Going Viral: A Gravity Model of Infectious Diseases and Tourism Flows

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Abstract

This paper develops an augmented gravity model framework to estimate the impact of infectious diseases on bilateral tourism flows among 38,184 pairs of countries over the period 1995–2017. The results confirm that international tourism is adversely affected by infectious disease risk, and the magnitude of this negative effect is statistically and economically significant. In the case of SARS, for example, a 10% increase in the number of confirmed cases leads, on average, to a reduction of 4.7% in international tourist arrivals. Furthermore, while infectious diseases appear to have a smaller and statistically insignificant negative effect on tourism flows to advanced economies, the magnitude and statistical significance of the impact of infectious diseases are much greater in developing countries, where such diseases tend to be more prevalent and health infrastructure lags behind.

Keywords Infectious diseases · International tourism flows · Gravity model · Panel data

JEL Classification Numbers C21 · C23 · F11 · F14 · F47 · R12 · Z30

1 Introduction

The COVID-19 pandemic has turned into a global crisis in a staggeringly short space of time like no other in modern history. As of April 21, 2021, there are over 143 million confirmed cases of COVID-19 in 190 countries, with more than 3 million deaths.¹ The widespread containment and mitigation measures designed to slow the spread of the

¹The latest figures can be found at John Hopkins University's Center for Systems Science and Engineering: <https://www.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6>.

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coronavirus have severely affected international travel and tourism, which had become a leading engine economic growth and the major source of foreign exchange earnings in many countries across the globe (Fig. 1).² Other infectious diseases have had significant economic effects worldwide, including several pandemics in the 20th and twenty-first century caused by an influenza virus or a coronavirus. Although the mortality rate for COVID 19 is found to be lower than past epidemics, it has had unprecedented health, social, and economic consequences, given its high contagion rate and global spread. Looking forward, while past pandemics have generally been short lived, how each country comes out of the current crisis will depend on policy choices made during the pandemic, the required adjustment, and the economic and institutional strength prior to COVID-19. Therefore, analyzing the evolution of international tourism flows during past epidemics can shed light on the impact of the COVID 19 pandemic.

Epidemics have always been a fact of life, and the COVID-19 outbreak is not the first infectious disease with profound economic effects across the world. While many factors contribute to the emergence and spread of infectious diseases, cross-border movement of people has always been a potent vector of transmission throughout history (McNeill 1976; Wilson 1991; Wilson 1995; Richter 2003; Snowden 2019). Numerous diseases with epidemic and pandemic potential, including avian flu, cholera, Ebola, malaria, and coronaviruses such as Severe Acute Respiratory Syndrome (SARS), Middle East Respiratory Syndrome (MERS) and now COVID-19, can spread easily through international travel in an increasingly interconnected world and affect consumer behavior and travel patterns at a global scale with far-reaching economic and financial repercussions.

There is a large body of literature on gravity models in international trade, but scarce research on modeling bilateral tourist movements in a gravity framework, especially taking into account the effect of infectious diseases. Most studies in this context look at the impact of disease outbreaks, such as the SARS and avian flu epidemics, on tourism in a specific country or region over a short period of time (Zeng and De Lacy 2005; Cooper 2006; Wilder-Smith 2006; Kuo et al. 2008). This paper is most closely related to Roselló et al. (2017) that analyzes the benefits of eradicating diseases in terms of tourism flows and revenues during the 2000–2013 period, although using dummy variables that do not capture the scale and dynamism of infectious diseases. To learn from past episodes, this paper contributes to the literature by (i) expanding the dataset in terms of country coverage and time-series dimension to 38,184 pairs of countries over the period 1995–2017, (ii) measuring the actual number of confirmed infectious-disease cases (Ebola, malaria, SARS, and yellow fever) scaled by population, and (iii) estimating the impact on international tourism flows with alternative methodologies, including the pseudo poisson maximum likelihood (PPML), the two-stage least squares (2SLS) with instrumental variable (IV), and the ordinary least squares (OLS), in a gravity framework that controls for macroeconomic factors, geographic and cultural characteristics, and historical ties.

