The effect of population mobility on economy during the Coronavirus pandemic: Evidences of stock index movements

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ABSTRACT

During the COVID-19 pandemic, government restrictions caused substantial shifts in travel patterns and population movement. This research examines the relationship between travel behavior and stock market responses across 11 countries, by observing the impact of population mobility on stock market returns and volatility. The Google Community Mobility Index is used to gauge the population mobility to 6 destinations. The daily data are observed during the February 2020 – October 2022. The research finds a noteworthy impact of travel intensity on stock market volatility. Specifically, the results clearly indicate that the level of population mobility has significantly affected the stock market volatility at the industry level. These findings help investors in the stock market minimize the risks of asset allocation, particularly during the period of market uncertainty.

Keywords: Google Community Mobility Index, Stock markets, COVID-19

1. Introduction

The outbreak of the novel coronavirus disease 2019 or COVID-19, which began in early 2020, has severely impacted global populations. The World Health Organization (WHO) reported that as of March 2024, there were more than 774 million confirmed cases worldwide and over 7 million deaths. In Thailand, there were more than 4.8 million confirmed cases and over 34,000 deaths. Statista revealed that the Global Gross Domestic Product (Global GDP) in 2020 decreased by 3.40% compared to 2019, with unemployment rates increasing by 6.18%.[1] Additionally, COVID-19 has affected the stock market, with the Dow Jones Index plummeting by over 12% on March 12, 2020, marking one of the most severe declines since Black Monday in 1987 when the index fell by more than 22%. On March 9 and 12, 2020, these dates ranked among the top 15 highest single-day declines in Dow Jones history, reflecting investor concerns and the pandemic's financial impact.

The severity of the pandemic has caused people to change their behavior by reducing travel, maintaining social distance to minimize contact, and adhering to government control measures that prioritize travel restrictions. This new way of life with reduced travel has had economic repercussions at all levels because travel contributes significantly to spending. When people reduce travel, economic activities as well as the number of foreign tourists decline accordingly.

This research examines the relationship between population mobility and changes in the stock market, using time-series analysis techniques. Daily data from Thailand and from the top 10 countries with the highest confirmed COVID-19 cases are examined.[2] The study reports on the spread of COVID-19 and population mobility levels, sourced from Google's Community Mobility Reports between 2020 and 2022.

2. Literature Review

The novel coronavirus infection, COVID-19, spreads through direct contact with infected individuals or by touching contaminated surfaces and then transferring the virus to the body through the nose, mouth, or eyes. The World Health Organization (WHO) states that the virus spreads more easily in enclosed spaces and densely populated areas, thereby increasing the risk of infection during travel due to greater opportunities for contact with infected individuals.[3] Consequently, countries worldwide have implemented epidemic control measures, including border closures, restrictions on leaving homes, domestic travel limitations, and social distancing. Numerous previous studies, such as Wilson (1995), highlight the relationship

[1] Statista Research Department, 2022, Impact of the coronavirus pandemic on the global economy - Statistics & Facts, Retrieved form https://www.statista.com/topics/6139/covid-19-impact-on-the-global-economy/#dossierKeyfigures.

[2] The highest confirmed COVID-19 cases as of October 15, 2022 includes the United States, India, France, Brazil, Germany, South Korea, United Kingdom, Italy, Japan, and Russia.

[3] World Health Organization (WHO), 2022, Coronavirus disease (COVID-19): How is it transmitted?, Retrieved form https://www.who.int/news-room/questions-and-answers/item/coronavirus-disease-covid-19-how-is-it-transmitted.

between travel and the historical spread of infectious diseases. Technological advancements have increased travel volume and frequency, making remote areas more accessible, thereby facilitating the transmission of pathogens among humans, animals, plants, and objects. Mangili and Gendreau (2005) and Findlater and Bogoch (2018) suggest that air travel increases the risk of disease transmission, especially for respiratory infections like the severe acute respiratory syndrome (SARS) outbreak in 2002, where air travel acted as a catalyst for global spread and potentially future pandemics. Ostroff and Kozarsky (1998) estimated that one can travel anywhere in the world within 36 hours, a critical window for the rapid spread of infectious diseases.

A public health study utilizing travel data of the population during the COVID-19 pandemic by Yilmazkuday (2021) used Google mobility data from 130 countries between February and May 2020. The study found that if the public reduced their visits to transportation stations by 1% per week, the number of confirmed cases would decrease by 25 cases per week, and COVID-19 related deaths would decrease by three cases per week. Additionally, it was found that if the public reduced going to work by 1% per week, the number of confirmed cases would decrease by 18 cases per week, and COVID-19 related deaths would decrease by two cases per week.

Cot *et al.* (2021) studied the first wave of COVID-19 outbreaks in Europe and the United States using travel data from Google and Apple. They found that infection rates decreased within two to five weeks after the public reduced their travel. Infection rates in Europe and the United States decreased by 20-40% and 30-70% respectively when social distancing was implemented. Next, Nouvellet *et al.* (2021) studied the travel patterns of people in 52 countries and found that in 73% of these countries, the number of confirmed cases varied with the level of travel. However, when travel restrictions were relaxed, no relationship was found between the level of travel and the level of outbreaks in 80% of the countries studied. The results also confirmed that in countries where the relationship was significant both before and after relaxing travel restrictions, the rate of outbreaks continued to decrease even after the measures were relaxed, indicating a permanent change in public behavior. Moreover, Noland (2021) reported that in the United States, stay-at-home measures were effective in controlling the disease. The reproduction rate would be greater than one when travel restrictions to retail stores, transportation stations, and workplaces were relaxed. However, the level of activity at parks, markets, and pharmacies had a low impact on the outbreak.

