WP/20/112

IMF Working Paper

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

by Serhan Cevik

INTERNATIONAL MONETARY FUND

IMF Working Paper

Western Hemisphere Department

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

Prepared by Serhan Cevik[1]

Authorized for distribution by Manuela Goretti

July 2020

Abstract

This paper develops a 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 disease risk, and the magnitude of this negative effect is statistically and economically significant. In the case of SARS, for example, a 10 percent rise in confirmed cases leads to a reduction of as much as 9 percent in 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.

JEL Classification Numbers: C21; C23; F11; F14; F47; R12; Z30

Keywords: Infectious diseases; international tourism flows; gravity model; panel data

Author's E-Mail Address: scevik@imf.org

---

[1] The author would like to thank Manuela Goretti, Salma Khalid, Marina Marinkov, Samuel Pienknagura, Cyril Rebillard, Luca Ricci, Jorge Salas, Fatih Yilmaz, and participants of a virtual seminar at the Western Hemisphere Department of the IMF for insightful comments and suggestions, and Rahul Ainapur, Ben Sutton and Tianle Zhu for excellent assistance in data collection and management. The views expressed herein are those of the author and should not be attributed to the IMF, its Executive Board, or its management.

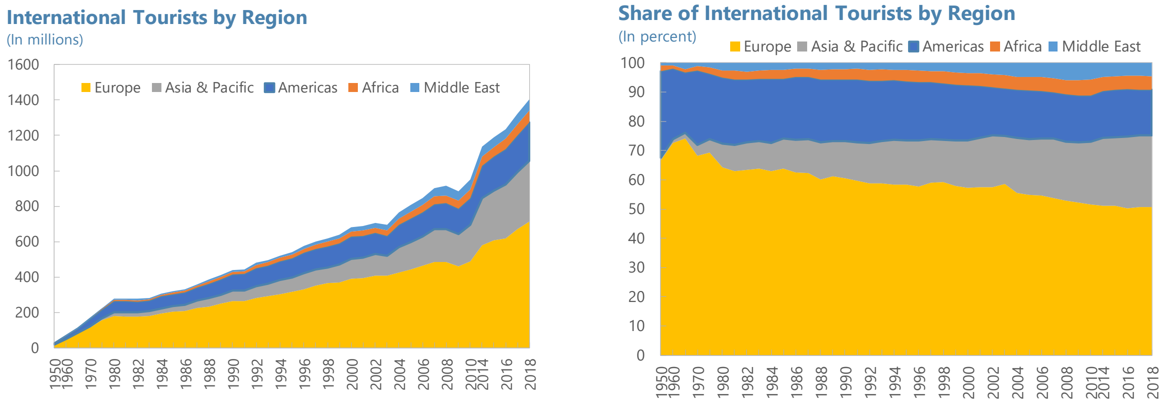
Contents **Page**

I. 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 June 30, 2020, there are over 10.5 million confirmed cases of COVID-19 in 188 countries, with more than 512,500 deaths.[2] Much is still unknown about the novel coronavirus. Since there are no specific vaccines or treatments for COVID-19 at this time, the best way to prevent and slow down spread of the coronavirus is through mitigation and containment measures, including travel restrictions, business and school closings, and social distancing in general, according to the World Health Organization (WHO). With most of the world imposing strict containment and mitigation measures, the rapid spread of the COVID-19 pandemic is exacerbating social conditions and aggravating existing economic vulnerabilities at the aggregate and sectoral levels. Although the magnitude and distribution of its economic consequences remain highly uncertain, it is already evident that the COVID-19 pandemic has caused a collapse in international travel and tourism, which has become a leading engine economic growth and the major source of foreign exchange earnings in many countries across the world (Figure 1).[3]

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,

Figure 1. International Tourism Flows



International Tourists by Region

Share of International Tourists by Region

Source: WTO; author's calculations.

---

[2] The 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.

[3] 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 percent of global GDP and more than 320 million jobs worldwide. Preliminary data indicate that the COVID-19 pandemic already caused a fall of 22 percent in international tourist arrivals in the first quarter of 2020, with a 57 percent drop in March, compared to 2019.

