Environmental and Economic Factors Affecting COVID-19 Infection in 175 Countries

Boontarika Paphawasit*, Chayanut Phantharot, and Teewara Suwan

Abstract—**This study explores a potential correlation between environmental and economic factors and the confirmed COVID-19 cases. This article uses official infection rate data and environmental and economic factors that may help accelerate transmissions, such as temperature, humidity, and GDP. Using statistical methods, i.e., ordinary least squares and quantile regression, our findings indicate that temperature, moisture, and island condition were the most influential explanatory variables. Nevertheless, the other factors, which are population density of a country, GDP, and country's regime, are not statistically significant, indicating that those factors do not significantly explain changes in the confirmed COVID-19 cases.**

Index Terms—**Temperature, Covid-19, economic factor, pandemic, environmental factor**

I. Introduction

The unpredictable emergence of the novel coronavirus (COVID-19) has led to a large number of infections and deaths and is rapidly spreading around the world. COVID-19 originated in a seafood market in Wuhan, the capital of Hubei Province, the People's Republic of China, in late 2019. The virus causes respiratory illnesses in humans through person-to-person transmission and is spread to other regions worldwide by traveling from one region to another [1]. COVID-19 symptoms range from mild symptoms (e.g., fever or chills, cough, difficulty breathing, fatigue) to severe symptoms (e.g., kidney injury or failure, pneumonia) or death in very severe cases.

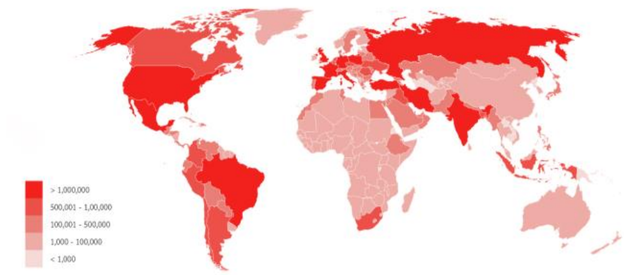

Fig. 1. Covid-19 cases as of November 6, 2020.

The World Health Organization declared this international public health emergency a pandemic in March 2020 [2]. Fig. 1 shows the epidemic that has caused a large number of infections and deaths across the world. In addition to causing a lot of infections and deaths, it also severely impacts the economy, society, and national security. Many businesses had to be closed, resulting in countless people losing their jobs. Many countries run rampant food and consumer goods hoarding, and social inequality and food shortages intensify.

Many factors are related to the spread of the COVID-19 virus among individuals. Environmental and geographical factors were the main determinants of the epidemic in terms of population density per area, average temperature, and the nature of the terrain [3]. Several studies have shown that the COVID-19 virus is significantly related to environmental and geographical factors. The literature claims that an increase or decrease in temperature affects the survival time of coronavirus on infected surfaces, leading to the conclusion that temperature can affect the risk of spreading the virus [4, 5]. In addition, the population density factor has a clear impact on the spread, infection, and mortality of the epidemic [6-8]. From the influence of atmospheric factors and pollution from the spread of the COVID-19 virus and the mortality rate, it can be concluded that the environment is a health risk factor causing millions of deaths. At the same time, atmosphere and aerosols are co-factors of indirect effects within the human body and are also associated with inflammatory mechanisms, conditions of the lungs, and organs outside the lungs [9].

The epidemic data shows the severity of the COVID-19 outbreak that causes change and loss. It is also a significant public health problem worldwide due to the spread of the COVID-19 virus, which is widespread and highly severe to the body's work system. The severity of symptoms and patient mortality may be caused by factors such as gross national product, population, and area. Moreover, the transmission pattern of pathogens has changed due to climate change. In this case, we need to examine the cause-effect relationships and assess the impact of the climate conditions on the epidemic by predicting distribution patterns to cope with the risks arising from factors related to environmental geography, which is crucial to understanding and predicting the rise and spread of diseases. We also examine if GDP and the political regime are associated with the confirmed cases. Therefore, this study investigates the factors affecting COVID-19 infection among the first 175 countries with the highest number of infected people. This paper aims to test the relationship between geographic and economic factors and the country's regime with the number of COVID-19 cases.

