Science Publications

International Journal of Mathematical, Engineering, Biological and Applied Computing, 2022, 1, 519
www.scipublications.org/journal/index.php/ijmebac
DOI: 10.31586/ijmebac.2022.519

Research Article

The Application of Machine Learning in the Corona Era, With an Emphasis on Economic Concepts and Sustainable Development Goals

Milad Shahvaroughi Farahani [1, *], Amirhossein Esfahani [2], Fardin Alipoor [3]

[1] Department of Finance, Faculty of Finance, Khatam University, Tehran, Iran
[2] Department of Accounting, Eslamshahr University, Tehran, Iran
[3] Department of Finance, Khatam University, Tehran, Iran

*Correspondence: Milad Shahvaroughi Farahani (m.shahvaroughi@khatam.ac.ir)

Abstract: The aim of this article is to examine the impacts of Coronavirus Disease -19 (Covid-19) vaccines on economic condition and sustainable development goals. In other words, we are going to study the economic condition during Covid19. We have studied the economic costs of pandemic, benefits in terms of gross domestic product (GDP), public finances and employment, investment on vaccines around the world, progress and totally the economic impacts of vaccines and the impacts of emerging markets (EM) on achieving sustainable development goals (SDGs), including no poverty, good health and well-being, zero hunger, reduced inequality etc. The importance of emerging economies in reducing the harmful effects of the Corona has also been noted. We have tried to do experimental results and forecast daily new death cases from Feb-2020 to Aug-2021 in Iran using Artificial Neural Network (ANN) and Beetle Antennae Search (BAS) algorithm as a case study with econometric models and regression analysis. The findings show that Covid19 has had devastating economic and health effects on the world, and the vaccine can be very helpful in eliminating these effects specially in long-term. We observed that there is inequality in the distribution of Corona vaccines in rich countries compared to poor which EM can decrease the gap between them. The results show that both models (i.e., Artificial intelligence (AI) and econometric models) almost have the same results but AI optimization models can robust the model and prediction. The main contribution of this article is that we have surveyed the impacts of vaccination from socio-economic viewpoint not just report some facts and truth. We have surveyed the impacts of vaccines on sustainable development goals and the role of EM in achieving SDGs. In addition to using the theoretical framework, we have also used quantitative and empirical results that have rarely been seen in other articles.

Keywords: Economic Growth; Covid19 Vaccine; Gross Domestic Product; Emerging Economies; Sustainable Development Goals.

How to cite this paper:
Shahvaroughi Farahani, M., Esfahani, A., & Alipoor, F. (2022). The Application of Machine Learning in the Corona Era, With an Emphasis on Economic Concepts and Sustainable Development Goals. *International Journal of Mathematical, Engineering, Biological and Applied Computing*, *1*(2), 95–149. Retrieved from https://www.scipublications.com/journal/index.php/ijmebac/article/view/519

Received: August 31, 2022
Accepted: November 20, 2022
Published: November 29, 2022

1. Introduction

In the last two decades, developed and developing countries have invested dramatically in health and immunization of the people [1]. As a result, we have seen the development of new vaccines as well as the growth of new financing mechanisms through organizations such as Gavi, the Vaccine Alliance, and the Pan American Health Organization [2]. Vaccine development programs are very important in stakeholder decisions because they have valuable effects on people's health and the economy of the community [3]. Some focus only on the immunization and health implications of the vaccine such as medical cost savings, while the vaccine has far-reaching effects on

economies [4]. It is important to note that health improvement leads to improving the economy such as decreasing fertility, strengthening macroeconomic stability, and improving educational outcomes. There are two kinds of benefits for immunization: 1) narrow 2) broad [5]. Gain in health, health care cost, and care-related productivity typically considered in microeconomic evaluations were categorized as 'narrow' benefits, while additional benefits not normally incorporated were categorized as 'broad' benefits.

Covid19 has affected millions of people around the world and many people have been lost their lives because it is a formidable disease [6]. Many researchers have been tried to present the vaccines to the market as soon as possible. Meanwhile, some countries have been tried to introduce some vaccines and they have been successful. Some countries have started vaccinations too. Governments, especially the wealthier one, for secure vaccination of their people have tried to sign purchase agreements with vaccine producers [7]. When governments care about the needs of individuals and prioritize them over other domestic needs, this situation is often referred to as 'vaccine nationalism'. Some features can decrease the rate of vaccination around the world until 2024: 1. Limited global manufacturing capacity 2. the profusion of bilateral purchase agreements. So, many poor countries cannot be vaccinated quickly which resulting poor vaccination, high daily death rate and sick economy. On the other hand, this can divide the world to high death rate and risky countries vs. lower death rate along with lower risk which is harmful. Unequitable access to vaccines along with Covid-19 outbreaks have destructive economic effects [8]. Vaccination should be extending and governments can't decrease or control disease regardless of other countries. So, they should be more coordinated and harmonized. For example, wealthier countries can offer and dedicate vaccines to poor countries.

Eurasia Group have done research which shows that global equitable access to COVID-19 vaccines can generate economic benefits of at least US$ 153 billion in 2020–21, and US$ 466 billion by 2025, in 10 major economies [9]. World Health Organization (WHO) and its partners are trying to make some plans for equitable access and distribution to Covid19 vaccines. They need to make some certainty about equal access to people because it can be beneficial. There are many data that show if you do not pay attention to poor countries, all economies will suffer and put "decades of economic progress" at risk [10].

Emerging markets have the main roles and impacts on the global economic for some reasons which we will explain it in separate section. Tracking vaccination and the rate of progress can be important. Different researches and articles have written about inequality of access to COVID-19 vaccine in emerging markets which can be a dangerous and threat for SDGs.

The other concept which is very significant and could make a revolution in doing work is artificial intelligence (AI). By applying and using AI or Machine Learning (ML), different tasks or challenges such as prediction of Covid-19 new cases and new death cases, prediction of stock price, customer credit rating etc. can be addressed or to be improved. On the other hand, it is possible to optimize your solutions and save your time because AI can consider many parameters and do complicated tasks simultaneously. ML is a sub-branch of AI which is working based on learning and improving by experience. So, ML needs to access data and use it to learn. As a result, this process including three steps such as learning (the acquisition of information and rules for using the information), reasoning (using the rules to reach approximate or definite conclusions) and self-correction. In addition, by applying AI, it is possible to produce intelligent computer programs. Therefore, AI can be characterized as a series of system, methods, and technologies that display intelligent behavior by analyzing their environments and taking actions with some degree of autonomy toward achieving pre-specified outcomes [11].

The structure of the paper is as follows:

First, we have surveyed the history of vaccine and the link between health and economic output. Second, we surveyed the cost-benefit of vaccines and progresses in making Corona vaccine and examine the advantages and disadvantages of vaccine. We study the role of vaccine on sustainable development too. We have dedicated a separate section to emerging economies, their characteristics, the rate of vaccine development, and the goals of sustainable development in these countries. We dedicated a part to methodology and findings and results. The last part, is about conclusions and remarks.

2. Literature Review

Many articles have been published about COVID-19 since its advent. Each article has tried to address the importance of this phenomenon from different angles such as economic, social, psychological, political etc. because this is a mission. Whenever we face to new phenomenon, especially harmful one, we must analyze it from different aspects since it can impact on our life and maybe control it. Therefore, it is imperative for researchers to study these phenomena and gain more knowledge and control their destructive effects. In this part, we have tried to survey some articles which almost are about the impacts of COVID-19 on SDGs.

Leal Filho, W., et al. (2020) [12] discussed how COVID-19 can impact on SDGs. They used an analysis of the literature, observations and an assessment of current world trends as a method. They concluded that we need to pay attention to other diseases such as malaria, yellow fever and others simultaneously while excessive attention to the COVID-19 can reduce attention to other diseases. Extreme attention and abundant care can increase the percentage of suffers.

Nerini, F. F., et al. (2020) [13] in an article about sustainable development in the wake of COVID-19 addressed the impacts of COVID-19 on SDGs and its implementation. They used a review method. They found that the pandemic can have negative impacts on achieving SDGs. However, Covid19 can be impactful and beneficial for achieving 66 targets (40%) which is due to changes spurred by the crisis, given that appropriate decisions are made.

Pan, S. L., & Zhang, S. (2020) [14] surveyed the opportunities and challenges of Covid19 on SDGs. So, they pointed to the six relevant themes that have evolved during the pandemic and the corresponding topics that future researchers could focus on. The results showed that beside the negative impacts of COVID-19 on human's life, it can be an excellent opportunity for the human to act in solidarity and turn these challenges to opportunity to achieve the United Nation's (UN) Sustainable Development Goals (SDG).

Kashte, S., et al. (2021) [15] surveyed different vaccines, their types, how they are different in structure, associated challenges and future prospects.

ElBagoury, M., et al. (2020) [16] reviewed background of COVID-19 vaccines, discussed viral structure and life cycle of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) as owing a comprehensive visualization about the key factor of the pandemic, COVID-19 clinical symptoms etc. They concluded that in this emergency situation, vaccine is highly recommended. Of course, we need to follow the same protocols of previous pandemic such as Middle East Respiratory Syndrome Coronavirus (MERS-CoV) and SARS-CoV.

Roy, S. (2020) [17] analyzed economic impacts of COVID-19 such as tourism industry, oil industry, aviation industry, financial sector and healthcare sector. He analyzed data from different parts, investigated the effect of external macroeconomic shocks on the global economy.

Berchin, I. I., & de Andrade, J. B. S. O. (2020) [18] surveyed the effects of the Coronavirus disease 2019 (COVID-19) outbreak on sustainable development and future perspectives. They explored the development of sustainable development by defining the term Gaia, which imposes constraints on human activities to make better use of technologies and resources through analytical methods. They concluded that humans

play an important role in the balance of Gaia and that humanity needs to accelerate its path to developed goals, and that future studies should follow the social effects of the virus, its trends, and its long-term effects on our society.

Ujunwa, A. I., et al. (2021) [19] in an article with the title of "Rethinking Africa's Globalization Program: Lessons from COVID-19 Reviewed" examined Africa and the growing globalization debate that is fueling inequality and poverty, and concluded that the promotion of active and global investment in these areas, as well as active dialogue, is mainly in streamlining the globalization agenda. Helps with the epidemic.

The following table presents different researches about the applications of AI in prediction of Covid-19.

Table 1. Previous researches about the prediction of AI/ML and COVID-19

No	Author(s) (year)	Journal Name	Objectives	Findings
1	**Zawbaa et al., (2021) [20]**	**International Journal of Clinical Practice**	**Prediction and forecasting different countries daily confirmed-cases and daily death-cases**	**The results proved usefulness in modelling and forecasting the end status of the virus spreading based on specific regional and health support variables.**
2	**Gray et al., (2021) [21]**	**BMJ Health & Care Informatics**	**Training machine learning models to predict Covid-19 cases growth and understanding the social, physical and environmental risk factors associated with higher rates of SARS-CoV-2 infection in Tennessee and Georgia counties**	**African American and Asian racial demographics present comparable, and contrasting, patterns of risk depending on locality**
3	**Rios et al., (2021) [22]**	**Scientific reports**	**Presented a temporal analysis on the number of new cases and deaths among countries using artificial intelligence**	**1. They showed the historical infection path taken by specific countries and emphasize changing points that occur when countries move between clusters with small, medium, or large number of cases. 2. They estimated new waves for specific countries using the transition index.**
4	**Malki et al., (2021) [23]**	**Environmental science and pollution research**	**Applying machine learning approaches to predict the spread of Covid-19 in many countries.**	**Covid-19 infections will greatly decline during the first week of September 2021 when it will be going to an end shortly afterward.**
5	**Muhammad et al., (2021) [24]**	**SN computer science**	**Prediction of Covid-19 infection (positive and negative cases in Mexico) using ML algorithms such as logistic regression, decision tree, SVM, naïve Bayes and ANN.**	**Decision tree model has the highest accuracy of 94.99% while the support vector machine model has the highest sensitivity of 93.34% and Naïve Bayes model has the highest specificity of 94.30%.**

6	**Kuo et al., (2022) [25]**	**International Journal of Medical Informatics**	**The accuracy of machine learning approaches using non-image data for the prediction of Covid-19: A meta-analysis**	**The results show that non-image data can be used to predict Covid-19 with an acceptable performance. Further, class imbalance and feature selection are suggested to be incorporated whenever building models for the prediction of Covid-19, thus improving further diagnostic performance.**
7	**Mohan et al., (2022) [26]**	**Computers in Biology and Medicine**	**Predicting the impact of the third wave of Covid-19 in India using hybrid statistical machine learning models: A time series forecasting and sentiment analysis approach**	**A spike in daily confirmed and cumulative confirmed cases was predicted in India in the next 180 days based on the past time series data. The results were validated using various analytical tools and evaluation metrics, producing a root mean square error (RMSE) of 0.14 and a mean absolute percentage error (MAPE) of 0.06. The Natural Language Processing (NLP) processing results revealed negative sentiments in most articles and blogs, with few exceptions.**

In this article, we have done a different and almost comprehensive research means qualitative and quantitative article with important issues such as sustainable development, vaccines and emerging market as well.

2.1. Vaccine History

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

The development of the vaccine began two centuries ago by Dr. Edward Jenner. He treated a young boy by injecting [27]. The injection provided immunity to the smallpox [28]. The name of the virus was used to coin the term "vaccine." The first vaccine used to target smallpox was nearly 225 years ago. In 1980, the World Health Assembly by the WHO, could eradicate the smallpox. So, smallpox eradicated completely which it could no longer kill or blind people. According to WHO, when you can prevent circulating a disease in a region, you can control and then eliminate it. For instance, in 1979 in the US, a disease which is called polio, eliminated due to widespread vaccination efforts. We can say eradicated only when a disease is eliminated worldwide.

According to the Centers for Disease Control and Prevention (CDC), there are 14 infectious diseases, that once were prevalent in the U.S. before the development of vaccines for each of them [29]. Those are polio, tetanus, flu, hepatitis B, hepatitis A, rubella, Hib, measles, whooping cough, pneumococcal, rotavirus, mumps, chickenpox and diphtheria. These diseases no longer could be a threat because of widespread vaccination and immunization the majority of people.

Potential vaccines should be checked and they have a certain and clear path. This path is defined and overseen by the Food and Drug Administration (FDA). The producer

must explain some vaccine qualifications such the manufacturing process and efficiency, effectiveness in animal testing. Each vaccine consists of a series of three clinical trials laid out in phases [30]. All phases should be completed successfully by manufacturer.

- Phase I: This part evaluates the strength, safety and ability of the vaccines to generate an immune system response in a small group of people.
- Phase II: In order to determine the right dosage levels, we need to test on many people, possibly hundreds.
- Phase III: This tests thousands of people to analyze the safety and effectiveness of the drug.

Every vaccine needs to get license from different number of reviews and regulatory for different purpose such as efficacy, safety and manufacturing before releasing to the public. We need to monitoring consistently. When we make sure that it has the minimum side effects or doesn't have any, the vaccine is released to further assess effectiveness among large numbers of people.

Some conditional vaccines which are used virus in their structures, can take years to validate their success, due to the process of collecting the viruses and adapting them in the lab [31]. Complex purification and testing are two custom production process which each new conventional vaccine requires. Pfizer and Moderna are COVID-19 vaccines that using genetic code instead of virus itself with a technique using messenger RNA (mRNA) [32]. According to Pfizer, the mRNA is based on genetic recipe which is made of a Deoxyribonucleic acid (DNA) template in the lab. The DNA can be sent across the world instantly by computer and synthesizing from an electronic sequence. Generation of an experimental batch of an mRNA vaccine takes about a week. The genetic recipe directs cells to make pieces of the spikes that sit atop the Coronavirus. Once it's injected, the body's immune system makes antibodies that recognize these spikes. In case a vaccinated person is later exposed to the Coronavirus, those antibodies are ready to attack the virus.

In this part, we have tried to study the history of vaccine, functions and phases. You can see more details about vaccine history in Table2 [33].

Table 2. Vaccine history

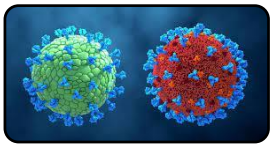
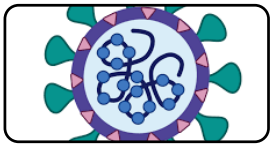
Date	Explanations
1798	**Edward Jenner publishes work on smallpox vaccine, coining the terms "vaccine" and "vaccination"; by1800, smallpox vaccination becomes commonplace.**
1870s-1880s	**Louis Pasteur develops first live attenuated bacterial vaccine (chicken cholera) and first live attenuated viral vaccine (rabies)**
1918	**Spanish influenza (flu) pandemic kills 25-50 million worldwide.**
1945	**Inactivated influenza vaccine licensed in US.**
1952	**Nearly 60000 cases of polio reported in US.**
1955	**First polio vaccine pioneered by Jonas Salk licensed in US.**
1961	**Orally-administrated polio vaccine developed by Albert Sabin licensed in US.**
1963	**Measles vaccine licensed in US.**
1974	**Meningococcal polysaccharide vaccine licensed in US; first conjugate meningococcal vaccine licensed in US in 2005.**
1980	**Smallpox is the first infectious disease eradicated by vaccination**
1987	**First Hib conjugate vaccine licensed in US.**
2000s	**Measles and rubella no longer endemic in the US. First conjugate pneumococcal vaccine licensed in US.**
2006	**Vaccine to prevent cervical cancer due to human papillomavirus (HPV) licensed in US.**

2009	**Vaccines against 2009 Hemagglutinin1 Neuraminidases1 (H1N1) pandemic strain and high-dose influenza vaccine licensed in US.**
2014	**CDC estimates vaccines will prevent 21million hospitalizations and 732000 deaths among children born in the last 20 years alone.**
2020	**Several vaccines are in development stage for SARS-CoV-2, the Coronavirus that causes COVID-19. As of Jan 15,2021, nearly 2 million people worldwide have died during the pandemic and more than 94 million confirmed cases of COVID-19 have been reported which nearly 54 million people have recovered.**

2.1.1. COVID-19 vaccines progress

There has been good research on the Covid-19 vaccines along with brilliant results. You can get comprehensive information about the progress of the Corona vaccines and different kinds of vaccines through the following table.

Table 3. COVID19 vaccines

	Short for ribonucleic acid, RNA is one of the crucial macromolecules – larger molecules comprising proteins, lipids and carbohydrates – for life. RNA vaccines work by introducing an mRNA sequence (the molecule which tells cells what to build) into the system which is coded for a disease-specific antigen.
	Short for deoxyribonucleic acid, DNA is another of the crucial macromolecules for life. A DNA vaccine involves the direct introduction into appropriate tissues of a plasmid – a double-stranded molecule which exists in bacterial cells.
	These vaccines use live viruses to carry DNA into human cells. It is one of the more effective means of gene transfer to modify specific cell types or tissue for therapeutic purposes.
	This type of vaccine contains molecules that mimic the virus but are not infectious and, therefore, not a danger. virus-like particles (VLP) has been an effective way of creating vaccines against diseases such as human papillomavirus (HPV), hepatitis and malaria.
	This uses a part of the virus, in this case, the protein component, to create a vaccine. These vaccines can be administered to almost anyone who needs them, including people with weakened immune systems and long-term health problems because they do not harm the immune system.
	This particular type of vaccine uses the part of a virus which is no longer active, but which causes the disease. These vaccines do not usually provide the same degree of immunity as a live vaccine. Booster shots at a later date may be necessary to maintain immunity.

(In the appendix TableA1, you can see the advantages and disadvantages of different vaccine platforms).

Recently, London school of hygiene and tropical medicine declared that there are 11 different vaccines for COVID-19 throughout the world which being tested on human beings.

WHO stated that there are more than 150 vaccines under development for COVID-19 [34]. They are in different phases. Some of them are getting closer to release as they pass through the third phase of human trials. Some of them are ready for injection on huge population. According to the WHO, in phase one of human trial, vaccines test and carry out on 30 to 50 people to make sure about side-effects and its safety. In Phase two, for testing enough immunization, the number of vaccinated people increasing. In Phase three, we need to test the efficacy of the vaccine, which is how well it protects a person against infection, as well as its safety in such a large group. So, we should increase the number of vaccinated people to thousands or million people.

In Table 4, we have taken a look at Covid-19 vaccines and their conditions in different stages and process:

Table 4. Important Vaccines under development

Vaccines	Trial phase (1 2 3)	Prior vaccine development experience	Approval status	Pre-orders (Later, -, Soon)	Immune response
Astrazeneca-Oxford	**1 2 3**	**No**	**Review**	**Soon**	**70%***
Cansino biologics	**1 2 3**	**Yes**	**Limited**	**Soon**	**High**
Gamaleya research institute	**1 2 3**	**Yes**	**Limited**	**Soon**	**Moderate**
Inovio-cepi	**1 2 3**	**No**	**-**	**Later**	**Not reported**
Johnson & Johnson Barda Janssen	**1 2 3**	**Yes**	**-**	**Later**	**Moderate**
Moderna-Niaid	**1 2 3**	**No**	**Review**	**Soon**	**94.5%**
Novavax	**1 2 3**	**No**	**-**	**-**	**High**
Pfizer-Biontech	**1 2 3**	**No**	**Review**	**Soon**	**95%**
Sinopharm-Beijing institute of biological products	**1 2 3**	**Yes**	**Limited**	**-**	**Moderate**
Sinovac-instituto Butantan	**1 2 3**	**No**	**-**	**-**	**Low**

One dosing regimen showed vaccine efficacy of 90 percent when it was given as a half dose. Followed by a full dose, at least one month a part. Efficacy was 62 percent when it was given as two full doses at least one month apart. The combined analysis from both dosing regimens resulted in an average efficacy of 70 percent. (Source:** REUTERS, WHO. NOV 24, 2020)*

(For getting more information about the differences between Covid-19 vaccines and classical, and Covid-19 vaccines in development and trials, you can refer to the appendix Figure A1 and Figure A2).