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 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 on tourism, such as the SARS and avian flu epidemics, on a specific country or region over a short period of time (Zeng, Carter, and De Lacey, 2005; Cooper, 2006; Wilder-Smith, 2006; Kuo and others, 2008). This paper is most closely related to Roselló, Santana-Gallego, and Awan (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 ordinary least squares (OLS), the pseudo poisson maximum likelihood (PPML), and the two-stage least squares (2SLS) with instrumental variable (IV), 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 risk of infectious diseases and the magnitude of this negative effect is statistically and economically significant. In the case of SARS, for example, a 10 percent increase in the number of confirmed cases leads to, on average, a reduction of as much as 9 percent in international tourist arrivals. 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 10 percent increase in the number of infections leads to a decline of 3.2 percent in bilateral tourism flows in advanced economies, but almost 12 percent in developing countries.

From a policy point of view, the immediate priority is ensuring adequate healthcare resources to protect the population, take care of the sick, and slow the spread of the coronavirus. Addressing public health concerns will set the stage for economic recovery and the return of international tourists. In addition, since the consequences of the COVID-19 pandemic are not distributed equally throughout the economy, well-targeted fiscal and financial measures are critical to mitigate the pandemic's impact. Countries that depend heavily on tourism have been severely affected, but those managing the consequences of the coronavirus pandemic better, thus preventing excessive economic disruption, will recover faster toward their long-term potential.

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.

II. 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. [4] 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 and population 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 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-Pesaran-Shin (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.

---

[4] The list of countries, including territories, is presented in Appendix Table A1.

table 1. Descriptive Statistics

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
International tourism flows	261,488	78,737	918,199	1.0	81,100,000
Real GDP, origin	410,680	13,155	16,243	184	111,968
Real GDP, destination	381,210	16,926	22,269	184	194,188
Distance	370,208	7,273	4,564	27	19,951
Common language	370,208	0.2	0.4	0.0	1.0
Colonial history	370,208	0.0	0.1	0.0	1.0
Geographical contiguity	370,208	0.0	0.2	0.0	1.0
Population, origin	411,470	54,300,000	186,000,000	9,298	1,390,000,000
Population, destination	395,038	45,900,000	160,000,000	9,298	1,400,000,000
Infectious diseases					
Ebola	382,651	2.3	89	0.0	3,811
Malaria	382,651	62,369	531,507	0.0	15,000,000
SARS	382,651	312	368	0.0	5,327
Yellow fever	384,194	2.0	31	0.0	1,192

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

III. 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, Llorca-Vivero, and Martínez-Serrano, 2007; Head and Ries, 2008; Santana-Gallego, Ledesma-Rodríguez, and Pérez-Rodríguez, 2010). The standard gravity equation states that bilateral flows between two countries are proportionate to economic size and inversely proportionate to geographic distance:

$$T_{ij} = \mathrm{B}\frac{(GDP_i)^{\alpha}(GDP_j)^{\gamma}}{(Dist_{ij})^{\vartheta}}\,U_{ij} \qquad (1)$$

where T_{ij} denotes international tourist flows between countries *i* (origin) and *j* (destination); GDP refers to the gross domestic product of each country; $Dist_{ij}$ is the distance between countries i and *j*; and $U_{ij}$is a log-normal distributed error term. In a panel data context, this expression can be transformed using natural logarithms to:

$$ln\,(T_{ijt}) = \beta + \alpha\, ln\,(GDP_{it}) + \gamma\, ln\,(GDP_{jt}) + \vartheta\, ln\,(Dist_{ij}) + \eta_{ij} + \mu_t + \varepsilon_{ijt} \qquad (2)$$

in the η_{ij} and μ_t coefficients designate the country fixed effects capturing all time-invariant factors that affect the volume of international travel between two countries 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 estimate the effect of infectious diseases on international tourism, the model is further augmented with additional control variables along with the number of confirmed cases of Ebola, malaria, SARS, and yellow fever:

$$ln\,(T_{ijt}) = \beta + \alpha ln\,(GDP_{it}) + \gamma ln\,(GDP_{jt}) + \vartheta ln\,(Dist_{ij}) + \delta X_{ijt} + \varphi \ln\,(Vir_{jt}) + \eta_{ij} + \mu_t + \varepsilon_{ijt} \quad (3)$$

where X_{ijt} denotes a vector of control variables, including the logarithm of population in origin and destination countries and binary variables for common language, colonial history and geographical contiguity; Vir_{jt} denotes the number of confirmed cases of Ebola, malaria, SARS, and yellow fever scaled by population in destination countries. To account for possible heteroskedasticity, robust standard errors are clustered at the country-pair level.