For the study on the relationship between travel levels and economic impact, Spelta and Pagnottoni (2021) used data from the first two waves of the COVID-19 outbreak in Europe. They found that travel restrictions had a negative impact on industrial production. This study confirmed the findings of Bravo and Jooste (2020), who used travel data from Latin American and Caribbean countries. Gimbrone *et al.* (2021) confirmed that reduced travel was an economic pressure factor for the people of the United States. Additionally, they found that travel restrictions were associated with mental health issues and suicides during the COVID-19 outbreak. Renaud

(2020) reported that reduced travel impacted the income and future of the cruise ship business. Narayan *et al.* (2021) presented a study on G7 countries, finding that travel restrictions had a positive impact on their stock markets. Similarly, Bouri *et al.* (2022) found a positive response in industrial indices on the New Zealand stock market, except for the technology, health, and real estate sectors.

3. Data and Methodology

3.1 Data

To answer the research question of whether the level of public travel affects changes in stock market indices, this study uses daily data from Google's Community Mobility Reports. These reports show travel trends of the population, categorized by area and type of activity, including retail and recreation, groceries and pharmacies, parks, transit stations, workplaces, and residential areas, from February 17, 2020, to October 15, 2022. The data is collected by Google from users in 132 countries who have enabled Location History on their devices. Google provides statistics on population changes in each location by comparing them to normal levels, calculated from the average number of people in those locations on the same day in the past (Baseline Day). Positive values indicate more people traveled to that location than usual, while negative values indicate fewer people traveled to that location than usual. Google ensures user anonymity and does not report statistics if the sample size is too small to limit data inaccuracies. Even though, there are many databases providing travel information including Facebook, Apple, and Twitter, Google's database has several advantages, such as the largest number of device users, the longest range of data, and being a publicly accessible source available for free at all times

The stock market index data of 11 countries, including Thailand and the top 10 countries with the highest number of confirmed COVID-19 cases as of October 15, 2022 was collected on a daily basis from February 17, 2020, to October 15, 2022. From the Our World In Data database, the number of confirmed cases, confirmed deaths, and reproduction rate were collected on a daily basis with the same period. The details of the data are shown in Table 1.

Table 1 Data description

Country	Abbreviation	Stock Exchange	Market Index
Brazil	BRA	B3	IBOVESPA
France	FRA	Euronext Paris	CAC 40
South Korea	KOR	Korea Exchange	KOSPI
Germany	GER	Frankfurt Stock Exchange	DAX
India	IND	National Stock Exchange	NIFTY 50
Italy	ITA	Borsa Italiana	FTSE MIB
Japan	JAP	Tokyo Stock Exchange	Nikkei 225
Russia	RUS	Moscow Exchange	MOEX Russia
Thailand	THA	Stock Exchange of Thailand	SET Index
United Kingdom	UK	London Stock Exchange	FTSE 100
United States	USA	Various Exchanges	S&P 500

3.2 Methodology

The study examines the relationship between the level of public travel and changes in the number of confirmed cases, confirmed deaths, and the reproduction rate. Travel destinations are divided into six categories: retail and recreation, groceries and pharmacies, parks, transit stations, workplaces, and residential areas. The study also includes two control variables: the number of confirmed cases and the number of confirmed deaths. Time series analysis is used to analyze, with the following equation;

$$\Delta Cases_t = \alpha_0 + \sum_{i=1}^{6} \beta_i Mobility_{i,t} + \varepsilon_t \quad (1)$$

$$\Delta Deaths_t = \alpha_0 + \sum_{i=1}^{6} \beta_i Mobility_{i,t} + \varepsilon_t \quad (2)$$

$$\Delta Reproduction_t = \alpha_0 + \sum_{i=1}^{6} \beta_i Mobility_{i,t} + \varepsilon_t \quad (3)$$

Where $Mobility_{i,t}$ is the Community Mobility Index to six categories of destinations: retail and recreation, groceries and pharmacies, parks, transit stations, workplaces, and residential areas on day t. $\Delta Cases_t$ is the change in the number of confirmed COVID-19 cases on day t compared to the previous day. $\Delta Deaths_t$ is the change in the number of confirmed COVID-19 deaths on day t compared to the previous day. $\Delta Reproduction_t$ is the change in the COVID-19 reproduction rate on day t compared to the previous day.

The study examines the relationship between the level of public travel and the response of each country's stock market index, considering two main cases separately: the rate of return and the volatility of the stock market index and industry indices, based on the following equations.

$$Return_t = \alpha_0 + \sum_{i=1}^{6} \beta_i Mobility_{i,t} + \beta_7 Return_{m,t} + \varepsilon_t \quad (4)$$

$$Volatility_t = \alpha_0 + \sum_{i=1}^{6} \beta_i Mobility_{i,t} + \beta_7 Volatility_{m,t} + \varepsilon_t \quad (5)$$

where $Return_t$ is the daily return of the MSCI World Index on day t. $Volatility_t$ is the volatility of the stock market index, calculated from the change from the lowest to the highest index on day t. $Volatility_{m,t}$ is the volatility of the MSCI World Index, calculated from the change from the lowest to the highest index on day t.