Due to a tally by the Reuters news agency, nearly 4.4 billion doses of the different vaccines have been pre-ordered around the world. Competition for fast vaccination is at the center of attention by many governments and they want to vaccinate their population as soon as possible. Different vaccines have different capabilities and qualifications such as the temperature of storing, the number of required dozes etc. which can be a practical

advantage over some others. Every vaccine has a price for each dose. For example, AstraZeneca put its cost at about $2.50 a dose to considered organizations and counterparty. Pfizer's vaccine will cost about $20 a dose, while Modena's will cost $15-25, based on agreements the companies have struck to supply their vaccines to the US government. The following figure shows the number of pre-ordered vaccines until Nov2020:

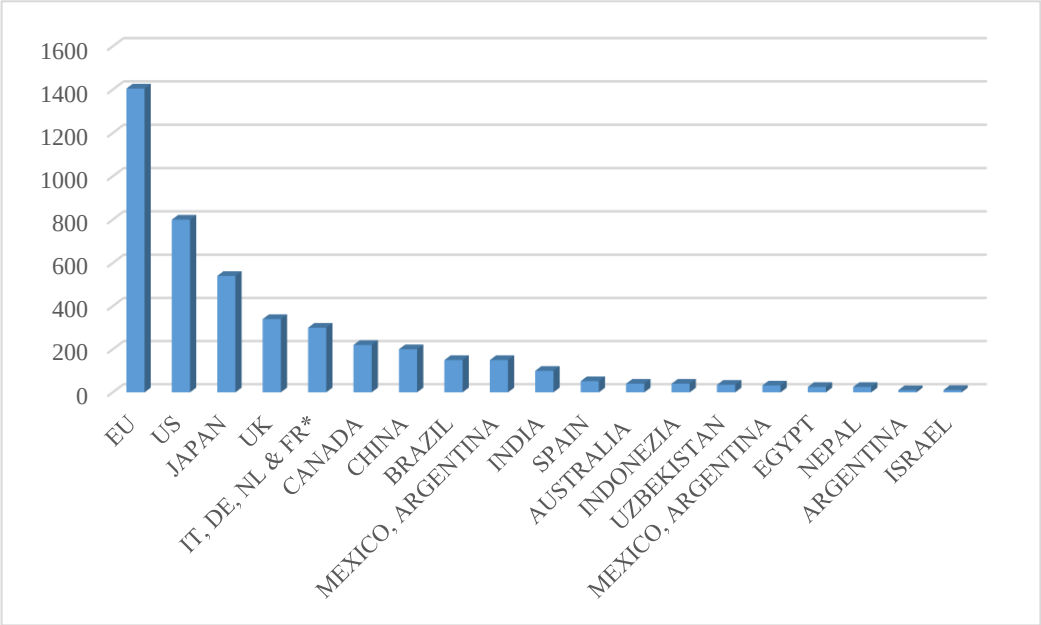


Figure 1. Countries have pre-ordered vaccines; (***Source***: REUTERS, WHO. NOV 24, 2020)

2.2. Cost-benefit of the COVID-19 vaccine

In this part, we have tried to study the impact of vaccines on health, economic and social perspectives. We cannot figure out all of the possible costs because it couldn't possible and there is not sufficient data. As a result, the effects of the pandemic on the economy can be measured based on three parameters: 1. its impact on GDP 2. employment 3. general government net lending [35]. GDP measures the market value of all the final goods and services produced and sold in a specific time period by countries. While GDP could not measure the economic welfare completely, it is probably the most common form of measurement. Employment (or unemployment) as a complementary parameter can act as a measure of economic activity. In the absence of Covid19 or in a normal condition, the situation or status is different which government could allocate more resources to welfare, employment and totally economic improvement [36]. The government assesses, for instance, that the costs of economic measures in 2020 in response to the pandemic amount to almost SEK 200 billion (Swedish krona) during 2020, or around 4 per cent of GDP [37]. It is obvious that, by declining economic activity, public revenue from taxes declines.

This review will highlight the benefits of vaccinations to society from the perspectives of health, economy, and social fabric (Figure 2), which need to be considered in the overall assessment of impact to ensure that vaccines are prioritized by those making funding decisions [38].

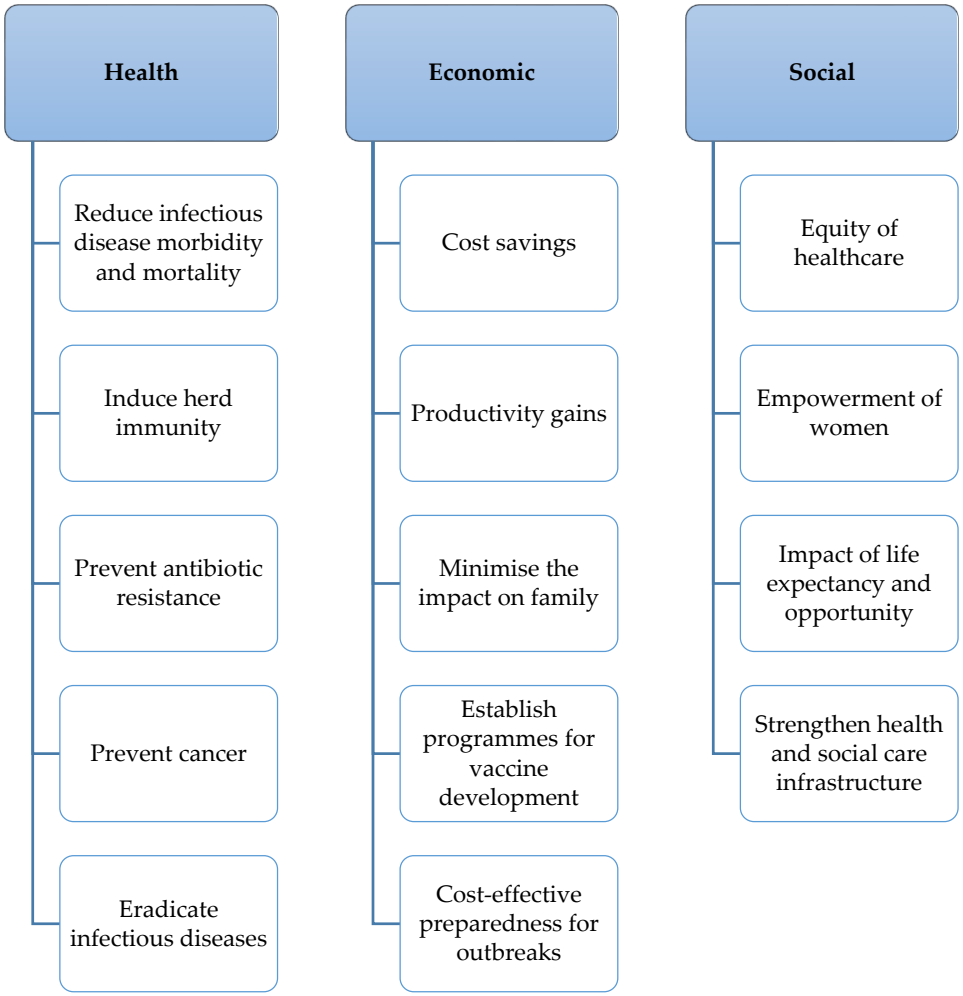


Figure 2. Impacts of vaccines

In order to having a conceptual framework about the gains of a rapid vaccination process, Figure 3 has been depicted. The red line shows the rate of GDP before pandemic. It is clear that this rate is much lower than no pandemic means the blue line in 2020. This can be as a result of the spread infectious and different restrictions and outbreaks. It is clear that vaccination cause decreasing the mortality rate and can increase the immunization. So, this can lead to economic improvement and GDP improvement in 2021. To illustrate the gains of rapid vaccination, we have considered two scenarios. In one scenario, it is assumed that the spread of infection will stop one month earlier than in the other scenario. The light blue and yellow lines show how the economic recovery develops respectively. We assume that the economic recovery will follow the same path in both scenarios, which is illustrated by these lines having the same slope. Because of small time interval (i.e., a month), it can be a reasonable assumption between two scenarios.

The rate and size of the gain depends on the rate of vaccinations and immunization. (The difference between the blue and red lines). Using our assumptions, the gain corresponds to the pandemic's average effects on GDP per month in 2020.

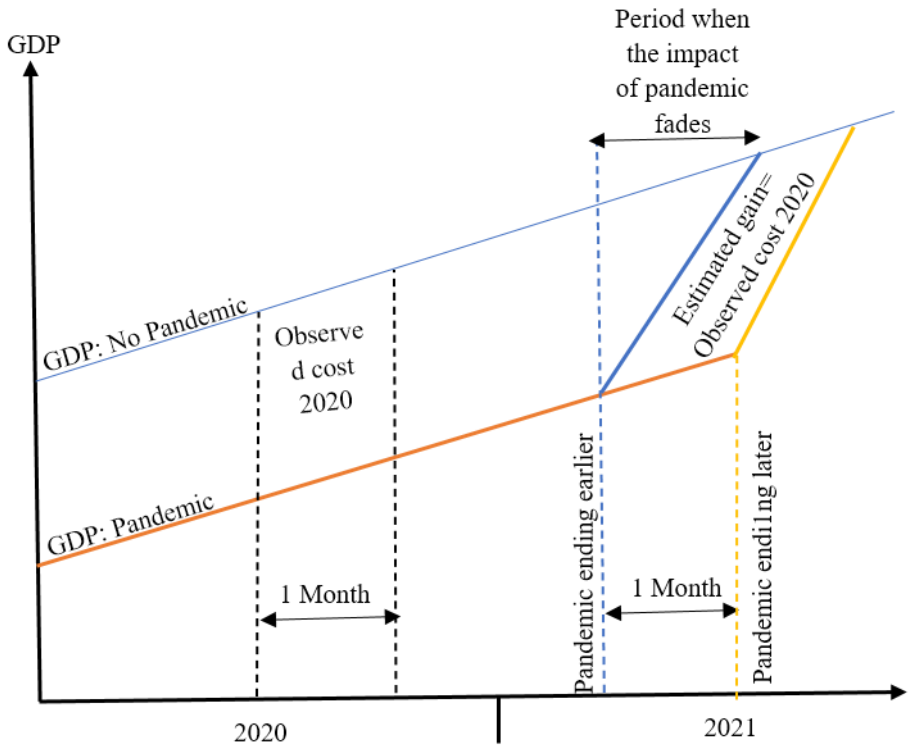


Figure 3. Conceptual framework to illustrate how the gains of a rapid vaccination are calculated.

This conceptual framework is of course very simplified. It can be possible to use different assumptions and various scenarios about the gains of vaccination. So, you need to take other parameters and changing the figures. We used this approach because it's easy and doesn't need any complicated mathematical methods, data and several assumptions.

Because we can't estimate the rate of GDP due to high volatility during vaccination period, this factor can be the most important uncertainty factor in our calculations [39]. In Figure 4, this entails an uncertainty regarding the red and blue lines for 2021. The size of benefit depends on the rate of GDP, i.e., that GDP and benefit due to vaccination have direct relationship. The benefit also depends on how the spread of infection develops and how large the economic consequences will be (higher or lower placement of the red curve). How uncertainty about near term economic developments can affect the calculations is discussed in more detail below. There are more details about the relation and link between health and economic output and the role of prevention program which one of them is vaccine in the appendix (Figure A3).

2.2.1. Benefits in terms of GDP, public finances and employment

We have tried to survey the impact of rapid vaccination based on GDP and its economic benefits during pandemic. We can take a look and study the effects of other variables such as labor market and public finances to give broader picture.

2.2.2. GDP

Now, we have tried to study the effect of one-month earlier vaccination on GDP. As we discussed earlier, this estimation is uncertain because it depends on different economic variables. In Figure 1 this means that the red line could become higher or lower in 2021. As it is clear, spread of infection and economic activity have indirect relationship. Sweden activity index has estimated GDP on a monthly basis. So, we can use it and estimate our own GDP. We can calculate the GDP loss at around SEK 40 billion on average when the

infection was spreading rapidly means in April and May. For March and September, we can consider lower GDP loss on average around SEK 15 billion. According to some facts, we have assessed the benefits of a rapid vaccination between SEK 15 and 40 billion, depending on how quickly we can assume that infection spreads before the vaccination process is complete in 2021.

By rapid vaccination and shortening the period around one-month, GDP can be around SEK 25 billion after rounding off, or just over half a per cent of annual GDP. However, due to spread of infection and its speed in 2021 and based on the experiences of 2020, this can vary between SEK 15 and 40 billion per month

Our estimation is comparable with other studies for other countries. Nugroho (2020) used general equilibrium model and reported calculations of the cost of vaccination in Indonesia being delayed by six months. The cost was estimated at 44 billion dollars, or around 4 per cent of the country's GDP. It is clear that every method has its own assumption. So, the Nugroho method is different with us but based on as a percentage of GDP, it is roughly the same.

2.2.3. Public finances

Public finances can be affected by pandemic around SEK 20 billion on average per month with an interval of between SEK 10 and 30 billion. We can measure the impact of rapid vaccination one-month earlier on public debt. This is an effect that comes in addition to the calculated gain in terms of GDP. Definitely, we can't generalize and adaptation calculation of public finances in 2021 based on 2020 because the structure of finance and its rate would be different.

Different factors can be considered to determine the higher or lower effect. So, we need to use a factor that presents smaller effects. Larger effects can be indicated based on calculations (i.e., the costs of the Government's measures to deal with the pandemic in 2020 and a normal relationship between GDP developments and automatic stabilizers). Smaller effects may be indicated based on the measure the outcomes for the second and third quarters of 2020 in relation to the corresponding quarter in 2019. This is a period in 2020 when the monthly costs for the government's reforms are assessed to have been particularly high. It is also probable that other factors than the pandemic have affected the developments in general government finances between 2020 and 2019.

As an assumption, if the pandemic is shortened by a month, we think that SEK 20 billion per month is a reasonable assessment of the savings made by the public sector. This estimation considers both the actual developments in general government net lending and the assessment that the benefit in terms of GDP amounts to SEK 25 billion and that the need for active fiscal policy declines. The interval of SEK 10-30 billion is constructed on the basis of the interval for the gain in terms of GDP.

2.2.4. Labor Market

As it is clear, the labor market has been affected by the pandemic significantly. Governments tried to decline the negative consequences of Covid19 on employment but it has declined substantially and it has risen. Different jobs have different status. Some jobs improved and some of them vanished. After the emergence of Covid19 and its outbreak, at the end of 2020, the effects of pandemic mean 130,000 fewer people are employed than was the Riksbank's assessment prior to the pandemic.

It is explicit the rate of mitigation means unemployment will be stable until more immunization. That is, that around 130,000 fewer people are employed. This number depends on spread of infection and the level of economic activity. High-frequency variations in employment are normally limited, however, and the current conditions for furloughing reduce the need to give notice of redundancy to staff as a result of temporary changes in demand.

We have considered that after population vaccination and rapid immunization, employment condition can turn into normal situation. Which is illustrated in Figure 4. So, vaccination has a positive correlation with employment and labor market. This can be compared with the recovery in GDP according to Figure 1, where the vertical distance between the light blue and yellow lines now instead represents the difference in the number of employed. During the time, the positive effect of vaccination on employment will diminish. We need to consider a point that employment is not only related to vaccination, while it depends on other factors such as the speed of the recovery (the slope of the light blue and yellow curves respectively). If, for instance, the recovery takes six (twelve) months, this will correspond to 20,000 (10,000) more people employed per month during the recovery period.

The benefits of vaccination one month earlier can also be described in terms of 130,000 more man-months or monthly salaries.

2.2.5. More benefits for society

We can numerate a lot of reasons which vaccination not to be delayed against Covid19:

1. high pressure on the medical system
2. dying and suffering a lot of people
3. Reducing stress and pressure on people
4. Make sure our schools, businesses and communities can reopen safety

In addition, the macroeconomic benefits of rapid vaccination are most probably considerable. The benefits are less if the pandemic and the economy develop more favorably while the vaccination process is under way in 2021, compared with 2020, but can be greater if developments are poorer. Based on the assumptions and calculations, fiscal and monetary policy support economic activity during 2021 in about the same way as during 2020.

3. COVID-19 vaccine and sustainable development goals

SDGs are a collection of 17 global goals to achieve and sustainable future life for all of the people by 2030 [40]. These goals are economic, social, environmental, etc., which affect the conditions of different countries. Annual reports on the success rate of achieving sustainable development goals are published. The SDGs are as follows:

Table 5. SDGs

No	goals
1	**No Poverty**
2	**Zero Hunger**
3	**Good Health and Well-being**
4	**Quality Education**
5	**Gender Equality**
6	**Clean Water and Sanitation**
7	**Affordable and Clean Energy**
8	**Decent Work and Economic Growth**
9	**Industry, Innovation and Infrastructure**
10	**Reduced Inequality**
11	**Sustainable Cities and Communities**
12	**Responsible Consumption and Production**
13	**Climate Action**
14	**Life Below Water**

15	**Life on Land**
16	**Peace and Justice Strong Institutions**
17	**Partnerships to achieve the Goal**

COVID-19 can affect these goals in different manners. For example, with the announcement of a nationwide quarantine, some people lose their jobs, which leads to unemployment, the development of poverty and hunger. The different effects of COVID-19 on each of the sustainable development goals are presented in Table 6:

Table 6. Impact of COVID-19 on SDGs (*Source:* [41]).

No	SDGs	Impacts
1	**No poverty**	**Due to closures and quarantines, people's income levels have fallen, leading to falling below the poverty line.**
2	**Zero hunger**	**Disrupting the production and distribution of food**
3	**Good health and well-being**	**Mental and physical injuries due to the disease and its complications.**
4	**Quality education**	**Remote learning doesn't have enough efficiency and all of the people don't have equal access to internet. Just 54% of the global population use the internet and in the least developed countries only 19% have online access.**
5	**Gender quality**	**Women are more vulnerable to the impact of outbreak and most of the nurses are women.**
6	**Clean water and sanitation**	**You need to wash your hands and accessing to clean water is important. Supply disruption and inadequate access to clean water is a problem**
7	**Affordable and clean energy**	**Curbing investments and threatening to slow the expansion of key clean energy technologies is the result of COVID-19**
8	**Decent work and economic growth**	**Business closures, unemployment, declining incomes, rising medical costs and declining economic growth**
9	**Industry, innovation and infrastructure**	**Some industries, such as the film and tourism industries, suffered more. Some industries, such as the pharmaceutical industry, benefited the most. Corona strengthened medical infrastructure and cyberspace.**
10	**Reduced inequality**	**Inequality and discrimination in the treatment of elderly and young patients, and discrimination in the distribution of vaccines among countries**
11	**Sustainable cities and communities**	**Cities with high population densities and poor sanitation are at greater risk**
12	**Responsible consumption and production**	**The COVID-19 pandemic offers countries an opportunity to build recovery plans that will reverse current trends and change our consumption and production patterns towards a more sustainable future.**
13	**Climate action**	**Due to the importance of the issue of Corona and its harmful effects, more attention is drawn to itself and less attention is paid to the issue of climate changes than before.**
14	**Life below water**	**The temporary shutdown of activities and human mobility due to COVID-19 may have provided marine environments time and space to start to recover. Still, long-term commitments to ocean preservation must remain a priority! Recovery after the pandemic offers the opportunity to invest in action plans to conserve our oceans and ensure progress toward the health and recovery of the planet.**
15	**Life on land**	**Increasing production and use of medical products such as masks, oxygen capsules, etc. is a threat to the planet earth. On the other hand, closures and pollution reduction are in the interest of planet earth**
16	**Peace, justice, and strong institutions**	**United Nations Development Program (UNDP) country offices are supporting national partners to address situations of emergency and mitigate negative effects of COVID-19 through tailor-made interventions. Evidence shows that there is no justice in the distribution of the vaccine, medical devices to reduce the Corona.**

17	**Partnerships for the goal**	**The novel Coronavirus (COVID-19) pandemic has underscored the importance of enhancing global collaboration and effective partnerships among all sectors and stakeholders, while building back better, together.**

As a result, the goals of sustainable development will be pursued with the discovery of the COVID-19 vaccine and its distribution among countries. But the point is that the distribution of the vaccine takes a long time and may not be fair in the distribution of the vaccine because this has been mentioned in various studies. For example, some countries have vaccinated half of their population, while some countries have not yet received a single dose of the vaccine. So, many companies tried to help each of the SDGs. You can see the help of each company on SDGs in Table 7:

Table 7. Companies that have contributed to the goals of sustainable development in the time of COVID-19

No	SDGs	Explanations
1	**No poverty**	**During Corona, some companies decided to relocate employees to avoid layoffs. An example is McDonalds Germany signed an agreement with Aldi that will refer McDonald's workers to the retailer's stores quickly and un-bureaucratically**
2	**Zero hunger**	**The focus of PepsiCo on meal distribution, Helping the hungry in deprived areas.**
3	**Good health and well-being**	**Improving testing capability and providing digital and high-tech tools to raise awareness on health by Roche and Apple respectively.**
4	**Quality education**	**Continue education at home by expanding global learning platform (Microsoft company)**
5	**Gender quality**	**Pay more attention to women because of higher risk and creating an organization to support this goal (MasterCard company)**
6	**Green water and sanitation**	**Lack access to handwashing products in poor countries and assistance of companies such as Unilever in this area**
7	**Affordable and clean energy**	**Providing extra help to decreasing energy bills (British Gas & EDF companies)**
8	**Decent work and economic growth**	**Commitment to continue payments at least the first two weeks of lockdown. (Walmart, Microsoft, Apple etc. companies)**
9	**Industry, innovation and infrastructure**	**Shifting or adding new lines to mask production and ventilators (Dyson and BlackRock companies)**
10	**Reduced inequalities**	**Equal access to virtual learning around the world (Zoom company)**
11	**Sustainable cities and communities**	**Identify the areas that are most at risk against COVID-19 like urban footprint using urban planning tool**
12	**Responsible consumption and production**	**Promote the consumption of health products and support suppliers by wholesalers using advancing payments (EDP company)**
13	**Climate action**	**Cutting carbon footprint and being carbon neutral (Australian Airlines)**
14	**Life below water**	**Analysis the impact of COVID-19 on seafood industry (NOAA fisheries)**

15	**Life on land**	**Invest in guaranteed purchase of farmers' products or vulnerable suppliers and support them (Unilever company)**
16	**Peace, justice and strong institutions**	**NGOs are calling to use empty Greek Hotels to host refugees threatened by COVID-1933, so tourism industry can help these people in risk during these uncertain times.**
17	**Partnerships for the goals**	**Participation in the manufacture and production of vaccines (Johnson & Johnson company)**

Most emerging countries are countries where vaccination rates are very slow and mortality and morbidity rates are higher. So, it is necessary to examine this issue in more details.

