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Epidemiological susceptibility risk and tourist flows around the world

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ABSTRACT

Global tourist flows have increased in recent decades, but so have the outbreak and spread of epidemics, with enormous social and economic costs for the tourism sector. These developments affect the tourists' decisions to travel through their perception of travel risk and safety. Tourists need to assess whether destinations can identify and manage epidemiological risks to improve travel safety. This paper responds to this challenge by constructing an index of epidemiological susceptibility risk using objective information on the quality of health, environmental safety and communications infrastructures, demographics, economic activity, and institutional governance. The index appears to be a significant predictor of inbound tourist flows and occasionally of outbound flows. The effect on inbound flows is stronger in larger countries and weaker for outbound flows. It remains robust after applying sensitivity and endogeneity tests and economic and non-economic controls. The index could potentially provide a useful policy tool for predicting and managing the implications of epidemics on the tourism industry.

Introduction

The outbreak and worldwide spread of infectious diseases threatens the livelihood and health of people (Morse et al., 2012) and the vitality of the tourism sector (WTO, 2009). The resulting social and economic costs are tremendous. Whilst documented for previous disease outbreaks (CDCP, 2020), the costs for the ongoing COVID-19 pandemic are still a matter of speculation. As of the end of June 2020, more than 470 thousands deaths have been registered worldwide and provisional estimates raise the pandemic's economic costs to over USD one trillion for the world economy during 2020 alone (Financial Times, 2020) and to several USD trillion in the coming years (The IMF, 2020). These developments naturally affect the potential tourists' decisions to visit infected destinations and to travel more generally. The impact of epidemiological episodes on tourist flows materializes mainly through the tourists' perception of risk and travel safety (Larsen et al., 2009; Korstanje, 2009). Whilst often being ignorant or inconsiderate, tourists are becoming increasingly aware of these risks and safety conditions and adjust their behavior and choice of destination accordingly.

Given the social and economic costs of epidemics especially for the tourism sector, it is critical to assess whether countries are prepared to identify and respond to these risks adequately so as tourists perceive them as safe destinations to visit (Guevara & Richards, 2020). Despite significant investments in health monitoring and capability globally, many countries remain unprepared to respond and manage the risks of infectious diseases. This paper responds to this challenge by constructing a country-level index of epidemiological

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susceptibility risk, which it subsequently uses to document potential association with tourist flows around the world. This effort aims at the better understanding of how epidemics affect tourist flows. Many factors can affect a country's susceptibility to epidemiological risk. However, in order to produce a measure based on objective and reproducible information with useful policy implications, the construction of the index is restricted to accounting for key relevant factors, such as health infrastructure; environmental safety infrastructure; communications infrastructure; demographics; economic activity; and governance institutions.

The empirical results show that the index of epidemiological susceptibility risk appear to be a potentially significant predictor of inbound flows around the world and affects outbound flows under specific circumstances. The effect remains broadly robust after applying several sensitivity tests, endogeneity analysis and additional economic and non-economic controls. The effect on inbound tourist flow is stronger in larger countries relative to smaller ones but weaker for outbound flows. The index could therefore be a useful tool for tourism policy.

Whilst this is the first research effort, to our knowledge, to link epidemiological susceptibility risk with tourist flows, our paper is related to previous studies regarding the role of risk perceptions (Larsen et al., 2009; Korstanje, 2009; Reisinger & Mavondo, 2005; Wang et al., 2019) and the impact of diseases (Page et al., 2006; Rosselló et al., 2017) for tourism demand. However, previous studies mainly examine the impact of the incidence of specific diseases, whilst our study examines the impact of structural conditions affecting the contagion of diseases. We construct a country-level measure of epidemiological risk that captures diverse conditions, which may affect the contagion of the epidemiological episode and therefore it could potentially be a useful tool for prediction, response and prevention. We believe our analysis is a novel approach to tourism studies and more generally to assessing the importance of risk for people's decisions.

We organize the paper in the following parts: Section 2 offers a brief background literature; Section 3 describes the data and the empirical strategy; Section 4 presents the baseline estimation results; Section 5 applies further checks of robustness; and, finally, Section 6 concludes the paper. An online Appendix includes information on the index's construction and the results of the sensitivity and endogeneity analysis.

