An Intelligent Algorithm to Predict GDP Rate and Find a Relationship Between COVID-19 Outbreak and Economic Downturn

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Abstract
With the spread of COVID-19, economic damages are challenging for governments and people’s livelihood besides its dangerous and negative impact on humanity’s health, which can be led to death. Various health guidelines have been proposed to tackle the virus outbreak including quarantine, restriction rules to imports, exports, migrations, and tourist arrival that were affected by economic depression. Providing an approach to predict the economic situation has a highlighted role in managing crisis when a country faces a problem such as a disease epidemic. We propose an intelligent algorithm to predict the economic situation that utilizes neural networks (NNs) to satisfy the aim. Our work estimates correlation coefficient based on the spearman method between gross domestic product rate (GDPR) and other economic statistics to find effective parameters on growing up and falling GDPR and also determined the NNs’ inputs. We study the reported economic and disease statistics in Germany, India, Australia, and Thailand countries to evaluate the algorithm’s efficiency in predicting economic situation. The experimental results demonstrate the prediction accuracy of approximately 96% and 89% for one and more months ahead, respectively. Our method can help governments to present efficient policies for preventing economic damages.

Keywords COVID-19 · Economic damage · Neural network · Intelligent algorithm · Prediction

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1 Introduction

After identifying COVID-19 and confirming its epidemic via the WHO as a dangerous virus for human health in January 2020, the involved countries’ economies faced the crisis. Applying the restriction rules, including migration, import, export, and tourist arrival, and increasing government spending to tackle the epidemic and health services led to the economic downturn in most countries. The disease epidemic leads to bankruptcy of some companies and production line shutdown of several manufacturers where are reduced employed persons and a rising unemployment rate, which are caused by applying the rules of social distance and quarantine. The case studies demonstrated the role of the economic situation in tackling the disease epidemic with human resource management (HRM) and supporting health services and health care workers while economic weak infrastructure affects increasing COVID-19 new cases and rising death rate (Abel & McQueen, 2020). Aurelia et al. (2020) studied HRM’s role during COVID-19 and investigate the impact of different technologies, including machine learning, cloud computing, and the Internet of Things (IoT) on improving the efficiency of human resource management, which can be affected by confronting the disease epidemic. The virus’s stability and its specific features created a big challenge for the world economy and people’s livelihood during COVID-19 where its negative impacts can be affected the economy’s depression, and mental and physical health over several months after clearing the virus (Rahmani et al., 2020). Hence, prediction approaches can help approximate the negative impacts of the disease epidemic on humane society from different aspects when the various case studies tried to provide a model to follow the issue and satisfy the purposes.

Rahman et al., (2020) studied the quarantine impact on the economic situation that led to lockdown due to heavy restriction rules to business from different angles, such as closing the shops, restaurants, cafes, and the specific rules for air and ground lines to transfer the passengers. This work focused on a model to simulate lockdown behavior and an algorithm for dynamic clustering to face the economic damages. Before employing the algorithm for dynamic clustering, the study predicted the negative impact of the virus outbreak on the economic downturn and tried to solve the problem by simulating lockdown behavior. Some studies applied prediction of the relationship between people’s economic welfare and increasing or reducing new cases and death rates caused by the virus outbreak, which can be affected on control and management of the situation before the occurring crisis (Brouard et al., 2020; Müller & Rau, 2020). Beyer et al. (2020) investigated the role of the COVID-19 outbreak on the economic situation by presenting a method to monitor the electricity consumption during applying the quarantine rules in India, which observations proved the higher consumption the night time than before implementing the quarantine restrictions. It leads to an increase in government spending to produce electricity and hurts India’s economic situation. Also, a case study analyses the negative and positive impacts of the disease epidemic on human life from different aspects in Pakistan that demonstrated the economy’s damages caused by stopping and losing some
businesses such as street peddlers (Ali et al., 2020; Shafi et al., 2020). Mishra et al., (2020) studied the negative role of the COVID-19 outbreak on the countries’ economic situation besides investigating social damages by comparing two parameters before and after identifying the virus, which the study illustrated the negative impact of the involved countries with the disease epidemic on the economy of other noninvolved countries. Some researchers utilized machine learning (ML) algorithms-based methods to predict the condition of the virus outbreak worldwide using collecting primary data on the disease epidemic where it can help people and governments in tackling COVID-19 in different countries and also facing the other viruses in the future (Kavadi et al., 2020).