3.1. The Impact of countries in achieving inequality reduction

Sustainability is a fundamental concept. Today, it is a challenge for the world and the society and it could be efficient and impactful.

In the meantime, there are challenges in our lives that we face, challenges such as; poverty, climate change, inequality, diseases, etc. that countries face to change the world towards a sustainable future, and questions such as;

"What are the main and important causes of poverty and inequality in the world? has inequality between countries and within them increased due to globalization, and what policies should be used to achieve the goal of economic equality and poverty alleviation!"

The reduction of inequalities does not depend only on homogeneous factors, and therefore proper analysis to evaluate the performance of countries in this field is very difficult and tedious, while neo-liberal countries have turned society into winners and losers.

The issue of globalization has some extent contributed to the increase of social injustice and inequality between countries, but the main argument is that these inequalities and injustices are not only a consequence of the policies used for globalization but also, they are the result of internal weaknesses including lack of diplomatic relations and weak relations of third world countries with leading countries in industry and technology, inflation etc. In spite of appearing positive signs to reduce inequality in some dimensions, inequality still persists and Covid-19 has widened the gap because it has done the most damage to the most vulnerable and poorest sections of society, while social, political and economic inequalities have also increased the effects of the epidemic, rising global unemployment and declining workers' incomes have jeopardized progress. The limitations that have occurred in the area of gender equality and women's rights are inequalities and they are more harmful for society with a very weak immune system that provides a poor health system for its citizens. The other main issues along with these inequalities are the situation of refugees and migrants as well as indigenous, elderly people, people with disabilities, especially children, are clearly visible and tangible. Covid-19 has challenged not only the systematic approach to global health, but also altruism and humanity.

That is why the secretary-general of the United Nations recently announced in a message with a wonderful meaning to the world: "Now is the time to stick to our commitment and approach and not leave anyone behind!"

The UN secretary-general called for solidarity with the poorest and most vulnerable countries in the world who need immediate support to respond to their worst economic and social crisis. There are several goals and strategies to form and lead human societies to achieve sustainable development goals (https://www.un.org/sustainabledevelopment/inequality):

- Promoting social, economic, political participation and empowerment of the people regardless of age, gender, disability, race, ethnicity, religion or economic status.
- Ensure equal opportunities and reduce inequalities, including the elimination of discriminatory laws, policies and practices, and the promotion of appropriate laws, policies and practices in this area.
- Adopt policies, especially fiscal, wage and social protection policies that will gradually achieve greater equity.
- Improve regulation and oversight of global markets and financial institutions and strengthen enforcement of such regulation.
- Ensure representation and greater participation of developing countries in decision-making in international economic and financial institutions in order to establish more effective, credible, accountable and legal institutions.
- Facilitate regular, safe and responsible migration and mobility of individuals through the implementation of planned and managed immigration policies.
- Implement special and different behavior for developing countries, especially underdeveloped countries, in accordance with World Trade Organization (WTO) agreements.
- Encourage formal development assistance and financial flows, including foreign direct investment, to most desired countries, especially underdeveloped African countries, small island developing countries and landlocked developing countries, as planned; Their national programs.
- By 2030, the cost of migrant remittance transactions will be reduced to less than 3% and remittance corridors with costs above 5% will be eliminated.

3.2. Emerging market economies and COVID-19 vaccines

Emerging markets refers to economies with some characteristics such as considerable economic growth and possess some qualifications of developed economy. These markets are countries that moving towards developed countries. It is a transition from developing to developed phase. Some characteristics of emerging market economies are as follows:

- Economies making a transition
- Rapid industrialization (i.e., development of secondary and tertiary sectors)
- Have potential to become developed economies
- Low per capita and faster long-term economic growth than most developed economies
- Many inhabitants still in poverty and high-income inequalities
- Business struggle to access global markets (e.g., trade barriers) and chronic shortage of resources.
- Huge diversity within market
- Weak, highly variable infrastructure
- Technology is underdeveloped
- Weak distribution channels and media infrastructure

As it is clear, these countries have characteristics that will definitely cause problems when vaccinated, such as delayed access to vaccines, improper distribution, rent-seeking, and so on. In the next section, we will look at how vaccines are distributed in emerging countries.

3.2.1. The priority of human health over income generation

In 1990, John Kenneth Galbraith, a Canadian American economist, politician, and diplomat, called poverty the strongest and most common human tragedy. About three decades have passed since that day, and despite the costs incurred in controlling poverty around the world, its powerful and devastating effects are being sacrificed because poverty effect deeply on education system, health, and so on.

Over the years, researchers who work on health field, have found ample evidence that shows how social and economic factors, including income, education, and goods they have access to, as well as structural factors such as racism and political inequality, affect health.

Although governments and reputable individuals spend the most budgets to combat this scourge, since no particular person or government has been able to control it, and this has led to irreparable damage for social health over time. But there is a main question:

"Has the allocation of such resources by governments or reputable individuals optimally reduced poverty?"

- Relationship between income and health

"Your income affects your health," says Lavdan Aron of the urban Institute. Aaron also admitted in an interview;

"Wherever you are [in terms of income], there are better people than you who are healthier and live longer, and people who are more financially disadvantaged will probably not live longer on average as a group!"

- Longevity is not the only thing that changes with income level

Aaron and colleagues cite data from the center for disease control and prevention, which shows that some diseases are less common among higher-income groups.

Cardiovascular disease, stroke, diabetes, arthritis and many other physical problems affect sections of the low-income population.

According to the data, the more money you earn, the less likely you are to have a stroke.

Also keep in mind that health also affects income, which means that people with poor physical or mental health will work harder.

We enumerate a few cases of such problems in order to pay more attention and consciously in the interests of society, health and public welfare (https://www.businessinsider.com/how-income-affects-health):

- People with lower incomes usually have less money to take care of themselves, whether to see a doctor and medicine or to eat healthy food and having free time.
- Low-income stress, especially in childhood, increases the risk of heart disease, stroke, cancer and diabetes
- People with higher incomes live in areas with healthier resources such as grocery stores, safe housing, exercise opportunities, clean air and better schools.

Poor health and disability can prevent more people from earning more, so it is not possible to say exactly that in any scenario, low income causes weakness health or vice versa, but there is no doubt that there is a strong and close relationship between low income and poor health.

Due to the impact of social and economic factors on health, better coordination, participation and integration with the human services sector helps to improve this situation. So, as a result, the health care sector cannot improve health outcomes lonely. Therefore, health care and human services can be considered as a subset of broader multi-sectoral collaborations, and finally, in order to understand the potential integration of health care and social services, scientific gaps in key areas must be filled.

3.3. Vaccination progress in emerging countries

With the discovery of the COVID-19 vaccine, countries have begun to vaccinate the public. But in emerging countries, there are some challenges. Governments don't have enough doses of vaccine in order to immunize entire population. So, the distribution function can be difficult or time-consuming. This function depends on economic infrastructure. Research shows that emerging countries are keen to use the COVID-19 vaccine if it is available. The following figure shows the tendency of emerging economies to adopt the COVID-19 vaccine compared to some developed countries.

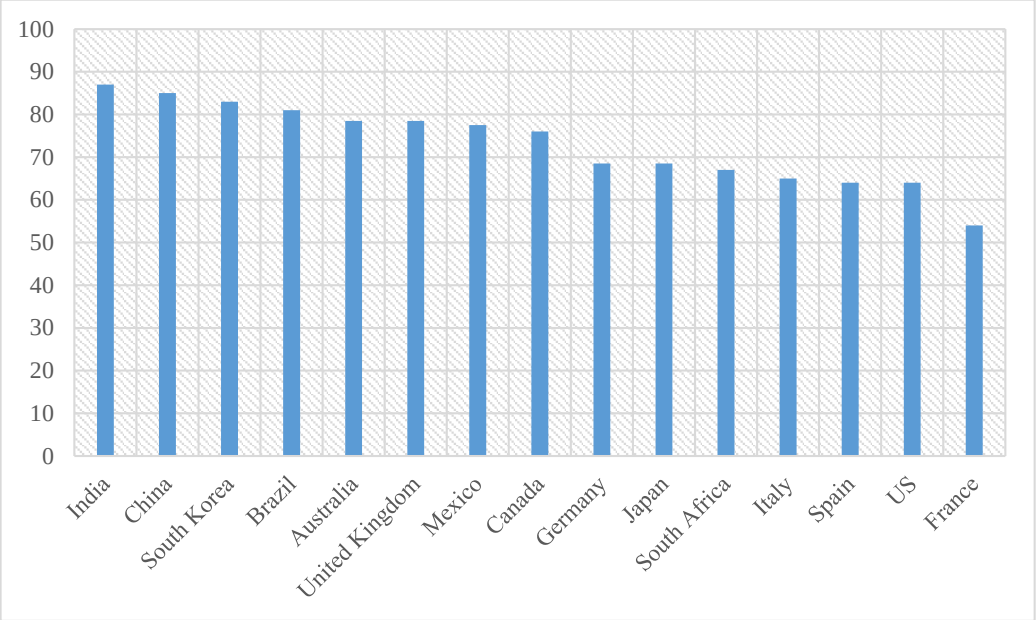


Figure 4. Percentage of people in emerging and developed countries who are willing to be vaccinated (**Source:** IPSOS Mari, Schroders Economic Group. 15 OCT-2020)

As it is clear, emerging countries are more likely to seek vaccines, while in practice the share of developed countries is higher. The motto of the world health organization has always been equality, but in practice it has failed. Statistics show that the power of developed countries has been greater in pre-order vaccines to immunize populations several times. Below figure shows the vaccination treatments per capita on order. It is clear that the share of EM is fewer on order from a narrower basket of producers.

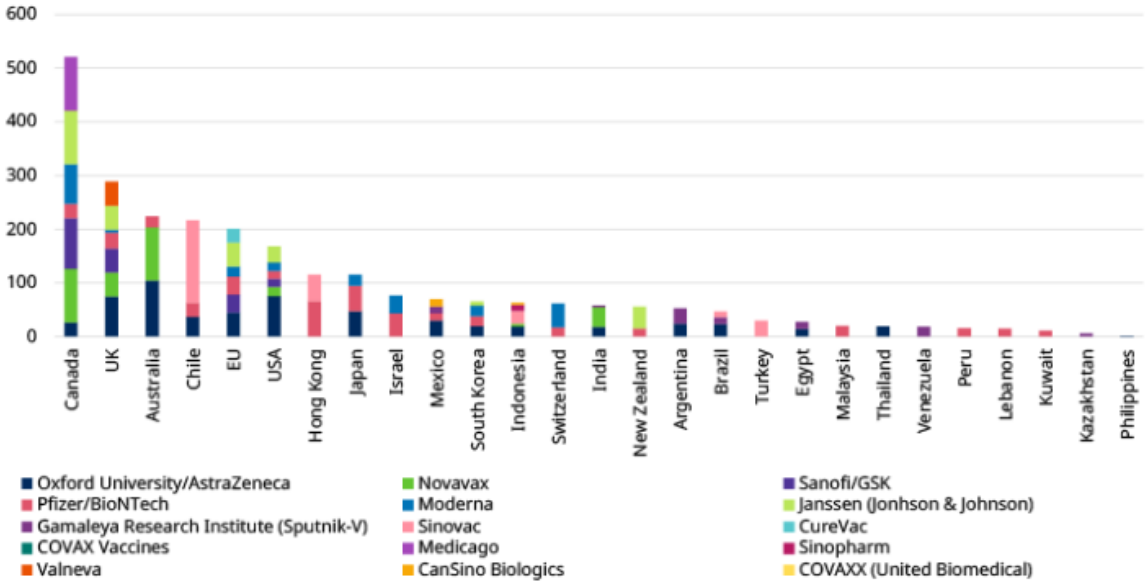


Figure 5. Vaccination treatments per capita on order (%); (**Source:** Duke University, International Monetary Fund (IMF), Schroders Economics Group. 15 Dec-2020)

Emerging economies have access to vaccines that are not yet in the final phase and are not very popular. For example, Pfizer/BioNTech almost used in UK and US because it is expensive and includes harsh storage conditions such as freezing temperatures that is challengeable for some EM that have climate changes. Instead, many EM selected alternative vaccines which belong to Russia and China such as Gamaleya's Sputnik V, Sinovac, Sinopharm etc.

Many people may die by the time some vaccines in emerging countries prove effective. Even if the vaccine is available, they will have trouble distributing it. So, some EM with high populations and poor infrastructure such as India and Brazil will have trouble.

The economic impact of COVID-19 vaccine is different in EM countries. Some EM deal with COVID-19 relatively well such as China and Taiwan and benefit more than others. Thus, the rate of exports is much more than before. On the other hand, some countries with good tourism industries such as Brazil, Thailand and Egypt were affected by the advent of the Corona. In the following figure, you can see the countries that are more service-based.

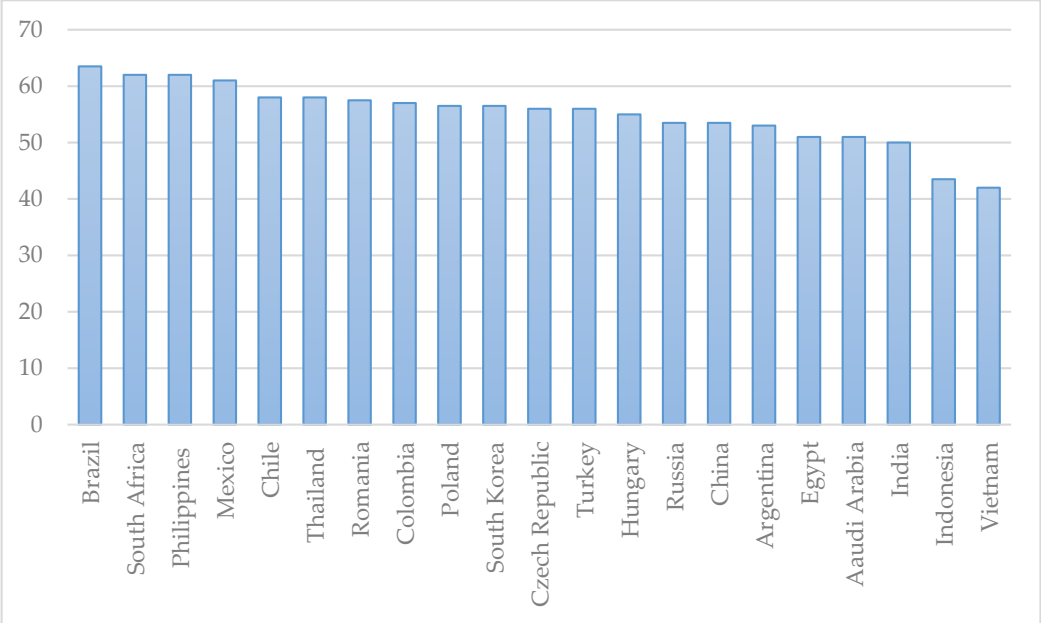


Figure 6. Value added of services (% GDP, 2019); (**Source:** Refinitiv Datastream, World Bank, Schroders Economic Group. 15 Dec-2020)

It can be understanding that vaccines are likely to be of more benefit to countries with large services sectors.

The percentage of vaccinated population varies in emerging countries. For example, Chile's population had received at least one dose of vaccination, and it had inoculated an impressive 5% of the population in the previous seven days. Some countries in central eastern Europe made more progress, i.e., they have vaccinated about 7% of their populations. The following Table shows the percentage of vaccinated population against COVID-19 (Source: Deutsche Bank, 24 Feb-2021).

Table 8. COVID-19 vaccination as % of population

Country	Total vaccinations	Total people vaccinated	Total vaccination as % of pop	7day (total vaccinations)	7day (total people vaccinated)	Total vaccination as % pop in last 7 days	Latest data as on
Israel	**7.535.543**	**4.459.874**	**87.06**	**897.582**	**447.772**	**10.37**	**22-Feb-21**
United Arab Emirates	**5.557.793**	**N/A**	**56.19**	**470.958**	**N/A**	**4.76**	**22-Feb-21**
United Kingdom	**18.348.165**	**17.723.840**	**27.47**	**2.508.384**	**2.423.689**	**3.76**	**21-Feb-21**
United States	**64.177.474**	**44.138.118**	**19.39**	**11.293.118**	**5.845.848**	**3.41**	**22-Feb-21**
Chile	**2.994.139**	**2.938.813**	**15.66**	**811.027**	**811.009**	**4.24**	**22-Feb-21**
Turkey	**6.837.302**	**5.738.471**	**8.11**	**2.655.275**	**2.130.323**	**3.15**	**22-Feb-21**
Poland	**2.759.436**	**1.824.654**	**7.29**	**600.290**	**323.743**	**1.59**	**22-Feb-21**
Switzerland	**611.842**	**474.437**	**7.07**	**130.437**	**N/A**	**1.51**	**17-Feb-21**
Greece	**730.410**	**486.820**	**7.01**	**175.665**	**100.771**	**1.69**	**22-Feb-21**
Hungary	**662.816**	**457.096**	**6.86**	**189.265**	**115.138**	**1.96**	**22-Feb-21**
Spain	**3.090.351**	**1.893.290**	**6.61**	**528.743**	**401.773**	**1.13**	**21-Feb-21**

Finland	**363.938**	**287.998**	**6.57**	**87.469**	**78.488**	**1.58**	**21-Feb-21**
Germany	**5.220.336**	**3.413.730**	**6.23**	**907.879**	**584.434**	**1.08**	**22-Feb-21**
Italy	**3.608.645**	**2.272.519**	**5.97**	**531.209**	**493.722**	**0.88**	**22-Feb-21**
Belgium	**672.987**	**407.296**	**5.79**	**82.884**	**33.598**	**0.71**	**21-Feb-21**
Sweden	**585.843**	**398.092**	**5.78**	**127.981**	**56.436**	**1.26**	**19-Feb-21**
France	**3.726.513**	**2.564.530**	**5.71**	**830.041**	**308.933**	**1.27**	**21-Feb-21**
Czech	**545.381**	**337.829**	**5.09**	**88.799**	**47.701**	**0.83**	**21-Feb-21**
Nether-lands	**806.744**	**N/A**	**4.70**	**199.883**	**N/A**	**1.16**	**21-Feb-21**
Canada	**1.554.003**	**972.407**	**4.12**	**281.074**	**N/A**	**0.75**	**22-Feb-21**
Brazil	**7.028.356**	**5.857.080**	**3.31**	**1.734.377**	**780.970**	**0.82**	**22-Feb-21**
China	**40.520.000**	**N/A**	**2.82**	**N/A**	**N/A**	**N/A**	**09-Feb-21**
Russia	**3.900.000**	**2.200.000**	**2.67**	**N/A**	**N/A**	**N/A**	**10-Feb-21**
Argentina	**722.234**	**458.822**	**1.60**	**112.443**	**86.641**	**0.25**	**22-Feb-21**
Saudi Ara-bia	**501.710**	**N/A**	**1.44**	**57.245**	**N/A**	**0.16**	**18-Feb-21**
Mexico	**1.733.404**	**1.277.187**	**1.34**	**983.722**	**613.703**	**0.76**	**22-Feb-21**
India	**11.424.094**	**10.308.552**	**0.83**	**2.907.323**	**1.889.899**	**0.21**	**22-Feb-21**

Most of the EM countries are rarely vaccinated. For example, India and Mexico had delivered a first shot of vaccine to about only 1% of their populations, while Brazil had inoculated only 3%. Most EM countries are import-based. So, we should expect such delays because first the developed countries vaccinate and then they export them to EM countries. Some EM countries such as Brazil and Egypt have licensed and manufacture and produce vaccine themselves and it could speed up vaccination in the months ahead. But there are some EM countries that relying on imports of shots. So, the vaccination will be slow.