The empirical analysis finds strong evidence that international tourism is adversely affected by the scale and dynamism of infectious diseases and the magnitude of this

² According to the United Nations World Tourism Organization (WTO), international tourism had grown rapidly from 25 million visitors in 1950 to 440 million by 1990 and over 1.5 billion in 2019, accounting for over 10% of global GDP and more than 320 million jobs worldwide. Preliminary data indicate that the COVID-19 pandemic already caused a fall of 68% in international tourist arrivals in the first half of 2020, compared to the same period of 2019.

Fig. 1 International Tourism Inflows

negative effect is statistically and economically significant. In the case of SARS, a 10% increase in the number of confirmed cases leads, on average, to a reduction of 4.7% in international tourist arrivals across all countries. These results withstand several robustness checks, including alternative specifications and estimation methodologies, to address omitted-variables bias and potential endogeneity. In particular, partitioning the sample into income groups highlights heterogeneity in how the risk of infectious diseases affects international tourism flows. While infectious diseases appear to have a smaller and statistically insignificant negative effect on tourism flows to advanced economies, the magnitude and statistical significance of the impact of infectious diseases are much greater in developing countries, where such diseases tend to be more prevalent and health infrastructure lags behind. Using SARS as an example, the results indicate that a 10% increase in the number of confirmed infections led to a decline of about 8% in international tourist arrivals to developing countries—almost twice as much as the average impact on all countries.

The remainder of this study is organized as follows. Section II provides an overview of the data used in the empirical analysis. Section III introduces the salient features of our econometric strategy. Section IV presents the empirical results, including a series of robustness checks. Finally, Section V offers concluding remarks with policy implications.

1.1 Data Overview

The empirical analysis presented in this study is based on an unbalanced panel of annual observations for 38,184 pairs of countries during the period 1995–2017.³ Bilateral tourism flows for 172 countries of origin and 222 countries of destination are taken from the WTO database, yielding a dataset of over 261,488 observations over the sample period. The main explanatory variable of interest is the number of confirmed infectious-disease cases, including Ebola, malaria, SARS, and yellow fever, which is obtained from the WHO database. Following the literature, real GDP, the real effective exchange rate (REER),

³ The list of countries, including territories, is presented in Appendix Table 4.

population and life expectancy are introduced as control variables, drawn from the IMF's World Economic Outlook (WEO) database and the World Bank's World Development Indicators (WDI) database.

Standard gravity variables such as bilateral distance between countries, common official language, colonial history and geographical contiguity are taken from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) database, as presented in Mayer and Zignago (2011). Geographic distance is measured as the great-circle distance in kilometers between the capital cities of each country pair. Binary variables for language, colonial history and geographical contiguity are assigned a value of 1 if a country pair share a common official language, a colonial tie, and an adjacent border and a value of 0 otherwise.

Descriptive statistics for the variables used in the empirical analysis are presented in Table 1. There is a significant degree of dispersion across

Table 1 Summary Statistics

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
International tourism flows	261,488	78,737	918,199	1	81,100,000
Real GDP					
Origin countries	410,680	13,155	16,243	184	111,968
Destination countries	381,210	16,926	22,269	184	194,188
REER, destination	371,190	100.5	25.5	7.4	740.6
Distance	370,208	7273	4564	27	19,951
Common language	370,208	0.173	0.378	0.000	1.000
Colonial history	370,208	0.015	0.123	0.000	1.000
Geographical contiguity	370,208	0.027	0.163	0.000	1.000
Life expectancy, destination	382,122	70.4	9.4	31.0	85.4
Population					
Origin countries	411,470	54,300,000	186,000,000	9298	1,390,000,000
Destination countries	395,038	45,900,000	160,000,000	9298	1,400,000,000
Infectious diseases					
Origin countries					
Ebola	411,470	22	496	0	14,124
Malaria	411,470	69,328	631,885	0	15,000,000
SARS	411,470	3	115	0	5327
Yellow fever	411,470	3	40	0	1192
Destination countries					
Ebola	386,101	15	413	0	14,124
Malaria	386,101	130,202	746,793	0	15,000,000
SARS	386,101	3	108	0	5327
Yellow fever	378,948	3	34	0	1192

Source: WTO; IMF; World Bank; WHO; author's calculations

countries in terms of international tourist flows and considerable heterogeneity in the occurrence of infectious diseases. It is essential to analyze the time-series properties of the data to avoid spurious results by conducting panel unit root tests. Accordingly, the stationarity of all variables is checked by applying the Im et al. (2003) procedure, which is widely used in the empirical literature to conduct a panel unit root test. The results, available upon request, indicate that the variables used in the analysis are stationary after logarithmic transformation.