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 OLS method, the PPML estimator recommended by Santos Silva and Tenreyro (2006), and the 2SLS-IV methodology using the lagged infectious disease as instrument to account for potential endogeneity.[5]

IV. ESTIMATION RESULTS

As a baseline, the gravity model described in Equation (3) is estimated using the OLS model for the period 1995–2017 and start with a specification including only macroeconomic and demographic variables and standard gravity factors in column (1) of Table 2 as a point of reference. The number of infectious diseases 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. With the adjusted R-squared value of around 0.83, the estimated gravity model explains much of the cross-country variation in international tourism flows.

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

---

[5] 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-destination dummies controlling for all possible time-invariant country-pair characteristics yield similar results.

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—contribute positively to international tourism.

With regards to the main variable of interest in this study, the number of confirmed cases of infectious disease is found to have a statistically significant negative effect on international tourism flows. The coefficient on infectious diseases ranges between -0.003 and -0.785 depending on the disease, but always remaining negative and statistically significant, except in the case of yellow fever. The estimated coefficients on malaria and yellow fewer are considerably smaller in magnitude, whereas the coefficients on Ebola and SARS are found to be both statistically and economically significant. 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 are transmitted from human to human. Therefore, within a country, the distribution of cases and places of risk is very different. Malaria and yellow fever may be endemic in some countries' forested areas, but not in large cities. Conversely, given human to human transmission, cities and airports may be places where risks of catching Ebola and SARS can be non-negligible during an epidemic.

- *Existence of treatment or vaccine*. There is a vaccine against yellow fever, and treatments exist against malaria. However, to our 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.

On the whole, the empirical results indicate that the higher the risk of infectious disease, the lower the number of international tourist arrivals into a destination, as expected. In the case of SARS, for example, a 10 percent increase in the number of confirmed cases is associated, on average, with a decline of about 8 percent in bilateral tourism flows.

Turning to the standard PPML method as an alternative to correct for country heterogeneity, the estimation results, presented in Table 3, remain qualitatively unchanged. The PPML is found to perform better than the OLS method in the presence of zero tourism flows. Across all specifications, the estimated coefficients are smaller in magnitude, but remain statistically

Table 2. Infectious Diseases and International Tourism—Baseline Estimations

(Dependent variable: Bilateral tourism flows)

	[1]	[2]	[3]	[4]	[5]
Real GDP, origin	0.956***	0.948***	0.948***	0.909***	0.950***
	[0.032]	[0.033]	[0.033]	[0.049]	[0.033]
Real GDP, destination	0.833***	0.824***	0.823***	0.817***	0.823***
	[0.033]	[0.033]	[0.033]	[0.046]	[0.033]
Distance	-1.701***	-1.708***	-1.708***	-1.718***	-1.709***
	[0.016]	[0.017]	[0.017]	[0.023]	[0.017]
Common language	1.229***	1.231***	1.231***	1.196***	1.217***
	[0.036]	[0.036]	[0.036]	[0.048]	[0.048]
Colonial history	0.846***	0.848***	0.848***	1.039***	0.854***
	[0.112]	[0.113]	[0.113]	[0.144]	[0.113]
Geographical contiguity	1.229***	1.234***	1.233***	1.358***	1.215***
	[0.108]	[0.107]	[0.107]	[0.133]	[0.107]
Population, origin	0.497***	0.521***	0.523***	0.523***	0.518***
	[0.060]	[0.061]	[0.061]	[0.089]	[0.061]
Population, destination	0.565***	0.536***	0.556***	0.344***	0.532***
	[0.058]	[0.060]	[0.061]	[0.084]	[0.060]
Ebola		-0.048***			
		[0.011]			
Malaria			-0.005**		
			[0.002]		
SARS				-0.785***	
				[0.103]	
Yellow fever					-0.003
					[0.006]
Number of observations	233,538	224,961	224,961	114,878	225,828
Origin FE	Yes	Yes	Yes	Yes	Yes
Destination FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.82	0.83	0.83	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 not shown in the table. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 3. Infectious Diseases and International Tourism—PPML Estimations