Manuscript received March 1, 2022; revised April 19, 2022; accepted July 23, 2022.

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doi: 10.18178/ijssh.2023.13.2.1125

II. Literature Review

Geography can be broadly divided into human geography and physical geography. Physical geography is a field that focuses on studying geography related to earth sciences to understand the nature and problems of the lithosphere, hydrosphere, atmosphere, and biosphere. Human geography is a field that focuses on studying the forms and processes of human society, which contains human, social, economic, political, and cultural. Geography is highly interdisciplinary since place and space affect various things (e.g., economics, health, climate, flora, and fauna). The geographic methodology's nature is based on an interest in the affinity of physical and human phenomena and the resulting spatial patterns [10]. The differences between these study methods lead to the merging of physical and human geography, namely environmental geography. In this case, environmental geography is the branch of geography that describes the facts and interprets nature from the interaction between the individual or human society and the natural environment [11], becoming more apparent as the relationship between humans and environmental changes resulting from globalization and technological change. Since environmental geography helps to take the environment into account in terms of its relationship with people, it can be the topic of analyzing different social science and humanities perspectives and using them to understand the processes between humans and the environment [12]. Also, the relationship between humans and the environment is often ambiguous, making environmental geography an essential analytical tool for assessing the human impact on the environment by measuring the effects of human activity on the landforms and cycles of nature [13]. Studies related to environmental geography include environmental resource management, sustainability, emergency management, and political ecology.

The pandemic leading to the global health crisis has been geographically intertwined with geographic, social, economic, and political crises that intensify the current inequality and unjustifiably affect society's most vulnerable groups [14, 15], leading to the urgent demand for geographers and other parties to investigate its impact critically. So that an examination of the pattern of the epidemic and its relationship to geographical factors related to the nature of the outbreak, such as heat, humidity, wind speed, population density, and relevant social elements, such as the total economic value generated in the country and the political regime, can help decision-makers formulate adequate safeguards. Also, these analyses help to understand outbreaks' nature, size, and severity to plan public health-related prevention and management actions. The simplified categories can be distinguished to investigate factors that influence COVID-19 infection as follows:

A. Environmental Conditions

Many processes and organisms are associated with the spread of infectious diseases, especially those influenced by environmental instability, the predominant culprits being temperature, precipitation, and humidity, which are part of climate variability. If regional climate change has already occurred, it is expected to cause disease patterns to shift over a large area, for example, warming from climate change spreading across geographic areas both by height and along latitudes, making pathogens more viable to spread [16]. Although these contagious diseases can occur due to many factors, environmental factors are categorized as the top determinants of coronavirus disease [17-20] as the temperature, wind speed, and humidity are important climatic conditions in the spread of SARS [21]. Climate factors can also influence human and social behavior, leading to infectious diseases, for example, staying more at home with others during cold weather [22]. Therefore, even a slight climate change can immediately impact human health. Temperature is associated with living, where temperature plays a vital role in epidemic control [23]. Literature on the spread of COVID-19 in the affected countries found that low temperatures are beneficial for higher transmission of the coronavirus [24, 25]. Some respiratory conditions, such as the SARS virus in Hong Kong in 2003, also depend on temperature and humidity [26]. Low temperature and low humidity facilitate the transmission of the virus in the community as SARS CoV maintains its infectivity for up to 2 weeks. Other environmental factors such as wind speed, daily sunlight, and atmospheric pressure have been associated with the spread of SARS [5]. From the study of the effects of humidity on the spread of the COVID-19 virus, it was found that humidity had an impact on the spread of the coronavirus [27], consistent with another study in which a warm climate and high humidity seem to reduce the spread of the COVID-19 virus [19]. In other words, cold and dry conditions are factors that may affect the transmission of the virus.