According to upper mentioned concepts, the spread of COVID-19 had a highlighted role in economic depression where providing a prediction method can affect managing crises by applying policies to prevent imposing more damages to a country’s economy. Therefore, we propose a method to predict the economic situation based on the GDP rate’s value, which utilizes neural networks to satisfy the purpose. We present an intelligent two-phase algorithm, including collecting dataset in phase 1 and predicting the economic situation for one or more months ahead in phase 2 where Fig. 1 gives an overview of the work’s steps. Our work focuses on the statistics of the COVID-19 outbreak and the economy in Germany, India, Australia, and Thailand in February-October 2020 for analyzing the proposed algorithm’s efficiency in predicting the GDP rate for a country. Our algorithm utilizes the different reported economic statistics of various categories that lead to predicting the economic situation based on effective economic parameters and the relationship between them and the disease epidemic. This work utilizes the spearman-based correlation coefficient between GDP rate and other reported
economic statistics to detect effective parameters on GDPR and determine the NN inputs. Therefore, the highlighted motivations of our work are defined as follows:

- Providing an intelligent algorithm
- Finding the relationship between GDPR and other economic parameters using estimating CC
- Finding a relationship between COVID-19 new cases and the economic parameters as the NN inputs using estimating CC
- Predicting the economic situation based on the reported economic statistics, which access to them is easier than other parameters such as analyzing electricity consumption
- Being generalized the algorithm in facing a different crisis such as other viruses outbreak using replacing the neural network’s COVID-19 input with other parameters

Our work affects managing critical situations and applying policies to prevent economic downturn by creating opportunities for governments to find a suitable and efficient approach against economic damages by predicting GDPR for one or more months ahead. Also, preventing the economic depression and maintaining the level of welfare of the community has an impressive effect on mental health people and their tackling of the COVID-19 epidemic or other viruses outbreaks.

We overview the rest of the paper’s sections that include: Sect. 2 reviews the related studies on the relationship between the COVID-19 outbreak and the economic situation and the role of proposed prediction approaches. Section 3 presents the details of our idea to predict the economy situation of countries. The observations and results are analyzed by Sects. 4, and 5 concludes the paper’s concepts.

2 Literature Review

According to the relationship between the virus outbreak, economic downturn, and some research about analyzing the issue, this section reviews the related case studies on the economy’s situation in the different countries during the disease epidemic. Also, we investigate the role of different proposed prediction methods in preventing the virus outbreak and its other negative or positive impacts on the health of humanity and natural environments.

With the COVID-19 outbreak and the highlighted role of the economic situation on people’s mental and physical health, the researchers focused on evaluating the impact of the economic infrastructure of the various countries on facing the disease epidemic, which the lockdown of applying the social distance and quarantine rules led to a decline in the social welfare (Tisdell et al., 2020). Tisdell (2020) studied the impact of individual and social ethics, and economic situation on the virus outbreak and increasing or reducing the number of new cases and death rate that analyzed the countries’ economic situation based on a provided model for estimating GDP. This model found a relationship between the risky groups’ economic situation and death rate, which was demonstrated the role of
efficient policies in reducing economic damages and the death rates caused by the disease epidemic (Acemoglu et al., 2020). Norouzi et al. (2020) utilized a neural network and a regression model to approximate electricity and petroleum consumption during the COVID-19 outbreak, which the case study results proved to increase two energy resources’ demands and falling economic situation for the involved countries with the virus. Applying the rules of social distance and quarantine reduced the number of employed persons and increased time spent at home that was led to enhance the demands for electricity and petroleum by the people and health centers. Verma et al., (2020) studied the impact of the virus outbreak and export and import restriction laws on trading petroleum and other fuels. The research targeted the properties that applying the rules’ enforcement on them created problems for fuel handling, including top-of-line, and bottom-of-line corrosions (TLC, and BLC) caused by the middle or complete lockdown worldwide specific for the involved countries with COVID-19. Trading petroleum and other fuels have an impressive effect on increasing foreign exchange reserves as an economic parameter that applying the restriction trading rules and its lockdown leads to the economic downturn.