Some analysts believe that EM countries with low income and insufficient fiscal budget or low GDP will get into trouble for vaccination until the end of 2022.

Goldman Sachs has a base case scenario for herd immunity to be reached in most emerging markets between late 2021 and mid-2022, with richer economies and those with greater vaccine supply reaching it sooner. You can see more details in Figure 7:

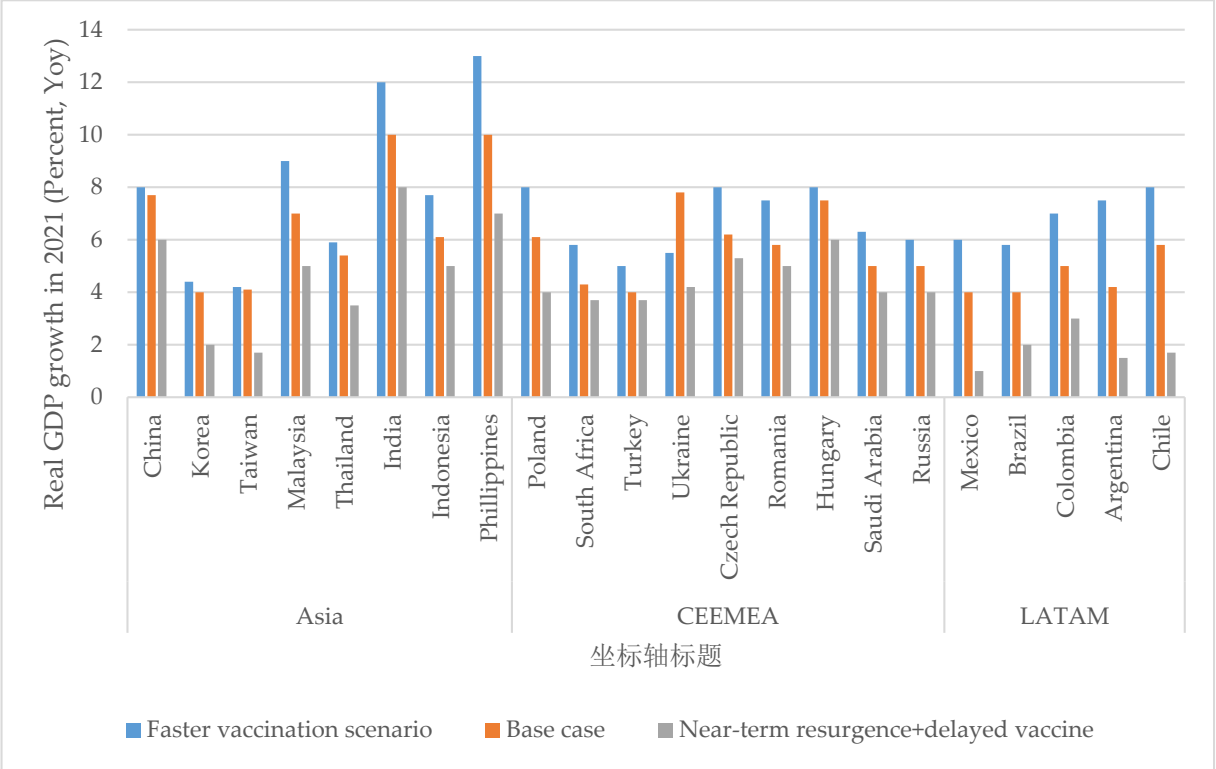


Figure 7. EM growth in 2021 sensitive to timing of vaccine rollout; (**Source:** Goldman Sachs Global Investment Research)

There are some reasons that cause increasing the gap between EM and developed countries:

- Lack of adequate vaccine supply in emerging markets
- The large purchases of vaccine doses by developed markets
- Late start to vaccinations in Asia

3.3.1. How the vaccine is distributed among the countries?

Doctors Without Borders/ Médecins Sans Frontières (MSF) calls on wealthy countries to lead to fulfill this exemption, in a bid to oppose not blocking rescue aid for billions of people in other parts of the world.

They believe that there is no equal situation and in this critical situation, no one is exempt from helping the world community if it is able to control it, and this epidemic will not end until it is over for everyone.

The purpose of the Intellectual Property Exemption (IP) is to allow countries not to apply patents and other patents that could impede the production and supply of COVID-19 medical devices. If the exemption is approved, it will send an important signal to potential manufacturers that they can produce the tools required for COVID-19 without fear of being blocked by the invention or other patents. The proposal is now formally supported by Eswatini, Kenya, Mozambique, Pakistan, Mongolia, Venezuela, Bolivia, Zimbabwe and Egypt. However, a small group of WTO members, including the European Union, the United Kingdom, the United States, Japan, and Switzerland, Brazil, Canada, Ecuador, El Salvador and Australia continue to oppose it.

Given the statistics since the appearance and spread of the epidemic, the need to ensure global open access and the right to manufacture and supply COVID-19 health technologies is widely accepted. Despite the efforts and statements of several heads of

state that COVID-19 medical products are considered "global common goods", due to the epidemic, especially in African countries, little has been achieved to date.

However, countries opposed to the IP exemption plan continue to delay reaching common ground and advancing the process, and continue to use delayed tactics to halt the passage of the enactment.

There is only an important point and that is the life of human societies over time, which means that the lives of many people are related to the adoption of this important issue (https://www.msf.org/msf-urges-wealthy-countries-not-block-covid-19-patent-waiver?).

How many COVID-19 vaccines are the United States and other G7 countries committed to testing?

The United States has pledged to donate 500 million more doses of the Pfizer vaccine to poorer countries starting next year, bringing its total commitment to more than 1 billion doses.

The grant is driven by COVAX, an international plan designed to ensure that low-income countries retreat in the fight against COVID-19, so that rich countries pay attention (financial support) to poorer countries with the primary goal of providing two billion doses of vaccine in worldwide in 2021 and 1.8 billion doses to 92 poor countries by early 2022.

Ghana was the first country to receive COVAX vaccines in February.

Since, more than 303 million doses of the vaccine have been delivered through COVAX to 142 countries, including Bangladesh, Brazil, Ethiopia and Fiji.

- Which countries donate the vaccine and how many?

Sponsors of the project (COVAX) include the United States, the United Kingdom, Canada, Japan, Australia, New Zealand, the United Arab Emirates, France, Germany, Italy, Spain, Sweden and Portugal, and have pledged to donate both additional money and additional doses of vaccine sources.

- How was COVAX released?

According to Oxford university, while many high-income countries have already given at least one injection to more than half of their population, only 2% of people in low-income countries have received the first dose, while some Countries have fully vaccinated large numbers of their populations, many countries have just started or in some cases are still waiting for their first doses.

For instance, according to official statistics from the Bloomberg website, despite the fact that the America, Asia and Australia have vaccinated a high percentage of their citizens, African countries have vaccinated a very small percentage of their citizens, while Morocco, with a population of 36 million, has 59 million doses, but overall, it does not provide acceptable statistics on the continent, and it is much lower and more critical than the world standard.

According to experts, even if COVAX achieves its goal of vaccinating 20 percent of the population in its 92 target countries, it is the lowest level needed to end the epidemic (https://www.bbc.com).

- Corona vaccination around the world

More than 6.27 billion doses have been prescribed in 184 countries, and more than 4.1 billion people have received at least one dose of the Covid-19 vaccine, or 46.4 percent of the world's population while the last rate was approximately 31.2 million doses per

day. (For getting more information, you can see Our world in data project at the university of Oxford).

Vaccine doses are relatively scarce worldwide, and demand is still expected to exceed supply by the end of 2021.

Countries with some qualifications such as low income, low GDP or generally, third world countries rely on the distribution of COVAX vaccines, which were originally intended to provide two billion doses by the end of the year, but have repeatedly lowered their forecasts due to production problems, export bans and vaccine hoarding by rich countries. In its latest forecast, a total of 1.4 billion doses are expected to be available by the end of 2021.

By only 0.5% of doses administered in low-income countries and 78% of vaccination statistics worldwide in high-and middle-income countries, this can lead to a significant gap between different areas around the world.

Africa has the slowest vaccination rate among other continents. Only 6.8 percent of people have received at least one dose of the vaccine.

According to Bloomberg, in the United States, 398 million doses have been administered so far, and last week, an average of 725,777 doses were administered per day.

The highest-income countries and regions are vaccinated more than 20 times faster than the low-income countries (https://www.nytimes.com/interactive/2021/world/covid-vaccinations-tracker.html).

Keep in mind that on a global scale, this level of vaccination is very alarming.

Globally, the latest vaccination rate averages 31,175,855 doses per day, but at this rate, it will take another six months to reach 75% of the world's population.

Israel has shown for the first time that vaccines can prevent COVID-19 infections. It was a world leader in early vaccination, with more than 84 percent of people 70 and older receiving two doses by February.

Elsewhere in the world, vaccine distribution in the United States is administered by the federal government, and more than half of the US population has been fully vaccinated, although the United States has been a world leader in vaccination since then. Several countries have overtaken them in the field of vaccination.

According to Bloomberg, 214 million American have received at least one dose of the vaccine [That means about 83.1 percent of the adult population and at least 185 million people have completed the vaccination regimen.]

The United States also sends part of its supply surplus to other affected regions of the world.

U.S. health officials are currently focusing on how to vaccinate people who do not want to be vaccinated. The young and unvaccinated population is increasingly the key to controlling the epidemic (Source: https://www.bloomberg.com/graphics/covid-vaccine-tracker-global-distribution).

3.4. Sustainable development goals in emerging economies

Five members of EM countries which are called BRICS (Brazil, Russia, India, China and South Africa) as well as Argentina, Indonesia, Mexico, Nigeria and Turkey play an important role in achievement of sustainable development goals. Global food security is very crucial and China, Brazil and India have decided to take a part in these activities in terms of production, exports and imports and they have negotiated with WTO and their vital roles on international trade. So, they can fight against hunger and help undernourished people around the world (SDGs no.1).

They have also been successful in technology. For example, China and Brazil or Russia have tried to transfer their technologies to other countries with weaker infrastructures such as Africa (SDGs no. 9). Recently, consumer demand has increased in

EM countries most notably Brazil, Russia, India and China and it has decreased in developed countries such as US and in Western Europe. Because the products of emerging markets are cheap, high quality and diverse, it has a lot of fans, which is in the interest of the global economy (SDGs no. 8 & 12).

Most of the emerging economies had high growth rate and this can help them combat and fight against poverty (SDGs no. 1). Poverty can lead to inequality in different dimensions such as social protection, erratic access to education and to basic services, difficulties for women in obtaining employment and progressing in their careers, ethnic, as well as regional differences. EM countries have always tried to pay attention to climate changes which affecting agriculture and food production, infectious disease etc. (SDGs no. 13). They always hold and execute conferences and seminars on environmental issues. Because of inequality in rural area, they face discrimination in accessing productive resources, such as land, extension services, technical training and markets.

3.5. Vaccination progress in Iran (Islamic Republic of)

First of all, let's check the statistical and numbers of COVID-19 daily new cases, daily death cases in Iran.

Table 9. Statistical information about COVID-19 in Iran

Country	Iran	Vaccination
Coronavirus cases	**2.479.805**	**Doses given: 939K**
Deaths	**71.351**	**Fully vaccinated: 194K**
Recovered	**1.938.064**	**% of population fully vaccinated: 0.2%**
Active cases	**470.390**	**In mid condition: 465.023 (99%)** **Serious or Critical: 5.367 (1%)**
Closed cases	**2.009.415**	**Recovered / Discharged: 1.398.064 (96%)** **Deaths: 71.351 (4%)**
Date	**30-Apr-2021**	

Various projects for the production of Iranian Corona vaccine in the country are being developed by researchers, and 8 active projects are being licensed to enter the clinical phase. Among the vaccine producing countries, our country is also active and has started producing vaccines. Iran is currently ranked 11th in the world in terms of (number of vaccines) among the 16 manufacturers of Corona vaccines. According to ministry of health officials, 12 teams are working on producing the Corona vaccine. Executive staff of Imam Khomeini (RA) and Barekat Institute, Pasteur Institute of Iran, Razi Vaccine and Serum Institute, a number of universities of medical sciences, ministry of defense, companies and knowledge-based institutions are some of the implementers of this project in our country. The situation of Iranian Corona vaccine production projects is different. Some have submitted their clinical phase information to the food and drug administration for authorization, while others are in the animal phase status. The platform for the production of this vaccine (Barekat), which is in the human testing phase, is based on "killed virus" and 56 volunteers have been considered for the injection of this vaccine.

In the Corona vaccine co-produced with Cuba, the animal phase has passed. Phase one of the clinical trial was conducted under the supervision of the Pasteur institute of Iran in that country; Phase 2 is also underway, and after analyzing the results of Phase 2, Phase 3, which is the safest phase, will be performed on about 50,000 people in February and March.

Another of these vaccines is the Razi company vaccine. The vaccine is based on "recombinant protein" and human tests are underway.

Until the vaccines were prepared, the authorities were thinking of importing valid vaccines into the country, including Sputnik V, Sinovak, Sinofarm, etc. People were divided into different groups to start vaccinating the general public. First the medical staff, then the elderly and those with underlying diseases, and then the employed and the young.

In the following, you can see the table of active Iranian Corona vaccine projects;

Table 10. Active Iranian Corona vaccine projects

No	Institute or company	Vaccine-based type	Phase	Similar to the foreign Corona vaccine
1	**Imam Khomeini Executive Headquarters; Barekat Institute**	**Killed or inactivated virus**	**The third stage of the clinical trial**	**Oxford/Astrazeneca, Sinovac, Sputnik**
		-	**Obtaining a clinical license**	**-**
		DNA	**-**	**-**
		Subunit	**-**	**-**
		mRNA	**Completion of the animal phase**	**Pfizer / Moderna vaccine**
		Stem cells	**Completion of the animal phase**	**-**
2	**Razi Vaccine Institute**	**Recombinant protein**	**The third clinical stage**	**Novavax**
3	**Knowledge-based company**	**mRNA**	**Obtaining a clinical license**	**Pfizer / Moderna vaccine**
4	**Pastor Institute of Iran**	**Recombinant protein**	**Phase 3 Joint clinical trial with Cuba**	**Novavax**
5	**Knowledge-based company**	**Adenovirus is a non-replicating viral vector**	**Animal phase**	**In terms of the type of virus in China and Russia; Technologically similar to the two and Astrazeneca and Johnson**
6	**Knowledge-based company-Ministry of Defense**	**Inactivated virus**	**Check for clinical license**	**Oxford/Astrazeneca, Sinovac, Sputnik**
7	**Knowledge-based company**	**Inactivated virus**	**Animal phase**	**Oxford/Astrazeneca, Sinovac, Sputnik**
8	**Baqiyatallah University of Medical Sciences**	**Recombinant protein**	**Animal phase**	**Novavax**

People are being vaccinated more quickly, and a number of vaccines are in the final stages of mass production like Barekat. We hope that this disease will be eradicated in Iran and in the world as soon as possible.

4. Methodology

In this part, we have tried to prediction daily new death cases in Iran as a case study. So, we got considered data from https://ourworldindata.org/coronavirus. The considered time interval is from Feb-2020 to August-2021. Beetle Antennae Search (BAS) and Artificial Neural Network (ANN) are considered algorithms. Econometric models such as Autoregressive–moving-average (ARMA) along with regression analysis is being used as a benchmark and comparability.

Authors should discuss the results and how they can be interpreted from the perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

4.1. Artificial Neural Network (ANN)

Artificial neural network is the simulation of thinking mechanism in human. It has three layers: 1. Input layer 2. Hidden layer 3. Output layer. Data transfer from input layer to hidden layer and each layer has an activation function for recognition. The first activation function is a non-linear function. Each layer contains some weights and a bias and they sum together and make ready for transferring to the next layer means output layer or target. There is an activation function between hidden and output later which is linear function. Again, weights and bias are added together.

The number of neurons and layers can be obtained by trial and error. Thus, the network uses 1-32 neurons to achieve the best one. It is clear that our output variable (i.e., target) is new vaccinations.

This process can be seen in Figure 8 and is the architecture of the considered network [42].

This process can be seen in Figure 8 and is the architecture of the considered network [42].

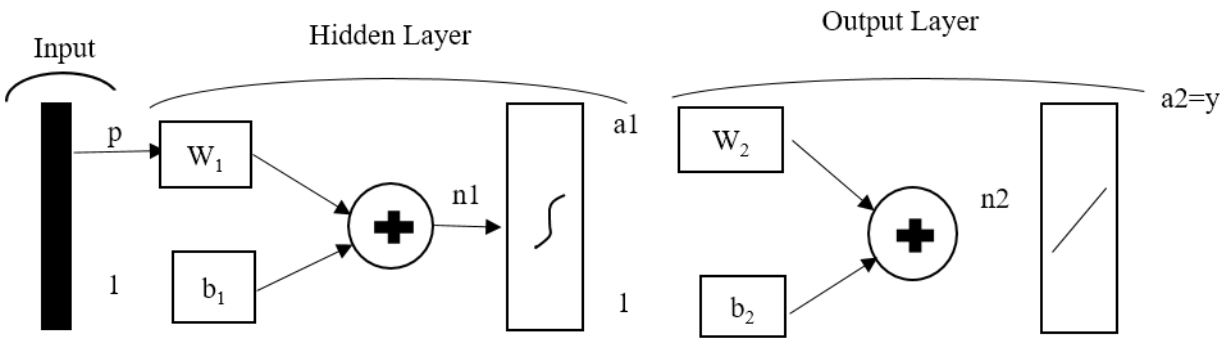


Figure 8. Architecture of the proposed neural network

In Figure 2, P is the input pattern, b1 is the vector of bias weights on the hidden neurons, and W1 is the weight matrix between 0th (i.e., input) layer and 1th (i.e., hidden) layer. a1 is the vector containing the outputs from the hidden neurons, and n1 is the vector containing net-inputs going into the hidden neurons, a2 is the column-vector coming from the second output layer, and n2 is the column-vector containing the net inputs going into the output layer. W2 is the synaptic weight matrix between the 1st (i.e., hidden) layer and the 2nd (i.e., output) layer and b2 is the column-vector containing the bias inputs of the output neurons. Each row of W2 matrix contains the synaptic weights for the corresponding output neuron [43]. Firstly, the neuron receives information from the environment and then this information multiplied by the corresponding weights is added together and used as a parameter within an activation (transfer) function. [44]. The transfer functions are used to prevent outputs from reaching very large values that can

'paralyze' ANN structure. For hidden layer, suitable transfer function is particularly needed to introduce non-linearity into the network because it gives the power to capture non-linear relationship between input and output [45].

There are two important functions in ANN: 1. Training 2. Testing. We used 70% of data for training and 30% for testing.

In order to using ANN, firstly, we should normalize data between [-1, +1]. So, it can be possible using the following equation:

$$S_i = \frac{\left(S_i - S_{min}\right)}{S_{max} - S_{min}}. \; i = 1 \ldots . N \tag{1}$$

Where:
$\widetilde{S_i}$: Normalized data
S_i: Each observation of each variable
S_{min}: Minimum value of each variable
S_{max}: Maximum value of each variable
In equation 1, numerator i is the amount of data. Considered parameters are expressed in table11.

Table 11. Parameters

Parameters	Explanations
Training	**Back-propagation (BP)**
Optimization algorithm	**Levenberg-Marquardt (LM)**
Training rate	**0.01**
Iterations	**1000**
Activation function	**Tan-Sigmoid**
	Pure line

BP algorithm is used as a network learning method. LM is used as an optimization algorithm to decrease the rate of error. At first, the rate of training is equal to 0.01 which can decrease to 0.001. Two types of activation function (non-linear and linear) have been used.