1.2 Empirical Methodology

The gravity model framework is widely used in the economic literature to analyze the patterns of international trade and capital movements, as well as migration and tourism flows (Tinbergen 1962; Anderson and van Wincoop 2003; Bergstrand and Egger 2007; Gil-Pareja et al. 2007; Head and Ries 2008; Santana-Gallego et al. 2010). Bilateral flows between two countries tend to increase with per capita income and decline with transportation costs as proxied by physical distance between the countries. This gives a simple gravity model, in which the number of tourists traveling in one direction between two countries depends on the economic sizes of the countries and the geographical distance between them. Building on Santos Silva and Tenreiro (2006), the baseline gravity specification takes the following form in a panel data context:

$$\ln(T_{ijt}) = \beta + \alpha \ln(GDP_{it}) + \gamma \ln(GDP_{jt}) + \vartheta \ln(Dist_{ij}) + \eta_i + \varphi_j + \mu_t + \varepsilon_{ijt} \quad (1)$$

in which T_{ij} denotes international tourist flows between countries i (origin) and j (destination); GDP is the level of per capita income in origin and destination country, respectively; $Dist_{ij}$ is the physical distance between countries i (origin) and j (destination); the η_i , φ_j and μ_t coefficients designate the country fixed effects capturing all time-invariant factors in origin and destination country and the time fixed effects controlling for common shocks that may affect international tourism across all countries in a given year, respectively. ε_{ijt} is an idiosyncratic error term that meets the standard assumptions of zero mean and constant variance.

Since the objective is to understand the effect of infectious diseases on international tourism, the parsimonious gravity model is augmented with additional control variables along with the number of confirmed infectious-disease cases:

$$\begin{aligned} \ln(T_{ijt}) = & \beta + \alpha \ln(GDP_{it}) + \gamma \ln(GDP_{jt}) + \vartheta \ln(Dist_{ij}) + \delta X_{ijt} + \varphi \ln(Vir_{ijt}) \\ & + \eta_i + \varphi_j + \mu_t + \varepsilon_{ijt} \end{aligned} \quad (2)$$

where X_{ijt} denotes a vector of control variables, including the REER, population, life expectancy, and binary variables for common language, colonial history and geographical contiguity; Vir_{ijt} denotes the number of confirmed cases of Ebola, malaria, SARS, and yellow fever scaled by population in origin

and destination countries. To account for possible heteroskedasticity, robust standard errors are clustered at the country-pair level.⁴

Most gravity models are estimated with cross-sectional data, which may lead to biased results due to potential correlation between explanatory variables and unobservable country characteristics as it does not control for heterogeneity. Panel data estimations help address such econometric concerns by controlling for country and time fixed effects (Egger 2000). Therefore, in this paper, the gravity model is estimated with the PPML estimator recommended by Santos Silva and Tenreiro (2006) and the 2SLS-IV methodology using the lagged infectious disease as instrument to account for potential endogeneity.⁵

1.3 Estimation Results

As a baseline, the gravity model described in Eq. (3) is estimated using the PPML model, which has several important advantages as compared with other estimators by dealing appropriately with heteroscedasticity, model misspecification and excess zeros. Table 2 presents the estimation results starting with a specification including only macroeconomic and demographic variables and standard gravity factors in column (1) as a point of reference. The number of infectious diseases in origin and destination countries is then introduced into the regression in column (2) for Ebola, column (3) for malaria, column (4) for SARS, and column (5) for yellow fever. The results demonstrate a consistent picture with the signs of all estimated parameters corresponding to their expected values across different specifications. Most of the coefficients are highly significant, and the model's performance in terms of goodness of fit is found to be highly satisfactory.

The level of income in both origin and destination countries have a positive impact on bilateral tourism flows, suggesting that international tourism is significantly related to the two countries' economic size. Distance between the countries, on the other hand, is negatively associated with bilateral tourism flows, representing an obstacle for international travel as expected. The greater the distance between the two countries, the smaller the flow of tourists across the two countries, due to higher cost of travel. This is also consistent with the positive effect of the geographical contiguity variable, indicating that tourists tend to travel more to closer destinations. Cultural similarities and historical ties—proxied by common official language and colonial relations, respectively—are found to have the expected positive effects on bilateral tourism flows. Likewise, demographic factors—measured population in origin and destination countries and life expectancy in destination countries—contribute positively to international tourism.