B. Topographic Conditions

Islands are characterized by their lack of physical connectivity to the mainland; these territories face many challenges due to persistent conditions, especially those related to the health of their citizens. However, several studies have shown that island nations can deal with coronavirus very well in the early stages of the COVID-19 outbreak, which can be seen as very low infection and death rates compared to other countries [28]. One of the reasons is strict border policies that include shutting down the country entirely or forcing travelers to stay in hotels for extended periods to ensure the virus does not spread to the country's population [29]. Therefore, closing borders is a very effective priority policy adopted by island nations when the epidemic arrives, such as Australia, New Zealand, Singapore, and some Pacific island nations [30-32]. For example, when India faced the second wave of outbreaks, Australia had the strictest immigration policy as the state forbids the citizens from returning to the country. Once the virus has spread to the public, there is a thorough follow-up process for those at risk to stop the infection from spreading further. Singapore is another excellent example of how a country can manage when a new outbreak cluster is found. Implementing this early control policy provides a shield for the local population and brings them back to a near-normal situation that allows them to begin to ease lockdown measures [33]. However, literature also reported the negative effect of being islands towards the decease transmissions. In the case of the Pacific Islands, the continued influx of travelers was a critical factor in the domestic spread, with correlation analyzes showing that connectivity was positively correlated with disease transmission rates [34]. In this case, the island geography helps support the effective implementation of such policies.

C. Economic Factors

The impact of the COVID-19 pandemic has contributed to global GDP growth, which saw a global recession at its lowest level since the end of World War II. The global economy shrinks by 3.5 percent in 2020, according to the World Economic Outlook Report for April 2021 published by the IMF. It said the global economy would lose 7 percent from a previously projected 3.4 percent growth compared to October 2019, and almost every country around the world has seen negative growth and a marked recession [35, 36]. The gross domestic product in countries is one of the economic indexes measuring how people live in a country. Most literature pointed out the impact of the coronavirus on the economy, but on the other hand, research on the impact of the economic index on the outbreak is undersized. The issue is interesting because developed countries or their well-being are speculated to make people more prepared to deal with the spread of COVID-19. Most people are alert and try to build immunity in themselves or those around them. Economic developments and public health interventions are expected to be the main drivers of the global incidence of these vector-borne diseases over the past decade, as infection relies on several factors (e.g., the wealth of a country and the quality of the healthcare system). However, several studies reveal that trade growth can significantly increase influenza [37] and the spread of HIV [38], viruses transmit faster during a flourishing economy [37], and increases in employment are involved in a rising incidence of influenza [39].

D. Political Factors

When society is under a problem situation that severely impacts the people in the broader society, the damage caused by such problems is beyond the ability of ordinary individuals to manage. Therefore, state power is more significant due to the violence and damage caused by such a situation. Crisis management is a situation that challenges the government or those in state power to have the ability to respond or have a way to manage a crisis so that it can be controlled and appropriately reduce the impact or damage to society. The measures taken to deal with the COVID-19 pandemic and their impact will vary from country to country. It depends on the political regime and its ability to respond to events. The government's reaction to the pandemic has changed how public health systems deal with the situation. For example, the complete disappearance or further demolition of the welfare state due to neoliberal restructuring has had an unfair effect on those who suffer from class, racial, ethnic, and gender inequalities [40], which may be reflected in the right of access to medical care leading to death. In this case, the country's political determinism is an essential factor, reflecting the country's health promotion and financial and administrative power to manage sanitation, as well as promoting actions that prevent the deaths of citizens. As the state can enforce various laws to benefit national health, good politics will create opportunities for people to access the health care system. The political condition has led to different actions, resulting in different infection and death rates [41].

Besides the factors mentioned above, population density can also influence infection numbers as density measures population per unit area. In the case of high densities, it may be a risk factor for outbreaks as well as causing difficulty in controlling the outbreak. A study examining the relationship between urban density and the number of epidemic infections, comparing each city in the United States, found that large numbers of influenza transmissions were seen in densely populated urban areas in the same direction [17]. However, several studies have not found a correlation between density and transmission rates. For example, the hospitalization, infections, and mortality related to COVID-19 investigation reported that the evidence to support that population density plays a significant role in the transmission of COVID-19 in high-density cities of the Netherlands was not found [42], which was in line with the study of [43].

To investigate the impact of the factors mentioned above on the confirmed COVID-19 cases, the hypotheses are framed as follows:

H1: A country's average temperature negatively impacts the number of confirmed cases of COVID-19.

H2: A country's GDP positively impacts the number of confirmed cases of COVID-19.