Figure 9 represents the methodology:

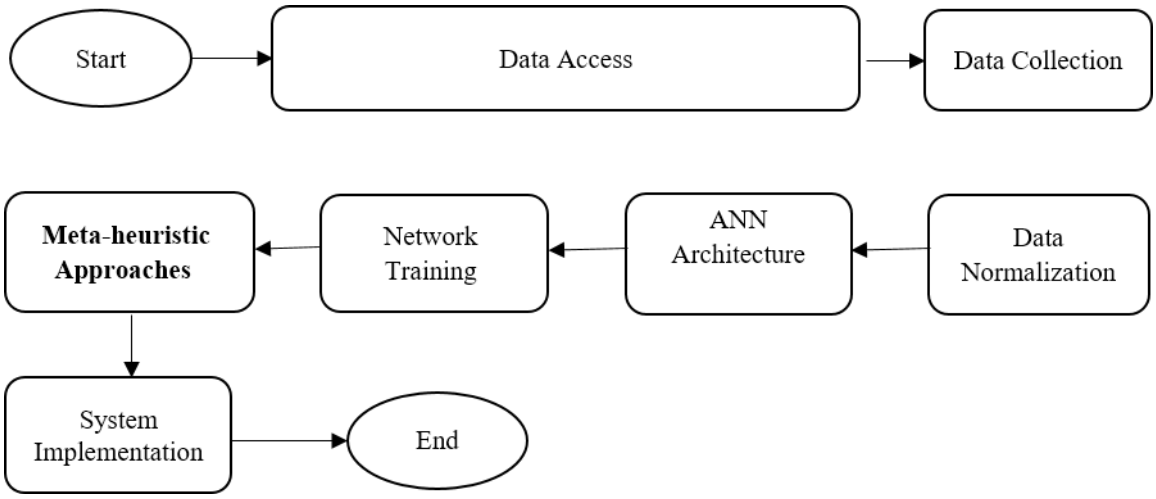


Figure 9. Research Methodology

4.2. Beetle Antennae Search (BAS) Algorithm

Beetle Antennae Search (BAS) introduced by Jiang. X and Li, S., in 2017 which is inspired by the search behavior of longhorn beetles [46]. These beetles have some special qualifications such as interesting antennae which acting as sensing systems and warning mechanism. They have two important roles: 1. Bind to odors of prey and 2. Obtain the sex pheromone of potential suitable mate. Their search and exploration mechanism are randomly. It could be possible to formulate these mechanisms. So, we should consider different parameters such as position of the beetle as a vector x^t at tth time instant ($t = 1.2.\dots$) and the concentration of odor at position x to be $f(x)$ which known as fitness function. We need to formulate two kinds of behavior: (i) searching behavior and (ii) detecting behavior. As we mentioned earlier, the searching mechanism of these beetles are randomly. So, we can formulate it as below equation:

$$\vec{b} = \frac{rnd(k.1)}{\|rnd(k.1)\|} \tag{2}$$

Where;
rnd (.): a random function
k: dimensions of position
it could be possible to imitate and formulate the mechanism of two antennae sides.
$x_r = x^t + d^t\vec{b}$

$$x_l = x^t + d^t\vec{b} \tag{3}$$

Where;
x_r: a position lying in the searching area of right-hand side
x_l: a position lying in the searching area of left-hand side
d: the sensing length of antennae corresponding to the exploit ability

We should note that d is better to be large enough for covering an appropriate searching space and preventing local minima.

The next step is formulating the behavior of detecting by considering the searching behavior:

$$x^t = x^{t-1} + \delta^t\vec{b}\ sign(f(x_r) - f(x_l)) \tag{4}$$

Where;
δ: the step size of searching which is related to convergence speed that following a decreasing function or a constant.
Sign (.): a sign function
We should update two parameters such as antennae length d and step size δ as follows:

$$d^t = 0.95d^{t-1} + 0.01 \tag{5}$$

$$\delta^t = 0.95\delta^{t-1} \tag{6}$$

The BAS algorithm pseudo-code can be expressed as follows:

Table 12. BAS pseudo-code for global minimum searching

Input: Establish an objective function (x^t) , where;
variable $x^t = [x_1.\dots.x_i]^T$, initialize the
parameters $x^0.d^0.\delta^0$.
Output: $x_{bst}.f_{bst}$.
While $(t < T_{max})$ *or* $(stop\ criterion)$ do

Generate the direction vector unit $\vec{b}$ *according to* (1);
Search in variable space with two kinds of antennae according to (2);
Update the state variable x^t *according to* (3);
if $f(x^t) < f_{bst}$ ***then***
$f_{bst} = f(x)^t . x_{bst} = x^t$
Update sensing diameter d and step size δ *with decreasing functions* (4)*and* (5) *respectively. which could be further studied by the designers*
Return $x_{bst}. f_{bst}$

4.3. Other optimization algorithms

This article is based on two methods means ANN and BAS algorithm. But, four other algorithms such as particle swarm optimization (PSO), time-varying acceleration coefficients particle swarm optimization (TVAC-PSO), modified particle swarm optimization (MPSO) and Chimp optimization (Cho) algorithms have been used as optimization algorithms.

4.3.1. PSO algorithm

PSO algorithm proposed by [47]. It begins with initial population and in sequential iterations moving toward optimization answer. In each iteration, two answers calculate (X^{Gbest} and $X^{i-pbest}$) which represent the best acquired location for each particle and best location in current location respectively. Each particle has two main parameters means speed and velocity.

4.3.2. MPSO algorithm

The simple PSO doesn't have inertia weight parameter. In PSO algorithm, inertia factor ω according to literature decrease linearly.

$$\omega=\omega_{max} - \frac{\omega_{max}-\omega_{min}}{iter_{max}} \times iter \tag{7}$$

Here $iter_{max}$ is the biggest evolution of algebra, $iter$ is the algebra for this evolution. Improved particle swarm optimization algorithm BP operations driven by the amount of correction of the weights of the way, that the amount of correction of the weights between the neural network node m and node n from below equation:

$$\Delta\omega_{nm}(t+1)=\alpha\Delta\omega_{nm}(t) + \eta S_n(t) y_m(t) \tag{8}$$

Here, the amount of correlation of the conventional BP, α is algorithm, and $y_m(t)$ is the momentum term inertia coefficient for the output node m [48].

4.3.3. MPSO-TVAC

There is a parameter for improving exploitation and exploration and preventing local trap. In this strategy, each particle has its own $[rbest_i{}^j = rbest_{i1}{}^j . rbest_{i2}{}^j . \ldots . rbest_{id}{}^j]$ which is randomly selected from the best position (Pbest) of other particles (Yitong, L., et al. 2007). A similar approach is applied to other particles in the swarm. We can use the following equations for updating velocity:

$$V_{j+1}^i = W_j V_j^i + c_1 r_1 \left(X_j^{i.pbest} - X_j^i\right) + c_2 r_2 \left(X_j^{Gbest} - X_j^i\right) + c_3 r_3 \left(rbest_{id}{}^j - X_j^i\right) \tag{9}$$

where, c_3 is the acceleration coefficient that pulls each particle towards rbest. Both coefficients should be change in order to improving exploitation and exploration.

4.3.4. Cho algorithm

Generally, the hunting process of chimps is divided into two main phases: Exploration which consists of driving, blocking and chasing the prey and Exploitation which consists of attacking the prey.

The chimps hunting model means driving, blocking, chasing and attacking is modeled in this section.

In order to summarize the contents and paper, we have tried to present a general information and explanations about each optimization algorithm. For more information about each algorithm, their parameters and history or differences, please refer to Shahvaroughi Farahani, M. (2021).

4.4. Regression analysis and ARMA forecasting

Econometric models are statistical models have been used in econometrics [49]. Econometric models can be used when there are several independent variables and we want to check the impacts of each one on dependent variable, separately. Using suitable and appropriate econometric model is a sensitive operation because firstly, you need to know the properties and qualifications of your model and then, applying the best one. Normality and the type of distribution of data is important. There are many methods for testing normality [50]. We used Jarque-Bera (J-B) test. This is a goodness of fit test. it has some advantages than competitors due to symmetric distributions with medium up to long tails and for slightly skewed distributions with long tails. After finding data distribution, you can use an appropriate regression model. The next main point is testing for stationarity. We should check it because the trend and seasonality will affect the value of time series at different times [51]. As a result, Augmented-Dickey-Fuller (ADF) test is used as testing stationarity. For non-stationary time series, it could be possible to use differencing to make them stationary.

After performing the aforementioned tests, we will be able to choose an appropriate regression model. It should be noted that you can use linear or nonlinear regression models with respect to your data structure.

A simple linear regression with one independent variable and two dependent variables is presented below:

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i. \qquad i = 1. \ldots . n \tag{10}$$

Where:
y_i: dependent variable
β_0: intercept
β_1: x_i coefficient
x_i: independent variable

Finally, we predicted return for the next day using Autoregressive Integrated Moving Average (ARIMA) model. ARIMA is a statistical analysis model that uses time series data to either better understand the data set or to predict future trends.

The ARIMA model has three basic components: [p, d, q]. Each one has an application. Autoregressive (AR(p)) model is an autoregressive model where specific lagged values of Y_t are used as predictor variables. Lags are where results from one-time period affect following periods. (p) presents the order. AR model means that the Y_t is only depends on its previous values or own lags.

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \cdots + \beta_p Y_{t-p} + \varepsilon_1 \tag{11}$$

where, $(Y_{t-1}.Y_{t-2}.\ldots.Y_{t-p})$ are the previous series values (lags), $(\beta_1.\beta_2.\ldots.\beta_p)$ are the coefficient of lag that the model approximate and α is the intercept, also estimated by the model.

Moving Average (MA(q)) model is a model which Y_t depends only on the lagged forecast errors

$$Y_t = \alpha + \varepsilon_t + \emptyset_1\varepsilon_{t-1} + \emptyset_2\varepsilon_{t-2} + \cdots + \emptyset_q\varepsilon_{t-q} + \varepsilon_{t-q} \quad (12)$$

where the error terms are the errors of the autoregressive models of the respective lags. The errors ε_t and ε_{t-1} are the errors from the following equations:

$$Y_t = \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \cdots + \beta_0 Y_0 + \varepsilon_1 \quad (13)$$

$$Y_{t-1} = \beta_1 Y_{t-2} + \beta_2 Y_{t-3} + \cdots + \beta_0 Y_{t-n} + \varepsilon_{t-1} \quad (14)$$

That was AR and MA models respectively.

ARIMA model can form by integration of both AR(p) and MA(q) with a differencing. So, the equation becomes:

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \cdots + \beta_p Y_{t-p} + \varepsilon_1 + \emptyset_1\varepsilon_{t-1} + \emptyset_2\varepsilon_{t-2} + \cdots + \emptyset_q\varepsilon_{t-q} \quad (15)$$

Figure shows the regression analysis and ARIMA process:

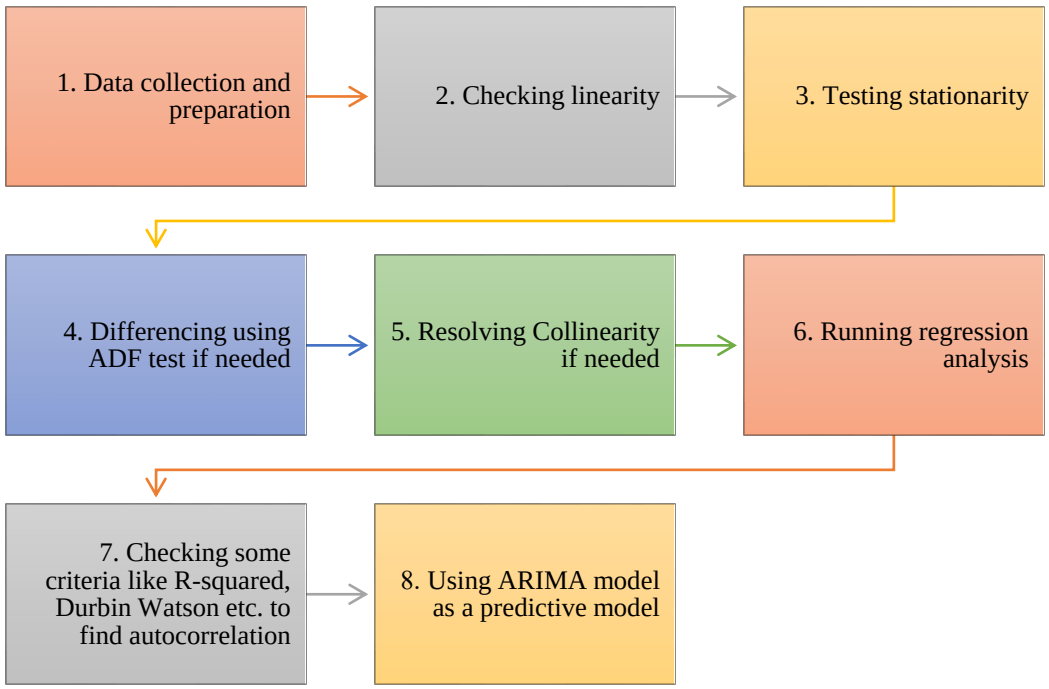


Figure 10. Regression analysis process

According to above Figure, first of all, you need to ensure about the availability of data. Then, based on the econometric model's assumption, you should check linearity because it can impact on your applicable considered methods. Testing stationarity is helpful because the trend and seasonality will affect the value of time series at different times [52]. So, by differencing we can resolve this problem. Sometimes, there is a collinearity between predictor variables and it needs to correction because they cannot independently predict the value of the dependent variable. Now, the regression analysis can do. There are some criteria such as R-squared, Durbin Watson etc. which can present the goodness of fit. For applying ARIMA model as a predictive model, correlogram should check. Based on the figures, it is possible to diagnose the ARMA model.

5. Finding and Results

5.1. Artificial Neural Network (ANN)

First of all, as we mentioned earlier, we should normalize data. We used ANN in three steps: 1. Finding the best architecture 2. Training the network 3. Validation and testing. We used 70% of data and 30% for training and validation and testing respectively. The following pie chart details the uses of all the instances in the data set. The total number of instances is 534. The number of training instances is 374 (70%), the number of selection (validation) instances is 80 (15%), the number of testing instances is 80 (15%), and the number of unused instances is 0 (0%). Here, the number of variables is 3 i.e., new deaths and the new deaths with lag 1are as two inputs and the new deaths for the next period is as target. Validation data provides the first test against unseen data, allowing data scientists to evaluate how well the model makes predictions based on the new data (Source: https://www.applause.com).

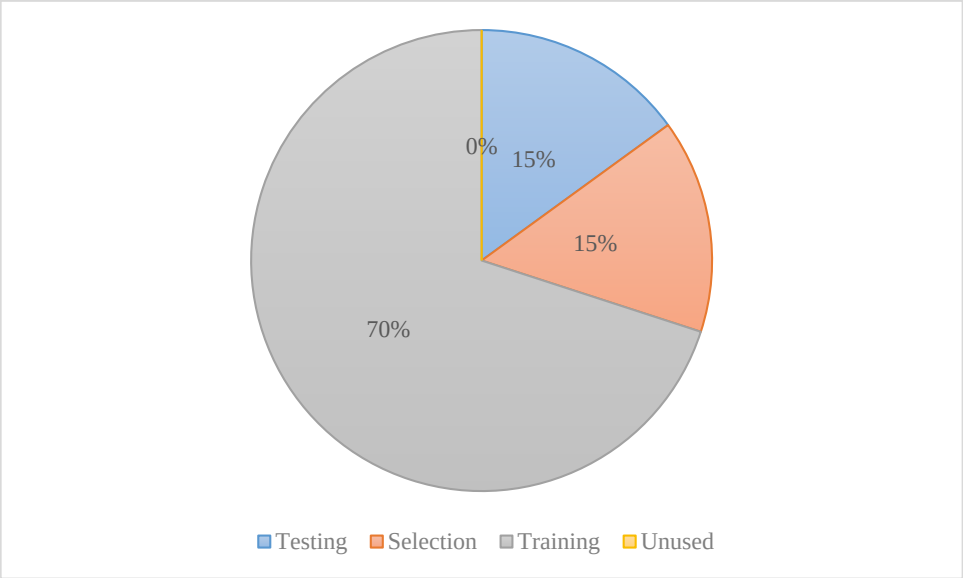


Figure 11. Instance pie chart

Table 13 shows the best architecture after 500 iterations:

Table 13. Network architecture

ID	Architecture	# of Weights	Fitness	Train Error	Validation Error	Test Error	AIC	Correlation	R-Squared
1	**[2-1-1]**	**5**	**0.03994**	**18.26**	**16.68**	**25.03**	**-1083**	**0.978**	**0.957**
2	**[2-7-1]**	**29**	**0.04057**	**16.37**	**14.54**	**24.64**	**-1074**	**0.981**	**0.963**
3	**[2-4-1]**	**17**	**0.04030**	**16.36**	**14.42**	**24.81**	**-1099**	**0.981**	**0.964**
4	**[2-5-1]**	**21**	**0.04079**	**17.21**	**15.72**	**24.51**	**-1072**	**0.980**	**0.961**
5	**[2-6-1]**	**25**	**0.04073**	**16.39**	**14.57**	**24.54**	**-1082**	**0.981**	**0.963**

The best architecture is obtained based on Akaike information criterion (AIC) or fitness through trial and error. The best architecture is including 2 input layers means new death cases and new death cases with a lag, the number of hidden neurons in hidden layer which is 5 and 1 output layer which is the number of new cases for the next period. This structure has the highest R-Squared which is 0.961552. On the other hand, it has the lowest

Akaike information criteria among the other architecture. Figure 12 shows the best network error after each iteration:

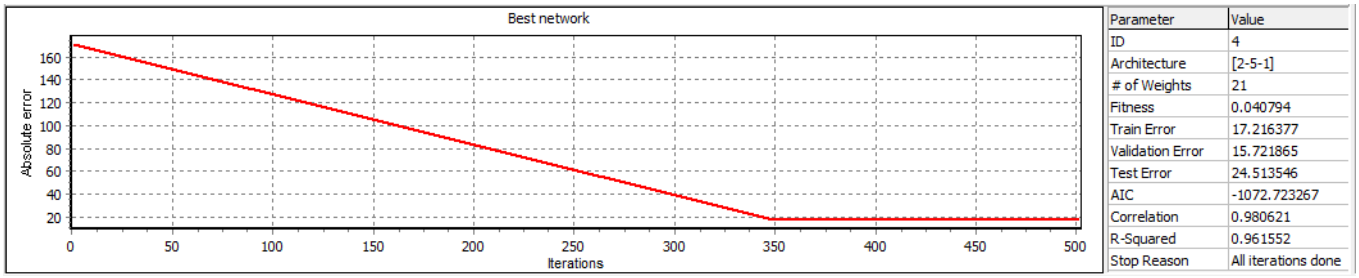


Figure 12. Network error during iterations

Almost after 350 iterations, the rate of error has not decreased and is stable. The network qualifications and its properties are as the following table:

Table 14. Network properties

Parameter	Value
Input activation FX	**Logistic**
Output name	**Daily death cases (CLOSE)**
Output error FX	**Sum-of squares**
Output activation FX	**Tangent-Sigmoid (Tan-sig)**

As we mentioned earlier, two types of activation function have been used (linear and non-linear). The next step is training the network. We used LM algorithm for training. Data set error and training and validation error can be seen in Figure 13.

Figure 13. Network training error during epochs

The number of iterations is 8 because there was no error improvement. The error distribution and its parameters have been shown in Figure14 and table15 respectively.

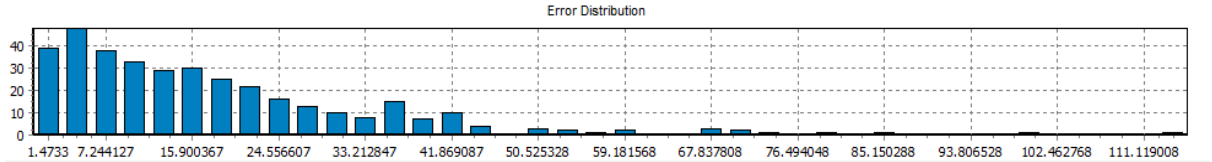


Figure 14. Error histogram during iterations

As it is clear from figure 14, there are more errors at first and then it has decreased by training. There are more details about training parameters such as the number of iterations, the number of layers, the considered algorithm etc. in Table 13.

Table 15. Training parameters

Parameters	Training	Validation
Absolute error	**155.551001**	**152.558441**
Network error	**0.96796**	**0**
Error improvement	**0.000073**	
Iteration	**8**	
Training speed, ite/sec	**39.999999**	
Architecture	**[2-2-1]**	
Training algorithm	**Levenberg-Marquardt**	
Training stop reason	**No error improvement**	

Levenberg-Marquardt is used as an optimization algorithm to diminish the network error. After using LM algorithm, the rate of error has decreased to 0.000073. Because after 8 iterations there was not any improvement in network error, the training has stopped.

