Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 256 (2025) 538–546

Procedia Computer Science

www.elsevier.com/locate/procedia

CENTERIS - International Conference on ENTERprise Information Systems / ProjMAN - International Conference on Project MANagement / HCist - International Conference on Health and Social Care Information Systems and Technologies

Analyses of pandemics' quantitative data and economic indicators

Kathleen Carvalho[ab]*, Luis Paulo Reis[b], João Paulo Teixeira[c]

[a] *Research Centre in Digitalization and Intelligent Robotics (CeDRI)—Instituto Politecnico de Braganca, 5300-253 Bragança, Portugal;*
[b]*Faculdade de Engenharia da Universidade do Porto*
[c] *Laboratório para a Sustentabilidade e Tecnologia em Regiões de Montanha (SusTEC), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal;*

Abstract

The proposed work is a study that attempts to evaluate the financial impacts of pandemic mitigation strategies in order to be part of a central model that forecasts different scenarios in pandemic situations considering the impact of mitigation procedures in the Economic System and Healthcare System. Economic fluctuations impose a more significant challenge on prediction models, and pandemic modeling methodologies are primarily concerned with the variability of epidemic features, the efficiency of control measures over time, and the development of different viral variants. In this context, this paper correlates economic indicators with quantitative parameters of the last three respiratory virus pandemics, specifically the GDP and the unemployment rates, with a sample encompassing three European countries, the United Kingdom (UK), France, and Germany, that pass through the pandemics under study. The results provide intriguing information, such as the moderated and weak correlation factor between deaths with GDP in the Spanish flu and Swine flu, and the WWI and the 2009 crises can explain which. On the other hand, the correlation factors associated with COVID-19 show a weak to moderate correlation parameter with GDP and unemployment rates but present interesting numbers when the number of people fully vaccinated is compared with GDP. Also, as the correlation factor does not presente a strong relation between daily deaths and GDP, this indicates a necessity for comparison with other economic parameters.

Keywords: Gross Domestic Product; Pandemics; Economic parameters; Correlation Analysis; COVID-19; Swine Flu; H2N2; H1N1; H3N2; SARS.

* Corresponding author. Tel.: +0-000-000-0000 ; fax: +0-000-000-0000 .
E-mail address: carvalho.kath@gmail.com

10.1016/j.procs.2025.02.150

1. Introduction

As is known by the history of the world, pandemics or outbreaks directly impact the economic system of entire regions or even several countries, changing not only the living standards but also the socioeconomic indicators [1]–[3]. Until the COVID-19 pandemic, the Spanish flu (Influenza A H1N1), 1918-1920, also named the Great Influenza, was the worst pandemic the world faced. Afterward, epidemics occurred during the 20th century, such as Asian flu (Influenza A H2N2), Hong Kong Flu (Influenza A H3N2) [4]–[6], and 21st century like SARS (Sars-Cov), Swine flu pandemic (Influenza A H1N1 pdm09), and the last COVID-19 (Sars-Cov-2) [7]–[11].

Image excluded.

The main goal of this paper is to contribute to an additional analysis of a research line developed since 2020 during the COVID-19 pandemic. The papers around this theme provide a forecasting time series of coronavirus numbers, one using cumulative numbers [12], another which compares the daily numbers of cases, deaths, and Intensive Care Unit (ICU) patients compared with mitigation procedures, such the mandatory use of face masks and the vaccination campaign [13]. The last one verifies the accuracy of the model developed by [13] with new variants of the virus, more specifically the Omicron, and tests a reduced dataset in order to compare the ability of the artificial neural network to be trained with data only from the last year [14].

This work has analyzed the correlation of the last three pandemic numbers with economic parameters, specifically, the Gross Domestic Product (GPD) and the Unemployment rate of the United Kingdom (UK), France, and Germany. The choice of the dataset was based on the information publicly available that characterizes the pandemics with almost the same parameters. The pandemic-related limitations on economic activity, including lockdowns, temporary closures, and international tourists, caused a supply shock and supply chain disruption. Additionally, negative economic expectations forced consumers to reduce their spending because their earnings would continue to decline in the future [1].

Macroeconomic statistics are crucial for both governmental and private-sector decision-making [15]. The rising association between credit and business cycles needs a thorough understanding of the mechanisms driving bank loan growth and its consequences and relevance to actual economic activity [16]. Domestic credit cycles have traditionally been strongly related to global economic trends and capital flows. However, in recent years, governments have begun to employ macroprudential guidelines and credit support measures to influence banks' lending to minimize financial stability risks or boost economic activity during downturns [17], [18].