Arthi and Parman (2020) focused on the previous economic depression in facing the critical situation such as other diseases’ epidemics and investigated the economic parameters that were directly impressed by confronting the virus outbreak (The spread of Influenza in 1918). According to the case study observations, the proposed approaches against a disease epidemic mostly affected the falling countries’ economic situation when was destroyed some businesses, and reduced the employed persons and social welfare by applying the restriction rules. The researchers also analyzed the economic situation impact on improving the rate of patients with COVID-19 based on people’s age categories, their life insights, and individual welfare level (Mann et al., 2020). The experimental results demonstrated an increase the economic anxiety in young adults and people with children compared with the elders and carefree persons (Mann et al., 2020). With the rising telecommuting rate because of following the rules of social distance and quarantine, increasing the broadband affected the growing up economy according to improving the data transfer rate and speedup of communication between hosts (Zhang, 2021).

The prediction has a highlighted role in tackling the critical situation with help providing the prevention methods, which the various researches were dedicated to predicting crisis and curbing deploying it such as preventing acute respiratory distress syndrome (ARDS) in the patients with coronavirus (Salehi et al., 2020). Taboe et al., (2020) presented a predict-based method to face the disease epidemic in West Africa using analyzing the number of new cases before and after applying the special health and treatment measures and efficient policies. The results of the case study help governments and health organizations to decide about providing the extent of effective medical services to reduce the number of new cases and death rates in West Africa. Škare et al. (2020) utilized the previous studies, observations, and experimental results to investigate a virus outbreak’s impact on tourist arrival and its industry for presenting a model to predict the tourism industry’s situation.
with the COVID-19 epidemic and managing it as the effective parameter in the economic downturn.

Some case studies utilized the Dynamic stochastic general equilibrium (DSGE or CGE) modeling in the specialized domain of computational economics to predict economic growth and actual business cycle in micro and macroeconomics in ordinary situations for the long term run. The CGE-based models improved predicting the economic situation for general conditions or after passing a critical situation, which has a highlighted role to propose the solutions in the long term run by employing Markov chains (Lim, 2021; Yang et al., 2021). Researchers proved that the dynamic stochastic general equilibrium models had not an impressive effect in timely forecasting and predicting sudden and critical situations with high accuracy and updating their characteristics and unstable features for decision-making in a short time (Olayode et al., 2021; Shin et al., 2021).

An overview of the upper mentioned studies determined the highlighted role of predicting the economic situation and infrastructure in tackling the virus outbreak. The study presents an intelligent algorithm to predict the economic situation for one or months ahead using neural networks and training them. We utilize the effective economic parameters on GDP rate and the disease new cases to determine the NN inputs where access to the history and current economic statistics is simpler than employing other parameters (Such as petroleum, other fuels, and electricity).

3 Predicting the Economic Situation

This section explains our data collecting method to utilize for predicting the economic situations in different countries, which are introduced standard, medium, and critical conditions. We investigate the statistics on economic and COVID-19 in Germany, India, Australia, and Thailand countries to find the relationship between the virus outbreak and economic damages after the disease epidemic in a country in 2020.

3.1 Collecting Dataset and Analyzing it

We first monitor the gross domestic product rate and the number the new patient with COVID-19 in the mentioned countries, and also extract some parameters from the labor, price, money, trade, government, and consumer categories that can affect the deteriorating or growth of GDPR for collecting a dataset of effective parameters in falling or rising economic situation and the virus new cases (https://tradingeconomics.com/germany/indicators, https://tradingeconomics.com/india/indicators, https://tradingeconomics.com/australia/indicators, https://tradingeconomics.com/thailand/indicators). Some economic statistics are reported as seasonal (Such as GDPR and wage growth) while other presented parameters are monthly (Such as employed persons, imports, and exports). In this condition, we have to integrate
the reported information in seasonal or monthly to decide about the relationship between the parameters and GDPR where Fig. 2 shows the steps of collecting the dataset and integrating them.