Finally, we need to test the network with real data. Figure15 shows the testing error graph (actual Vs. target) during each iteration:

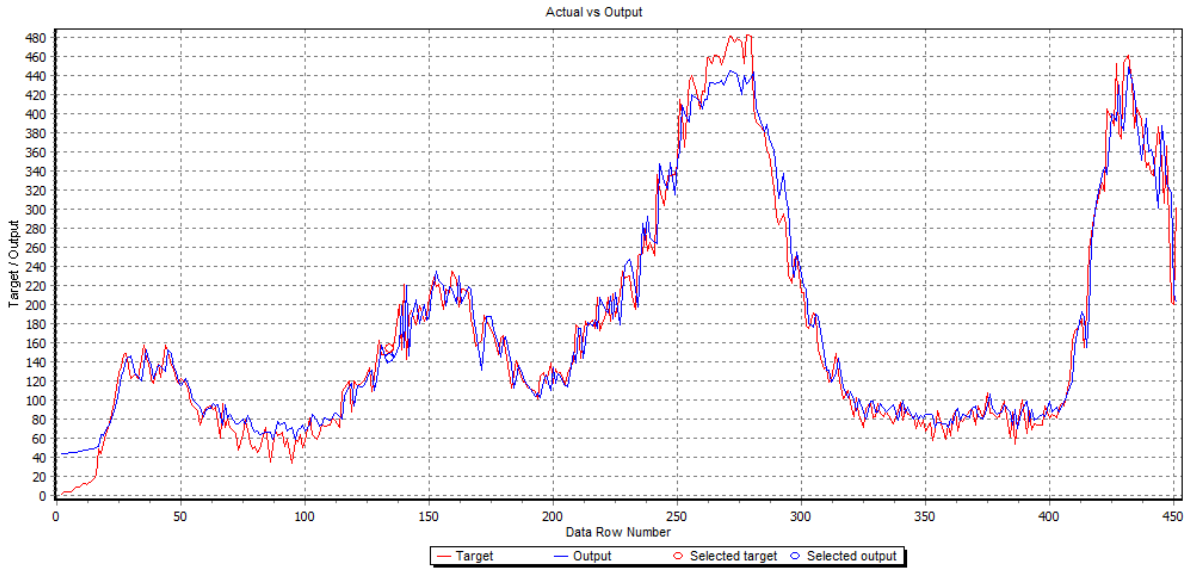


Figure 15. Testing error (Actual vs. output graph)

As can be seen, the network can predict actual data because target and output lines (i.e., red and blue lines respectively) are almost match and coincident and it a sign of good training. But it can improve because still there are some gaps between actual versus predicted which is far from full (complete) coincident and a perfect prediction. As a result, we have stated different solution to overcome and address this problem.

More details about testing error means some means statistical errors and parameters can be seen in the following table:

Table 16. Summary

Statistics	Target	Output	AE	ARE
Mean	**170.139726**	**172.442177**	**18.233843**	**0.403942**
Std. Dev	**119.789151**	**113.738766**	**16.53856**	**2.515076**
Min	**1**	**43.263726**	**0.030594**	**0.000266**
Max	**483**	**448.879082**	**115.447128**	**42.521055**
Correlation		**0.979299**		
R-Squared		**0.953156**		

It is clear that the amount of R^2 is approximately high and it can be a good indication of well-trained and goodness of fit.

The average of daily new death cases is approximately 170 while the minimum and maximum is 1 and 448 respectively.

As a result, after these steps, the number of new death cases for the next period is 463.895934 and the result graph is as Figure 16.

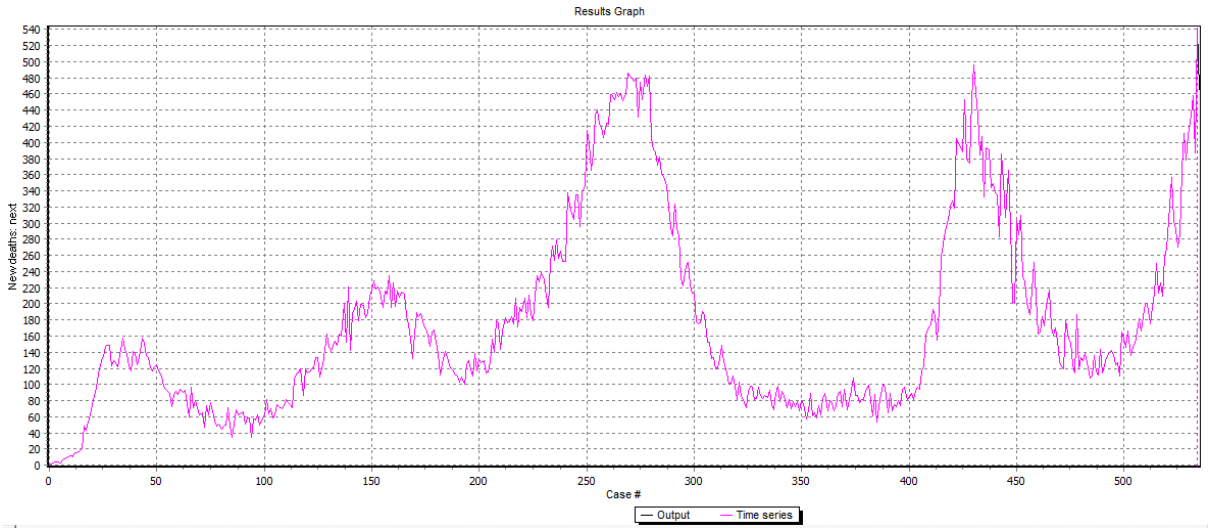


Figure 16. Prediction of daily new death cases for the day ahead (output)

5.2. Beetle Antennae Search (BAS) algorithm

In this article, we used BAS for network optimization, So, the considered parameters are as follows:

Table 17. Setup parameters

Antennae distance			
d_0	**d_1**	**d**	**eta_d**
0.001	**3**	**d_1**	**0.95**
Random walk			
l0	**l1**	**l**	**eta_l**
0	**0**	**11**	**0.95**
Steps			
Step-length	**eta_step**	**Iterations (n)**	**Space dimension (k)**
0.8	**0.95**	**100**	**2**
x_0	**x**	**x_{best}**	
2*rands (k,1)	**x_0**	**x0**	

As we mentioned earlier, beetle antennae use random walk to search. We used Michalewicz function as a fitness function and to show the efficacy and validate the algorithm.

$$f(x) = \sum_{i=1}^{d} \sin(x_i) \left[\sin\left(\frac{ix_i^2}{\pi}\right)\right]^{2m} \quad (16)$$

Where $m = 10$ and $i = 1.2.\ldots.n$ the minimized value satisfies $f_* \approx -1 \cdot 801$ locating in $x_* \approx 2 \cdot 2051$ and 1.5719 in $i = 2$ dimensions.

The searching result can be seen in Figure17.

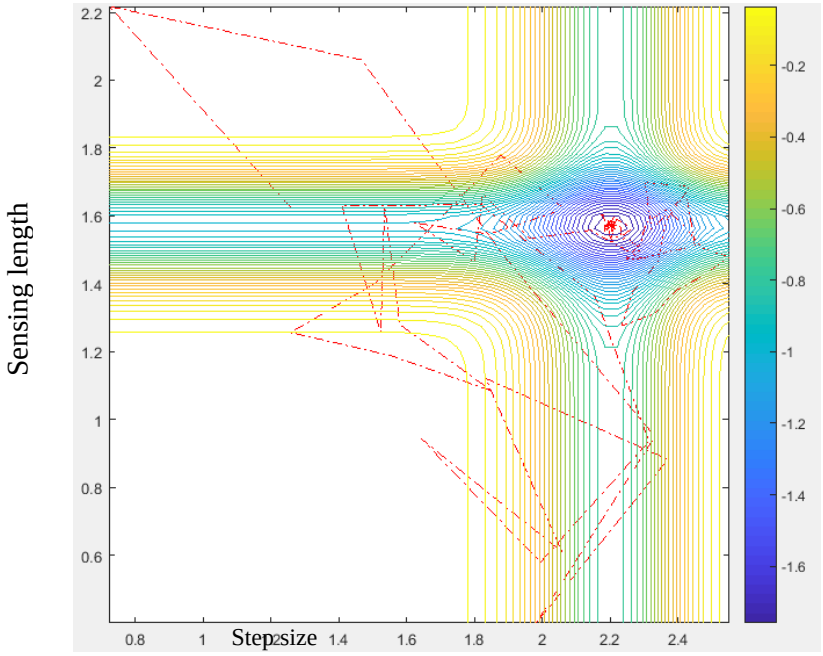


Figure 17. Searching plot

This algorithm has three main factors: 1. Random walk 2. Sensing (antennae) length 3. Step size. Figure 17 shows the sensing length during each step size through the random walk process. As can be seen, BAS beginning stochastically and during each iteration, it can be very closed to the considered objective means minimum error and finding the best solution.

The rate of error during iterations is depicted in Figure 18.

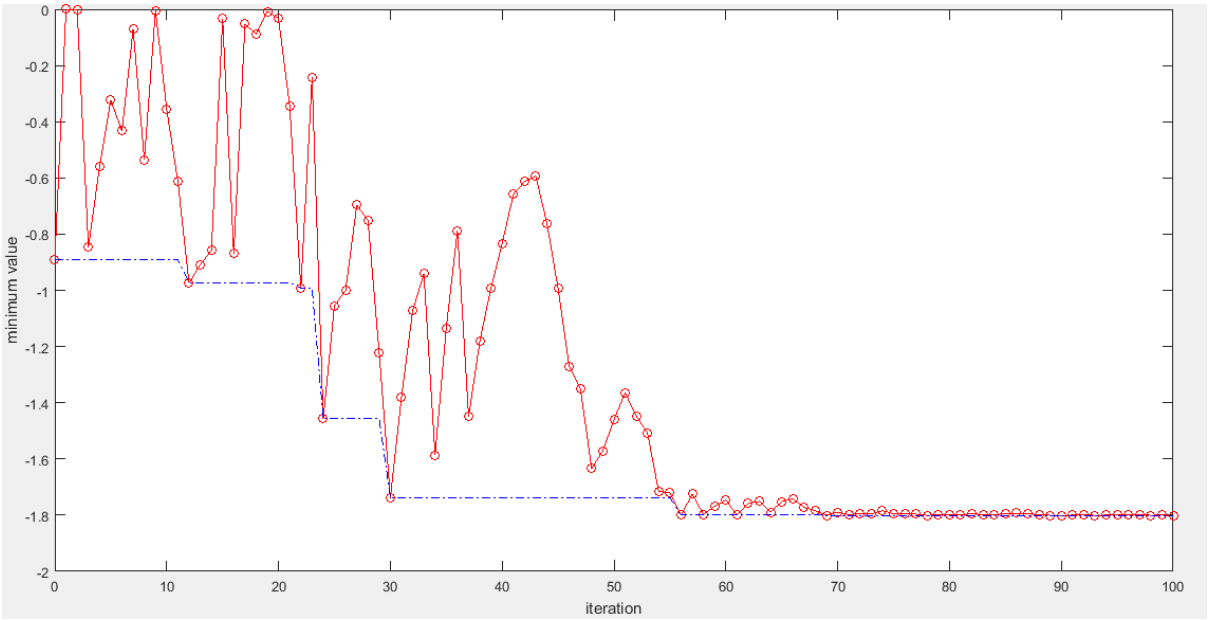


Figure 18. Error rate during iterations

After 100 iterations, $fbest$ and $xbest$ are equal to (2.2051, 1.5719) and -1.8012 respectively. As it can be observed, the rate of error is not changeable after 70 iterations. R-Squared is equal to 95.9958 which is almost equal to R-squared in ANN i.e., 0.953156.

The other optimization algorithms such as MPSO, PSO, TACPSO and ChOA and their results is as figure 19.

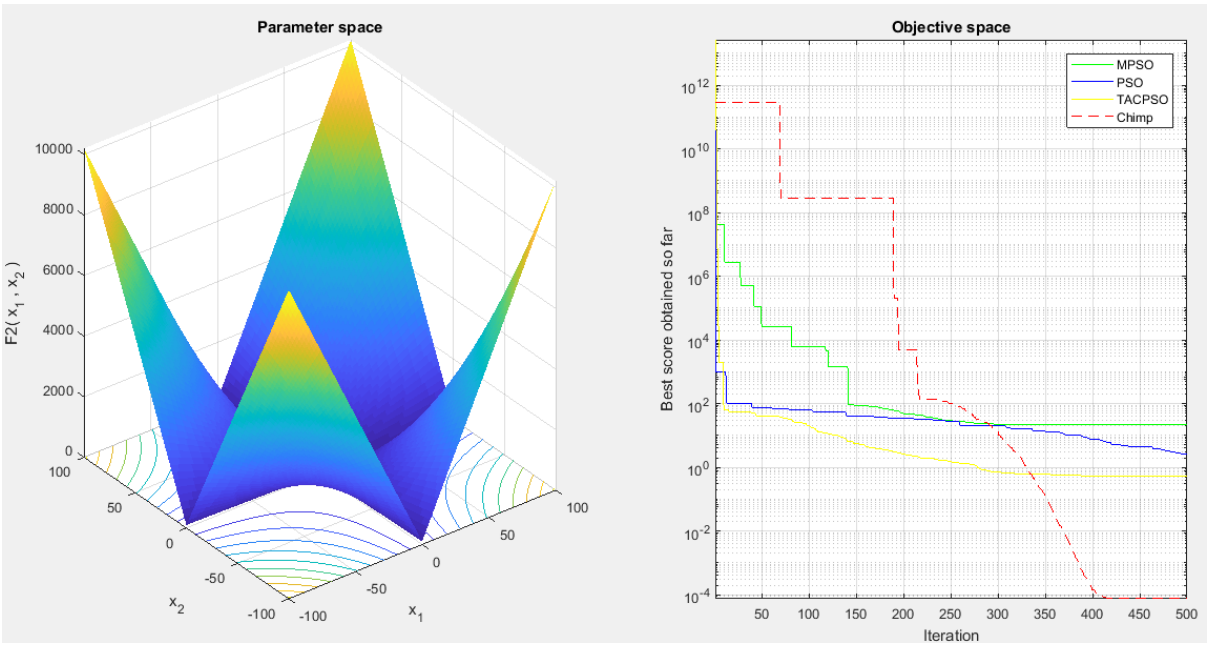


Figure 19. Test function and convergence curve

Between these algorithms, ChOA has the lowest error estimation. The best optimal value of the objective function found by TVACPSO, PSO, MPSO, and ChOA are 1.4797, 4.0839, 40.1701 and 1.6474e-05 respectively. More details about ChOA is expressed in table 18.

Table 18. Parameters and errors

Search agents' number	**30**
Maximum number of iterations	500
Upper bound	100
Lower bound	-100
Best score ChOA	7.4341e-05
Best score MPSO	21.4027
Best score MPSO-TVAC	0.5373
Dim	12

5.3. Regression analysis and ARMA results

As we mentioned earlier, it is better to check the normality because it is a main assumption. The following figure shows the new death cases distribution:

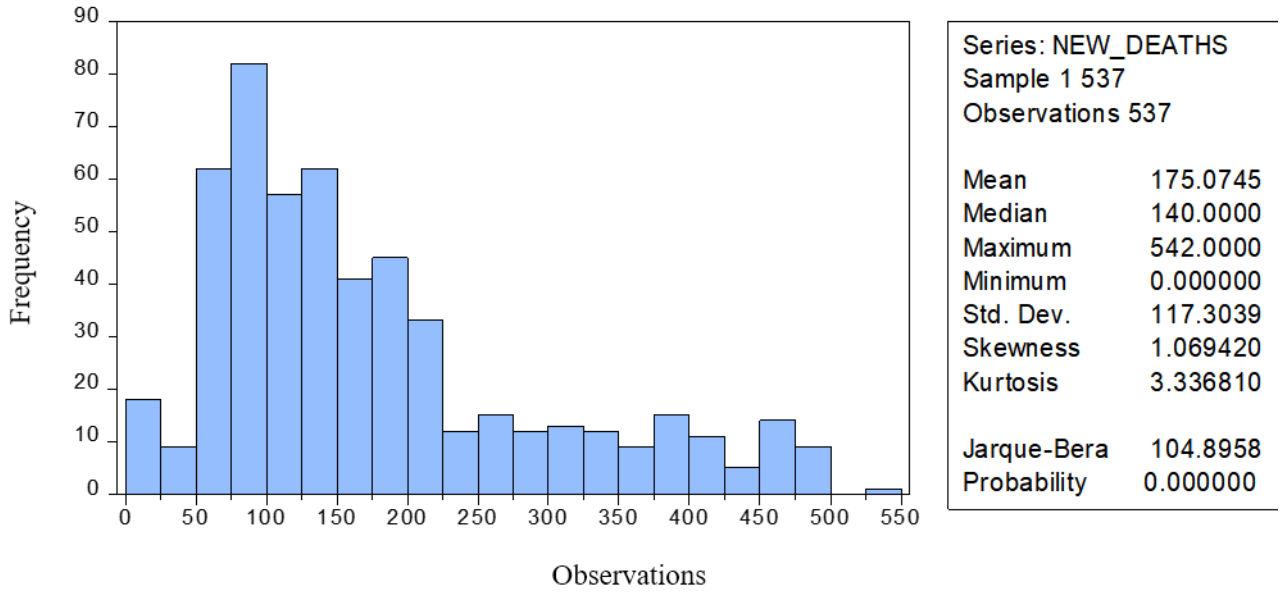
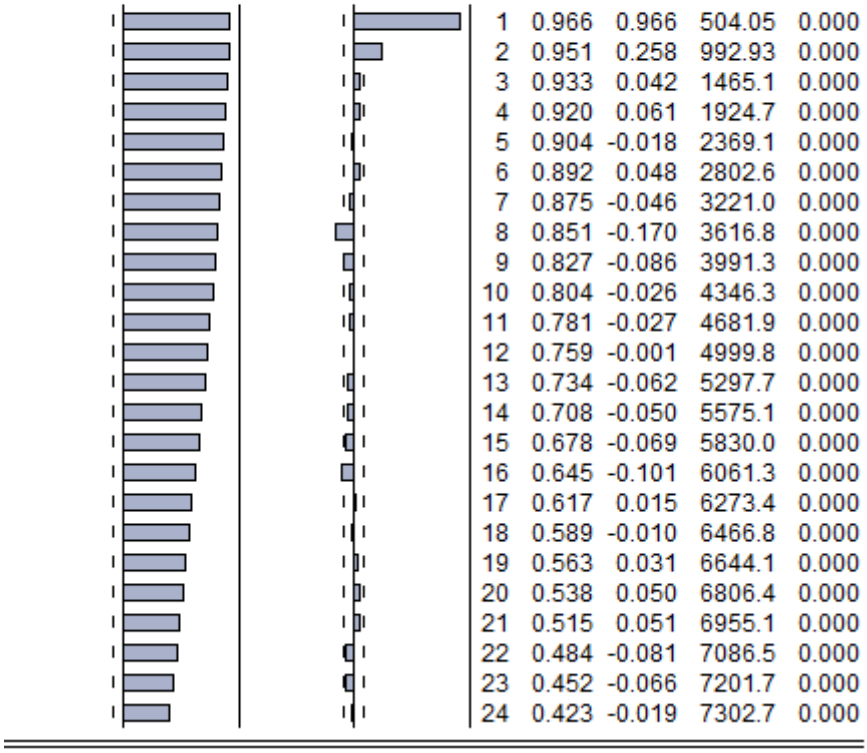


Figure 20. Daily new death cases histogram

Figure 19 shows the positive skewness. So, we should be careful about using an appropriate model in regression analysis. To determine ARMA (p, q) order, the correlogram graph is needed. The following Figure shows the correlogram of daily new death cases.

Date: 05/06/22 Time: 08:03
Sample: 1 537
Included observations: 537



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.966	0.966	504.05	0.000
		2	0.951	0.258	992.93	0.000
		3	0.933	0.042	1465.1	0.000
		4	0.920	0.061	1924.7	0.000
		5	0.904	-0.018	2369.1	0.000
		6	0.892	0.048	2802.6	0.000
		7	0.875	-0.046	3221.0	0.000
		8	0.851	-0.170	3616.8	0.000
		9	0.827	-0.086	3991.3	0.000
		10	0.804	-0.026	4346.3	0.000
		11	0.781	-0.027	4681.9	0.000
		12	0.759	-0.001	4999.8	0.000
		13	0.734	-0.062	5297.7	0.000
		14	0.708	-0.050	5575.1	0.000
		15	0.678	-0.069	5830.0	0.000
		16	0.645	-0.101	6061.3	0.000
		17	0.617	0.015	6273.4	0.000
		18	0.589	-0.010	6466.8	0.000
		19	0.563	0.031	6644.1	0.000
		20	0.538	0.050	6806.4	0.000
		21	0.515	0.051	6955.1	0.000
		22	0.484	-0.081	7086.5	0.000
		23	0.452	-0.066	7201.7	0.000
		24	0.423	-0.019	7302.7	0.000

Figure 21. Correlogram of daily new death cases

By looking at t-statistic and correlogram status, it is inferred that at least there is a unit root. So, we have used first-level differencing:

Checking stationary is the next step. So, ADF is used as a unit root test.