Related literature

The impact of epidemiological episodes on tourist flows materializes mainly through the tourists' perception of risk. Risk is a multi-faceted factor influenced by realities, personal experience and perceptions, social interactions, culture and personal judgment (Boholm, 1998; Rogers, 1997; Sjoberg, 2000). Tourism provides alternative venues that expose tourists to new experiences, cultures and facts, thereby affecting their perception of risk (Fischhoff et al., 2004). Accumulating studies of tourist activity have consistently identified several risk factors that critically affect tourists' decisions. Key among them are political instability and conflict (Ioannides & Apostolopoulos, 1999; Mansfeld, 1996); health consequences (Page et al., 2006; Rosselló et al., 2017); crime and unrest (Brunt et al., 2000; Dimanche & Leptic, 1999; Pizam, 1999); terrorism (Sönmez & Graefe, 1998); natural disasters (Mazzocchi & Montini, 2001); and economic crises (Reddy et al., 2020; Ritchie et al., 2010; Song & Witt, 2000).

A key determinant of tourists' risk perception is travel safety. Korstanje (2009) argues that tourist flows depend on tourists' perception of travel safety, which is inversely related to their travel anxiety. Larsen et al. (2009) show that people, prior to travelling, seem to worry more about trips than people who are already travelling, but there is no way to know how people judge the experience from their previous trips. Reisinger and Mavondo (2005) show that cultural orientation and psychographic factors affect people's perception of travel anxiety, which in turn affects their intention to travel internationally. Wang et al. (2019) argue that providing health and safety assurance whilst at travel contributes to tourists' benefit and affects their intensions and actions to travel. Thus, risk perceptions influence tourists' choice of destinations and their intention to travel there (Sönmez & Graefe, 1998). However, the association between travel anxiety, travel safety and tourist activity is mediated by both personal and objective factors. The former include experience from travelling (Lepp & Gibson, 2008); culture and ethnicity (Reisinger & Mavondo, 2005) as well as psychology and personality (Roehl & Fesenmaier, 1992). The latter include geography (Sönmez & Graefe, 1998), media coverage (Page et al., 2006) and advertising (Gabriel & Schubert, 2008), among others. There are different models for assessing the impact of epidemiological episodes on risk perceptions. For example, Abdulkareem et al. (2020) used experiments to show that leader-based groups outperformed intelligent judgment by individuals regarding epidemiological risks and the selection of adjustment strategies. They also argue that social interaction improves individual and group adaptation against epidemiological risks whilst prevalent cultural and social norms determine how social learning works.

The association between health-related risk and tourist flows depends on tourist behavior and exposure. Tourists are constantly exposed to microbial pathogens, which they carry as mere carriers, sufferers and processors. Their arrival/departure can affect destination/origin populations depending on the extent and depth of social interaction subject to existing environmental and health conditions in the destination/origin countries. Tourists try local cuisines, pursue extreme sports, indulge in local habits, hike in the jungles or mountains and engage in various injury-prone or sexual activities that they would not risk at home. Their behavior leads to the transmission of pathogens through body fluid exposure. The extent of mobility, technological progress, and the pattern of travelling affect the spread of microbes and the contagion of disease outbreaks. More and more frequent tourists accelerate contagion if they are early infected and the disease outbreak has not been under control (Hollingsworth et al., 2007). The transport network, the aviation routes, the volume of passengers carried, the speed of transport, and the overall airborne capacity are important determinants of estimating the spread of modern epidemics, whilst travel restrictions and isolation of urban areas are constraints on the spread of epidemics (Hufnagel et al., 2004). With respect to epidemiological contagion, tourism is a feedback loop and not merely a point of origin and destination. Properly designed epidemiological control policies focusing on imposing necessary and timely travel restrictions, establishing effective surveillance systems to detect infected tourists (Guan et al., 2003) and pursuing long-term population immunity through proper vaccination can contain contagion (WHO, 2019).

The extent and containment of epidemiological contagion depends to some extent on the nature of transmitted pathogens. Some diseases have a temporary nature, whilst others are endemic. Both types have huge real consequences, largely felt in the tourism industry. For example, the avian flu (H5N1) outbreak spread in about 60 countries and caused 191 deaths (WHO, 2007) and a reduction of about 12 million tourist arrivals to the Asian and Pacific region (Wilder-Smith, 2006). The outbreak of the severe acute respiratory syndrome (SARS) resulted in about 3 million job losses in the tourism industry associated with revenue losses of about USD 20 billion (World Travel and Tourism Council, 2003). The UK foot-and-mouth disease outbreak resulted in revenue losses of about GBP 7.5 million, a fifth of which was due to the shrinkage of tourist flows (Blake et al., 2003). The outbreak of the Middle East respiratory syndrome (MERS) spread in 27 countries resulting in 858 deaths and USD 16 billion of output loss mostly in the tourism sector (Al Ruthia et al., 2019). The Lyme disease has spread very fast worldwide and has become endemic in the Americas, Asia and Europe, with considerable implications for tourist demand (Donohoe et al., 2015). Moreover, endemic diseases, such as Malaria, Yellow Fever, Dengue, and Ebola, have been transmitted through infected tourists (Freedman et al., 2006; Gautret et al., 2009). Rosselló et al. (2017) study the association between infectious diseases and tourism flows and document significant adverse effects, especially for malaria and yellow fever. Page et al. (2006) note that, owing largely to the excessive media coverage, the outbreak and spread of diseases can often damage the image of a safe tourist destination of affected countries, thereby reducing tourist inflows considerably.