By utilizing the averaging method, we convert the monthly reported statistics to seasonal information to integrate the collected dataset. The data distribution has to determine before estimating the correlation coefficient (CC) to find the relationship between GDPR and other economic parameters. We employ Kolmogorov–Smirnov test and histogram chart to identify normal or non-normal data distribution to decide on utilizing the CC method, which engages the spearman approach to compute the correlation coefficient, according to non-normal distribution for some parameters (Such as GDP). Equations (1)–(2) demonstrate the Kolmogorov–Smirnov test and spearman-based correlation coefficient method that their variables are introduced in Tables 1 and 2, respectively (Daniel, 1999; Kolmogorov et al., 1933).

**Table 1** The definition of the Kolmogorov–Smirnov test’s variables

| Variable  | Definition                                      |
|-----------|------------------------------------------------|
| $F_n(x)$  | Empirical distribution function                |
| $I_{[a,b]}(X_i)$ | Indicator function                          |
| $X_i$     | The supremum of the set of distances          |
| $n$       | Number of independent and identically distributed ordered observations |

**Table 2** The definition of the spearman correlation coefficients variables

| Variable | Definition                                      |
|----------|------------------------------------------------|
| $\rho$   | Spearman’s rank correlation coefficient        |
| $d_i$    | Difference between the two ranks of each observation |
| $n$      | Number of observations                         |
After computing CC and finding the effective parameters on GDPR for the countries (Germany, India, Australia, and Thailand), we again convert the seasonal reported statistics to monthly information to increase the number of data by employing the interpolation method. Indeed, the estimated CCs are determined by the neural networks’ inputs to perform predicting the economic situation with the spread of COVID-19 or other dangerous viruses to help the governments for managing the crisis.

3.2 The Neural Networks and Predicting Economic Situations

We provide four different neural network architectures to predict the economic situation in Germany, India, Australia, and Thailand in 2020, according to the number of determining inputs for NNs by evaluating estimated CCs. The number of NNs’ hidden layers and their neurons are determined by employing the trial and error method and also monitoring their cost. We utilize the supervised learning method and rectified linear unit (ReLU) as the activation function to generate the NNs’ output for achieving a value between zero and one to predict the countries’ economic situation for one or more months ahead. According to the mentioned method to collect the dataset, this work employs the normalized dataset for training the neural networks, which consists of the monthly statsits of COVID-19 new cases and the economic parameters in Germany, Australia, India, and Thailand (https://github.com/yasamanhosseini/Economic-COVID-19/blob/main/Dataset.xlsx).

We utilize the gradient distance-based method for training the neural networks with various architectures, employ economic factors, and the disease new cases as the NNs inputs, which are dedicated to different categories (Trade, government, labor, price, money) to the different countries by considering the computed correlation coefficients. The neural networks are first trained using input data (new cases and effective parameters on GDPR) and output data including the gross domestic product rate for the countries. After passing the training phase, we inject the new values of the inputs to the NN to investigate GDPR value and also test prediction accuracy using importing previous monthly statistics of the economic and new cases and their impact on the gross domestic product rate for one or more months ahead.

Figure 3 illustrates the proposed NN’s architecture to predict Germany’s economic situation based on the determined inputs, which are included the disease new cases (x), imports (z), exports (e), wage growth (w), and tourist arrivals (t). This architecture consists of one input, one output, and one hidden layer with five, one, and six neurons, respectively, in which y defines GDP rate values for Germany in

\[
F_n(x) = \frac{1}{n} \sum_{i=0}^{n} I_{[\infty,x]}(X_i)
\]

\[
\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}
\]
2020. We first train the neural network based on the gradient distance method using the above-mentioned input and output data in Germany in 2020.