Table 19. Unit root test

Null Hypothesis: NEW_DEATHS has a unit root Exogenous: Constant Lag Length: 10 (Automatic - based on SIC, maxlag=18)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.665211	0.0809
Test critical values:	1% level	-3.442554	
	5% level	-2.866815	
	10% level	-2.569640	
*MacKinnon (1996) one-sided p-values.			
Augmented Dickey-Fuller Test Equation Dependent Variable: D(NEW_DEATHS) Method: Least Squares Date: 05/06/22 Time: 07:53 Sample (adjusted): 12 537			

Included observations: 526 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
NEW_DEATHS (-1)	-0.023181	0.008698	-2.665211	0.0079
D (NEW_DEATHS (-1))	-0.408744	0.044433	-9.199134	0.0000
D (NEW_DEATHS (-2))	-0.243107	0.047070	-5.164797	0.0000
D (NEW_DEATHS (-3))	-0.169858	0.046295	-3.669005	0.0003
D (NEW_DEATHS (-4))	0.051552	0.044085	1.169396	0.2428
D (NEW_DEATHS (-5))	0.044174	0.043705	1.010731	0.3126
D (NEW_DEATHS (-6))	0.198895	0.043747	4.546444	0.0000
D (NEW_DEATHS (-7))	0.435494	0.044755	9.730560	0.0000
D (NEW_DEATHS (-8))	0.369658	0.047910	7.715750	0.0000
D (NEW_DEATHS (-9))	0.250180	0.048986	5.107131	0.0000
D (NEW_DEATHS (-10))	0.140641	0.046210	3.043514	0.0025
C	4.840190	1.794175	2.697725	0.0072

R-squared	0.259813	Mean dependent var	1.013308
Adjusted R-squared	0.243972	S.D. dependent var	25.23712
S.E. of regression	21.94364	Akaike info criterion	9.037381
Sum squared resid	247502.9	Schwarz criterion	9.134688
Log likelihood	-2364.831	Hannan-Quinn criter.	9.075481
F-statistic	16.40174	Durbin-Watson stat	1.965415
Prob(F-statistic)	0.000000		

According to Table 19, the series at least has one-unit root based on t-statistic (i.e., -2.665211) in 1% and 5% level. So, we used first level differencing. You can see the results after a differencing:

Table 20. 1st difference

Null Hypothesis: D(NEW_DEATHS) has a unit root
Exogenous: Constant
Lag Length: 9 (Automatic - based on SIC, maxlag=18)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.745142	0.0672
Test critical values:	1% level	-3.442554	
	5% level	-2.866815	
	10% level	-2.569640	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(NEW_DEATHS,2)
Method: Least Squares
Date: 05/06/22 Time: 07:57
Sample (adjusted): 12 537
Included observations: 526 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D (NEW_DEATHS (-1))	-0.457832	0.166779	-2.745142	0.0063

D(NEW_DEATHS (-1),2)	-0.960351	0.165024	-5.819464	0.0000
D(NEW_DEATHS (-2),2)	-1.211160	0.164673	-7.354955	0.0000
D(NEW_DEATHS (-3),2)	-1.389519	0.162449	-8.553567	0.0000
D(NEW_DEATHS (-4),2)	-1.348947	0.155132	-8.695479	0.0000
D(NEW_DEATHS (-5),2)	-1.318161	0.142308	-9.262725	0.0000
D(NEW_DEATHS (-6),2)	-1.133112	0.127129	-8.913077	0.0000
D(NEW_DEATHS (-7),2)	-0.712904	0.105758	-6.740912	0.0000
D(NEW_DEATHS (-8),2)	-0.359906	0.078565	-4.581003	0.0000
D(NEW_DEATHS (-9),2)	-0.126670	0.046183	-2.742777	0.0063
C	0.807411	0.969821	0.832535	0.4055

R-squared	0.687555	Mean dependent var	0.292776
Adjusted R-squared	0.681488	S.D. dependent var	39.11144
S.E. of regression	22.07328	Akaike info criterion	9.047304
Sum squared resid	250923.3	Schwarz criterion	9.136502
Log likelihood	-2368.441	Hannan-Quinn criter.	9.082229
F-statistic	113.3288	Durbin-Watson stat	1.964641
Prob(F-statistic)	0.000000		

Again, the previous conditions exist in both level (i.e., 1% &5%). So, we used the second differencing.

Table 21. 2nd difference

Null Hypothesis: D(NEW_DEATHS,2) has a unit root
Exogenous: Constant
Lag Length: 8 (Automatic - based on SIC, maxlag=18)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-17.29157	0.0000
Test critical values:	1% level	-3.442554	
	5% level	-2.866815	
	10% level	-2.569640	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(NEW_DEATHS,3)
Method: Least Squares
Date: 05/06/22 Time: 07:58
Sample (adjusted): 12 537
Included observations: 526 after adjustments

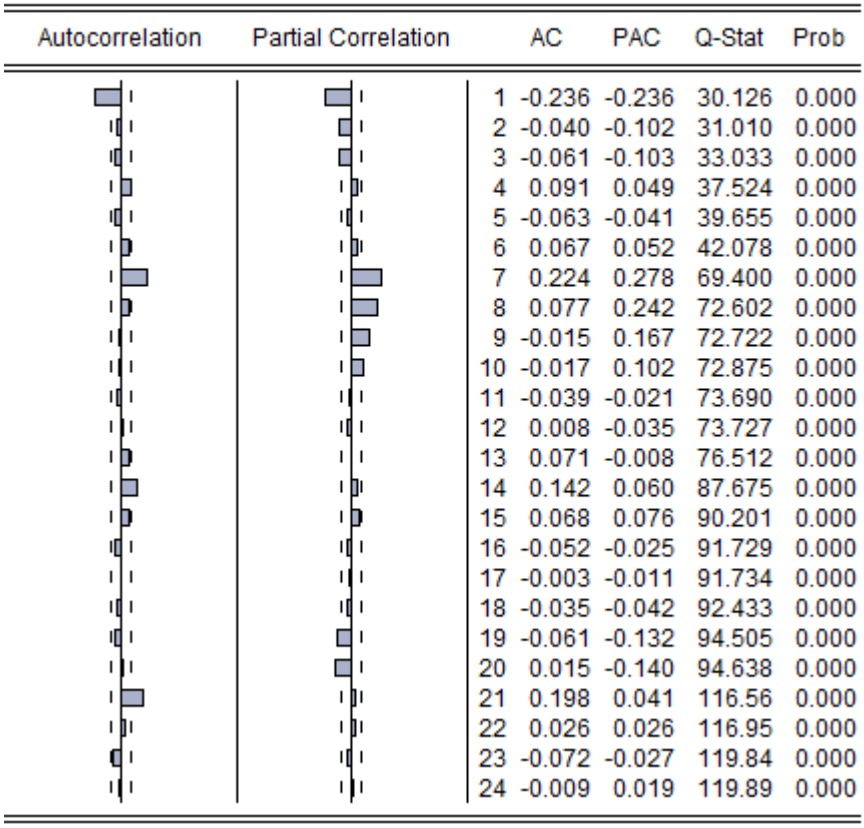
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(NEW_DEATHS (-1),2)	-11.70773	0.677077	-17.29157	0.0000
D(NEW_DEATHS (-1),3)	9.310673	0.649145	14.34297	0.0000
D(NEW_DEATHS (-2),3)	7.694249	0.590573	13.02845	0.0000
D(NEW_DEATHS (-3),3)	5.943338	0.506712	11.72921	0.0000
D(NEW_DEATHS (-4),3)	4.290097	0.408210	10.50953	0.0000
D(NEW_DEATHS (-5),3)	2.729251	0.305450	8.935186	0.0000
D(NEW_DEATHS (-6),3)	1.415214	0.204167	6.931652	0.0000
D(NEW_DEATHS (-7),3)	0.582039	0.114799	5.070048	0.0000
D(NEW_DEATHS (-8),3)	0.153783	0.045399	3.387331	0.0008

C	0.487370	0.968867	0.503031	0.6152

R-squared	0.895802	Mean dependent var	0.429658
Adjusted R-squared	0.893985	S.D. dependent var	68.22072
S.E. of regression	22.21263	Akaike info criterion	9.058028
Sum squared resid	254595.0	Schwarz criterion	9.139117
Log likelihood	-2372.261	Hannan-Quinn criter.	9.089778
F-statistic	492.9029	Durbin-Watson stat	1.976637
Prob(F-statistic)	0.000000		

Now the series is stationary. So, for reassurance, we plotted a correlogram graph as the following:

Date: 05/06/22 Time: 08:06
Sample: 1 537
Included observations: 536



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.236	-0.236	30.126	0.000
		2	-0.040	-0.102	31.010	0.000
		3	-0.061	-0.103	33.033	0.000
		4	0.091	0.049	37.524	0.000
		5	-0.063	-0.041	39.655	0.000
		6	0.067	0.052	42.078	0.000
		7	0.224	0.278	69.400	0.000
		8	0.077	0.242	72.602	0.000
		9	-0.015	0.167	72.722	0.000
		10	-0.017	0.102	72.875	0.000
		11	-0.039	-0.021	73.690	0.000
		12	0.008	-0.035	73.727	0.000
		13	0.071	-0.008	76.512	0.000
		14	0.142	0.060	87.675	0.000
		15	0.068	0.076	90.201	0.000
		16	-0.052	-0.025	91.729	0.000
		17	-0.003	-0.011	91.734	0.000
		18	-0.035	-0.042	92.433	0.000
		19	-0.061	-0.132	94.505	0.000
		20	0.015	-0.140	94.638	0.000
		21	0.198	0.041	116.56	0.000
		22	0.026	0.026	116.95	0.000
		23	-0.072	-0.027	119.84	0.000
		24	-0.009	0.019	119.89	0.000

Figure 22. Correlogram of daily new death cases after differencing

One of the main software in econometric is Eviews. For estimation of ARIMA model, we have used automatic ARMA forecasting in Eviews10.

Table 22. ARMA forecasting

Automatic ARIMA Forecasting
Selected dependent variable: D(NEW_DEATHS)
Date: 05/06/22 Time: 08:11
Sample: 1 537
Included observations: 536
Forecast length: 0

Number of estimated ARMA models: 25
Number of non-converged estimations: 0
Selected ARMA model: (4,2)
AIC value: 9.07883619765

The results show that the best order for ARMA estimation based on AIC is ARMA (4,2). The best model is ARIMA (4,1,2) because of differencing. Figure23 shows the top 20 best ARMA model based on AIC.

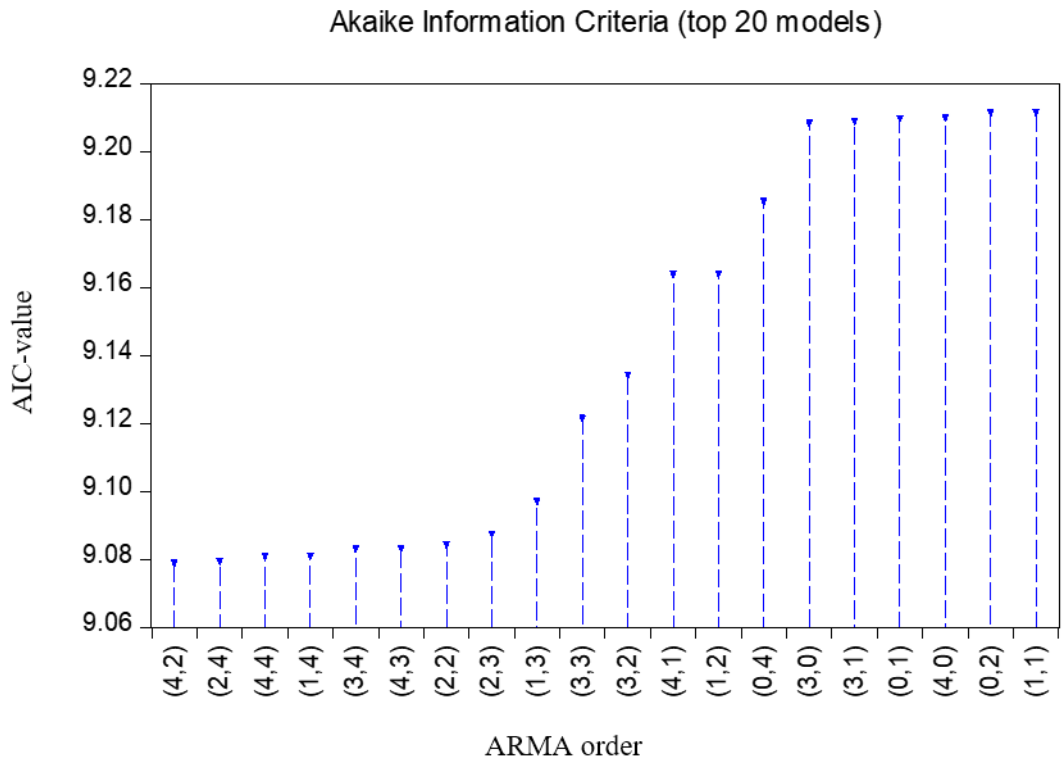


Figure 23. Akaike information criteria

In the appendix, there are equation output with model selection criteria (Table A2 & A3).

The next step is regression analysis. Eviews10 has been used as a main tool for calculations. Least Squares (Gauss-Newton / Marquardt steps) method along with 500 iterations has been used.

Table 23. Equation estimation

Dependent Variable: TARGET
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 05/06/22 Time: 08:26
Sample: 1 537
Included observations: 537
TARGET=C (1) +C (2) *NEW_DEATHS

	Coefficient	Std. Error	t-Statistic	Prob.
C (1)	3.957745	1.936313	2.043960	0.0414
C (2)	0.982797	0.009191	106.9325	0.0000

R-squared	0.955303	Mean dependent var	176.0205
Adjusted R-squared	0.955220	S.D. dependent var	117.9522
S.E. of regression	24.96026	Akaike info criterion	9.276164
Sum squared resid	333312.8	Schwarz criterion	9.292127
Log likelihood	-2488.650	Hannan-Quinn criter.	9.282409
F-statistic	11434.56	Durbin-Watson stat	2.471785
Prob(F-statistic)	0.000000		

R-squared is approximately 0.95 which is high and can be a sign of good regression. C (2) is the next day daily new death cases.

The next Figure shows the actual vs. predicted (fitted) value along with residual:

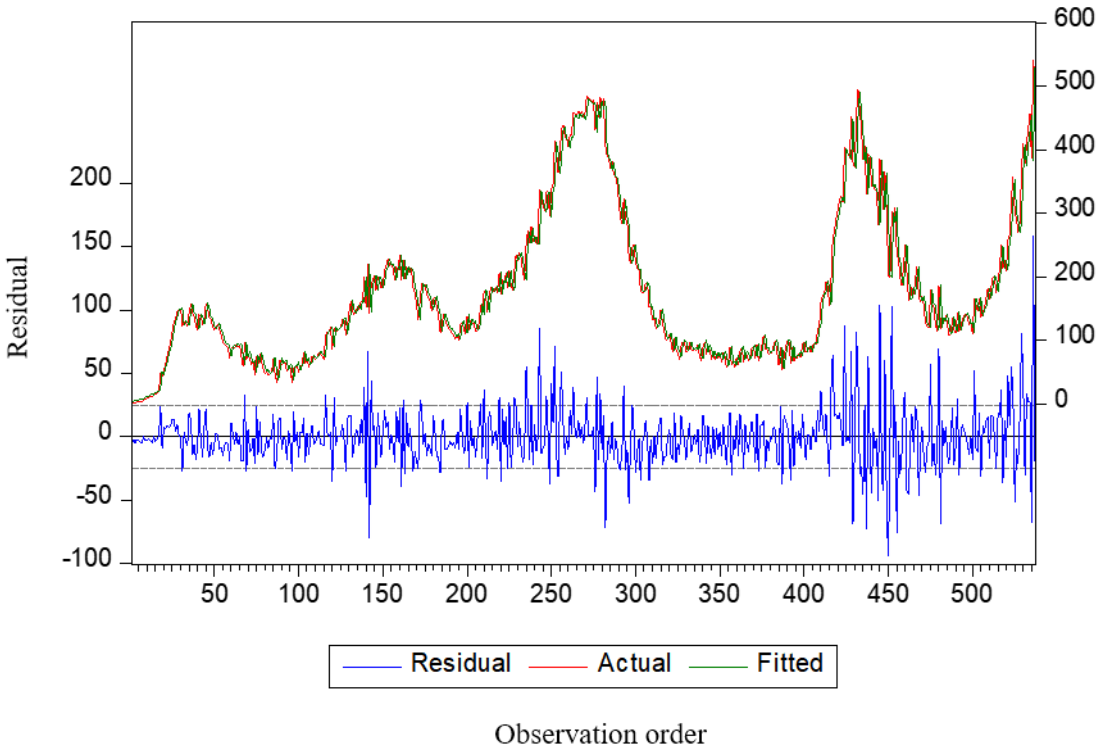


Figure 24. Actual, fitted and residual

The red-line shows the actual data and the green-line shows the predicted data. The blue-line shows the residual too. As you can see, the red and green lines match well, which means that the forecast is pretty good.

5.4. Comparing the results

In this paper, we have tried to use different methods to prediction of new death cases in Iran using AI based models and algorithms such as ANN, BAS algorithm, TACPSO, PSO, MPSO, and ChO algorithms. Table 24 shows the summary results:

Table 24. Summary results

No	Algorithm / Model	Error Estimation	R^2
1	**ChOA**	**0.00001**	**0.97**
2	**BAS**	**0.00009**	**0.95**
3	**ANN**	**0.00007**	**0.95**
4	**ARMA**	**0.9695**	**0.93**
5	**TACPSO**	**1.4797**	**0.91**
6	**PSO**	**4.0839**	**0.89**
7	**MPSO**	**40.1701**	**0.87**

According to Table 22, the best and the worst performance belong to ChOA and MPSO algorithms respectively. The ARMA model has the average or median performance.

6. Conclusion

In this paper, we surveyed the impacts of Covid19 on economic condition and sustainable development goals from different point of view. As a case study, we predicted daily new death cases in Iran with AI based methods such as ANN and BAS algorithm and econometric models.

Definitely, Covid19 is the biggest challenges in 21th century. This pandemic has overshadowed various aspects of human life such as economy, social, health etc. One of the best ways to overcome Covid19 is to get vaccinated. The distribution of the vaccine among different countries was discussed and we said that there is a gap between rich and poor countries in vaccine distribution.

We discussed the role of SDGs during pandemic and we shouldn't ignore it because it is a kind of mission which must be accomplished until 2030 and it is helpful for reducing the negative effects of pandemic.

The other point is that it needs to pay more attention to emerging economies because they have important role in economic growth and in achieving sustainable development goals. Vaccine can increase the achievement of sustainable development goals. As a result, countries that produce vaccines must be supported by international organizations such as WHO.

Finally, as a case study, we predicted daily new death cases in Iran from Feb-2020 to Aug-2021 using Beetle Antennae Search (BAS) algorithm and Artificial Neural Network (ANN) along with other algorithms such as ChOA, MPSO etc. As a complementary or as a benchmark model, we used time series model such as ARMA model with regression analysis. The results showed that both models mean AI based (ANN) and econometric model have the same R-squared (0.9531 & 0.9552) relatively. On the other hand, the rate of error is very close to each other (i.e., 113.7387 & 117.9522). But optimization algorithms have improved and boosted the models such as ChOA which has the lowest error (**7.4341e-05**) among other algorithms.

We cannot say which model (AI or econometric models) is better. But AI based models have some characteristics such as speed up calculations, compatible with complex data structure, improve by training etc. which can make them difference from other models like econometrics.

The last note is that we can end Corona reign as soon as possible and celebrate its end by coordinating internationally and avoiding rent-seeking.

As a recommendation, it is possible to use novel metaheuristic algorithms such as Artificial hummingbird algorithm (2022), Archimedes optimization algorithm (2021), Honey Badger Algorithm (2022) etc. to predict the new waves or end of the pandemic.

Patent: Not available

Supplementary Materials: Not Available

Author Contributions: The Idea, Computations and methodology belongs to Milad Shahvaroughi Farahani. All of the other authors have the same contribution means literature review and other parts.

Funding: this research is not supported by any organization.

Data Availability Statement: Mainly, the data was obtained through two sites which are called Yahoo Finance and Federal Reserve Economic Data (FRED) respectively Which are at the following address:

https://finance.yahoo.com/quote/DOGE-USD/history?p=DOGE-USD

https://fred.stlouisfed.org

Acknowledgments: I want to be grateful to my parents specially my mother for her patient and supports and motherhood.

Conflicts of Interest: The authors have no conflicts of interest to declare that are relevant to the content of this article.