Given the risk posed by infectious diseases on the tourism sector, it is critical to systematically assess the preparedness of countries worldwide and identify destinations that are less able to coordinate and respond to these risks. Resilience of destinations to external shocks is a key factor for their attractiveness (Guevara & Richards, 2020). Despite significant investments in capacity building and health surveillance globally, many countries remain less prepared to manage infectious disease risks. Indeed, few countries fully comply with the World Health Organization's 2005 International Health Regulations (Gupta et al., 2018). These frameworks measure country preparedness based on health-related monitoring functions, which are important but inadequate to capture other factors that are also critical for assessment and decision-making. A more suitable measure would need to account for objective infrastructural, economic and institutional conditions and capacities, which are essential building blocks of an effective monitoring of and response to epidemics of infectious diseases and therefore enter tourists' perceptions of risk and decision-making processes. Accordingly, there is a need to develop a multilevel measure of a country's capability to identify, respond and withstand epidemiological risks.

Recent studies have explored the measurement issue from various perspectives. For example, Zimmermann et al. (2020) argue that the degree of country globalization affects the speed of Covid-19 transmission, where more globalized countries are experiencing faster and more substantial transmission rates. They suggest that temporary inter-country restrictions on human mobility could contain the spread of pandemics. Karabulut et al. (2020) use a revised version of the World Economic Uncertainty Index and document a negative effect on tourist arrivals especially for low-income countries. Demir et al. (2019) use a composite index of geopolitical risk that comprises economic and political instability factors and document its adverse effect on inbound tourist flows for 18 countries.

This paper contributes to the development of a country-level index of epidemiological susceptibility risk, which it subsequently uses it to predict tourist flows around the world. The construction of the index is based on six building blocks: health infrastructure; demographics; environmental safety infrastructure; economic activity; communications infrastructure; and governance institutions. An effective health infrastructure is key for timely detection and containment of infectious tourists at various levels. Early detection requires surveillance capacity and analysis of outbreak patterns for rapidly detecting and tracking the spreading of infectious tourists and hence the resulting surges in the disease (Morse, 2007). This capacity requires international cooperation for monitoring large populations and geographies. Adequate health care financing is a key element of health infrastructure effectiveness (Kruk & Freedman, 2008).

Further, an effective communications infrastructure will improve the surveillance of travelling patterns, raise awareness of the disease and the speed of the private and public response by managing relevant information, tourists and labor mobility and medical supply-chains (Rainwater-Lovett et al., 2016). An effective transportation infrastructure, on the one hand, facilitates the movement of infected tourists but, on the other hand, it also facilitates the response and provision of necessary care.

Moreover, an effective clean water infrastructure provides the necessary means for infected tourists to contain the spread of the disease and for the public health sector response to adhere to high sanitary standards (Phelps et al., 2017). Transmission during a disease outbreak occurs through both the short-cycle (based on the use of local household water) and the long-cycle (based on using natural or fabricated water sources and sanitation systems).

An effective institutional capacity will facilitate the planning and management of response, the efficient allocation of containment resources during an outbreak as well as the coordination of response implementation (Pritchett et al., 2013). Effective public governance structures are important for the identification, prioritization and mitigation of risks. Institutional governance capacity develops slowly; it is subject to political influence and may lead to conflict or insecurity (Gayer et al., 2007). Ineffective governance will seriously impede the containment of an outbreak and fail to provide the necessary coordination required to guide tourists into proper actions. Ritchie and Jiang (2019) stress the importance of developing efficient government policies for tourism recovery after a disaster. Botterill and Mazur (2004) note that institutional conditions of human capital enhancement improve the objective perception and assessment of risks.

Demographics play a role too. The demographic structure of populations across the globe is changing due to declining fertility and increasing life expectancy. This has created smaller households and older populations. The repercussions of these demographic transformations for the structure of tourist flows and the spread and control of infectious diseases have only recently been explored. For example, Geard et al. (2015) find that declining fertility is associated with lower incidence of disease outbreaks but also older age of first infection, mediated by vaccination and other prevention measures. They also stress the increased risk of infection of unvaccinated households and their highly mobile members. A World Tourism Organization report argues that these demographic developments have profound effects on the volume and composition of tourist flows around the world (WTO, 2010). From another perspective, the increasing degree of urbanization, whilst in general associated with better health infrastructure relative to rural areas, provides a fertile ground for the emergence of new pathogens that, due to closer human encounter, create a new potential source of emergence and rapid spread of zoonotic diseases (Neiderud, 2014).