Many countries' economic development has decreased due to reduced employment, rising production costs, higher transitory inflation, and lower social consumption. Several governments' consequent severe lockdown measures to safeguard vulnerable populations led to the economic slowdown [19]. During the last pandemic, COVID-19 has aggravated the world economy. Disease outbreaks, industrial disruptions, and, most recently, inflation have all made policymaking exceedingly challenging [20]–[22]. The COVID-19 pandemic pushed governments in several nations to establish various measures to limit travel and slow the spread of the coronavirus. These policies have directly influenced the Economy's growth, both regionally and worldwide. This pandemic undermines attempts to continue and accelerate economic development. One of the repercussions is that many of the population lost their job or earnings source, decreasing their own and their family's income [23], [24].

In addition to economic effects, the coronavirus pandemic has had a detrimental impact on many other areas, including the labor market. The crisis is fueled by a considerable number of deaths and verified cases, as well as unprecedented containment efforts adopted by national governments to keep the coronavirus from proliferating. As a result, some businesses have been temporarily shut down, and numerous workers have been restricted to their homes. The loss of hospitality, tourist industry, and private education jobs was largely offset by growth in business and technology services, retail commerce, and construction. According to Eurostat data, the Eurozone's seasonally adjusted unemployment rate declined to 8.3% in November 2020 [25].

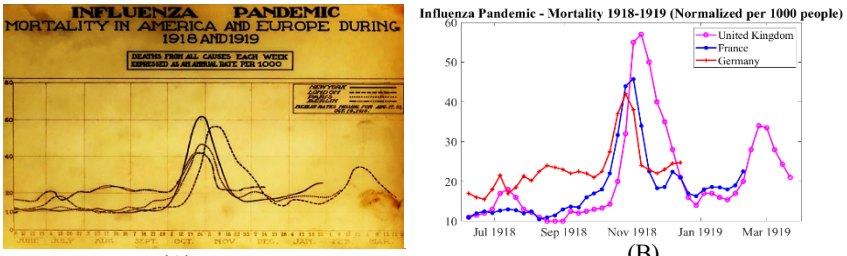
Following this introduction, the work is divided into a section materials and methods, which describes the build of the database, considering the outbreaks' numbers from different sources and the economics parameters per quarter (by trimester), considering the Eurostat data and UK available data. The results section analyzed the correlation of the parameters in order to verify the correlation of different parameters over time in each country's Economy. Lastly, a conclusion is shown in section four.

2. Material and Methods

2.1 Data collection and processing

As presented in the introduction section, the dataset for this paper was based on European countries and the economic impact of respiratory pandemics on each one of them. It is important to highlight that some data were estimated based on percentages of mortality provided by the Centers for Disease Control and Prevention (CDC) and organized by [26].

The case of the report of mortality of Spanish Flu, published in a News Paper at the time (already in the Public Domain), provided weekly data from the three capitals and a big city, London, Paris, Berlin, and New York, as seen in Fig. 1A. Moreover, it is important to remember that World War First (WWI) was happening during the same period, being declared concluded on November 11th of 1918, which probably influenced the number of deaths presented by the curve, even with a clear wave of infection. One important topic is that as New York is not in this study, the curve was not analyzed and reproduced by the data collected from the graphic.



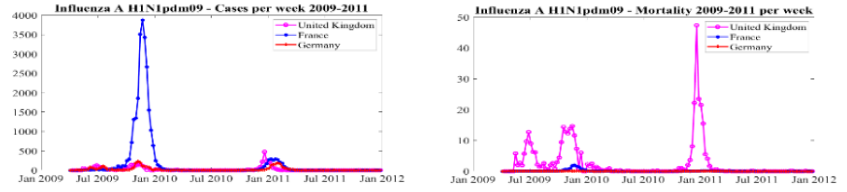
(A) (B)

Fig. 1. (A) - Report of weekly death numbers until March 1919. (B) Replot of week deaths numbers of Spanish Flu

The data collection was done by analyzing the graphic, considering the scale of the plot, and the same periods of death reports (weekly). To review the degree of similarity collected by the published graphic, the curves were replotted with the same proposed normalization in the original and can be visualized in Fig. 1B.