(Dependent variable: Bilateral tourism flows)

	[1]	[2]	[3]	[4]	[5]
Real GDP, origin	0.131***	0.130***	0.129***	0.122***	0.130***
	[0.006]	[0.006]	[0.006]	[0.009]	[0.006]
Real GDP, destination	0.129***	0.130***	0.130***	0.129***	0.129***
	[0.007]	[0.007]	[0.007]	[0.010]	[0.007]
Distance	-0.231***	-0.235***	-0.235***	-0.242***	-0.235***
	[0.004]	[0.004]	[0.004]	[0.006]	[0.004]
Common language	0.178***	0.176***	0.176***	0.195***	0.176***
	[0.007]	[0.007]	[0.007]	[0.010]	[0.007]
Colonial history	0.079***	0.082***	0.082***	0.085**	0.082***
	[0.016]	[0.007]	[0.016]	[0.028]	[0.016]
Geographical contiguity	0.034	0.033	0.033	0.066**	0.032
	[0.016]	[0.016]	[0.016]	[0.022]	[0.016]
Population, origin	0.064***	0.065***	0.065***	0.063***	0.064***
	[0.011]	[0.011]	[0.011]	[0.016]	[0.011]
Population, destination	0.092***	0.092***	0.092***	0.075***	0.091***
	[0.011]	[0.012]	[0.011]	[0.016]	[0.012]
Ebola		-0.011***			
		[0.003]			
Malaria			-0.001		
			[0.001]		
SARS				-0.032***	
				[0.020]	
Yellow fever					-0.001
					[0.001]
Number of observations	233,538	224,961	224,961	114,878	225,828
Origin FE	Yes	Yes	Yes	Yes	Yes
Destination FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.77	0.79	0.79	0.79	0.78

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.

significant.[6] As a further check for the robustness of the results, the gravity model is estimated with alternative specifications and estimation methodologies.[7]

- First, the sample is truncated at the 5th and 95th percentiles to remove the potential impact of extreme outliers.

- Second, the gravity model is estimated for a sub-sample of 1995-2007 to exclude the period after the global financial crisis.

- Third, additional health-related variables—life expectancy and the number of hospital beds per 1,000 people—are introduced to address omitted-variable bias and capture the impact of health conditions and infrastructure.

- Fourth, since tourist arrivals may influence the spread of infectious diseases, the model is estimated with the 2SLS-IV methodology using the lagged infectious disease to account for potential endogeneity.

These results, presented in Appendix Table A2, 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 health variables into the regression model reveals that health conditions and infrastructure in destination countries matter for bilateral tourism flows. The 2SLS-IV estimation increases the magnitude of the coefficient on the infectious disease (SARS)—to -0.86 compared to -0.79 in the baseline estimation, strongly supporting the contemporaneous impact of infectious diseases on international travel both in terms of magnitude and statistical significance.

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 A3, show a substantial contrast between advanced and developing countries. While infectious diseases—as measured by the number of confirmed SARS cases in this exercise—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. According to the baseline specification estimated via the 2SLS-IV approach, 10 percent increase in the number of confirmed cases of SARS leads to a decline of 3.2 percent in bilateral tourism flows in advanced economies, but almost 12 percent in developing countries. These findings also show systemic

---

[6] The only exception is geographical continuity, which has the expected sign but becomes statistically insignificant in some PPML specifications.

[7] To exhibit a concise table, the robustness checks are presented for only SARS, but the results remain consistent for other infectious diseases.

differences among geographical regions: the disease impact on bilateral tourism flows is significantly greater in Asia and Latin America and the Caribbean than the rest of the world.

V. 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 percent increase in the number of confirmed cases is found to lead , on average, to a reduction of as much as 9 percent in international tourist arrivals. These results withstand several robustness checks, including alternative specifications and estimation methodologies, to address omitted-variable bias and account for potential endogeneity.