Appendix A

Table A1. Advantages and disadvantages of different vaccine platforms

Vaccine Platform	Advantages	Disadvantages
Killed/Attenuated Parasites	• Very potent • Multivalent by nature • Simple formulation, no adjuvants required	• Manufacturing challenge • Requires stringent quality control • Risk for infection
Subunit/Recombinant Protein	• Non-infectious • Strong humoral response	• Need for additional immunes stimulants (adjuvant) • Need to develop new production process and stability assays for each new antigen • Multivalent formulations can be challenging
Viral Vector	• Strong innate immune response • Strong cellular and humoral responses	• Potential risk for infection • Inflammation could cause risk for adverse reactions • Pre-existing immunity against the vector • Mixed results immunogenicity in humans
DNA	• Non-infectious • Rapid development and production using standardized production pipeline • Options for multi-valency • Strong T cell responses	• Poor immunogenicity in humans • Potential risk at genetic integration
RNA	• Non-infectious • Rapid development and production using standardized production pipeline • Production free of any animal-derived products • Options for multi-valency • Very potent innate immune response • Strong T cell responses	• RNases can cause stability issues • Inflammation could cause risk for adverse reactions • Although becoming rapidly more affordable the current production costs are high

Table A2. ARMA forecasting details

Dependent Variable: D(NEW_DEATHS)
Method: ARMA Maximum Likelihood (BFGS)
Date: 05/06/22 Time: 08:19
Sample: 2 537
Included observations: 536
Convergence achieved after 37 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.453679	1.819925	0.798758	0.4248
AR (1)	1.277631	0.043545	29.34034	0.0000
AR (2)	-0.359668	0.052314	-6.875236	0.0000
AR (3)	-0.106441	0.054042	-1.969597	0.0494
AR (4)	0.134205	0.039509	3.396799	0.0007
MA (1)	-1.695622	0.042860	-39.56233	0.0000
MA (2)	0.791809	0.040812	19.40153	0.0000
SIGMASQ	496.8763	18.21129	27.28396	0.0000

R-squared	0.203591	Mean dependent var	1.007463
Adjusted R-squared	0.193032	S.D. dependent var	25.00123
S.E. of regression	22.45896	Akaike info criterion	9.078836
Sum squared resid	266325.7	Schwarz criterion	9.142778
Log likelihood	-2425.128	Hannan-Quinn criter.	9.103852
F-statistic	19.28222	Durbin-Watson stat	1.956108
Prob(F-statistic)	0.000000		

Inverted AR Roots	.94	.38-.46i	.38+.46i	-.41
Inverted MA Roots	.85-.27i	.85+.27i		

Table A3. Model selection criteria

Model Selection Criteria Table
Dependent Variable: D(NEW_DEATHS)
Date: 05/06/22 Time: 08:19
Sample: 1 537
Included observations: 536

Model	LogL	AIC*	BIC	HQ
(4,2)	-2425.128101	9.078836	9.142778	9.103852
(2,4)	-2425.309638	9.079514	9.143456	9.104529
(4,4)	-2423.674897	9.080876	9.160804	9.112146
(1,4)	-2426.695277	9.080953	9.136902	9.102841
(3,4)	-2425.273302	9.083109	9.155044	9.111252
(4,3)	-2425.295624	9.083193	9.155128	9.111335
(2,2)	-2428.584776	9.084272	9.132228	9.103033
(2,3)	-2428.437539	9.087454	9.143403	9.109342
(1,3)	-2431.986765	9.096966	9.144922	9.115727
(3,3)	-2436.562652	9.121502	9.185445	9.146518
(3,2)	-2441.006579	9.134353	9.190302	9.156242
(4,1)	-2448.941160	9.163960	9.219909	9.185848
(1,2)	-2450.986702	9.164129	9.204093	9.179764
(0,4)	-2455.671692	9.185342	9.233299	9.204104

(3,0)	-2462.884833	9.208525	9.248489	9.224160
(3,1)	-2462.046115	9.209127	9.257084	9.227889
(0,1)	-2465.256279	9.209911	9.233890	9.219292
(4,0)	-2462.294924	9.210056	9.258012	9.228818
(0,2)	-2464.695070	9.211549	9.243520	9.224057
(1,1)	-2464.738907	9.211712	9.243683	9.224220
(2,1)	-2464.612838	9.214973	9.254937	9.230608
(0,3)	-2464.693518	9.215274	9.255238	9.230909
(2,0)	-2466.003452	9.216431	9.248402	9.228939
(1,0)	-2468.797423	9.223125	9.247103	9.232506
(0,0)	-2485.394453	9.281323	9.297308	9.287577

Appendix B

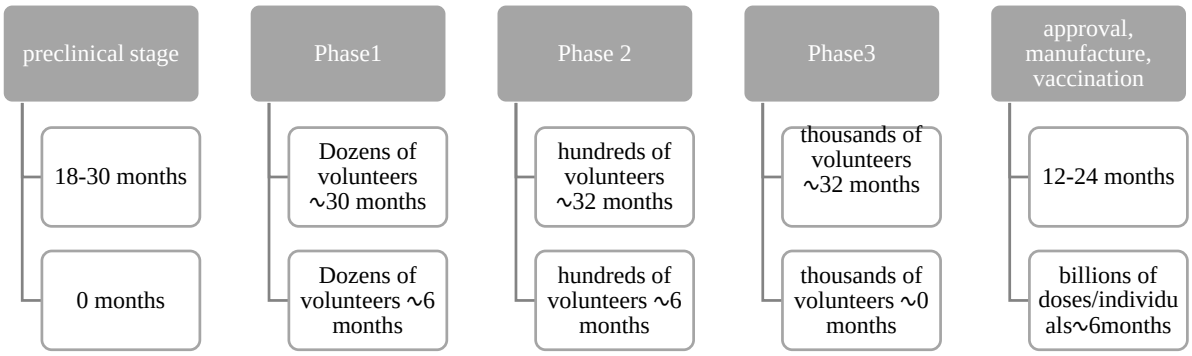


Figure A1. Differences between classical and COVID19 vaccines (the first box is classical vaccines and the second box is about COVID19 vaccine).

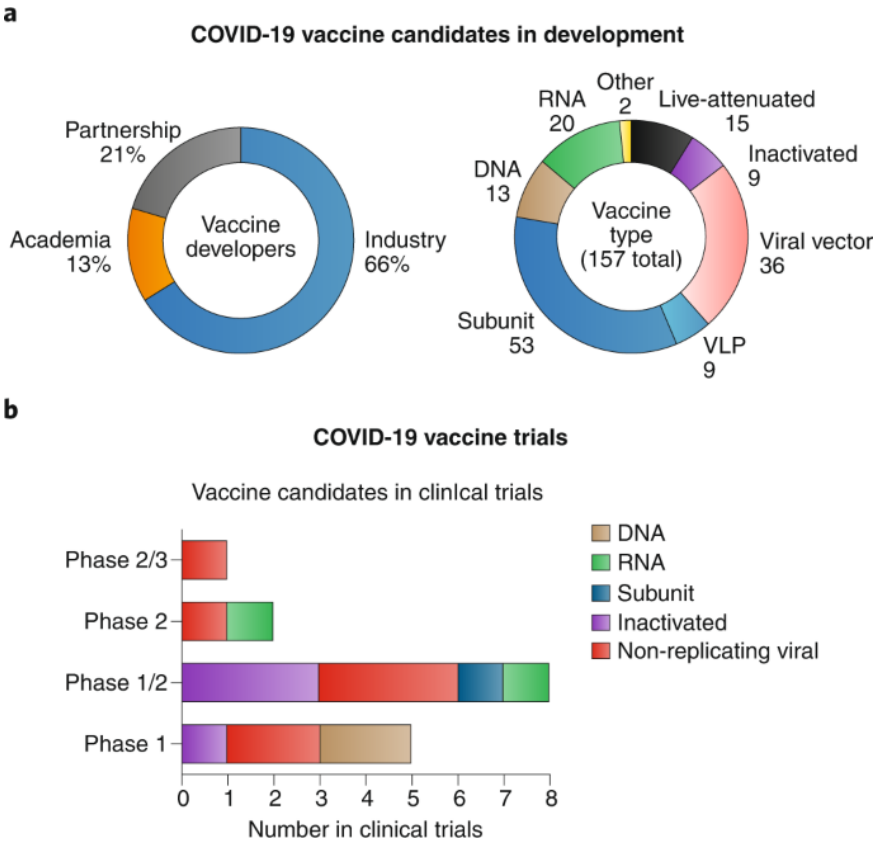


Figure A2. COVID19 vaccines in development and trials

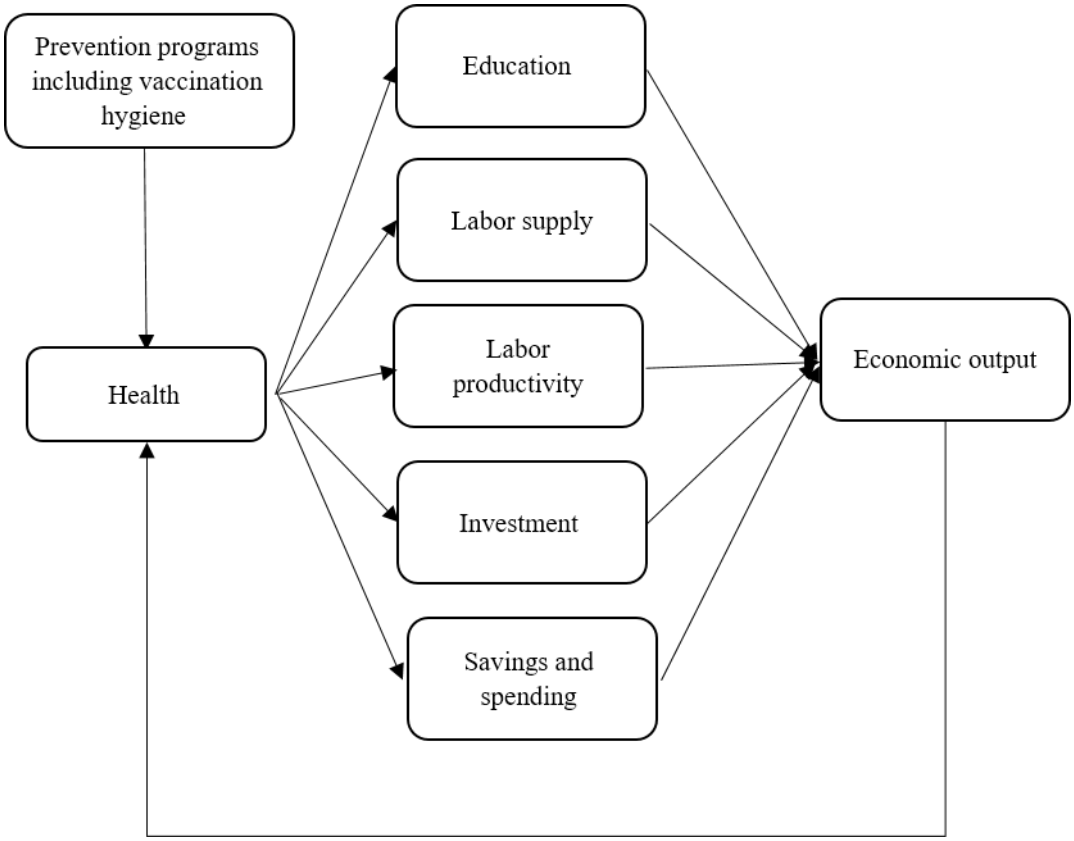


Figure A3. Potential mechanism for the link between health and economic output and the roles of prevention programs, including vaccination, and hygiene

References

[1] Bloom, D. E., Canning, D., & Weston, M. (2005). The value of vaccination. WORLD ECONOMICS-HENLEY ON THAMES-, 6(3), 15.
[2] Clinton, C., & Sridhar, D. (2017). Who pays for cooperation in global health? A comparative analysis of WHO, the World Bank, the Global Fund to Fight HIV/AIDS, Tuberculosis and Malaria, and Gavi, the Vaccine Alliance. The Lancet, 390(10091), 324-332.
[3] Ultsch, B., Damm, O., Beutels, P., Bilcke, J., Brüggenjürgen, B., Gerber-Grote, A., ... & Wichmann, O. (2016). Methods for health economic evaluation of vaccines and immunization decision frameworks: a consensus framework from a European vaccine economics community. Pharmacoeconomics, 34(3), 227-244.
[4] Luyten, J., & Beutels, P. (2016). The social value of vaccination programs: beyond cost-effectiveness. Health Affairs, 35(2), 212-218.
[5] Ozawa, S., Mirelman, A., Stack, M. L., Walker, D. G., & Levine, O. S. (2012). Cost-effectiveness and economic benefits of vaccines in low-and middle-income countries: a systematic review. Vaccine, 31(1), 96-108.
[6] Ryan, J. M. (2020). The SARS-CoV-2 virus and the COVID-19 pandemic. COVID-19: Volume I: Global Pandemic, Societal Responses, Ideological Solutions.
[7] Abbas, M. Z. (2020). Practical implications of 'vaccine nationalism': A short-sighted and risky approach in response to COVID-19.
[8] McKee, M., & Stuckler, D. (2020). If the world fails to protect the economy, COVID-19 will damage health not just now but also in the future. Nature Medicine, 26(5), 640-642.
[9] Ophinni, Y., Hasibuan, A. S., Widhani, A., Maria, S., Koesnoe, S., Yunihastuti, E., ... & Djauzi, S. (2020). COVID-19 Vaccines: Current Status and Implication for Use in Indonesia. Acta Medica Indonesiana, 52(4), 388.
[10] Song, L., & Zhou, Y. (2020). The COVID-19 Pandemic and Its Impact on the Global Economy: What Does It Take to Turn Crisis into Opportunity? China & World Economy, 28(4), 1-25.
[11] Biallas, M., & O'Neill, F. (2020). Artificial intelligence innovation in financial services.
[12] Leal Filho, W., Brandli, L. L., Lange Salvia, A., Rayman-Bacchus, L., & Platje, J. (2020). COVID-19 and the UN sustainable development goals: threat to solidarity or an opportunity? Sustainability, 12(13), 5343.
[13] Nerini, F. F., Henrysson, M., Swain, A., & Swain, R. B. (2020). Sustainable development in the wake of COVID-19.
[14] Pan, S. L., & Zhang, S. (2020). From fighting COVID-19 pandemic to tackling sustainable development goals: An opportunity for responsible information systems research. International Journal of Information Management, 55, 102196.

[15] Kashte, S., Gulbake, A., El-Amin III, S. F., & Gupta, A. (2021). COVID-19 vaccines: rapid development, implications, challenges and future prospects. Human cell, 1-23.
[16] ElBagoury, M., Tolba, M. M., Nasser, H. A., Jabbar, A., & Hutchinson, A. (2020). The find of COVID-19 vaccine: Challenges and opportunities. Journal of infection and public health.
[17] Roy, S. (2020). Economic impact of Covid-19 pandemic. A Preprint, 1-29.
[18] Berchin, I. I., & de Andrade, J. B. S. O. (2020). GAIA 3.0: Effects of the coronavirus disease 2019 (COVID-19) outbreak on sustainable development and future perspectives. Research in Globalization, 2, 100014.
[19] Ujunwa, A. I., Ujunwa, A., & Okoyeuzu, C. R. (2021). Rethinking african globalisation agenda: Lessons from COVID-19. Research in Globalization, 3, 100055.
[20] Zawbaa, H. M., El-Gendy, A., Saeed, H., Osama, H., Ali, A. M., Gomaa, D., ... & Abdelrahim, M. E. (2021). A study of the possible factors affecting COVID-19 spread, severity and mortality and the effect of social distancing on these factors: Machine learning forecasting model. International Journal of Clinical Practice, 75(6), e14116.
[21] Gray, J. D., Harris, C. R., Wylezinski, L. S., & Spurlock Iii, C. F. (2021). Predictive modeling of COVID-19 case growth highlights evolving racial and ethnic risk factors in Tennessee and Georgia. BMJ Health & Care Informatics, 28(1).
[22] Rios, R. A., Nogueira, T., Coimbra, D. B., Lopes, T. J., Abraham, A., & Mello, R. F. D. (2021). Country transition index based on hierarchical clustering to predict next COVID-19 waves. Scientific Reports, 11(1), 1-13.
[23] Malki, Z., Atlam, E. S., Ewis, A., Dagnew, G., Ghoneim, O. A., Mohamed, A. A., ... & Gad, I. (2021). The COVID-19 pandemic: prediction study based on machine learning models. Environmental science and pollution research, 28(30), 40496-40506.
[24] Muhammad, L. J., Algehyne, E. A., Usman, S. S., Ahmad, A., Chakraborty, C., & Mohammed, I. A. (2021). Supervised machine learning models for prediction of COVID-19 infection using epidemiology dataset. SN computer science, 2(1), 1-13.
[25] Kuo, K. M., Talley, P. C., & Chang, C. S. (2022). The accuracy of machine learning approaches using non-image data for the prediction of COVID-19: A meta-analysis. International Journal of Medical Informatics, 104791.
[26] Mohan, S., Solanki, A. K., Taluja, H. K., & Singh, A. (2022). Predicting the impact of the third wave of COVID-19 in India using hybrid statistical machine learning models: A time series forecasting and sentiment analysis approach. Computers in Biology and Medicine, 144, 105354.
[27] Bazin, H. (2011). Vaccination: a history from Lady Montagu to genetic engineering. John Libbey Eurotext.
[28] Jenner, R. S. E. (2005, January). the History of Smallpox and Vaccination. In Baylor University Medical Center Proceedings (Vol. 18, No. 1, pp. 21-5).
[29] Lewinsohn, D. M., Leonard, M. K., LoBue, P. A., Cohn, D. L., Daley, C. L., Desmond, E., ... & Woods, G. L. (2017). Official American Thoracic Society/Infectious Diseases Society of America/Centers for Disease Control and Prevention clinical practice guidelines: diagnosis of tuberculosis in adults and children. Clinical Infectious Diseases, 64(2), e1-e33.
[30] Piantadosi, S. (2017). Clinical trials: a methodologic perspective. John Wiley & Sons.
[31] Josefsberg, J. O., & Buckland, B. (2012). Vaccine process technology. Biotechnology and bioengineering, 109(6), 1443-1460.
[32] Calina, D., Sarkar, C., Arsene, A. L., Salehi, B., Docea, A. O., Mondal, M., ... & Sharifi-Rad, J. (2020). Recent advances, approaches and challenges in targeting pathways for potential COVID-19 vaccines development. Immunologic research, 1-10.
[33] Artenstein, A. W., Opal, J. M., Opal, S. M., Tramont, E. C., Peter, G., & Russell, P. K. (2005). History of US military contributions to the study of vaccines against infectious diseases. Military medicine, 170(suppl_4), 3-11.
[34] McKee, M., & Stuckler, D. (2020). If the world fails to protect the economy, COVID-19 will damage health not just now but also in the future. Nature Medicine, 26(5), 640-642.
[35] Lenzen, M., Li, M., Malik, A., Pomponi, F., Sun, Y. Y., Wiedmann, T., ... & Yousefzadeh, M. (2020). Global socio-economic losses and environmental gains from the Coronavirus pandemic. PLoS One, 15(7), e0235654.
[36] Sharma, H. B., Vanapalli, K. R., Cheela, V. S., Ranjan, V. P., Jaglan, A. K., Dubey, B., ... & Bhattacharya, J. (2020). Challenges, opportunities, and innovations for effective solid waste management during and post COVID-19 pandemic. Resources, conservation and recycling, 162, 105052.
[37] Kavaliunas, A., Ocaya, P., Mumper, J., Lindfeldt, I., & Kyhlstedt, M. (2020). Swedish policy analysis for Covid-19. Health Policy and Technology, 9(4), 598-612.
[38] Rodrigues, C. M., & Plotkin, S. A. (2020). Impact of Vaccines; health, economic and social perspectives. Frontiers in microbiology, 11.
[39] Baker, S. R., Bloom, N., Davis, S. J., & Terry, S. J. (2020). Covid-induced economic uncertainty (No. w26983). National Bureau of Economic Research.
[40] Kloke-Lesch, A. (2015). The G20 and the Sustainable Development Goals (SDGs): reflections on future roles and tasks. Chongyang Institute for Financial Studies (ed.), G20 and global governance: blue book of G20 Think Tank, 2016, 55-71.
[41] Leal Filho, W., Brandli, L. L., Lange Salvia, A., Rayman-Bacchus, L., & Platje, J. (2020). COVID-19 and the UN sustainable development goals: threat to solidarity or an opportunity? Sustainability, 12(13), 5343.
[42] Shahvaroughi Farahani, M. (2021). Prediction of Interest Rate Using Artificial Neural Network and Novel Meta-Heuristic Algorithms. Iranian Journal of Accounting, Auditing and Finance, 5(1), 1-30.
[43] Ahmed, J., Jafri, M., Ahmad, J., & Khan, M. I. (2005). Design and implementation of a neural network for real-time object tracking. Paper presented at the Proceedings of machine vision and pattern recognition in 4th world enformatika conference, Istanbul.

[44] Haider, A., & Hanif, M. N. (2009). Inflation forecasting in Pakistan using artificial neural networks. Pakistan economic and social review, 123-138.
[45] Ravichandran, K., Thirunavukarasu, P., Nallaswamy, R., & Babu, R. (2005). Estimation of return on investment in share market through ANN. Journal of Theoretical and Applied Information Technology, 3.
[46] Jiang, X., & Li, S. (2017). Beetle antennae search without parameter tuning (BAS-WPT) for multi-objective optimization. arXiv preprint arXiv:1711.02395.
[47] ElBagoury, M., Tolba, M. M., Nasser, H. A., Jabbar, A., & Hutchinson, A. (2020). The find of COVID-19 vaccine: Challenges and opportunities. Journal of infection and public health.
[48] He, Jie & Guo, Hui. (2013). A Modified Particle Swarm Optimization Algorithm. TELKOMNIKA Indonesian Journal of Electrical Engineering. 11. 10.11591/telkomnika. v11i10.2947.
[49] Shobana, G., & Umamaheswari, K. (2021, January). Forecasting by Machine Learning Techniques and Econometrics: A Review. In 2021 6th International Conference on Inventive Computation Technologies (ICICT) (pp. 1010-1016). IEEE.
[50] Hernandez, H. (2021). Testing for Normality: What is the Best Method. ForsChem Research Reports, 6, 2021-05.
[51] Trapani, L. (2021). A test for strict stationarity in a random coefficient autoregressive model of order 1. Statistics & Probability Letters, 109164.
[52] Ryabko, D. (2019). Asymptotic nonparametric statistical analysis of stationary time series. Springer International Publishing.