Economic activity also affects the spread of diseases. Adda (2015) finds that disease outbreaks spread faster during economic booms, when people move more and faster, thereby increasing personal interaction. In contrast, Suhrcke et al. (2011) argue that most studies document adverse infectious disease outcomes during economic downturns, due to congestion, worsened living conditions and worsened access to health provision.

Based on the dimensions described above, we construct an index of epidemiological susceptibility risk. The index reflects the extent to which economic and non-economic factors and other structural conditions provide an indication of the degree of a country's susceptibility to epidemiological risk. The key channel of influence is through the tourists' perception of risk. Higher index values imply lower epidemiological susceptibility risk of countries, better perceptions of travel safety and therefore stronger tourist flows. The index might be used as a prediction and policy tool. Then, we use the index to predict inbound and outbound tourist flows.

Data and empirical strategy

The key explanatory variable is the index of epidemiological susceptibility risk, ESR. The index reflects the importance of six building blocks of epidemiological risk: health infrastructure; demographics; environmental safety infrastructure; economic activity; communications infrastructure; and governance institutions. Whilst there can be other important factors, the selected ones and the associated variables are highlighted by the literature, they are objectively measured, have a low incidence of missing values and are reproducible for future use. The ESR index values are available for all countries and years; higher index values imply a lower risk of epidemiological susceptibility. We make the reasonable hypothesis that, as tourists evaluate their experience and face the future health and economic costs of being infected by temporary and endemic diseases during domestic and international travel, they will pay closer attention to the general conditions of epidemiological susceptibility risk of the destination countries and more generally adjust their overall travelling behavior mindful of these conditions. The online Appendix describes the construction of the index in detail. Further Table A3 in the online Appendix presents the average index values for each country.

For the outcome variables, we collect data on annual tourist flows for 188 countries during 2000–2018 from the Yearbook of Tourism Statistics and on annual tourist expenditures from the Compendium of Tourism Statistics (WTO, 2009). In our analysis, the basic outcome variables are the logarithms of the number of inbound (TOURINB) and outbound (TOUROUT) tourists in a country. For purposes of sensitivity testing, later we use the logarithms of the value of tourist expenditures (EXPEND) and receipts (RECPT) as alternative outcome variables.

We further add standard predictors of tourist flows. Song and Witt (2000), Peng et al. (2015), Gunter et al. (2019), Assaf and Tsionas (2019) and Ritchie and Jiang (2019) provide surveys of findings and methods. The surveyed studies analyze the various ways of modelling tourist flows with respect to origin/destination and tourist product/services considerations. Drawing on the literature, we select predictors that we consider relevant for our analysis. First, we account for the impact of the macroeconomic environment at destination, which may be especially pronounced at the presence of episodes of epidemiological contagion. Anggraeni (2017) documents a complex bidirectional relation between tourist flows and economic growth in the ASEAN countries. Akan et al. (2008) argue that economic growth produces more and better-diversified goods and services for tourists in a country thereby stimulating growth of inbound tourism. Xu (2013) find that unemployment in the destination country has a positive effect on domestic tourism demand, because of devoting more time in recreational or physical activity, which is part of the tourist product. Croes et al. (2018) find that business cycles are associated with both domestic and foreign changes in tourism demand. To capture these effects, we use the logarithm of real GDP in the destination country (RGDP), from the Penn World Tables. The variable uses purchasing power parity valuation, which better captures true purchasing power (Heston et al., 2011). We expect a positive sign of the real GDP effect on inbound tourist flow. Moreover, higher domestic real income will also encourage outbound tourism flows due to higher spending power (Song & Witt, 2000).

Second, we account for the role of competitiveness conditions at destination and their effect on the cost of travelling. Garín-Muñoz (2009) and Lim (2006) argued that variations in the price of the tourist product at destination have a significant and negative effect on tourist demand. Otero-Giráldez et al. (2012) showed that persistent increases in the average price level in the destination country have a negative effect on the demand for tourist services. In their survey, Peng et al. (2015) argue that the mostly negative price elasticities documented in various studies demonstrate that rising destination prices discourage tourism demand. To capture the relative price effects, many studies use the relative inflation rates; other studies use hotel price indexes (Narayan, 2004), specific service price indexes (Cheung & Law, 2001), or the weighted prices of the supply chain (Dwyer et al., 2000); whilst more recent studies use the real exchange rates (Croes et al., 2018). In making plans, tourists get information easier and understand better the implications of changes in the exchange rate regimes between their own and the destination countries. In our study, we use the log of the real effective exchange rate (FOREXD) of the destination country, from the World Development Indicators. It is the nominal effective exchange rate (a measure of the value of a domestic currency against a weighted average of several foreign currencies) divided by a price deflator or index of costs and thus it allows taking into account the destination country's relative competitiveness. We expect a negative sign of the real exchange rate effect on inbound tourist flow. On the other hand, a higher real exchange rate of domestic relative to foreign currencies will render destinations cheaper thereby encouraging tourist outflows.