In the case of the Swine flu (2009-2011) and COVID-19, the data were collected from reports provided by the website OurWorldInData [27]. However, since the website is a 2011 project, some data from the Influenza A H1N1 pmd09, like the weekly deaths, must be estimated based on the Centers for Disease Control and Prevention (CDC) numbers, more specifically multiplying the number of deaths for the mortality rate presented by CDC. The following images show this number for the Swine Flu (Fig. 2A.) and COVID-19 (Fig. 2B.).

(A)



(B)

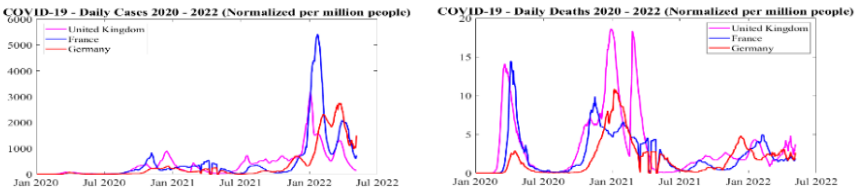


Fig. 2. Cases and deaths per week: (A) - Swine flu; (B) - COVID-19

Economic variables such as GDP and unemployment rates were collected by the Eurostat website for France and Germany and from 'The Guardian' and the International Monetary Fund [28] to the UK to begin the analysis of economic parameters. These variables were chosen in order to analyze macroeconomic parameters considered essential to the human development indicators of the countries. These parameters were analyzed in the results section by quarter; nevertheless, for Spanish flu, the comparative numbers used in GDP were the annual GDP in 1917 and 1920 to verify the economic cost of the pandemic, but without forgetting the war period.

2.2 Linear Correlation

Measures of causality between variables are ordinal or continuous, not nominal. The linear correlation coefficient is the most often used parameter. For pairs of values $(x_i, y_i), i = 1, \dots, N$, the linear correlation coefficient *r,* also known as a sometimes product-moment correlation coefficient, or Pearson's *r,* is given by Equation 1:

$$r = \frac{\sum_i (x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_i (x_i - \overline{x})^2}\ \sqrt{\sum_i (y_i - \overline{y})^2}} \tag{1}$$

where, as usual, $\bar{x}$ Is the mean of the x_i's, $\bar{y}$ Is the mean of the y_i's.
The value of r fluctuates between −1 and 1. It takes on a value of 1, named "complete positive correlation," when the data points lie on a straight line with a positive slope, with x and y increasing together. In a negative slope, when y decreases as x increases, then r has the value −1; this is called a "complete negative correlation.". A value of r near zero indicates that the variables x and y are uncorrelated [29]. Moreover, the coefficient of correlation r^2 by definition is a metric that determines the degree of coherence of a linear association between the two parameters in a correlation study.

2.3 State of the art

Some researchers have already suggested analyzing the impact of respiratory virus pandemics on macroeconomic parameters. Some examples are Hysa, et. Al, based in 22 European countries and the 3 first quarters of 2020, having a result that in emergencies, governments must launch appropriate efforts to restore the trust of socially responsible overseas investors during tough times caused by black swan events [30]. Moreover, Péter Halmai presents an analysis that identifies the effects of the COVID-19 crisis on growth, particularly the potential for expansion in the European Union (EU), as part of a larger economic analysis. This paper's quantitative study focuses on the financial and economic Great Recession of 2008 and 2009, its recovery, and COVID-19 [31]. Also, Andrej Privara studied the link between infections and mortality rates of COVID-19 is not the best variable for economic growth and labor market indicators. On the other hand, it presented that an increase in the number of new cases significantly negatively impacts the Economy, considering only European Union countries [32].

3. Results

The selection of countries, such as the UK, France, and Germany, that comprise the database considers the data from the last three respiratory pandemics. The following sub-sections will present analyses of the correlation between the Cumulative deaths and GDP to the Spanish flu and Influenza A H1N1pdm09 and a deeper analysis of GDP and Unemployment rates to COVID-19.

3.1 Spanish Flu Pandemic

In the case of the Great Pandemic, due to the limited availability of economic data, a linear decrease in GDP from 1917 to 1920 was assumed to correlate the number of deaths with economic performance. Despite the simplicity of this estimation, it was not feasible to analyze quarterly fluctuations, and collecting data from specific years, such as 1918, proved challenging. It is important to note that all the countries analyzed participated in World War I (WWI), which influences the GDP even more than a pandemic. In

Table 1, it is noted that there is a low correlation factor between the daily deaths and GDP. However, this probably is related to the end of the war.