4. Empirical Results

Table 2 shows the relationship between the level of travel to six destinations and COVID-19 outbreak statistics. Panel A presents the number of confirmed COVID-19 cases, with the Adjusted R-squared values ranging from 0.0669 (Germany) to 0.4750 (United States). The relationship between the level of travel to six destinations and the number of confirmed COVID-19 cases is mostly statistically significant, particularly for travel to workplaces and parks, where the relationship is consistent across all countries. In other words, increased travel levels are associated with an increase in the number of confirmed COVID-19 cases. However, for retail

and recreation, groceries and pharmacies, transit stations, and residential areas, the relationship is less clear. In some countries, increased travel to these places is associated with a decrease in the number of confirmed cases. This inconsistency may be due to the travel data covering the entire outbreak period, including both the initial severe outbreak phase, when there was a lack of knowledge, tools, and policies to control the spread, and the later phase, when countries were better prepared to handle the transmission.

Panel B shows the relationship between the level of travel to six destinations and the number of confirmed COVID-19 deaths. The Adjusted R-squared values range from 0.0075 (Thailand) to 0.4838 (United States), which is a wider range than in Panel A. Two countries (Germany and Thailand) did not show any relationship in all cases. However, the overall results are consistent with Panel A, indicating that the level of travel to workplaces and parks is associated with an increase in the number of confirmed COVID-19 deaths. For travel to retail and recreation, groceries and pharmacies, transit stations, and residential areas, relationships were found in both directions, but the negative relationships were fewer, suggesting that increased travel levels are generally associated with higher numbers of confirmed COVID-19 deaths.

Panel C shows the relationship between the level of travel to six destinations and the COVID-19 reproduction rate. The Adjusted R-squared values range from 0.0030 (United Kingdom) to 0.1484 (Russia), which are lower than those in Panel A and Panel B, reflecting the reduced ability of the model to explain the data compared to Panels A and B. Furthermore, the study found that the relationship between the level of travel to the six destinations and the COVID-19 reproduction rate is uncertain. Specifically, all six destinations showed relationships in both directions, meaning that increased travel levels are associated with an increase in the COVID-19 reproduction rate, while in some countries, the relationship was in the opposite direction.

Table 2 The effect of community mobility on COVID-19

Note: This table demonstrates the associations between the Community mobility and COVID-19 statistics by using following equations $\Delta Cases_t = \alpha_0 + \sum_{i=1}^{6} \beta_i Mobility_{i,t} + \varepsilon_t$, $\Delta Deaths_t = \alpha_0 + \sum_{i=1}^{6} \beta_i Mobility_{i,t} + \varepsilon_t$, $\Delta Reproduction_t = \alpha_0 + \sum_{i=1}^{6} \beta_i Mobility_{i,t} + \varepsilon_t$ where $Mobility_{i,t}$ is the six destinations of Google Community Mobility Report on day t, $Cases_t$ is a COVID-19 total confirmed cases on day t, $Deaths_t$ is a COVID-19 total confirmed deaths on day t, and $Reproduction_t$ is a COVID-19 reproduction rate on day t.

Panel A: Confirmed cases

	BRA	FRA	KOR	GER	IND	ITA	JAP	RUS	THA	UK	USA
Intercept	-0.0196*	0.0423***	-0.0072	0.0160**	0.0618***	0.0553***	0.0029	-0.0008	0.0063*	0.1511***	0.1403***
	(-1.9178)	(6.1180)	(-1.2794)	(2.4624)	(8.1013)	(7.1986)	(0.9898)	(-0.1406)	(1.6931)	(16.9043)	(11.8861)
Retail and recreation	-0.0011**	0.0013***	-0.0004*	0.0002	0.0012***	0.0027***	0.0010***	-0.0001	-0.0010***	0.0009***	-0.0065***
	(-2.3710)	(4.2871)	(-1.7431)	(1.1138)	(4.4441)	(7.3551)	(3.5806)	(-0.2213)	(-2.6025)	(3.5641)	(-10.8067)
Grocery and pharmacy	0.0001	-0.0007***	0.0002	-0.0002*	-0.0008***	-0.0016***	-0.0003	0.0015***	0.0001	-0.0008***	0.0060***
	(0.2603)	(-3.2423)	(0.7187)	(-1.7469)	(-4.9898)	(-7.7847)	(-1.3406)	(4.1603)	(0.0328)	(-3.1319)	(12.6159)
Residential	0.0024**	0.0053***	0.0032***	0.0019	-0.0016***	0.0099***	0.0042***	0.0023***	-0.0012**	0.0203***	0.0157***
	(2.1175)	(4.5016)	(3.9756)	(1.4196)	(-3.0922)	(8.2446)	(5.1318)	(3.2628)	(-2.2033)	(14.3132)	(9.5732)
Transit stations	-0.0006	-0.0002	-0.0007***	-0.0003	-0.0028***	0.0002	-0.0011***	-0.0024***	-0.0004*	0.0049***	0.0053***
	(-1.1822)	(-0.6415)	(-2.6461)	(-1.1430)	(-6.9996)	(0.5609)	(-3.3925)	(-7.9338)	(-1.6708)	(11.5346)	(7.7979)
Parks	0.0006***	-0.0001	0.0001	-0.0001	0.0009***	0.0001	0.0006***	0.0001***	0.0003	-0.0001	0.0001
	(3.5741)	(-1.0114)	(1.1299)	(-1.4375)	(6.1502)	(0.2051)	(7.2303)	(2.6555)	(1.4356)	(-0.0654)	(1.2954)
Workplaces	0.0003	0.0013***	0.0008**	0.0006**	0.0004**	0.0022***	0.0021***	0.0006***	0.0003	0.0041***	0.0058***
	(1.3509)	(3.6044)	(2.4256)	(1.9638)	(2.3633)	(6.0216)	(7.2879)	(2.9767)	(1.3780)	(10.1309)	(11.0490)
Adjusted R^2	0.3189	0.0843	0.1507	0.0669	0.4403	0.1731	0.1303	0.4134	0.1026	0.1511	0.4750