Adding health-related variables—life expectancy and the number of hospital beds per 1,000 people—reveals health conditions and infrastructure in destination countries matter for bilateral tourism flows. Partitioning the sample into income groups and geographical regions, on the other hand, 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. These findings also show systemic differences among geographical regions: the disease impact on bilateral tourism flows is significantly greater in Asia and 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 percent 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 percent of international tourist arrivals, barely increasing over the past two decades. That is why the impact of some infectious diseases that are mostly prevalent in Africa is not found to be statistically significant. On the other hand, tourism in Asia grew rapidly to 24.5 percent of international tourist arrivals, from 12.8 percent in 1990 and 3.7 percent 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.[8]

From a policy point of view, at this stage, the main priority is ensuring adequate resources for healthcare systems to protect the population, take care of the sick, and slow the spread of the coronavirus. Addressing public health concerns will set the stage for economic recovery and the return of international tourists. In addition, since the consequences of the COVID-19 pandemic are not distributed equally throughout the economy, well-targeted fiscal and financial measures are critical to mitigate the pandemic's impact. To this end, although many tourism-dependent developing countries will have limited fiscal space to respond to the economic slump, economic policymakers should use timely and targeted cash and in-kind transfers, wage subsidies, loans and grants, tax relief to help households and businesses under strain to confront this temporary and sudden stop in economic activity. Countries that depend heavily on tourism are no doubt being severely affected, but those managing the consequences of the coronavirus pandemic better, thus preventing excessive economic disruption, will recover faster toward long-term potential. Sustaining economic recovery will also require preserving financial stability, reforming labor and product markets, strengthening human and physical capital, and building a more conducive environment for investment.

---

[8] Based on preliminary data, the WTO expects international tourist arrivals to decline by 60 to 80 percent 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 A1. List of Countries and Territories

Afghanistan
Albania
Algeria
American Samoa
Andorra
Angola
Anguilla
Antigua And Barbuda
Argentina
Armenia
Aruba
Australia
Austria
Azerbaijan
Bahamas, The
Bahrain
Bangladesh
Barbados
Belarus
Belgium
Belize
Benin
Bermuda
Bhutan
Bolivia
Bonaire
Bosnia And Herzegovina
Botswana
Brazil
British Virgin Islands
Brunei Darussalam
Bulgaria
Burkina Faso
Burundi
Cabo Verde
Cambodia
Cameroon
Canada
Cayman Islands
Central African Republic
Chad
Chile
China
Colombia
Comoros
Congo, Republic of
Cook Islands
Costa Rica
Côte d'Ivoire
Croatia
Cuba
Curacao
Cyprus
Czech Republic
Democratic Republic Of The Congo
Denmark
Djibouti
Dominica
Dominican Republic
Ecuador
Egypt
El Salvador
Equatorial Guinea
Eritrea
Estonia
Eswatini
Ethiopia
Fiji
Finland
France
French Guiana
French Polynesia
Gabon
Gambia, the
Georgia
Germany
Ghana
Greece
Grenada
Guadeloupe
Guam
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hong Kong SAR
Hungary
Iceland
India
Indonesia
Iran
Iraq
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kazakhstan
Kenya
Kiribati
Korea
Kuwait
Kyrgyz Republic
Lao P.D.R.
Latvia
Lebanon
Lesotho
Liberia
Libya
Liechtenstein
Lithuania
Luxembourg
Macao SAR
Madagascar
Malawi
Malaysia
Maldives
Mali
Malta
Marshall Islands
Martinique
Mauritania
Mauritius
Mexico
Micronesia
Moldova
Monaco
Mongolia
Montenegro
Montserrat
Morocco
Mozambique
Myanmar
Namibia
Nauru
Nepal
Netherlands
New Caledonia
New Zealand
Nicaragua
Niger
Nigeria
Niue
North Korea
North Macedonia
Northern Mariana Islands
Norway
Oman
Pakistan
Palau
Palestine
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Puerto Rico
Qatar
Reunion
Romania
Russia
Rwanda
Saba
Saint Eustatius
Saint Maarten
Samoa
San Marino
Sao Tome And Principe
Saudi Arabia
Senegal
Serbia
Seychelles
Sierra Leone
Singapore
Slovak Republic
Slovenia
Solomon Islands
Somalia
South Africa
South Sudan
Spain
Sri Lanka
St. Kitts and Nevis
St. Lucia
St. Vincent and the Grenadines
Sudan
Suriname
Sweden
Switzerland
Syria
Taiwan Province of China
Tajikistan
Tanzania
Thailand
Timor-Leste
Togo
Tonga
Trinidad And Tobago
Tunisia
Turkey
Turkmenistan
Turks And Caicos Islands
Tuvalu
Uganda
Ukraine
United Arab Emirates
United Kingdom
United States
United States Virgin Islands
Uruguay
Uzbekistan
Vanuatu
Venezuela
Vietnam
Yemen
Zambia
Zimbabwe