Table 1. Correlation factor 1918–1919 – Daily deaths x GDP

Correlation factor (R^2) Deaths x GDP 1918 - 1919	
United Kingdom	0,1613
France	0,1922
Germany	0,0797

Table 1 shows a low correlation between deaths per thousand and the variation in the GDP per billion. Meanwhile, it is important to highlight the regression of the GDP values made by the data from the years between 1917 and 1920. As all data are associated with a period, it is essential to highlight that the distance of each period in the table of Spanish Flu is associated with a day with the distance of a week. This period is related to the same period presented in Figure 2. It is known that the variation of GDP is not linear; however, with the reduced data available, this estimation was necessary to analyze the data. Another important topic to refer to is WWI, which happened in the same period and also interfered directly with the GDP of a country.

3.2 Swine Flu Pandemic

The 2008-2009 economic crisis had a significant and long-term impact on Europe's growth performance and prospects. The recovery from the double-dip recession was gradual and differentiated. Some EU Member States (MSs) have experienced chronic growth issues for years. In this scenario, it is important to notice that the pandemic numbers may contribute to the volatility of the GDP, but not being the only parameter, as presented in Table 2.

Table 2. Correlation factor 2009-2011 – Deaths X GDP

Correlation factor (R^2) Deaths x GDP 2009 - 2011	
United Kingdom	0,0031
France	0,00001
Germany	0,0797

Comparing the correlation factor of Swine flu with the Spanish flu, it is possible to see a difference in the parameters. The factor was smaller in the 2009 pandemic and classified as a shallow relation factor and not a stochastic regression. Moreover, the way to analyze the GDP is not more considering an estimated linear behavior, but now the real GDP per quarter as the period of cases and deaths were very similar, because of the estimations requested and because of the standardization of the parameters in order to compare with the previous pandemic, only the correlation between deaths and GDP was presented.

In addition, the linear values in the timeline are associated with the real GDP of each quarter of the range of years analyzed. Compared with the correlation present in the Spanish flu section, it is a decrease in the factors since the values of GDP were not linearly estimated in the Swine flu analysis and considered variations by quarter, not per week.

3.3 COVID-19 Pandemic

In the case of the last pandemic caused by the virus Sars-Cov-2, it was possible to collect more data by more

straight sources since the outbreak was very controlled by daily numbers provided by several websites, but the chosen one for this work was also *OurWorldInData*. Also, more than the correlation between deaths and GDP in Table 3,it was possible to analyze the variation between the deaths and GDP per quarter and verify the impact of the pandemic on the unemployment rates. Moreover, Figure 3 shows the variation of the GDP compared to daily deaths and the GDP per quarter in UK. It is interesting to see the variation in the values of GDP rigth after the first wave of the pandemic.

Table 3. Correlation factor

Correlation factor (R^2) Deaths x GDP 2020-2022	United Kingdom	0,0006
	France	0,0063
	Germany	0,3611
Correlation factor (R^2) – Deaths x Unemployment rate (%) 2020 - 2022	United Kingdom	0,2337
	France	0,1361
	Germany	0,0435

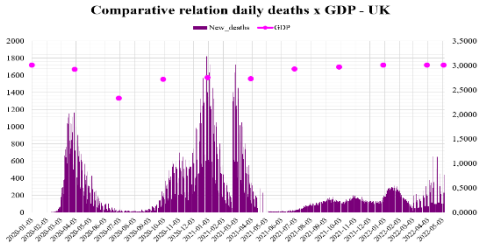


Fig. 3. Correlation –Daily deaths x GDP – 2020-2022

The previous Table 3 presented a correlation between weak depending on the country under analysis. The variations in the number of deaths among the countries can be explained by the distinct mitigation procedures dates, considering the mandatory use of masks, school closures, lockdowns, and the strength of the vaccination campaign. Furthermore, it is clear that in the case of the UK, the regression is almost independent, resulting in a low correlation coefficient; on the other hand, in France and Germany, it comes out as a low linear correlation. These graphics, like the Swine flu, consider the value of GDP per quarter, which the dots can notice plotted horizontally. Also, in this analysis, deaths were a weak factor in the unemployment rate, as presented in the following Table 3, which presents an independence of the parameter under analysis. On the other hand, when the parameter under analysis is the total of people fully vaccinated and GDP, the linear correlation shows better results, with the coefficients in the range of moderate to strong correlation (Table 5), which presents a stochastic regression function