Panel B: Confirmed deaths

	BRA	FRA	KOR	GER	IND	ITA	JAP	RUS	THA	UK	USA
Intercept	0.0169	0.0362***	-0.0110*	-0.0156	0.0925***	0.0592***	0.0043	0.0074	0.0213	0.1717***	0.0972***
	(0.5672)	(3.7605)	(-1.7490)	(-1.4800)	(6.9847)	(5.9731)	(0.8047)	(0.4221)	(0.8358)	(14.3719)	(8.8844)
Retail and recreation	-0.0014	0.0016***	-0.0007**	-0.0002	0.0021***	0.0031***	0.0008	0.0005	-0.0028	0.0006*	-0.0074***
	(-1.1018)	(3.6690)	(-2.4320)	(-0.5911)	(4.6593)	(6.5089)	(1.5483)	(0.4446)	(-1.0577)	(1.8392)	(-13.2688)
Grocery and pharmacy	-0.0006	-0.0009***	-0.0001	-0.0001	-0.0013***	-0.0019***	-0.0005	0.0022*	0.0003	-0.0003	0.0054***
	(-0.8485)	(-2.9947)	(-0.1926)	(-0.2998)	(-4.3637)	(-7.3231)	(-1.1433)	(1.9424)	(0.2339)	(-0.7730)	(12.3144)
Residential	-0.0010	0.0110***	0.0038***	0.0033	-0.0024***	0.0114***	0.0046***	0.0033	-0.0016	0.0246***	0.0109***
	(-0.3150)	(6.7106)	(4.2725)	(1.5073)	(-2.7036)	(7.3814)	(3.0447)	(1.5343)	(-0.4314)	(12.9785)	(7.1325)
Transit stations	-0.0013	0.0004	-0.0004	-0.0006	-0.0040***	0.0001	-0.0009	-0.0037***	0.0006	0.0062***	0.0051***
	(-0.8965)	(0.7833)	(-1.3567)	(-1.3467)	(-5.6964)	(0.1864)	(-1.5282)	(-4.0196)	(0.3543)	(10.9194)	(8.1821)
Parks	0.0010*	-0.0001	0.0003***	0.0001	0.0012***	0.0001	0.0007***	0.0002	0.0001	0.0001	0.0001
	(1.8889)	(-0.0130)	(2.7546)	(0.6240)	(5.1036)	(0.5912)	(4.6321)	(1.2563)	(0.0512)	(0.1267)	(0.1429)
Workplaces	0.0004	0.0021***	0.0011***	0.0006	0.0003	0.0026***	0.0023***	0.0011*	0.0002	0.0048***	0.0036***
	(0.6953)	(4.1996)	(3.1901)	(1.1757)	(0.9719)	(5.6433)	(4.2249)	(1.7923)	(0.1741)	(8.8700)	(7.3310)
Adjusted R^2	0.0867	0.1341	0.1251	0.0972	0.2824	0.1560	0.0452	0.1056	0.0075	0.1717	0.4838