H3: Island condition of a country negatively impacts the number of confirmed cases of COVID-19.

III. Research Methodology

A. Data and Variables

We retrieved secondary data as of November 6, 2020, related to temperature, population density, moisture, an island, GDP of each country, political regime, and the total number of COVID-19 cases as per the WHO Situation Report in 2020 (World Health Organization, 2020).

Among the countries with the most cases of COVID-19, 175 countries as of November 6, 2020 are: Indonesia, Pakistan, Nigeria, Bangladesh, Mexico, Japan, Philippines, Ethiopia, Egypt, Vietnam, Iran, DR Congo, Thailand, South Africa, Myanmar, Myanmar, South Korea, Kenya, Algeria, Ukraine, Sudan, South Sudan, Iraq, Ukanda, Poland, Canada, Morocco, Malaysia, Saudi Arabia, Uzbekistan, Peru, Venezuela, Afghanistan, Angola, Ghana, Nepal, Yemen, Mozambique, Madagascar, Austria, Australia, Ivory Coast, Cameroon, Taiwan, Niger, Sri Lanka, Burkina Faso, Romania, Mali, Syria, Kazakhstan, Malawi, Ecuador, Chile, Netherlands, Guatemala, Zambia, Cambodia, Senegal, Chad, Somalia, Zimbabwe, Rwanda, Guinea, Tunisia, Belgium, Benin, Bolivia, Cuba, Haiti, Jordan, Greece, Burundi, Czech Republic , Protugal, Dominican Republic, Dominica, Sweden, Azerbaijan, Hungary, United Arab Emirates, Belarus, Israel, Honduras, Tajikistan, Switzerland, Papua New Guinea, Sierra Leone, Togo, Paraguay, Bulgaria, Serbia, Laos, El Salvador, Libya, Nicaragua, Kyrgyzstan, Lebanon, Denmark, Singapore, Finland, Slovakia, Congo, Norway, Eritrea, New Zealand, Costa Rica, Ireland, Central African Republic, Oman, Liberia, Kuwait, Panama, Croatia, Mauritania, Georgia, Moldova, Bosnia and Herzegovina, Mongolia, Uruguay, Armenia, Albania, Lithuania, Jamaica, Qatar, Namibia, Botswana, Lesotho, Gambia, North Macedonia, Gabon, Slovenia, Latvia, Palestine, Kosovo, Guinea-Bissau, Bahrain, Trinidad and Tobago, Estonia, Mauritius, Equatorial Guinea, Timor-Leste, Eswatini, Djibouti, Fiji, Cyprus, Bhutan, Comoros, Guyana, Solomon

Islands, Montenegro, Luxembourg, Suriname, Cape Verde, Malta, Brunei, Belize, Bahamas, Muldives, Iceland, Vanuatu, Barbados, Sao Tome & Principe, Saint Lucia, St. Vincent & Grenadines, Graneda, Seychelles, Antigua and Barbuda, Andorra, Samoa, Marshall Islands, Saint Kitts & Nevis, Monaco, Liechtenstein, San Marino.

With a sample of 175 observations, the variables used in the study are listed as follows;

1) Dependent Variable: Number of people infected with COVID-19 collected from the Department of Disease Control service database.
2) Independent variable:
   - Gross Domestic Product (GDP): GDP is one of the economic indexes measuring how people live in a country.
   - Population Density: The number of biomass per unit area by finding the crude density to find the number of populations per total space.
   - Average temperature: It measures the kinetic energy of particles in matter corresponding to the heating or cooling of that matter.
   - Moisture: The relative humidity consists of wind speed and temperature to measure or alter the weather conditions for some time in that area.
   - Island country: It is a large land connected, or it can be a land area surrounded by water or a small feature that rises above the water surface.
   - Regime: There are five types of government: Parliamentary republic, Presidential republic, Presidential republic with a prime minister, Constitutional monarchy, and other types of regimes.