Appendix Table A2. Robustness Checks

(Dependent variable: Bilateral tourism flows)

	Truncated sample	Sub-sample (1995-2007)	Additional controls	Instrumental variable
Real GDP, origin	0.907***	1.100***	0.995***	0.897***
	[0.050]	[0.082]	[0.063]	[0.033]
Real GDP, destination	0.750***	0.823***	0.989***	0.786***
	[0.045]	[0.069]	[0.067]	[0.032]
Distance	-1.621***	-1.704***	-1.719**	-1.699***
	[0.022]	[0.026]	[0.026]	[0.006]
Common language	1.165***	1.111***	1.214***	1.237***
	[0.046]	[0.056]	[0.055]	[0.014]
Colonial history	1.014***	1.060***	1.008***	0.948***
	[0.149]	[0.142]	[0.144]	[0.036]
Geographical contiguity	1.355***	1.324***	1.332**	1.432***
	[0.137]	[0.136]	[0.138]	[0.025]
Population, origin	0.551***	1.196***	0.596***	0.377***
	[0.88]	[0.158]	[0.119]	[0.059]
Population, destination	0.254**	0.456***	0.444***	0.290***
	[0.083]	[0.136]	[0.118]	[0.050]
Life expectancy, destination			0.704*	
			[0.401]	
Hospital beds, destination			0.047**	
			[0.025]	
SARS	-0.828***	-1.191***	-0.608***	-0.858***
	[0.102]	[0.157]	[0.140]	[0.059]
Number of observations	104,184	54,123	56,587	112,206
Origin FE	Yes	Yes	Yes	Yes
Destination FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.78	0.82	0.82	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 not shown in the table. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Appendix Table A3. Income Groups and Regions (2SLS-IV Estimations)

(Dependent variable: Bilateral tourism flows)

	Advanced	Developing	Africa	Asia	Europe	Latin America	Middle East
Real GDP, origin	0.995***	0.880***	0.886***	0.949***	0.803***	0.762***	1.028***
	[0.017]	[0.023]	[0.043]	[0.054]	[0.053]	[0.049]	[0.057
Real GDP, destination	1.264***	0.638***	0.407***	0.923***	0.335***	0.428***	0.443***
	[0.035]	[0.022]	[0.049]	[0.051]	[0.080]	[0.058]	[0.056]
Distance	-1.385***	-1.810***	-1.533**	-1.778***	-1.563***	-1.798***	-1.426***
	[0.026]	[0.026]	[0.068]	[0.103]	[0.120]	[0.074]	[0.084]
Common language	0.562***	1.400***	1.199***	0.531***	0.336	1.480***	0.457**
	[0.053]	[0.053]	[0.078]	[0.140]	[0.501]	[0.106]	[0.147]
Colonial history	1.174***	0.865***	-0.030	1.513**	-0.183	0.569	0.764*
	[0.083]	[0.178]	[0.574]	[0.522]	[0.254]	[0.941]	[0.451]
Geographical contiguity	0.410	1.562***	1.332**	1.442***	1.420***	1.106***	1.191***
	[0.106]	[0.107]	[0.138]	[0.275]	[0.223]	[0.263]	[0.262]
Population, origin	0.196***	0.586***	0.690***	1.035***	0.968***	0.967***	0.206
	[0.091]	[0.041]	[0.075]	[0.103]	[0.093]	[0.089]	[0.098]
Population, destination	-0.003	0.343***	0.422***	0.680***	0.122	1.271***	0.915***
	[0.055]	[0.035]	[0.091]	[0.172]	[0.127]	[0.179]	[0.062]
SARS	-0.317	-1.109***	-1.472***	-3.736***	-1.544*	-4.462***	-0.615
	[0.135]	[0.212]	[0.446]	[0.622]	[0.576]	[0.630]	[0.406]
Number of observations	72,859	79,744	23,016	15,612	13,073	14,102	13,941
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	0.81	0.84	0.85	0.86	0.85	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 not shown in the table. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