⁴ The results remain broadly unchanged when standard errors are clustered at the country level.

⁵ The gravity model is also estimated using the OLS as a further robustness check, which are available upon request. Since the objective is to include standard time-invariant gravity factors (distance, common language, colonial history, geographical contiguity) in the panel regressions, the OLS model is estimated via the random-effects regression, instead of the fixed-effects model that would remove time-invariant variables. However, the fixed-effects estimations with origin and destination fixed effects controlling for all possible time-invariant country characteristics yield similar results.

Table 2 Infectious Diseases and International Tourism—PPML Estimations

(Dependent variable: Bilateral tourism flows)

	[1]	[2]	[3]	[4]	[5]
Real GDP, origin	0.129*** [0.006]	0.127*** [0.006]	0.127*** [0.006]	0.127*** [0.006]	0.131*** [0.006]
Real GDP, destination	0.129*** [0.007]	0.129*** [0.008]	0.129*** [0.008]	0.129*** [0.008]	0.132*** [0.008]
Distance	-0.228*** [0.004]	0.232*** [0.004]	0.231*** [0.004]	-0.232*** [0.004]	-0.229*** [0.004]
Common language	0.176*** [0.007]	0.174*** [0.007]	0.174*** [0.007]	0.174*** [0.007]	0.180*** [0.007]
Colonial history	0.080*** [0.016]	0.083*** [0.016]	0.083*** [0.016]	0.083** [0.016]	0.076*** [0.016]
Geographical contiguity	0.034 [0.019]	0.035 [0.016]	0.035 [0.016]	0.035 [0.016]	0.031 [0.016]
Population, origin	0.063*** [0.011]	0.065*** [0.011]	0.059*** [0.011]	0.063*** [0.011]	0.066*** [0.011]
Population, destination	0.080*** [0.012]	0.078*** [0.012]	0.082*** [0.012]	0.078*** [0.013]	0.084*** [0.012]
REER, destination	0.000*** [0.000]	0.000*** [0.000]	0.000*** [0.000]	0.000*** [0.000]	0.000*** [0.000]
Life expectancy, destination	0.097 [0.043]	0.103 [0.043]	0.113 [0.044]	0.091 [0.044]	0.088 [0.043]
Ebola					
Origin		-0.013*** [0.001]			
Destination		-0.010*** [0.002]			
Malaria					
Origin			0.001 [0.000]		
Destination			-0.001 [0.000]		
SARS					
Origin				-0.003*** [0.02]	
Origin				-0.040*** [0.02]	
Yellow fever					
Origin					0.003 [0.000]
Origin					-0.001
Number of observations	224,019	215,589	215,589	215,589	219,132
Origin FE	Yes	Yes	Yes	Yes	Yes

Table 2 (continued)

Destination FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Adjusted R ²	0.77	0.84	0.80	0.83	0.80

Note: The dependent variable is bilateral tourism flows (in log form). Robust standard errors, clustered at the country level, are reported in brackets. A constant is included in each regression, but not shown in the table. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively

With regard to the main explanatory variable of interest, estimation results establish a significant effect of infectious-disease episodes on international tourism flows, but with variation in magnitude and statistical significance depending on the nature of the disease. The estimated coefficients on malaria and yellow fever are considerably smaller in magnitude, whereas the coefficients on Ebola and SARS are found to be both statistically and economically significant. These results are robust to alternative estimations and specifications, including after controlling for health infrastructure. In the case of SARS, for example, a 10% increase in the number of confirmed cases leads, on average, to a reduction of 4.7% in international tourist arrivals (Table 2). There is, however, significant heterogeneity across country groups in the impact of pandemics on tourism, depending on the level of income and health infrastructure.