We consider an architecture for a neural network to predict India’s economic situation including one input, one output, and one hidden layer that consist of three, one, and neurons per layer, respectively, as shown in Fig. 4. The NN’s inputs demonstrate COVID-19 new cases (x), tourist arrival (z), and investment (i), and also y (output) defines GDPR’s values in India in 2020 whereas input data are dedicated according to the computed correlation coefficient and effective parameters on the gross domestic product rate. The neural network is trained the gradient distance-based method and predicts India’s economic situation using analyzing the GDP rate’s value as the NN’s output.

By determining the neural network’s inputs utilizing estimating CCs, we predict Australia’s economic situation using providing a NN, which its architecture consists of one input, one output, and one hidden layer with five, one, and six neurons per layer, respectively. As shown in Fig. 5, the dedicated inputs and outputs are included
the disease new cases (x), investment (i), job vacancy (j), wage growth (w), export (e), and GDPR (y) in Australia in 2020.

We design a fully-connected NN to predict Thailand’s economic situation and train it based on the gradient distance method, in which its architecture consists of six, one, and seven neurons per one input, one output, and one hidden layers, respectively. Figure 6 illustrates the proposed NN architecture with seven inputs, which consist of the COVID-19 new cases (x), employed persons (e), consumer price index (CPI) as z input, import (i), export (p), and tourist arrival (t) when output (y) defines GDPR values in Thailand in 2020.

We utilize the monthly reported statistics of gross domestic product rate, the disease new cases, and the effective parameters on GDP rate to train the existing neural networks for the mentioned countries in February–October in 2020. By employing the NNs, we predict the countries’ economic situation for one or more months ahead via importing related data to a country from the last months of 2020.
3.3 An Intelligent Two-Phase Algorithm

To achieve the upper-mentioned purposes (data collection and economic situation prediction), we propose an intelligent two-phase algorithm to decide about predicting a country’s economic situation for one or more months ahead in case of tackling crisis conditions such as the spread of COVID-19 or other dangerous viruses outbreak.

Two phases of the predictor economic situation (PES) algorithm consist of collecting a dataset including the disease new cases and the economic statistics for Germany, India, Australia, and Thailand, and also predicting the countries’ GDPR for one or more months ahead.

In phase 1, PES first investigate the economic statistics and select them from different categories (Such as GDP, trade, government, labor, and consumer) for Germany, India, Australia, and Thailand in 2015–2020. We test the normal or non-normal distribution of the selected data based on histogram and Kolmogorov Smirnov methods to decide about employing the CC approach, which test result demonstrates non-normal distribution for some parameters. Hence, PES utilizes the spearman method to estimate the correlation coefficient between GDPR and other economic parameters that registers them for determining the neural networks’ inputs in phase 2. PES identifies the effective economic parameters of GDPR and determines them as the NNs inputs where the condition of $CC \geq 0.5$ or $CC \leq -0.5$ is met. Before computing CC, we convert monthly reported economic statistics to seasonal data unification by averaging method, in which the collected dataset has to be normalized after unifying them. The next step of PES’s phase 1 includes converting the seasonal reported economic statistic to monthly by employing the interpolating method for increasing the number of the inputs and outputs data of the neural networks for the mentioned countries in 2020. Figure 7 illustrates the defined PES’s steps and operations.

As shown in Fig. 8, phase 2 of PES is dedicated to finding a relationship between COVID-19 new cases (NC) and other neural networks’ inputs including the effective economic parameters, which are determined due to the estimated CCs in phase 1. Data dependency between the NNs inputs (between NC and other neural networks’ inputs) is detected according to the estimated correlation coefficient in phase 2 where the condition of $CC \geq 0.5$ or $CC \leq -0.5$ is met. The collected dataset is normalized before computing CC, which consists of the statistics of new cases and economic parameters in the mentioned countries in February–October in 2020. We investigate data dependency between NC and other NNs’ input to determine the years from collecting datasets to train the proposed neural network using them. PES utilizes the statistics in 2020, according to find the relationship between the disease new cases and economic parameters because training the NNs with the related dataset before the COVID-19 epidemic reduces the prediction accuracy. The proposed NNs predict GDP rate for one or more months ahead after training with the monthly reported statistics of the disease new cases and economic parameters that are determined as the neural networks’ inputs based on estimated CCs between GDPR and other parameters in phase 1. PES returns the predicted GDP rate’s value (P) as the
output of the proposed algorithm. We also evaluate the proposed algorithm’s efficiency by comparing GDPR’s value before and after predicting in phase 2.