Third, we account for the role of the attractiveness and uniqueness of the destination country. A country's attractiveness raises the tourists' satisfaction from consuming the tourist product during their visit and beyond, thereby affecting the tourists' travel experience. Formica and Uysal (2006) highlighted the role of the quality of the tourist product at destination for tourism demand. Mayo and Jarvis (1981) argued that the attractiveness of the tourist product is often a matter of tourists' perception of satisfaction from consuming it. The existence of heritage sites in a country induces tourism specialization (Arezki et al., 2009), which increases inbound tourist flows. However, the measurement of a country's attractiveness for tourists is not easy. The amount of revenue generated from tourist's visits of cultural sites could be a good proxy, but it is difficult to obtain consistently on a cross-country setting. In this study, we draw on the literature on heritage tourism, which stresses the importance of history and culture as a predictor of tourist demand (Southall & Robinson, 2011). We therefore add the number of UNESCO sites per country (SITE), as a proxy for destination attractiveness. UNESCO provides the data. We expect a positive sign of the heritage effect on inbound tourist flow. Moreover, countries with significant cultural sites may induce larger outbound tourist flows too. Social psychology theory argues that cultural heritage is a key factor influencing people's self-esteem collectively and individually. In a much-cited cross-country study, Vignoles et al. (2014) documented that people base their self-worth on living up to the prevalent values of others within their historical cultural contexts. These collective cultural values appear to exert a stronger influence than personal individual values on their self-esteem. Perdue (2001) further argues that strong self-esteem increases confidence in evaluating the quality of destinations thereby encouraging travelling. Further, Murtagh et al. (2012) document that strong cultural heritage reduces people's perceived threat to their personal identity thereby reducing their resistance to travel to new destinations.

Fourth, we account for the role of the climate conditions. The latter affect the choice of destination, the season/timing of arrival, the length of stay, and the extent of participation in recreational activities (e.g. skiing depends on snowfall) (Hamilton & Tol, 2007; Scott et al., 2012). Climate conditions affect tourism activity through its global effect (e.g. temperature, rainfall), country-specific effect and destination-specific effect (e.g. skiing or coastal locations) (Michailidou et al., 2016). However, the evidence is inconclusive. For example, Hamilton and Tol (2007) and Scott and Lemieux (2010) argue that changes in temperature affect the demand for tourism. Scott and Lemieux (2010) show that higher rainfall adversely affects tourist's willingness to travel. In contrast, Lise and Tol (2002) find that higher precipitation increases the demand for certain recreation activities. Becken (2012) and Taylor and Ortiz (2009) find that precipitation does not affect tourism demand. We therefore add the degree of precipitation (RAINFALL) as a proxy for weather conditions. We also used the temperature, but the variable was collinear with the ESR and therefore excluded from the regression. The World Bank's Climate Change Knowledge Portal provides the data. We expect a negative sign of the extent of rainfall on inbound and outbound tourist flow.

Fifth, we account for the role of financial instability conditions. Hall (2010) classifies different types of crises and argues that both man-made crises and natural disasters affect tourism demand. The potential effects of crises episodes are expected to increase in both frequency and consequences as global tourism volume increases and the global economy becomes more interconnected and prone to more frequent and extensive business cycles. Ritchie et al. (2010) show that the recent financial crisis adversely affected tourism demand in North America. Inbound tourism in Canada recovered due to the Olympic Winter Games in the next year, whilst in Mexico it suffered further due to exchange rate fluctuations, the swine flu pandemic and the adverse weather conditions. Song and Witt (2000) use econometric modelling to produce forecasts of tourism demand under alternative future uncertainty scenaria. Reddy et al. (2020) describe a crisis recovery framework of the tourist industry. In order to assess the impact of crises, we add a binary variable that measures whether a country in a given year suffers from the effects of a systemic financial crisis (CRISIS). A systemic crisis occurs if both conditions are met: first, there are significant signs of financial distress (e.g. bank runs) in the financial system and, second, there are significant financial intervention measures in response to significant losses in the financial system. The World Development

Table 1
Summary statistics.