These estimated differences in how infectious diseases affect international tourism flows likely reflect disease-specific characteristics:

- **Vector of transmission.** While malaria and yellow fever are transmitted by mosquitoes, Ebola and SARS—similarly to COVID-19—are spread from human to human. Accordingly, while malaria and yellow fever may be endemic in rural areas, Ebola and SARS could spread more easily in densely populated cities and airports.
- **Existence of treatment or vaccine.** Although a vaccine for yellow fever and treatments for malaria exist, to the authors' knowledge there is no such treatment or vaccine against Ebola or SARS. Consequently, infection risks of these diseases have a greater effect on international tourism flows, especially to countries with weak health infrastructure.
- **Temporary outbreak vs. endemic presence.** When a disease is endemic like malaria and yellow fever, there is no point in delaying travel as long as precautions can be taken. Outbreaks of Ebola and SARS, on the other hand, are temporary in nature and, without any treatment or vaccine, incentivize tourists to delay visiting a particular country until the outbreak is over.

The robustness of baseline results is checked by estimating the gravity model alternative specifications and estimation methodologies. First, since tourist arrivals may influence the spread of infectious diseases, the model is estimated with the 2SLS-IV methodology using the lagged infectious disease as an instrument to account for potential endogeneity. Second, the sample is truncated at the 5th and 95th percentiles to remove the potential impact of extreme outliers. Third, the gravity model is estimated for a sub-sample of 1995–2007 to exclude the period after the global financial crisis. Fourth, an additional health-related control variables—the number of hospital beds per 1000 people—is introduced to address omitted-variable bias and capture the impact of health

infrastructure. To exhibit a concise table, some of these robustness checks are presented only for SARS, but the results remain consistent for other infectious diseases.

The 2SLS-IV estimation, presented in Table 3, increases the magnitude of the cumulative coefficient on the infectious disease (SARS)—to -0.465 compared to -0.043 in the baseline estimation, strongly supporting the contemporaneous impact of infectious diseases on international travel both in terms of magnitude and statistical significance. Other robustness checks, presented in Appendix Table 5, show that the negative and economically significant relationship between infectious diseases and international tourism flows remains unchanged in the context of 38,184 pairs of countries during the period 1995–2017, with some changes in the magnitude of estimated coefficients. Estimating the model with the truncated sample and for the period excluding the global financial crisis yields higher coefficients on the infectious-disease variable. Adding the number of hospital beds into the regression model reveals that health infrastructure in destination countries matter for bilateral tourism flows.

Finally, partitioning the sample into income groups and geographical regions highlights heterogeneity on how the risk of infectious diseases affects international tourism flows. These estimation results, presented in Appendix Table 6, show a substantial contrast between advanced economies and developing countries. Although infectious diseases appear to have statistically insignificant effect on tourism flows to advanced economies, the magnitude and statistical significance of the impact of infectious diseases are much greater in developing countries, where such diseases tend to be more prevalent and health infrastructure lags behind.⁶ For example, in the case of SARS, a 10% increase in the number of confirmed infections led to a decline of about 8% in international tourist arrivals to developing countries—almost twice as much as the average impact on all countries. These findings show systemic differences among geographical regions: the disease impact on international tourism flows is significantly greater in Asia, Latin America, and the Caribbean than the rest of the world.

2 Conclusion

How and to what extent do infectious diseases affect international tourism? This paper develops a gravity model of bilateral tourist flows among 38,184 country pairs over the period 1995–2017 to provide an empirical answer to these questions using previous infectious-disease episodes. The empirical analysis provides strong evidence that international tourism is adversely affected by the risk of infectious diseases as measured by the number of confirmed cases in past episodes. The magnitude of this negative effect is statistically and economically greater for Ebola and SARS, which are transmitted from human to human, unlike malaria and yellow fever. With no treatment or vaccine against Ebola and SARS, contagion risks of these infectious diseases have a greater impact on tourism flows. Consistently, in the case of SARS, a 10% increase in the number of confirmed cases leads, on average, to a reduction of 4.7% in international tourist arrivals across all countries. These results withstand several robustness checks,

⁶ Unlike past episodes, however, the impact of COVID-19 on tourism flows will be similar across all country groups, given the extent of containment measures put in place by all countries regardless the level of income.

