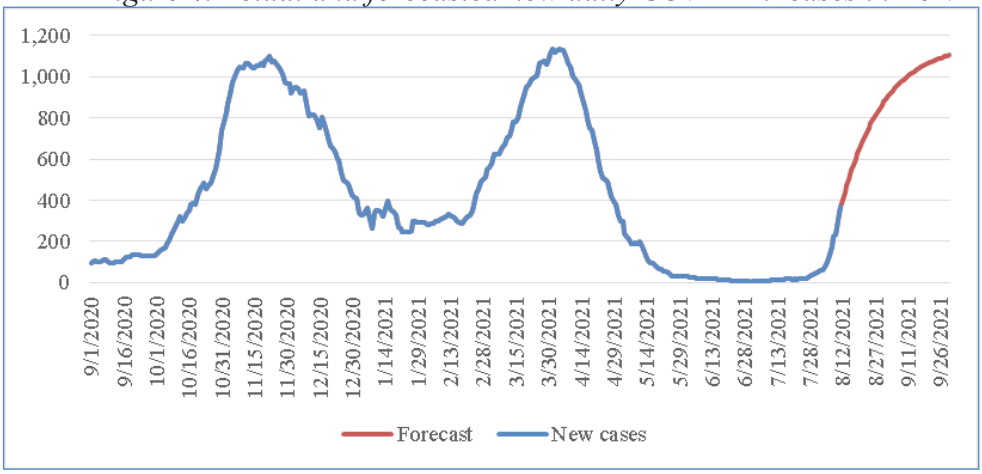
Figure 3. Forecast Comparison Graph



Source: Author's calculations

According to this model the number of new COVID-19 cases is on the rise, and it will continue to grow by the end of September 2021 when the growth is no more rapid. This trend is expected if the current situation remains, and no drastic restrictions are imposed.

Figure 4. Actual and forecasted new daily COVID-19 cases in RoNM



Source: ourworldindata.org, author's calculations

Figure 4 presents the historical trend and the forecasted values. After the stabilization in the spring and summer period, the forecasts predict steep rise in new COVID-19 cases during august and September 2021, reaching maximum value of 1.105 new cases by the end of this period and confirming

the coming of the fourth wave. This is a red alarm for the government not to postpone any restrictive measures, instead to activate them as soon as possible so that the effect from the fourth wave is as reduced as possible.

Conclusion

Since the COVID-19 crisis has evolved on global scale and data as time series become available, many researchers across the globe tend to test different statistical models to find those that provide precise and significant forecasts of the new COVID-19 infections, deaths, recoveries and vaccination trends. One of the most common applied methods that provide satisfactory results was the ARIMA model.

This model was tested on data for the new infections in North Macedonia. Using the automatic ARIMA forecasting, 45 simulations were made, providing forecasts of the further trend development. Using the Akaike information criteria the $ARIMA(1,1,8)ARIMA(1,1,8)$ specification was selected as the best. The results confirm increase in the new daily cases in second half of August and September, providing discrete stabilization at the end of the forecasted period. The presented trend confirms the coming of the fourth wave and predicts that its peak would reach the peaks of previous waves. Logically, the situation can be changed depending on the vigor and promptness of the new restrictions and vaccines administered.

This analysis has provided information to conclude that the ARIMA models are useful for forecasting the new COVID-19 cases per day, and it can be used for different countries and different statistics regarding the pandemic. Also, the results contribute as valuable information for the government to hasten with the restrictive measures in order to lessen the impact that the new COVID-19 infections will place on the economy, education and health system.

Literature

1. Arroyo-Marioli F., Bullano, F., Kucinskas, S. and Rondón-Moreno, C. (2021). Tracking R of COVID-19: A new real-time estimation using the Kalman filter. PLoS ONE 16(1): e0244474. https://doi.org/10.1371/journal.pone.0244474
2. Box, G. E. P. (2015). *Time Series Analysis: Forecasting and Control*, Wiley, ISBN 978-1-118-67502-1.
3. Carrión-García, A., Jabaloyes, J. and Grisales, A., (2021). The growth of

COVID-19 in Spain. A view based on time-series forecasting methods. In *Data Science for COVID-19* (pp. 643-660). Academic Press.