B. Model Specification

Thus, the model considered in this study can be defined as:

$$cases = \beta_0 + \beta_1 gdp + \beta_2 density + \beta_3 temperature + \beta_4 moisture + \beta_5 island + \beta_6 regime2 + \beta_7 regime3 + \beta_8 regime4 + \beta_9 regime5 + u \quad (1)$$

where *cases* is the number of the confirmed COVID-19 cases, *gdp* is GDP is the gross domestic productivity of a country, *density* is the value reflecting population density of a country, *temperature* is the average temperature of a country, *moisture* is total average relative humidity expressed as a percentage, *island* is the topographic condition where the country is classified as an island, regime1 refers to the country's regime is "parliamentary republic", regime2 refers to the country's regime is "presidential republic", regime3 refers to the country's regime is "presidential republic with a prime minister", regime4 refers to the country's regime is "constitutional monarchy", and regime5 refers to the country's regime is "other types of regimes".

IV. Results

Ordinary Least Squares (OLS) is a common technique for estimating unknown parameters in a linear regression equation. OLS makes certain assumptions about the data, such as linearity, normal distribution of errors, homoscedasticity, no autocorrelation, and no multicollinearity. It is necessary to check the nature of the preliminary data before the analysis by testing whether the variables are consistent with those assumptions. Failure to meet any preliminary assumption, alternative methods to the OLS are to be applied.

A. Assumptions for the OLS Estimator

By examining the data, testing from the variables used in the analysis with the OLS assumptions found that the response variable did not meet the linear equation conditions using the graphical test. The normality assumption needs to be checked using graphical and statistical testing using the Kolmogorov-Smirnov Test to test normal distribution. A histogram shows the confirmed cases of COVID-19 by countries; the graph is skewed to the right, as presented in Fig. 2.

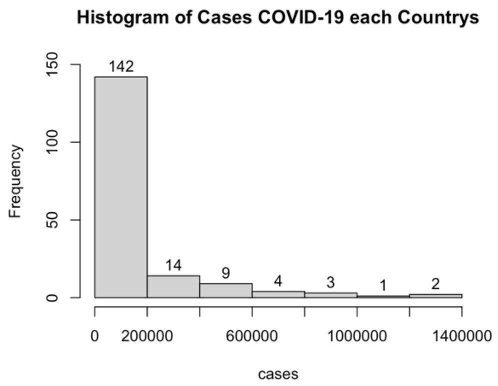

Fig. 2. Histogram of countries with the highest number of cases of COVID-19

The numerical test using the Kolmogorov-Smirnov test shows that the maximal absolute difference D is 0.988 (P-value < 0.001). Therefore, it can be concluded that the variable does not follow a normal distribution in our population and is in line with the results obtained from the Shapiro Wilk Test (W = 0.61104, < 0.001).

The Homoscedasticity test checks whether the error variance is constant by considering the scatter plot and using the Breusch-Pegan Test. From Fig. 3, the data showed that the error variance was constant and corresponded to the test result from Breusch-Pegan Test.

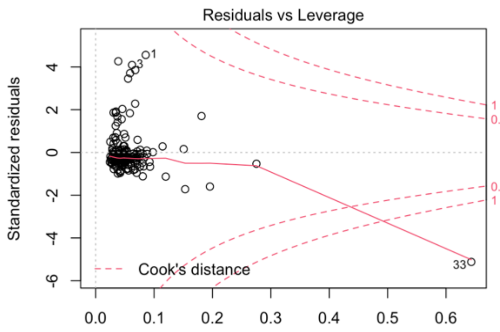

Fig. 3. Scatter Plot for Homoscedasticity test.

The Autocorrelation check, determined by Durbin-Watson statistics, indicated that the problem was not found. Moreover, multicollinearity was examined using Variance Inflation Factor (VIF), and Tolerance (TOL) statistic found no relationship between independent variables, so the Multicollinearity was not found.

From the OLS assumptions checking, this study used non-parametric statistics, in which Spearman's correlation coefficient and quantile regression analysis are appropriate for such data.

B. Hypothesis Testing

Data were subjected to the Spearman Correlation matrix. There is a negative feedback between the temperature and the number of cases ($p < 0.01$). The island condition and confirmed cases of COVID-19 also presented a negative relationship ($p < 0.01$). The GDP per capita reveals that the economic boom catalyzes such a phenomenon ($p < 0.01$). Interestingly, countries with low temperatures present high GDP. The evidence suggests that climate, economic power, and topographic conditions determine the number of confirmed cases in these nations.