Panel C: Reproduction rate

	BRA	FRA	KOR	GER	IND	ITA	JAP	RUS	THA	UK	USA
Intercept	0.0072**	0.0093***	0.0351***	0.0130***	0.0400***	0.0001	0.0277***	0.0176***	0.0099**	0.0030	0.0037
	(2.5275)	(3.4082)	(2.7581)	(3.3171)	(6.3160)	(0.0077)	(4.2148)	(6.6620)	(2.2771)	(0.9246)	(0.7274)
Retail and recreation	0.0004***	0.0003**	0.0014**	0.0002	-0.0005**	-0.0005***	0.0014**	0.0011***	-0.0001	0.0001	0.0015***
	(3.1466)	(2.2255)	(2.5253)	(1.2585)	(-2.0667)	(-2.5953)	(2.2784)	(5.9809)	(-0.1010)	(0.0516)	(5.9440)
Grocery and pharmacy	-0.0001	-0.0001	-0.0005	-0.0001	-0.0005***	0.0003***	-0.0019***	-0.0009***	0.0001	0.0001	-0.0009***
	(-1.1404)	(-0.8518)	(-1.0622)	(-1.0244)	(-3.3104)	(2.6448)	(-3.3313)	(-5.5925)	(0.3678)	(0.5664)	(-4.6209)
Residential	-0.0004	-0.0021***	-0.0039**	-0.0018**	-0.0031***	-0.0043***	0.0016	-0.0003	-0.0011*	-0.0001	0.0006
	(-1.3258)	(-4.4151)	(-2.1228)	(-2.1844)	(-7.2693)	(-6.6404)	(0.8843)	(-1.0339)	(-1.7522)	(-0.2658)	(0.8186)
Transit stations	-0.0003*	-0.0002	0.0011	0.0003	-0.0001	0.0003	0.0008	-0.0002*	0.0002	-0.0001	-0.0001
	(-1.8226)	(-1.4013)	(1.6381)	(1.5278)	(-0.0016)	(1.3348)	(1.0781)	(-1.6783)	(0.7354)	(-0.4104)	(-0.4912)
Parks	-0.0001	-0.0001***	-0.0003	-0.0001***	0.0005***	-0.0002***	0.0002	0.0001	0.0001	0.0001*	0.0001
	(-0.2943)	(-3.6423)	(-1.4226)	(-4.0158)	(4.0704)	(-5.3651)	(1.3296)	(0.8405)	(0.4106)	(1.8664)	(0.0989)
Workplaces	0.0001	-0.0005***	-0.0019***	-0.0007***	-0.0001	-0.0013***	-0.0002	0.0003***	-0.0004	0.0002	-0.0001
	(0.2286)	(-3.1202)	(-2.6345)	(-3.5586)	(-0.6728)	(-6.8409)	-0.3044	(3.0577)	(-1.5465)	(1.1150)	(-0.4254)
Adjusted R^2	0.0755	0.1069	0.0533	0.0513	0.1202	0.1233	0.0525	0.1484	0.0394	0.0030	0.1144

Table 3 shows the relationship between the level of travel to six destinations and stock market returns. Panel A analyzes the returns of the stock market index and finds that the Adjusted R-squared values range from 0.0651 (Russia) to 0.9481 (United States). Overall, the Adjusted R-squared is higher compared to Table 2, indicating better explanatory power of the model for this dataset. The study finds that stock market returns in all 11 countries significantly follow global market trends, as referenced by the MSCI World Index. However, only four countries (France, India, the United Kingdom, and the United States) show a statistically significant relationship between travel levels and stock market returns. Specifically, stock market returns are inversely related to travel levels to retail and recreation locations, workplaces, and parks, suggesting that increased travel to these destinations during the study period negatively impacts overall stock market investment. Conversely, stock market returns are positively related to travel levels to grocery stores and pharmacies, as these locations are crucial in managing COVID-19, thus benefiting the stock market. However, travel to transit stations and residential areas shows unclear relationships.

Panel B analyzes the returns of the industry indices for the top 500 publicly traded companies in the United States and finds that the Adjusted R-squared values are lower than in Panel A, ranging from 0.0468 (Energy) to 0.1007 (Information Technology). Although travel to retail and recreation locations, grocery stores and pharmacies, and parks does not show a relationship across all industries, travel to workplaces, transit stations, and residential areas shows a statistically significant positive relationship in nearly all cases. In particular, travel to workplaces has at least a 95% confidence level across all industries, indicating that travel to work benefits businesses, especially in activities not suited for online work, which represents most industries.

Table 3 The effect of community mobility on market return

Note: This table demonstrates the associations between the Community mobility and stock market return by using following equation $Return_t = \alpha_0 + \sum_{i=1}^{6} \beta_i Mobility_{i,t} + \beta_7 Return_{m,t} + \varepsilon_t$ where $Mobility_{i,t}$ is the six destinations of Google Community Mobility Report on day t, $Return_t$ is a market index (industrial index) daily return on day t, and $Return_{m,t}$ is the MSCI World index daily return on day t.