Variable	Obs.	Mean	S.D.	Min	0.25%	Mdn	0.75%	Max
TOURINB	3223	13.86	2.07	7.00	12.46	13.95	15.45	18.31
TOUROUT	1707	14.54	1.91	7.60	13.46	14.69	15.90	18.82
ESR	3572	−0.03	1.01	−3.64	−0.69	0.19	0.77	1.38
RGDP	3211	11.16	2.10	5.87	9.84	11.05	12.72	16.80
FOREXD	2976	4.60	0.19	3.96	4.54	4.60	4.65	8.02
SITE	3572	6.34	9.72	0.00	1.00	3.00	7.00	55.00
RAINFALL	3553	99.22	72.13	0.77	44.64	83.74	140.32	416.64
CRISIS	3591	0.06	0.21	0.00	0.00	0.00	0.00	1.00
GDPCAP	2738	0.99	0.99	−6.35	0.54	1.16	1.63	4.80
CREDIT	3229	3.47	1.00	−1.68	2.82	3.56	4.20	5.73
GINI	2755	40.82	9.44	16.80	34.30	39.80	47.20	74.30
MALARIA	2583	1.62	4.10	0.01	0.10	0.30	1.10	38.20
TUBERCULOSIS	3538	137.55	191.24	0.00	15.00	56.00	189.00	1280.00
IMMUNITY	2920	89.81	13.42	16.00	87.00	95.00	98.00	99.00
FRAETHN	3515	0.44	0.26	0.00	0.20	0.44	0.66	0.93
FRALING	3515	0.38	0.28	0.00	0.11	0.35	0.63	0.92
FRARLG	3553	0.43	0.23	0.00	0.21	0.45	0.64	0.86
POLITY	2964	3.74	6.35	10.00	−2.00	7.00	9.00	10.00
FREEDOM	3325	59.01	11.70	1.00	51.20	59.20	67.20	86.10
DUAL	3591	0.32	0.47	0.00	0.00	0.00	1.00	1.00
GPR	3591	96.97	50.27	39.49	64.96	81.76	121.54	258.73

Note. The table reports the summary statistics of the variables. The Appendix provides definition of the variables.

Indicators provide the data. We expect a negative sign of the variable on inbound tourist flow. Moreover, adverse domestic socio-economic conditions may discourage tourist outflows due to lower consumer confidence and spending power (Sheldon & Dwyer, 2010), but may also encourage outflows of people seeking, through emigration on tourist visas, better life alternatives elsewhere in terms of jobs, safety and security as well as due to political reasons (Xin et al., 2019).

The analysis of tourism demand should consider the dynamic structure of consumer preferences (Garín-Muñoz, 2006; Song & Witt, 2000). A way to capture dynamic preferences is to include a lagged value of the tourist flows as a regressor. We apply this later as a sensitivity test. We further include a second set of controls later in the analysis to account for additional economic and institutional influences. Table 1 shows the descriptive statistics of all the variables. These statistics show considerable variation among countries. For example, the log values of inbound and outbound tourists exhibit comparable means and standard deviations and large min-max deviation. The epidemiological susceptibility index, ESR, varies considerably between −3.64 (highest risk) and 1.38 (lowest risk) indicating substantial differences among countries. The control variables also exhibit considerable variation across countries.

Many studies of tourist flows between countries use gravity models (Morley et al., 2014). However, gravity models require detailed country-pairs of data, which for some countries is not available or adequate, leading to their exclusion from the estimation. They also do not deal well with the negative or zero values, such as for example is the case with our epidemiological susceptibility index. Finally, from a policy perspective the results of gravity models may not be clear because they luck an exact assumption about the factors driving the gravity incentive. We argue that the capacity and cost of travelling factors of gravity models may not be important when considering the effect of epidemiological contagion on people's travel. Other factors, such as the restrictions (e.g. lockdown or other policies) or the different incentives (e.g. not pleasure, but necessity, or force – the ongoing COVID-19 pandemic provides many examples worldwide) to move, may be decisive. Thus, it would make a better sense to study separately the effects of epidemiological susceptibility risk on the inventive to travel and hence on inbound and outbound tourist flows across countries. The results of the separate analysis will better inform policy-making for each type of flow.

We fit an OLS regression model to estimate the baseline model's parameters (Greene, 2012). The OLS estimates are useful for showing the unqualified correlations in the data and for comparing the parameter estimates of the different structural models applied by the sensitivity and endogeneity analysis. We include fixed effects in the analysis to capture time-invariant (i.e. institutions, religion, geography, etc.) heterogeneity and therefore contain OLS potential estimation bias in relative terms. We also include year effects to capture time factors that commonly influence all countries. We check the robustness of the baseline results by deploying alternative variable measurement, sample structures and estimation methods as part of our sensitivity and endogeneity analysis. We correct standard errors for heteroscedasticity. In the regression, we consider only non-missing observations of our variables. Our estimation model uses the following regression equation:

$$Y_{it} = \alpha + ESR_{it} * \beta_1 + X_{it} * \beta_2 + \mu_{it} \tag{1}$$

The outcome variable Y_{it} represents, alternatively, the logarithms of the number of inbound (TOURINB) and outbound (TOUROUT) tourists in country i in year t; ESR_{it} is the index of epidemiological susceptibility risk in country i in year t; X_{it} is the vector of k country-level determinants of tourist flows used as control variables in country i in year t; and the term μ_{it} is the regression's error term that encompasses the sum of η_j, λ_t and $e_{i,t}$ terms. The term η_i accounts for unobservable country effects, the term λ_t accounts for time effects;

Table 2
Baseline models. ESR and tourist flows by country size.