REFERENCES

Anderson, J., and E. van Wincoop, 2003, "Gravity with Gravitas: A Solution to the Border Puzzle," *American Economic Review*, Vol. 93, pp. 170–192.

Bergstrand, J., and P. Egger, 2007, "A Knowledge-and-Physical-Capital Model of International Trade, Foreign Direct Investment, and Foreign Affiliates Sales: Developed Countries," *Journal of International Economics*, Vol. 73, pp. 278–308.

Cooper, M., 2006, "Japanese Tourism and the SARS Epidemic of 2003," *Journal of Travel and Tourism Marketing*, Vol. 19, pp. 117–131.

Egger, P., 2000, "A Note on the Proper Econometric Specification of the Gravity Equation," Economic Letters, Vol. 66, pp. 25–31.

Head, K., and J. Ries, 2008, "FDI as an Outcome of the Market for Corporate Control: Theory and Evidence," *Journal of International Economics*, Vol. 74, pp. 2–20.

Gil-Pareja, S., R. Llorca-Vivero, and J. Martínez-Serrano, 2007, "The Effect of EMU on Tourism," *Review of International Economics*, Vol. 15, pp. 302–312.

Im, K., M. Pesaran, and Y. Shin, 2003, "Testing for Unit Roots in Heterogeneous Panels," *Journal of Econometrics*, Vol. 115, pp. 53–74.

Kuo, H-I., C-C. Chen, W-C. Tseng, L-F Ju, and B-W. Huang, 2008, "Assessing Impacts of SARS and Avian Flu on International Tourism Demand to Asia," *Tourism Management*, Vol. 29, pp. 917–928.

Mayer, T., and S. Zignago, 2011, "Notes on CEPII's Distance Measures: The GeoDist Database," CEPII Working Paper No. 2011-25 (Paris: Centre d'Etudes Prospectives et d'Informations Internationales)

McNeill, W., 1976, *Plagues and People* (New York: Anchor Press/Doubleday).

Richter, L., 2003, "International Tourism and Its Global Public Health Consequences," *Tourism Management*, Vol. 27, pp. 361–393.

Roselló, J., M. Santana-Gallego, and W. Awan, 2017, "Infectious Disease Risk and International Tourism Demand," *Health Policy and Planning*, Vol. 32, pp. 538–548.

Santana-Gallego, M., F. Ledesma-Rodríguez, and J. Pérez-Rodríguez, 2010, "Exchange Rate Regimes and Tourism," *Tourism Economics*, Vol. 16, pp. 25–43.

Santos Silva, J., and S. Tenreyro, 2006, "The Log of Gravity," *Review of Economics and Statistics*, Vol. 88, pp. 641–658.

Snowden, F., 2019, *Epidemics and Society: From the Black Death to the Present* (New Haven, Con: Yale University Press).

Tinbergen, J., 1962, "Shaping the World Economy: Suggestions for an International Economic Policy," *The International Executive*, Vol. 5, pp. 27–30.

Wilder-Smith, A., 2006, "The Severe Acute Respiratory Syndrome: Impact on Travel and Tourism," *Travel Medicine and Infectious Diseases*, Vol. 4, pp. 53–60.

Wilson, M., 1991, *A World Guide to Infections: Diseases, Distribution, Diagnosis* (New York: Oxford University Press).

Wilson, M., 1995, "Travel and the Emergence of Infectious Diseases," *Emerging Infectious Diseases*, Vol. 1, pp. 39–46.

Zeng, B., R-W. Carter, and T. De Lacy, 2005, "Short-Term Perturbations and Tourism Effects: The Case of SARS in China," *Current Issues in Tourism*, Vol. 8, pp. 306–322.