Panel A: Stock market Index

	BRA	FRA	KOR	GER	IND	ITA	JAP	RUS	THA	UK	USA
Intercept	-0.0040	-0.0032**	0.0048*	-0.0036*	-0.0082**	-0.0006	-0.0014	0.0003	0.0012	-0.0052**	0.0043***
	(-1.0033)	(-2.2002)	(1.8993)	(-1.8125)	(-2.1032)	(-0.2383)	(-0.6963)	(0.0705)	(0.6958)	(-2.1529)	(3.9520)
Retail and recreation	-0.0001	-0.0001**	0.0001	-0.0001	-0.0003**	0.0001	0.0002	0.0004	-0.0003	-0.0001	-0.0001
	(-0.5378)	(-2.0928)	(0.2504)	(-0.4257)	(-1.9751)	(0.4781)	(0.8995)	(1.1059)	(-1.6047)	(-0.6491)	(-0.3404)
Grocery and pharmacy	0.0001	0.0001*	-0.0001	0.0001	0.0001	0.0001	-0.0002	-0.0001	0.0001	0.0001	0.0001
	(0.3772)	(1.8666)	(-0.9808)	(1.5249)	(0.3456)	(0.2310)	(-1.4285)	(-0.3538)	(1.6110)	(0.9171)	(0.2726)
Residential	0.0003	-0.0001	-0.0002	-0.0001	0.0004	0.0004	0.0005	0.0005	-0.0003	-0.0009**	0.0003*
	(0.7812)	(-0.1403)	(-0.6112)	(-0.2222)	(1.5028)	(0.9516)	(0.9929)	(0.9337)	(-1.2485)	(-2.3758)	(1.8256)
Transit stations	0.0001	0.0001	0.0002	-0.0001	0.0004**	-0.0001	-0.0001	-0.0001	0.0001	-0.0002*	0.0001**
	(0.3146)	(0.9604)	(1.4170)	(-1.0017)	(2.1673)	(-0.1879)	(-0.3327)	(-0.0865)	(1.1265)	(-1.7526)	(2.4111)
Parks	0.0001	0.0001	-0.0001	0.0001	-0.0001	0.0001	0.0001	-0.0001	0.0001	-0.0001*	-0.0001
	(0.4125)	(0.3974)	(-1.4250)	(1.0440)	(-1.0578)	(0.7580)	(1.1986)	(-0.0718)	(0.0281)	(-1.8416)	(-0.7501)
Workplaces	0.0001	-0.0001	-0.0002	-0.0001	-0.0001	0.0001	0.0001	-0.0001	-0.0001	-0.0002*	0.0001
	(0.6353)	(-0.5067)	(-1.6342)	(-0.1836)	(-0.8297)	(0.9120)	(0.2925)	(-0.5365)	(-1.1445)	(-1.8779)	(1.5930)
MSCI World	0.8562***	0.8334***	0.3563***	0.8407***	0.4657***	0.8899***	0.3982***	0.5439***	0.2500***	0.6867***	1.1422***
	(19.2694)	(27.6896)	(9.5995)	(26.6455)	(11.0107)	(26.3331)	(10.8783)	(6.5532)	(6.9640)	(25.0916)	(107.9943)
Adjusted R^2	0.3715	0.5372	0.1304	0.5254	0.1744	0.5063	0.1595	0.0651	0.0779	0.5046	0.9481

Panel B: S&P500 industrial index

	Utility	Telecom Services	Real Estate	Materials	IT	Industrials	Health Care	Financials	Energy	Consumer Staples	Consumer Discretionary
Intercept	0.0205***	0.0273***	0.0235***	0.0257***	0.0276***	0.0250***	0.0170***	0.0273***	0.0335***	0.0160***	0.0255***
	(4.1005)	(5.5005)	(4.4315)	(4.9797)	(4.8844)	(4.8957)	(4.2862)	(4.6213)	(4.0250)	(4.4162)	(4.7541)
Retail and recreation	-0.0002	-0.0001	-0.0003	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	0.0006	-0.0001	0.0001
	(-0.6820)	(-0.0623)	(-1.1867)	(-0.1853)	(-0.3267)	(-0.4778)	(-0.6306)	(-0.1859)	(1.4318)	(-0.7377)	(0.3717)
Grocery and pharmacy	0.0002	-0.0002	0.0003	-0.0001	-0.0001	0.0001	0.0001	-0.0001	-0.0003	0.0001	-0.0001
	(0.9600)	(-0.9054)	(1.4691)	(-0.2521)	(-0.3889)	(0.4782)	(0.4720)	(-0.0526)	(-0.9961)	(0.2223)	(-0.3570)
Residential	0.0015**	0.0017**	0.0014*	0.0016**	0.0015*	0.0016**	0.0010*	0.0019**	0.0038***	0.0010*	0.0015**
	(2.1875)	(2.5436)	(1.8654)	(2.2831)	(1.9409)	(2.3089)	(1.8810)	(2.3567)	(3.3052)	(1.9396)	(2.0050)
Transit stations	0.0006**	0.0009***	0.0007**	0.0009***	0.0008**	0.0008***	0.0005**	0.0009***	0.0012**	0.0005**	0.0004
	(2.2353)	(3.0379)	(2.1530)	(2.9072)	(2.3744)	(2.7201)	(2.2072)	(2.8053)	(2.5529)	(2.1826)	(1.4220)
Parks	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	0.0001	-0.0001	-0.0001
	(-0.4497)	(-0.7924)	(-0.4619)	(-0.5163)	(-0.6622)	(-0.7337)	(-0.2657)	(-0.5467)	(0.4051)	(-0.1183)	(-0.3722)
Workplaces	0.0005**	0.0006***	0.0006***	0.0005**	0.0007***	0.0006**	0.0004**	0.0006**	0.0009**	0.0004***	0.0008***
	(2.4629)	(2.6596)	(2.7350)	(2.2976)	(2.6430)	(2.5326)	(2.4802)	(2.1910)	(2.3243)	(2.7023)	(3.4272)
MSCI World	0.2340***	0.3006***	0.2781***	0.2674***	0.4300***	0.2304***	0.2154***	0.3392***	0.3069***	0.2273***	0.2791***
	(4.7766)	(6.1932)	(5.3667)	(5.2928)	(7.7688)	(4.6145)	(5.5385)	(5.8681)	(3.7707)	(6.4243)	(5.3071)
Adjusted R^2	0.0478	0.0801	0.0632	0.0662	0.1007	0.0577	0.0606	0.0664	0.0468	0.0724	0.0724