Table 3 Infectious Diseases and International Tourism—2SLS-IV Estimations*(Dependent variable: Bilateral tourism flows)*

	[1]	[2]	[3]	[4]
Real GDP, origin	0.933*** [0.012]	0.935*** [0.012]	0.959*** [0.014]	0.957*** [0.012]
Real GDP, destination	0.865*** [0.013]	0.856*** [0.013]	0.861*** [0.015]	0.896*** [0.013]
Distance	-1.717*** [0.015]	-1.717*** [0.015]	-1.716*** [0.015]	-1.717*** [0.015]
Common language	1.241*** [0.034]	1.241*** [0.034]	1.241*** [0.034]	1.272*** [0.034]
Colonial history	0.849*** [0.086]	0.850*** [0.086]	0.850*** [0.086]	0.832*** [0.084]
Geographical contiguity	1.210*** [0.067]	1.207*** [0.067]	1.208*** [0.067]	1.163*** [0.066]
Population, origin	0.523*** [0.022]	0.517*** [0.023]	0.514*** [0.023]	0.498*** [0.022]
Population, destination	0.526*** [0.023]	0.562*** [0.024]	0.514*** [0.024]	0.576*** [0.022]
REER, destination	0.001*** [0.000]	0.001*** [0.000]	0.001*** [0.000]	0.001*** [0.000]
Life expectancy, destination	0.097 [0.070]	0.039 [0.078]	0.214 [0.081]	0.209 [0.068]
Ebola				
Origin	-0.065*** [0.005]			
Destination	-0.089*** [0.008]			
Malaria				
Origin		-0.001 [0.001]		
Destination		-0.007 [0.001]		
SARS				
Origin			-0.387*** [0.092]	
Destination			-0.078*** [0.104]	
Yellow fever				
Origin				0.004 [0.012]
Destination				-0.017 [0.104]
Number of observations	210,221	210,221	210,221	213,645

Table 3 (continued)*(Dependent variable: Bilateral tourism flows)*

Origin FE	Yes	Yes	Yes	Yes
Destination FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Pseudo R ²	0.83	0.83	0.83	0.84

Note: The dependent variable is bilateral tourism flows (in log form). Robust standard errors, clustered at the country level, are reported in brackets. A constant is included in each regression, but no shown in the table *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively

including alternative specifications and estimation methodologies, to address omitted-variable bias and account for potential endogeneity.

There is, however, significant heterogeneity across country groups in the impact of pandemics on tourism, depending on the level of income and health infrastructure. Partitioning the sample into income groups and geographical regions shows a substantial contrast between advanced economies and developing countries. Although infectious diseases appear to have statistically insignificant effect on tourism flows to advanced economies, the magnitude and statistical significance of the impact of infectious diseases are much greater in developing countries, where such diseases tend to be more prevalent and health infrastructure lags behind. For example, in the case of SARS, a 10% increase in the number of confirmed infections leads to a decline of about 8% in international tourist arrivals to developing countries—almost twice as much as the average impact on all countries. These findings show systemic differences among geographical regions: the disease impact on international tourism flows is significantly greater in Asia, Latin America, and the Caribbean than the rest of the world.

There are two important dimensions highlighted by this analysis: (i) the geographical disparity in international tourism flows and (ii) availability of treatment and preventive medicine. As of 2019, over 50% of international tourist arrivals worldwide were bound for to Europe, while the share of other regions remained relatively small. In particular, Africa accounted for 4.8% of international tourist arrivals, barely increasing over the past two decades. On the other hand, tourism in Asia grew rapidly to 24.5% of international tourist arrivals, from 12.8% in 1990 and 3.7% in 1970. Consequently, infectious diseases originating from Asia—like SARS and now COVID-19—can have a profound effect on international travel, especially considering the lack of treatment options and preventive medicine. Further, the COVID-19 outbreak is the first truly global pandemic in modern times, reaching every corner of the world and making geographical differentiation impossible for tourism. The collapse of international travel is therefore not an unexpected outcome of the COVID-19 pandemic that has had grave public health repercussions throughout the world.⁷ Scaling the estimated coefficient of SARS to the prevalence of COVID-19 as measured by the number of confirmed cases in population would yield an approximate decline of 82.5% in international tourism flows worldwide, which is broadly consistent with the actual impact of −65% registered in the first half of 2020.

⁷ Based on preliminary data, the WTO expects international tourist arrivals to decline by more than 80% in 2020, due to the closure of borders, travel bans, and containment measures put in place in many countries to slow the spread of COVID-19.