4. Gurova, S.M., (2021). COVID-19: Study of the spread of the pandemic in Bulgaria. In *22nd European Young Statisticians Meeting* (p. 66).
5. Katris, C., (2021). A time series-based statistical approach for outbreak spread forecasting: Application of COVID-19 in Greece. *Expert Systems with Applications*, 166, p.114077.
6. Lucic, M. C., Ghazzai H., Lipizzi, C. and Massoud Y., (2021). "Integrating County-Level Socioeconomic Data for COVID-19 Forecasting in the United States," in *IEEE Open Journal of Engineering in Medicine and Biology*, vol. 2, pp. 235-248, 2021, doi: 10.1109/OJEMB.2021.3096135.
7. Maitre, A., Rajeswari, K. and Vispute, S., (2020). Time Series Analysis for Understanding the Vaccination Rate using ARIMA.
8. Our World in Data (2021). COVID-19 Data Explorer (online database) available from: https://ourworldindata.org/, Accessed 13th of August 2021
9. Risteski, S., Tevdovski, D. and Trpkova, M. (2012). *Voved vo analizata na vremenskite serii*, Ekonomski fakultet – Skopje.
10. Sengupta, S., (2020). *Forecasting the Peak of Covid-19 Daily Cases in India Using Time Series Analysis and Multivariate lstm*, Technical report.
11. Sotomayor, D.A.C. and Carlos, F.B.S.M. (2021). Application of the Autoregressive Integrated Moving Average for the analysis of COVID-19 Case series in Peru, *Rev. Fac. Med. Hum. January 2021*; 21(1):65-74. DOI 10.25176/RFMH.v21i1.3307
12. Tandon, H., Ranjan, P., Chakraborty, T. and Suhag, V., (2020). Coronavirus (COVID-19): ARIMA based time-series analysis to forecast near future, *arXiv preprint arXiv:2004.07859*.
13. Yonar H, Yonar A, Tekindal M, Tekindal M. (2020). Modeling and Forecasting for the number of cases of the COVID-19 pandemic with the Curve Estimation Models, the Box-Jenkins and Exponential Smoothing Methods. *EJMO, 4(2): 160-165*
14. Yousaf, M., Zahir, S., Riaz, M., Hussain, S.M. and Shah, K., (2020). Statistical analysis of forecasting COVID-19 for upcoming month in Pakistan. *Chaos, Solitons & Fractals, 138*, p.109926.
15. World Health Organization (2021). WHO warns of risk of a new COVID-19 wave, Accessed August 13th, 2021, https://unric.org/en/who-warns-of-risk-of-a-new-covid-19-wave/

АРИМА ПРЕДВИДУВАЊЕ НА НОВИТЕ КОВИД-19 СЛУЧАИ ВО СЕВЕРНА МАКЕДОНИЈА

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Апстракт

Еден од најсериозните предизвици на светско ниво во изминатата година и половина беше КОВИД-19 пандемијата. Имајќи големо влијание на речиси секој сегмент од општеството, пандемијата донесе тешки надолни промени: ослабнување на економијата, предизвикување на огромен товер на јавното здравство, ставање ограничување на слободното движење и патувањата, сведувајќи го образованието на часови преку компјутер и слично. Еден комплициран аспект на пандемијата е нејзината непредвидливост искажана преку трите бранови кои донесоа пораст на инфекциите и почетокот на новиот четврт бран кој е резултат на новиот Делта сој.

Додека светот се надева на денот кога пандемијата ќе заврши, растечките броеви на новите КОВИД-19 инфекции го одложуваат крајот на кризата. Целта на овој труд е да го тестира АРИМА моделот за негово користење како добар модел за предвидување на новите дневни КОВИД-19 случаи во Северна Македонија. Доколку резултатите се покажат прифатливи, моделот може да се користи за предвидување кое би било корисен инпут за краторите на политиките и одлуките кои би ги донеле за новите и постоечките рестриктивни мерки.

JEL класификација: I18, C22, C53

Клучни зборови: КОВИД-19, АРИМА модел, предвидување