Table 4 shows the relationship between the level of travel to six destinations and stock market volatility. Panel A examines the impact on stock market indices and finds that the Adjusted R-squared values range from 0.1296 (Russia) to 0.8061 (United States). For all six destinations, most relationships are statistically significant. However, only travel to parks shows a one-directional relationship, where stock market volatility varies with the level of travel to parks. Additionally, only Brazil (negative relationship) and Russia (positive relationship) show one-directional relationships. Overall, travel to shopping malls and entertainment venues, parks, residential areas, and workplaces is associated with higher volatility, while travel to grocery stores and pharmacies is associated with lower volatility. This aligns with the explanation in Table 3 regarding the importance of grocery stores and pharmacies in managing the COVID-19 outbreak, while travel to other destinations increases the risk of a severe outbreak.

Panel B examines the relationship between the level of travel to six destinations and the volatility of industry indices for the top 500 publicly traded companies in the United States. The Adjusted R-squared values range from 0.5749 (Energy) to 0.8627 (Information Technology). Notably, only two destinations—transit stations and residential areas—show bidirectional relationships. Other destinations have unidirectional relationships: shopping malls and entertainment venues (negative relationship), and grocery stores and pharmacies, parks, and workplaces (positive relationship). This directional trend is consistent with the results in Panel A for the United States. However, the relationship directions for shopping malls and entertainment venues, and grocery stores and pharmacies, contradict findings in other countries. This discrepancy may be explained by the fact that travel to shopping malls and entertainment venues reflects a return to economic normalcy in the United States, while travel to grocery stores and pharmacies indicates ongoing concerns about the COVID-19 outbreak.

Table 4 The effect of community mobility on stock market volatility

Note: This table demonstrates the associations between the Community mobility and stock market volatility by using following equation $Volatility_t = \alpha_0 + \sum_{i=1}^{6} \beta_i Mobility_{i,t} + \beta_7 Volatility_{m,t} + \varepsilon_t$ where $Mobility_{i,t}$ is the six destinations of Google Community Mobility Report on day t, $Volatility_t$ is a rate of change between daily high and low of market index (industrial index) on day t, and $Volatility_{m,t}$ is a rate of change between daily high and low of MSCI World index on day t.

Panel A: Stock market Index

	BRA	FRA	KOR	GER	IND	ITA	JAP	RUS	THA	UK	USA
Intercept	0.0139***	0.0093***	0.0097***	0.0059***	0.0199***	0.0033	0.0032***	0.0261***	0.0117***	0.0065***	0.0070***
	(4.3890)	(8.8962)	(6.3974)	(4.3477)	(7.8624)	(1.6063)	(2.9637)	(5.1723)	(11.7460)	(3.3035)	(4.4834)
Retail and recreation	-0.0001	0.0002***	-0.0001	0.0001**	0.0002**	0.0001	0.0002**	0.0001	-0.0002**	0.0001**	-0.0004***
	(-0.9191)	(5.0708)	(-0.5571)	(2.0977)	(1.9817)	(1.3078)	(1.9720)	(0.3344)	(-2.3800)	(2.5147)	(-4.7615)
Grocery and pharmacy	-0.0001*	-0.0001***	-0.0001*	-0.0001***	-0.0002***	-0.0001*	0.0001	-0.0004	-0.0001	-0.0001***	0.0002***
	(-1.7283)	(-3.0763)	(-1.6696)	(-2.9028)	(-3.3503)	(-1.8747)	(0.6018)	(-1.4191)	(-1.5722)	(-2.9464)	(4.1208)
Residential	-0.0001	0.0005***	0.0006***	0.0002	-0.0007***	0.0001	0.0004	0.0022***	-0.0003***	0.0014***	-0.0002
	(-0.3027)	(2.7558)	(2.9254)	(0.5668)	(-4.6167)	(0.0273)	(1.4026)	(3.8456)	(-2.6151)	(5.4235)	(-0.8828)
Transit stations	0.0002	-0.0001***	0.0002***	-0.0001	-0.0004***	-0.0003***	-0.0003***	0.0002	0.0002***	0.0002**	0.0001
	(1.2435)	(-2.7750)	(2.9329)	(-1.4595)	(-3.0959)	(-3.0702)	(-2.6772)	(0.9901)	(2.9942)	(2.2244)	(0.0808)
Parks	-0.0001	0.0001	-0.0001	-0.0001	0.0002***	0.0001	0.0001	0.0001***	-0.0001	0.0001***	0.0001
	(-0.2783)	(0.3869)	(-0.7117)	(-0.0877)	(3.9810)	(1.4796)	(1.4396)	(2.7207)	(-0.6942)	(2.9690)	(1.0112)
Workplaces	-0.0002**	0.0002***	-0.0001	0.0001	-0.0001	0.0002*	0.0003***	0.0008***	-0.0001***	0.0003***	0.0002***
	(-2.5199)	(3.3757)	(-0.9802)	(1.1382)	(-1.0474)	(1.9072)	(3.0568)	(4.6578)	(-2.8689)	(3.5333)	(3.0235)
MSCI World	0.8587***	0.6870***	0.4290***	0.7294***	0.5125***	0.8700***	0.4465***	0.4898***	0.2955***	0.7823***	0.7700***
	(19.1545)	(27.8855)	(14.7128)	(29.6900)	(15.7148)	(24.6975)	(18.6465)	(4.2578)	(12.2207)	(31.2058)	(39.1224)
Adjusted R^2	0.4656	0.5971	0.3583	0.5811	0.4543	0.5497	0.4107	0.1296	0.3764	0.6836	0.8061