By reviewing the existing explanations of PES’ phases, the algorithm predicted GDPR based on identifying the effective economic parameters on the gross domestic product rate by employing the shared statistics of the parameters in the previous years for different countries. PES determined the effective parameters of GDPR by estimating the Spearman-based correlation coefficient after evaluating their distribution types via Kolmogorov–Smirnov test. We analyzed the role of other economic parameters in harming or improving the GDP rate except its main variables to train the neural networks for predicting the economy’s situation.
which Eq. (3) describes computing the gross domestic product (England, 1998; Petrović et al., 2021).

\[
GDP = private\ consumption + gross\ private\ investment + government\ investment + government\ spending + (exports - imports) \tag{3}
\]

The variables of GDP have a direct dependency on estimating the gross domestic product when considering them to predict GDPR’s values (As the neural network’s outputs) leads to incorrect results of training the NNs (Due to their inevitable roles in GDP). Therefore, PES collected a dataset based on other effective parameters of GDPR (After estimating CCs) and predicted its values for one or more months ahead in critical situations.

PES algorithm has a highlighted role to investigate the economic situation for the various countries in case of facing societies a critical situation in a long time, in which the proposed prediction method and its information help governments to manage economic crises such as the damages caused by the disease epidemic.
Observations and Experimental Results

After providing and explaining the proposed algorithm, we analyze the efficiency of PES in predicting the economic situation of the mentioned countries for one or more months ahead using estimating GDPR as the returned value. This section first

Fig. 9 a–h The relationship between GDPR and other economic parameters in Germany, India, Australia, and Thailand for seasons in 2015–2020
evaluates the relationship between different economic parameters in the collected dataset and demonstrates the dependency between the COVID-19 outbreak and them. We monitor the economic statistics besides assessing their impact on falling or rising economic situations and collect them from the different categories (Trade, labor, GDP, prices, government, housing, consumer, and money) based on their role in the economic situation. The collected dataset consists of the statistics of the different economic parameters and COVID-19 in Germany, India, Australia, and Thailand in 2015–2020, which we shared on Github (https://github.com/yasamanhosseini/Economic-COVID-19/blob/main/Dataset.xlsx).

We utilize the spearman-based correlation coefficient method to find the effective economic parameters on GDP rate where the economic situations of the addressed countries are predicted for one or more months ahead according to its value. PES estimates CC between GDPR and other economic parameters and identifies the effective parameters on GDP rate to determine the inputs of neural networks. Figure 9a–h show the relationship between GDPR and export, wage growth, investment, tourist arrival, import, and government spending in Germany, India, Australia, and Thailand for different seasons in 2015–2020. We only demonstrate two determined effective parameters for the countries that the estimated CCs between GDPR and other economic parameters are 0.82, 0.9, 0.92, 0.88, 0.65, 0.84, 0.66, and 0.92 for Fig. 9a–h, respectively. PES identifies the highlighted parameters in GDP rate

![Graphs showing relationships between new cases and economic parameters](image)

**Fig. 10 a–d** The relationship between new cases and other economic parameters in Germany, India, Australia, and Thailand in February–October 2020
based on the computed values of the correlation coefficients where the condition of $CC \geq 0.5$ or $CC \leq -0.5$ is met.

According to the role of data dependency in the result validation, this work evaluates the relationship between COVID-19 new cases as one of the NNs inputs and other the inputs of the neural network, which are included in the economic parameters. To follow the issue, we estimate CC between new cases and other NNs inputs based on the spearman method to investigate the impact of the disease epidemic on the economic parameters as the other neural networks’ inputs. As shown in Fig. 10a–d, increasing COVID-19 new cases affect rising or falling at least one of the NN inputs economic parameters in Germany, India, Australia, and Thailand in February–October in 2020. The data dependency between them reduces the prediction accuracy in the case of employing the economic statistics before the spread of COVID-19 (before 2020) and leads to incorrect results. We define data dependency between new cases and the economic parameters where the condition of $CC \geq 0.5$ or $CC \leq -0.5$ is met. The computation results illustrate the estimated CC approximately $-0.58$, $-0.95$, $0.5$, and $0.6$ for Fig. 10a–d, respectively.