	Inbound tourists			Outbound tourists		
	All countries	Larger countries	Smaller countries	All countries	Larger countries	Smaller countries
ESR	0.509***	0.676***	0.405***	0.136	0.090	0.303***
	(0.095)	(0.114)	(0.134)	(0.111)	(0.257)	(0.115)
RGDP	0.734***	0.714***	0.849***	0.919***	0.930***	0.958***
	(0.104)	(0.245)	(0.085)	(0.096)	(0.150)	(0.103)
FOREXD	−0.084*	0.117*	−0.137***	0.263***	0.811***	0.216**
	(0.049)	(0.038)	(0.050)	(0.092)	(0.147)	(0.090)
SITE	0.247***	1.736**	0.280***	0.175***	0.271	0.205***
	(0.038)	(0.024)	(0.035)	(0.027)	(0.241)	(0.032)
RAINFALL	0.001**	0.001***	0.001	0.001**	0.001	0.001*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
CRISIS	−0.051**	0.004	−0.091***	0.029	0.077**	−0.003
	(0.025)	(0.048)	(0.029)	(0.022)	(0.035)	(0.027)
Country effects	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.783	0.770	0.782	0.783	0.778	0.780
F-test	2883.204	1347.698	1655.337	2752.283	681.659	1898.124
N	1829	673	1156	1250	375	875

Note. The table reports the marginal effects of the baseline results. The outcome variables are the numbers of inbound tourists (log), TOURINB, and outbound tourists (log), TOUROUT, respectively. The key explanatory variable is the measure of epidemiological susceptibility risk, ESR. Control variables include the log of real GDP of the destination country (RGDP), the log of the real effective exchange rate (FOREXD), heritage sites (SITE), weather conditions in the destination country (RAINFALL) and the incidence of financial crisis (CRISIS). The parentheses report heteroscedasticity-robust standard errors. The sample period is 2000–2018. We split the sample between larger and smaller countries to account for country size effects. We use an OLS model with fixed effects. We do not report the fixed effects. The signs *, **, *** correspond to $p < 0.1$, $p < 0.05$, $p < 0.01$, respectively.

and the term ε_{it} is the residual error term that is assumed to fluctuate across country-years and follow the normal distribution. Due to potential endogeneity bias, we are careful to interpret our estimates as indications not of outright causation but of strength of association between the outcome variables and the regressors. Thus, we may use the terms "cause" or "predict" in the text only to facilitate exposition.

Analysis of the results

The parameter estimates report the marginal changes in the log values of the inbound and outbound tourist flows resulting from changes in the index of epidemiological susceptibility risk across countries. In order to account for potential nonlinear and country-size effects, we estimate the baseline model separately for large and small countries, by splitting the sample by the median country population. Lopez et al. (2006) document considerable differences in epidemiological outbreaks and their repercussions between different populations and regions. We do not include interaction effects to keep the analysis and interpretation simpler. Table 2 presents the baseline estimates. In all models, the ESR index is a positive and strongly significant predictor of inbound tourist flows. Higher values of the index (lower epidemiological susceptibility risk) are associated with higher inbound tourist flows, and vice versa. The effect of ESR on inbound tourist flow is stronger in larger countries relative to smaller ones. The effect on outbound tourist flows is significant only in smaller countries and weaker in magnitude. The index of epidemiological susceptibility risk appears to be a significant predictor of inbound tourist flows but a rather weak predictor of outbound flows. The structural conditions that comprise the ESR index affect the risk perceptions of tourists wishing to travel and therefore their choice of destination. The results corroborate those of previous studies that document a significant association between the incidence of disease and tourism (e.g. Page et al., 2006; Rosselló et al., 2017). Moreover, in order to examine the ESR effect on countries where tourism plays a different role in the economy, we re-estimate the baseline results after splitting the sample between countries in which tourism represents a high share of GDP and those in which it represents a low share of GDP. Table A5 in the Appendix presents the results, which show that the ESR index is significant predictor of inbound tourist flows regardless of the role of tourism in the economy as well as of outbound tourist flows in countries where tourism is an important contributor to the economy. These results are in line with our baseline results. The ESR index may therefore provide a useful tool for predicting the emergence and managing the implications of epidemics, such as the ongoing COVID-19 one, on the tourism industry around the world.