Appendix

Table 4 List of Countries and Territories

Afghanistan	Denmark	Liberia	Rwanda
Albania	Djibouti	Libya	Saba
Algeria	Dominica	Liechtenstein	Saint Eustatius
American Samoa	Dominican Republic	Lithuania	Saint Maarten
Andorra	Ecuador	Luxembourg	Samoa
Angola	Egypt	Macao SAR	San Marino
Anguilla	El Salvador	Madagascar	Sao Tome And Principe
Antigua And Barbuda	Equatorial Guinea	Malawi	Saudi Arabia
Argentina	Eritrea	Malaysia	Senegal
Armenia	Estonia	Maldives	Serbia
Aruba	Eswatini	Mali	Seychelles
Australia	Ethiopia	Malta	Sierra Leone
Austria	Fiji	Marshall Islands	Singapore
Azerbaijan	Finland	Martinique	Slovak Republic
Bahamas, The	France	Mauritania	Slovenia
Bahrain	French Guiana	Mauritius	Solomon Islands
Bangladesh	French Polynesia	Mexico	Somalia
Barbados	Gabon	Micronesia	South Africa
Belarus	Gambia, the	Moldova	South Sudan
Belgium	Georgia	Monaco	Spain
Belize	Germany	Mongolia	Sri Lanka
Benin	Ghana	Montenegro	St. Kitts and Nevis
Bermuda	Greece	Montserrat	St. Lucia
Bhutan	Grenada	Morocco	St. Vincent and the Grenadines
Bolivia	Guadeloupe	Mozambique	Sudan
Bonaire	Guam	Myanmar	Suriname
Bosnia And Herzegovina	Guatemala	Namibia	Sweden
Botswana	Guinea	Nauru	Switzerland
Brazil	Guinea-Bissau	Nepal	Syria
British Virgin Islands	Guyana	Netherlands	Taiwan Province of China
Brunei Darussalam	Haiti	New Caledonia	Tajikistan
Bulgaria	Honduras	New Zealand	Tanzania
Burkina Faso	Hong Kong SAR	Nicaragua	Thailand
Burundi	Hungary	Niger	Timor-Leste
Cabo Verde	Iceland	Nigeria	Togo
Cambodia	India	Niue	Tonga
Cameroon	Indonesia	North Korea	Trinidad And Tobago

Table 4 (continued)

Afghanistan	Denmark	Liberia	Rwanda
Canada	Iran	North Macedonia	Tunisia
Cayman Islands	Iraq	Northern Mariana Islands	Turkey
Central African Republic	Ireland	Norway	Turkmenistan
Chad	Israel	Oman	Turks And Caicos Islands
Chile	Italy	Pakistan	Tuvalu
China	Jamaica	Palau	Uganda
Colombia	Japan	Palestine	Ukraine
Comoros	Jordan	Panama	United Arab Emirates
Congo, Republic of	Kazakhstan	Papua New Guinea	United Kingdom
Cook Islands	Kenya	Paraguay	United States
Costa Rica	Kiribati	Peru	United States Virgin Islands
Côte d'Ivoire	Korea	Philippines	Uruguay
Croatia	Kuwait	Poland	Uzbekistan
Cuba	Kyrgyz Republic	Portugal	Vanuatu
Curacao	Lao P.D.R.	Puerto Rico	Venezuela
Cyprus	Latvia	Qatar	Vietnam
Czech Republic	Lebanon	Reunion	Yemen
Democratic Republic Of The Congo	Lesotho	Romania	Zambia

Table 5 Infectious Diseases and Tourism—Robustness Checks*(Dependent variable: Bilateral tourism flows)*

	Truncated sample	Sub-sample (1995–2007)	Additional controls
Real GDP, origin	0.961*** [0.013]	1.259*** [0.028]	1.023*** [0.018]
Real GDP, destination	0.808*** [0.015]	0.751*** [0.028]	0.967*** [0.019]
Distance	−1.632*** [0.015]	−1.688*** [0.021]	−1.704** [0.018]
Common Language	1.202*** [0.033]	1.170*** [0.046]	1.233*** [0.039]
Colonial history	0.755*** [0.089]	0.919*** [0.106]	0.864*** [0.093]
Geographical contiguity	1.116*** [0.072]	1.232*** [0.084]	1.261** [0.074]
Population Origin	0.478** [0.022]	1.224*** [0.057]	0.554*** [0.033]
Population destination	0.478** [0.023]	0.305*** [0.057]	0.625*** [0.032]
REER, destination	0.001** [0.000]	0.001** [0.000]	0.001** [0.000]
Life expectancy, destination	0.151 [0.078]	0.060 [0.136]	0.711*** [0.194]
Hospital beds, destination			0.027*** [0.010]
SARS			
Origin	−0.224*** [0.085]	−0.281*** [0.041]	−0.224*** [0.095]
Destination	−0.028*** [0.091]	−0.016*** [0.050]	−0.011*** [0.103]
Number of observations	179,489	96,416	111,519
Origin FE	Yes	Yes	Yes
Destination FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Adjusted R ²	0.79	0.83	0.83