Table 4. Fully vaccinations x GDP

Correlation factor (R^2) Fully vaccinations x GDP 2020 - 2022	
United Kingdom	0,3375
France	0,3934
Germany	0,6672

4. Discussion

Experts from the International Monetary Fund [†] emphasize that the COVID-19 pandemic greatly influenced the global Economy. Many nations' Gross Domestic Product (GDP) saw record reductions due to the cessation of economic activity, with tourism, air travel, and entertainment industries most heavily impacted. Unemployment rates surged worldwide, indicating a severe drop in demand for products and services and economic instability, which forced many enterprises to restructure or close. Other economic factors, such as inflation, displayed a variety of behaviors; in some situations, lower demand contributed to lower prices, while in others, supply chain interruptions produced temporary price increases. To counteract these consequences, governments and central banks launched emergency fiscal and monetary measures that provided economic stimulation and direct help to individuals and companies.

In this work, the main parameter analyzed is GDP, which shows that consumer spending is an important factor in GDP growth. As the population's consumption rises, firms must invest to match the expanding demand and raise profits. The cycle of increased consumption and corporate investment results in an increase in GDP. Nevertheless, as presented in the results section, the GDP was directly affected by the pandemic, at least not directly, such as wars and economic crises, Spanish and Swine flu, respectively.

5. Conclusion

This work investigated the linear correlation between the quantitative parameters of three pandemics and economic parameters to verify the regression among these baselines. The values were analyzed in the historical context, considering reservations about the war, crises, and other factors. From this paper, it is possible to analyze the waves of mortality of each pandemic for the UK, France, and Germany, and especially the correlation of cumulative deaths with GDP, as the analyses of Spanish flu and Swine flu present a weak and a moderate value for linear correlation factor, respectively.

On the other hand, in the COVID-19 analysis, the graphics show a weak correlation between cumulative deaths and GDP and unemployment rates. However, a moderate relation was noticed between the number of people fully vaccinated in each country and GDP.

It was possible to observe that the GDP is not so directly affected by a pandemic, specifically compared with deaths, even in case of war happening simultaneously (Spanish Flu). However, the Unemployment rate does not correlate strongly with daily deaths. On the other hand, the GDP is also moderately correlated with the number of people fully vaccinated.

In conclusion, while the known causes of unemployment and economic paralysis caused by the COVID-19 pandemic have been significant, this has not been reflected in GDP, possibly due to measures implemented by local and community governments, such as lowering interest rates, providing subsidies and aid to the population, and extending financial repayment periods. Thus, future research will need to examine additional economic indicators that may demonstrate the pandemic's impact on the Economy.

Acknowledgments

The authors are grateful to the Foundation for Science and Technology (FCT, Portugal) for financial support through national funds FCT/MCTES (PIDDAC) to CeDRI, UIDB/05757/2020 (DOI: 10.54499/UIDB/05757/2020) and UIDP/05757/2020 (DOI: 10.54499/UIDB/05757/2020) and SusTEC, LA/P/0007/2020 (DOI: 10.54499/LA/P/0007/2020). Also, the researcher Kathleen Carvalho is grateful to the Foundation for Science and Technology (FCT, Portugal) support with the Ph.D. scholarship 2023.05134.BD.

[†] RDM Team 2022, based on IMF (2021a). Data from the International Monetary Fund, Fiscal Monitor Database of National Fiscal Measures in Response to the COVID-19 Pandemic, Fiscal Affairs Department, https://www.imf.org/en/Topics/imf-and-covid19/Fiscal-Policies-Database-in-Response-to-COVID-19

References

[1] A. Privara, "Economic growth and the labor market in the European Union: lessons from COVID-19," *Oeconomia Copernicana*, vol. 13, no. 2, pp. 355–377, 2022, doi: 10.24136/oc.2022.011.

[2] L. A. Petrova, T. E. Kuznetsova, and V. M. Volodin, "Post-pandemic scenarios of economic development of developed countries and Russia," *Financ. Theory Pract.*, vol. 24, no. 4, pp. 47–57, 2020, doi: 10.26794/2587-5671-2020-24-4-47-57.