![Comparing real GDPR value and its predicted value in Germany](image1)

![Comparing real GDPR value and its predicted value in India](image2)

![Comparing real GDPR value and its predicted value in Australia](image3)

![Comparing real GDPR value and its predicted value in Thailand](image4)

**Fig. 11** Comparing the GDPR value before and after predicting for one, two, and three months ahead including August, September, and October in 2020; a comparing results for Germany; b comparing results for India; c comparing results for Australia; d comparing results for Thailand
By employing the four proposed neural network architectures, PES predicts the GDPR value of the mentioned countries for one or more months ahead after collecting the dataset to train the NNs using the different economic parameters and the disease new cases as the inputs and GDP rate as the output. We utilize the monthly statistics of economic parameters and COVID-19 to predict the economic situation in Germany, India, Australia, and Thailand in 2020, according to the determined inputs for the neural network based on the estimated CCs. Figure 11 a–d demonstrate the prediction accuracy of approximately 96%, 93%, and 89% for one, two, and three months ahead in Germany, India, Australia, and Thailand for August, September, and October months in 2020. We also train the neural networks using the economic statistics of the countries in 2019 with considering zero value for the related NN input to COVID-19 new cases to predict GDPR for spring in 2020. Nevertheless, data dependency between the disease epidemic and the economic parameters indicates reducing the prediction accuracy and archive the incorrect result when we utilize the related economic statistics before the disease epidemic.
Our simulation results likewise analyze the efficiency of the proposed algorithm by evaluating the prediction accuracy based on seasonal reports, which are covered by predicting the GDP rate for three months ahead. As shown in Fig. 12a–d, comparing the seasonal reported GDPR value before and after predicting illustrates the accuracy of approximately 93.25%, 94.27%, 94.2%, and 93.11% for Germany, India, Australia, and Thailand, respectively.

By analyzing the results and prediction accuracy, the study determined the economic situation using predicting the GDP rate for one or more months ahead when observations demonstrate the highlighted role of PES in predicting the maximum of three months with high accuracy. Due to training the NNs with the collected dataset, the low number of input data of the neural networks creates a restriction on the number of predicted monthly GDPR in 2020. Nevertheless, we achieved high accuracy to predict the economic situation for one season ahead (GPR rate prediction values for three months ahead), which has a highlighted role in deciding governments about efficient policies to manage crises and prevent an economic downturn. Also, our method can be generalized and affected by managing the critical situation when facing new problems such as the spread of other dangerous viruses to human health and economic situations.

5 Conclusion

The researchers identified economic depression as a big problem for the governments and human livelihood, which announces the current threat in the world by the COVID-19 outbreak. This problem affected providing health services and hurt people’s mental health besides their physical injuries. Some studies analyzed the negative effect of the disease epidemic and proved the highlighted role of the countries’ economic situation and infrastructure in tackling the virus outbreak and other critical conditions, which consists of human health guarantees via applying efficient policies. The case studies also illustrated the prediction’s role in managing the crisis via presenting the prevention methods (Such as identifying the locations), which can be the centers to start the next peak of the virus outbreak and lead to an economic downturn. This paper proposed a prediction method to investigate the countries’ GDP rate for one or more months ahead during the disease epidemic and facing other dangerous viruses. This work found a dependency between GDP rate and other economic parameters, which evaluated the disease new cases and economic statuses of the mentioned countries by presenting an intelligent algorithm. We investigated the proposed algorithm’s efficiency in predicting with estimating its accuracy by utilizing the statistics of COVID-19 and economic parameters in Germany, India, Australia, and Thailand. Our work employed neural networks to predict the countries’ GDP rate for one to three months ahead with high accuracy, which help governments with crisis management during the disease epidemic and tackling other dangerous viruses outbreak.
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Declarations

Competing interests  The authors declare that they have no competing interests.

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