In a comparative regression analysis between OLS and quantile at 0.5, the analysis results were obtained with mean coefficients, where the results obtained from the analysis were given median coefficients for quantile regression. The results of OLS and quantile regression share an agreed relationship but also have differences in some factors, as shown in Table I.

TABLE I: OLS AND QUANTILE REGRESSION ANALYSIS (0.5)

Variable	Full Model	
	OLS	Quantile (0.5)
gdp	0.153*** (0.038)	0.224 (0.195)
density	-4.949 (95.199)	9.488 (38.358)
temperature	-4,832.835*** (1,758,130)	-3,482.479*** (1,102.995)
moisture	223.863 (946.213)	-309.961** (132.904)
island	-30,207.360 (42,551.880)	-15,026.080** (6,474.435)
regime 2	12,246.030 (52,167.450)	2,573.337 (13,153.750)
regime 3	-11.663.930 (51,490.63)	805.794 (6,301.409)
regime 4	-63,998.840 (55,171.660)	-4,407.863 (8,327.542)
regime 5	19,664.230 (60,309.130)	-2,594.058 (10,498.920)
Constant	203,565.600** (90,537.390)	130,870.300*** (39,882.200)
Observations	175	175
R Square	0.172	
Adjusted R Square	0.127	
F Statistic	3.812***	

Note: * *P*-value < 0.1, ** *P*-value < 0.05, *** *P*-value < 0.01

There is sufficient evidence to conclude that temperature and confirmed cases of COVID-19 are significantly correlated, as confirmed by both OLS and quantile regression analysis. GDP factor facilitated the confirmation of more cases of COVID-19 from OLS analysis, while such a relationship was not found in the median regression model. It could be implied that people have more activities and frequent contact with people in a strong economy. Another possible reason is more infection testing when people can acquire these tests during the flourishing economy, leading to more numerous confirmed cases. Moreover, the significant contamination in countries with high GDP is caused by economic activities. The quantile results also reveal that moisture and island condition are the plausible factors of the confirmed cases.

TABLE II: QUANTILE REGRESSION ANALYSIS

Variable	Q (0.10)	Q (0.25)	Q (0.50)	Q (0.75)	Q (0.90)
gdp	0.02* (0.01)	0.03 (0.02)	0.22 (0.19)	0.66** (0.29)	1.41*** (0.54)
density	-6.25 (4.53)	18.17* (9.50)	9.48 (38.35)	54.10 (66.82)	-51.553 (280.29)
temperature	-24.374 (121.108)	-609.58 (446.15)	-3,482.47*** (1,102.99)	-7,440.05*** (1,927.84)	-10,164.76*** (2,687.99)
moisture	-46.05 (34.58)	-101.73* (57.55)	-309.96** (132.904)	-669.93** (311.02)	-1,237.20 (1,342.19)
island	-3,603.97** (1,752.44)	-8,655.25*** (2,708.085)	-15,026.08** (6,474.43)	-2,506.93 (16,587.53)	-3,164.94 (55,003.06)
regime 2	-1,232.01 (2,206.67)	-648.73 (8,011.75)	2,573.33 (13,153.75)	13,908.03 (22,330.64)	-14,880.22 (80,312.43)
regime 3	-1,467,75 (3,112.88)	-4,767.15 (8,285.35)	805.79 (6,301.40)	-4,897.57 (20,518.69)	-9,585.53 (90,935.54)
regime 4	-2,528.75 (2,349.82)	-2,397.79 (7,771.96)	-4,407.86 (8,327.54)	-30,991.91 (18,911.99)	-12,760.64 (116,068.70)
regime 5	-4,253.10 (8,677.57)	-9,155.82 (9,114.79)	-2,594.05 (10,498.92)	-13,289.01 (36,073.87)	8,771.26 (279,903.700)
Constant	8,307.09* (5,007.16)	35,560.86** (17,086.12)	130,870.30*** (39,882.20)	275,858.60*** (72,401.78)	414,241.60*** (135,351.50)
Observations	175	175	175	175	175