[3] L. Barbaglia, L. Frattarolo, L. Onorante, F. M. Pericoli, M. Ratto, and L. Tiozzo Pezzoli, "Testing big data in a big crisis: Nowcasting under Covid-19," *Int. J. Forecast.*, vol. 39, no. 4, pp. 1548–1563, 2023, doi: 10.1016/j.ijforecast.2022.10.005.

[4] R. Peckham, "Viral surveillance and the 1968 Hong Kong flu pandemic," *J. Glob. Hist.*, vol. 15, no. 3, pp. 444–458, 2020, doi: 10.1017/S1740022820000224.

[5] B. J. Jester, T. M. Uyeki, and D. B. Jernigan, "Fifty years of influenza A(H3N2) following the pandemic of 1968," *Am. J. Public Health*, vol. 110, no. 5, pp. 669–676, 2020, doi: 10.2105/AJPH.2019.305557.

[6] M. Honigsbaum, "Revisiting the 1957 and 1968 influenza pandemics," *Lancet*, vol. 395, no. 10240, pp. 1824–1826, 2020, doi: 10.1016/S0140-6736(20)31201-0.

[7] B. J. Cowling, L. M. Ho, and G. M. Leung, "Effectiveness of control measures during the SARS epidemic in Beijing: A comparison of the Rt curve and the epidemic curve," *Epidemiol. Infect.*, vol. 136, no. 4, pp. 562–566, 2008, doi: 10.1017/S0950268807008722.

[8] D. Pradhan, P. Biswasroy, P. K. Naik, G. Ghosh, and G. Rath, "A Review of Current Interventions for COVID-19 Prevention," *Arch. Med. Res.*, vol. 51, no. 5, pp. 363–374, 2020, doi: 10.1016/j.arcmed.2020.04.020 WE

[9] C. Morana, "A new macro-financial condition index for the euro area," *Economy. Stat.*, vol. 29, pp. 64–87, 2021, doi: 10.1016/j.ecosta.2021.09.005.

[10] R. Forman, R. Atun, M. Mckee, and E. Mossialos, "12 Lessons learned from the management of the coronavirus pandemic," *Health Policy (New. York).*, vol. 124, no. 6, pp. 577–580, 2020, doi: 10.1016/j.healthpol.2020.05.008 WE

[11] R. Noor and S. M. Maniha, "A brief outline of respiratory viral disease outbreaks: 1889–till date on the public health perspectives," *VirusDisease*, vol. 31, no. 4, pp. 441–449, 2020, doi: 10.1007/s13337-020-00628-5.

[12] K. C. M. De Carvalho, J. P. Vicente, and J. P. Teixeira, "COVID-19 Time Series Forecasting - Twenty Days Ahead," *Procedia Comput. Sci.*, vol. 196, no. 2021, pp. 1021–1027, 2021, doi: 10.1016/j.procs.2021.12.105.

[13] K. Carvalho, J. P. Vicente, M. Jakovljevic, and J. P. R. Teixeira, "Analysis and Forecasting Incidence, Intensive Care Unit Admissions, and Projected Mortality Attributable to COVID-19 in Portugal, the UK, Germany, Italy, and France: Predictions for 4 Weeks Ahead," *BIOENGINEERING-BASEL*, vol. 8, no. 6, 2021, doi: 10.3390/bioengineering8060084 WE

[14] K. Carvalho, L. P. Reis, and J. P. Teixeira, "Forecasting Omicron Variant of Covid-19 with ANN Model in European Countries – Num-ber of Cases, Deaths, and ICU Patients.," in *Pereira, A.I., Košir, A., Fernandes, F.P., Pacheco, M.F., Teixeira, J.P., Lopes, R.P. (eds) Optimization, Learning Algorithms and Applications. OL2A 2022. Communications in Computer and Information Science*, Springer, Cham, 2022, pp. 457–469. doi: https://doi.org/10.1007/978-3-031-23236-7_32.

[15] N. Wichitaksorn, "Analyzing and forecasting Thai macroeconomic data using mixed-frequency approach," *J. Asian Econ.*, vol. 78, no. November 2021, p. 101421, 2022, doi: 10.1016/j.asieco.2021.101421.

[16] W. Wu, P. Zhang, D. Zhu, X. Jiang, and M. Jakovljevic, "Environmental pollution liability insurance of health risk and corporate environmental performance: evidence from China," *Front. Public Heal.*, vol. 10, 2022, doi: doi.org/10.3389/fpubh.2022.897386.