Note: The dependent variable is bilateral tourism flows (in log form). Robust standard errors, clustered at the country level, are reported in brackets. A constant is included in each regression, but no shown in the table *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively

Table 6 Infectious Diseases and Tourism—Income Group and Region*(Dependent variable: Bilateral tourism flows)*

	Advanced Middle East	Developing	Africa	Asia	Europe	Latin	
America							
Real GDP, origin	1.008*** [0.017]	0.935*** [0.020]	0.860*** [0.044]	1.044*** [0.054]	0.754*** [0.44]	0.889*** [0.035]	1.169*** [0.052]
Real GDP, destination	1.083*** [0.44]	0.744*** [0.024]	0.304*** [0.040]	1.201*** [0.077]	0.575*** [0.045]	0.744*** [0.047]	0.371*** [0.060]
Distance	−1.351*** [0.026]	−1.821*** [0.019]	−1.512*** [0.053]	−1.932*** [0.077]	−1.518*** [0.085]	−1.737*** [0.051]	−1482*** [0.072]
Common Language	0.584*** [0.054]	1.404*** [0.040]	1.170*** [0.058]	0.697*** [0.112]	0.863 [0.406]	1.451*** [0.064]	0.781*** [0.126]
Colonial history	1.164*** [0.082]	0.848*** [0.146]	0.231 [0.499]	1.113** [0.409]	0.109 [0.208]	0.541 [0.529]	0.526 [0.388]
Geographical contiguity	0.480*** [0.106]	1.307*** [0.079]	1.126** [0.148]	0.936*** [0.185]	1.525*** [0.167]	0.970*** [0.150]	1.662*** [0.198]
Population, origin	0.219*** [0.030]	0.660*** [0.031]	1.010*** [0.065]	0.824*** [0.084]	0.860*** [0.068]	0.797*** [0.060]	0.156 [0.084]
Population, destination	0.231*** [0.063]	0.433*** [0.031]	0.398*** [0.133]	0.392 [0.179]	0.316 [0.148]	0.729*** [0.114]	0.885*** [0.065]
REER, destination	0.006*** [0.000]	−0.000*** [0.000]	0.000 [0.000]	−0.002*** [0.001]	0.000 [0.000]	0.000*** [0.000]	0.000 [0.000]
Life expectancy, destination	5.847*** [0.528]	0.585*** [0.087]	0.366* [0.146]	1.668** [0.554]	3.911*** [1.264]	0.745 [0.420]	0.887 [0.659]
SARS							
Origin	−0.472 [0.136]	−0.556*** [0.120]	−0.362 [0.221]	−0.993*** [0.315]	−0.144 [0.322]	−0.455** [0.219]	−0.850* [0.331]
Destination	−0.246 [0.110]	−0.243*** [0.091]	−0.207 [0.544]	−0.311*** [0.191]	−0.761 [1.505]	−0.204 [0.630]	−0.229 [0.371]
Number of observations	70,721	139,500	36,232	23,922	23,794	33,750	21,802
Origin FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Destination FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R ²	0.88	0.85	0.81	0.86	0.85	0.85	0.81

Note: The dependent variable is bilateral tourism flows (in log form). Robust standard errors, clustered at the country level, are reported in brackets. A constant is included in each regression, but no shown in the table *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively

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Data Availability Statement The data that support the findings of this study are available at the World Trade Organization and the World Health Organization and in the IMF's International Financial Statistics and World Economic Outlook databases, and the World Bank's World Development Indicators database.

Declarations

Conflict of Interest The author states that there is no conflict of interest.

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