Note: * *P*-value < 0.1, ** *P*-value < 0.05, *** *P*-value < 0.01

In quantile regression analysis further demonstrated the confirmed relationship in line with the OLS and QR comparison table (i.e., temperature, gross domestic product, moisture, and island condition). It showed factors that statistically impact the confirmed cases on different quantiles. These impacts are not constant across the response variables spectrum. Our quantile estimates indicated that the population density and the political regime do not significantly influence the confirmed COVID-19 cases, as shown in Table II. Temperature and moisture conditions are significant determinants in the medium to high-cases category. A country's GDP positively and significantly impacts the confirmed cases for the high cases quantile. Being island countries possibly reduced the confirmed cases at the low to medium cases quantile. The empirical results can help the government authorities in shaping pandemic control policies and medical strategies.

V. DISCUSSION AND CONCLUSIONS

The regression coefficients can be used to examine the impacts of environmental and economic factors on the confirmed COVID-19 cases. The quantile regression results show that temperature and moisture factors statistically impact infection following the literature [24, 25]. Besides, the benefits of being island may be prominent according to the number of cases [19]. According to the economic factor, GDP positively impacts the confirmed cases, in line with the previous study [37] that an economic boom accelerates the transmission of the virus. Nevertheless, the other factors, which are a country’s population density and regime, are not statistically significant, indicating that those factors do not significantly explain changes in the confirmed cases.

COVID-19 has become another testament for leaders with the decisions that will determine future change. It is also a guideline for the authorities to perform various related tasks, such as creating awareness about the disease, setting guidelines for health professionals, targeting at-risk groups for infection to limit the movement of the population, and allocating medical equipment. These decisions directly influence the number of people infected, survived, and deceased, whether right or wrong. Therefore, decision-makers must act swiftly, decisively, and accurately to save people's lives. One of the key elements for optimal decision support in these missions is the availability and accuracy of information to understand the factors and causes of problems. In the case of COVID-19, understanding the nature of people's movement, patterns of transmission of the virus, and the resilience of people and systems to respond to this malignant pathogen are essential for decision-makers to take appropriate measures to deal with such problems.

The additional problem is that vector-borne disease factors, such as climate change, may affect and interact with each other. Thus, the effect of one factor may be mediated through a process that binds to the other driver, causing it hard to differentiate the effects of the factor. Interpretation of results from the global aggregate model must also consider local conditions, such as control measures, health services, and source of pathogens. Moreover, model results should be carefully examined until they are reasonably reliable with historical data, requiring much more extensive detail to be incorporated into the model. Despite its limitations, mathematical modeling is a viable method for studying the impact of climate on carrier-borne diseases. It also points to the interplay between climate change, activities and movements of pathogenic populations, and the movement of human disease.

Our results open an exciting new avenue of study focused on geospatial data. With today's technological advancements, it is possible to quickly collect, analyze, synthesize and report on the information needed to make decisions. In addition to showing the quantity, the geospatial data or information accompanying the location data can also clearly tell the concentration or density in each area, for example, a map of the countries where infected people have accumulated. Geographic data can reflect more than one aspect of an area, such as how people in each area affect epidemics and climate contributing factors, which creates multidimensional understanding. The risk area analysis is a precautionary measure because it is often easier to prevent infection from entering an area than monitoring everyone and letting officials know areas that need urgent precautions. In this case, smartphones are another advancement in current technology that is helping decision-makers understand the movement patterns of people. As smartphones constantly record their location from one point to another, it becomes a movement path. When multiple paths come together, it forms a pattern of trends in the movement of people over time, which is essential for tracking and analyzing risk areas for new outbreaks. For future research, several geographic and demographic variables, such as educational quality, poverty, ethnicity, and immigration, on the infection of the people should be taken into further consideration to explain better the increase or decrease in the level of baseline infection in each country.

Conflict of Interest

The authors declare that we have no conflict of interest.

Author Contributions

Boontarika Paphawasit conducted the research, analyzed the data, and wrote the paper; Chayanut Phantharot analyzed and visualized the results; Teewara Suwan commented and revised the paper; all authors had approved the final version.

Acknowledgment

The first author would like to express special thanks to Sittichai Sansrichai, my IS student, for working hard on this research.

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