[17] T. Büyükbaşaran, G. Karasoy-Can, and H. Küçük, "Macroeconomic effects of bank lending in an emerging economy: Evidence from Turkey," *Econ. Model.*, vol. 115, no. July, 2022, doi: 10.1016/j.econmod.2022.105946.

[18] L. Pedauga, F. Sáez, and B. L. Delgado-Márquez, "Macroeconomic lockdown and SMEs: the impact of the COVID-19 pandemic in Spain," *Small Bus. Econ.*, vol. 58, no. 2, pp. 665–688, 2022, doi: 10.1007/s11187-021-00476-7.

[19] M. Bizuneh and M. Geremew, "Assessing the Impact of Covid-19 Pandemic on Emerging Market Economies' (EMEs) Sovereign Bond Risk Premium and Fiscal Solvency," *East. Econ. J.*, vol. 47, no. 4, pp. 519–545, 2021, doi: 10.1057/s41302-021-00201-y.

[20] B. Guo, W. Zhang, L. Pei, X. Zhu, P. Luo, and W. Duan, "Remote Sensing Evidence for Significant Variations in the Global Gross Domestic Product during the COVID-19 Epidemic," *Sustain.*, vol. 14, no. 22, 2022, doi: 10.3390/su142215201.

[21] S. Sharma, M. Bansal, and A. K. Saxena, "Forecasting of GDP (Gross Domestic Product) per Capita Using (ARIMA) Data-Driven Intelligent Time Series Predicting Approach," *2022 Int. Conf. Sustain. Islam. Bus. Financ. SIBF 2022*, pp. 85–90, 2022, doi: 10.1109/SIBF56821.2022.9939928.

[22] F. Syarifuddin and M. Setiawan, "The Relationship between COVID-19 Pandemic, Foreign Direct Investment, and Gross Domestic Product in Indonesia," *Sustain.*, vol. 14, no. 5, 2022, doi: 10.3390/su14052786.

[23] T. T. Do and V. H. Pham, "Influence of the Covid-19 Pandemic on Reducing the Income of Workers," *Corp. Gov. Organ. Behav. Rev.*, vol. 7, no. 2, pp. 138–146, 2023, doi: 10.22495/cgobrv7i2p12.

[24] T. P. Krumel, C. Goodrich, and N. Fiala, "Labour demand in the time of post-COVID-19," *Appl. Econ. Lett.*, vol. 30, no. 3, pp. 343–348, 2023, doi: 10.1080/13504851.2021.1985067.

[25] S. Petrou and M. Jakovljevic, "Reimagining the relationship between economics and health–WHO 'Health for all'provisions," *Cost Eff. Resour. Alloc. 22(1), 5*, 2024.

[26] M.-H. Nguyen, P.-H.; Tsai, J.-F.; Kayral, I.E.; Lin, "Unemployment rates forecasting with grey-based models in the post-COVID-19 period: A case study from Vietnam," pp. 1–27, 2021.

[27] P. Verma, A. Dumka, A. Bhardwaj, A. Ashok, M. C. Kestwal, and P. Kumar, "A Statistical Analysis of Impact of COVID19 on the Global Economy and Stock Index Returns," *SN Comput. Sci.*, vol. 2, no. 1, pp. 1–13, 2021, doi: 10.1007/s42979-020-00410-w.

[28] "GDP, current prices," *International Monetary Fund*, 2024. https://www.imf.org/external/datamapper/NGDPD@WEO/EU/EUQ/EAQ

[29] W. H. Press, S. A. Teukolsky, W. T. Vetterling, and B. P. F. EXXON, *Numerical Recipes in C The Art of Scientific Computing*, 2nd ed., vol. 76, no. 7. 1992.

[30] E. Hysa, E. Imeraj, N. Feruni, M. Panait, and V. Vasile, "COVID-19—A Black Swan for Foreign Direct Investment: Evidence from European Countries," J. Risk Financ. Manag., vol. 15, no. 4, 2022, doi: 10.3390/jrfm15040156.

[31] P. Halmai, "COVID-crisis and economic growth: Tendencies on potential growth in the European Union," Acta Oeconomica, vol. 71, no.

S1, pp. 165–186, 2021, doi: 10.1556/032.2021.00034.
[32] A. Privara, “Economic growth and labour market in the European Union: lessons from COVID-19,” Oeconomia Copernicana, vol. 13, no. 2, pp. 355–377, 2022, doi: 10.24136/oc.2022.011