Panel B: S&P500 industrial index

	Utility	Telecom Services	Real Estate	Materials	IT	Industrials	Health Care	Financials	Energy	Consumer Staples	Consumer Discretionary
Intercept	0.0086***	0.0091***	0.0078***	0.0076***	0.0040**	0.0068***	0.0075***	0.0067***	0.0189***	0.0075***	0.0137***
	(3.5459)	(4.2114)	(3.1324)	(3.6718)	(2.1833)	(3.4724)	(4.3756)	(2.9839)	(4.1036)	(4.4981)	(5.2774)
Retail and recreation	-0.0008***	-0.0002**	-0.0007***	-0.0003***	0.0001	-0.0002**	-0.0003***	-0.0001	-0.0001	-0.0004***	-0.0005***
	(-6.6080)	(-2.2051)	(-5.3793)	(-2.6238)	(0.1332)	(-2.1903)	(-3.9240)	(-0.6610)	(-0.5779)	(-4.9373)	(-3.7154)
Grocery and pharmacy	0.0006***	0.0001	0.0006***	0.0003***	0.0001	0.0003***	0.0002***	0.0003***	0.0002	0.0004***	0.0002**
	(6.6226)	(0.2986)	(6.2511)	(3.4718)	(0.7509)	(3.4092)	(3.5156)	(3.5473)	(0.9393)	(5.6058)	(2.1574)
Residential	0.0006**	-0.0005*	0.0004	0.0002	-0.0006**	0.0008***	-0.0001	0.0018***	0.0024***	0.0001	-0.0011***
	(2.0509)	(-1.9162)	(1.2891)	(0.8369)	(-2.4114)	(3.2660)	(-0.2074)	(6.4487)	(4.2292)	(0.3225)	(-3.2538)
Transit stations	0.0003**	0.0001	0.0001	-0.0001	-0.0003***	-0.0001	0.0001	0.0002	0.0004*	0.0001	-0.0001
	(2.2862)	(0.2263)	(0.7507)	(-0.6611)	(-2.9867)	(-0.2274)	(0.5182)	(1.4919)	(1.8229)	(0.7381)	(-0.5386)
Parks	0.0001	-0.0001	0.0001	0.0001*	-0.0001	0.0001***	0.0001	0.0001***	0.0001	0.0001	-0.0001
	(1.5651)	(-0.4161)	(1.2865)	(1.7950)	(-0.5083)	(3.5863)	(1.4183)	(2.7426)	(0.2828)	(0.9308)	(-0.2962)
Workplaces	0.0002**	0.0001	0.0003***	0.0002***	0.0001	0.0004***	0.0001*	0.0004***	0.0004**	0.0002***	0.0001
	(2.1826)	(0.1127)	(2.6242)	(2.6881)	(0.8940)	(4.5161)	(1.7069)	(4.5349)	(2.1360)	(2.8558)	(0.9626)
MSCI World	0.6918***	0.9746***	0.7234***	0.7056***	1.2216***	0.7397***	0.6160***	1.1937***	1.2488***	0.5911***	0.7531***
	(22.5009)	(35.5562)	(22.8918)	(26.8935)	(52.2998)	(29.6326)	(28.4016)	(42.1233)	(21.3304)	(27.9465)	(22.9227)
Adjusted R^2	0.6594	0.7547	0.6448	0.6684	0.8627	0.7194	0.6913	0.8309	0.5749	0.7027	0.5925

5. Conclusions

This study examines the relationship between the level of public travel during the COVID-19 outbreak and the stock market responses in 11 countries (the 10 countries with the highest number of confirmed cases worldwide and Thailand). The study uses data from Google's Community Mobility Report, which analyzes travel data from Google users—a search engine on the world's most popular internet database. The data is divided into six destinations: retail and recreation, groceries and pharmacies, parks, transit stations, workplaces, and residential areas. The study found that travel to parks and workplaces is associated with increases in the number of confirmed COVID-19 cases and deaths. However, the impact on the COVID-19 reproduction rate was unclear for all destinations.

Regarding the relationship between public travel levels and stock market index returns, the results were inconclusive, as most outcomes were not statistically significant. In terms of stock market volatility, the relationship was statistically significant in most cases, with only travel to parks showing a clear conclusion: increased travel was associated with higher stock market volatility. Conversely, when examining by industry, more distinct results emerged: industry indices increased when travel to workplaces, transit stations, and residential areas increased. In contrast, industry index volatility varied with travel to groceries and pharmacies, parks, and workplaces but was inversely related to travel to retail and recreation. For this reason, it can be concluded that travel levels are more suitable for consideration at the industry level and are more closely related to volatility than to returns

To further develop this research, the author suggests expanding the study by using industry indices from other countries and incorporating sector-specific indices, which provide deeper-level data. Additionally, other factors could be considered, such as restrictions on inter-city and international travel, school closures, and group gathering bans.

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