Further, out control variables appear mostly significant with the expected sign. Changes in real GDP in purchasing power parity terms are associated with changes in both inbound and outbound tourist flows in the same direction. The economic power of the destination country acts as a magnet for inbound tourists and provides the income capacity to encourage outbound tourism and vice versa. This maybe the result of the destination country having more resources to spend in improving the tourist product. After all, France and the United States are both the strongest tourist destinations and the richer countries in the world. This finding is in line with those of Anggraeni (2017) and Croes et al. (2018) among others, who stress the interaction between income, economic activity and tourist flows and the importance of business cycles for tourism demand. Further, changes in the real effective exchange rate are associated with inverse changes in inbound tourism flows highlighting a significant competiveness effect, except for large countries where the effect is insignificant. We document the opposite effect for outbound flows. These effects are line with the findings of many previous studies (Peng et al., 2015). The effect of culture and history is also strong. Changes in the number of heritage sites across countries are associated, as expected, with positive changes in inbound tourist flows in those countries and negative ones in outbound flows (Formica & Uysal, 2006; Southall & Robinson, 2011). The effect of weather conditions is rather weak. Higher precipitation appears to discourage both inbound and outbound tourism, but the effect is very weak on average and nonexistent in small countries. Finally, the financial crisis dummy is mostly significant and inversely associated with both inbound and outbound tourism, highlighting the detrimental effect of financial instability of both inbound and outbound tourist flows. In all models, the F-stat is large, indicating that the included fixed effects are significant. However, the robustness of the baseline estimates depends on addressing several potential econometric biases. In order to address these problems, we carry out sensitivity analysis using alternative variable measurement and alternative sample structures as well as endogeneity analysis using instrumental variables methods. The online Appendix describes these tests and presents the results of the sensitivity and endogeneity analysis.

Further robustness checks

The link between epidemiological susceptibility risk and tourist flows is multifaceted. Different origins and destinations undergo different business cycle fluctuations and are subject to different institutional influences. These differences may affect the ESR effect on tourist flows. We apply additional robustness assessments to control for the impact of such diverse conditions. We use different groups of new controls to contain measurement error and potential collinearity bias – we applied correlation checks before including the new controls in each group. We estimate again Eq. (1) to include the separate impact of a country's development conditions; health conditions; social conditions and political conditions. We do not include interaction effects to keep the analysis simpler and the results more easily interpreted.

First, we consider development conditions. Acemoglu and Johnson (2007) stressed the historical importance of diseases for economic development. Eugenio-Martin et al. (2008) argue that economic development is a key condition for tourist attraction. We check the importance of these suggestions by including in the newly estimated model (1) the log level of per capita GDP in purchasing parity terms (GDPCAP), from the Penn World Tables; the log level of total bank credit to the private sector (% GDP) (CREDIT) and the Gini measure of income inequality (GINI), from the World Development Indicators. Second, we consider health conditions. Rosselló et al. (2017) find that widespread diseases adversely affect tourism demand especially in developing countries and the effect is stronger in countries with higher tourist potential. We check the importance of these suggestions by including in the newly estimated model (2) the incidence of tuberculosis (TUBERCULOSIS) and malaria (MALARIA) and the vaccination rate (IMMUNITY) per country. The World Health Organization provides the data. Third, we consider social conditions. Das and Dirienzo (2012) find that ethno-linguistic fractionalization in society adversely affects tourism competitiveness and therefore inbound tourism and the effect is stronger in less developed countries. We check the importance of these suggestions by including in the newly estimated model (3) the degree of ethnic (FRAETHN), religious (FRARLG), and linguistic (FRALING) fractionalization in society. Alesina et al. (2003) provide the data. Finally, we consider political conditions. Antonakakis et al. (2016) argue that the political regime of the destination country affects tourism demand through its effect on the quality of governance and institutions and on the use of resources. They document a significant effect of political institutions. We check the importance of these suggestions by including in the newly estimated model (4) the extent of political autocracy of the state (POLITY), economic freedom (FREEDOM) and allowance of dual citizenship (DUAL). The Polity IV project and the Heritage Foundation provide the data, respectively.

Table 3 presents the results of the new estimation models (1) to (4). The new estimates document that, after accounting for economic and non-economic conditions in countries, the coefficient of ESR remains positive and significant in all models of inbound flows and most models for outbound flows. The effect is insignificant for outbound flows when controlling for social and political conditions. Subject to these additional controls, ESR remains a significant predictor of inbound tourist flows. As expected, both economic strength and financial development encourage inbound flows but only financial development and inequality encourages tourist outflows. Income inequality also has a significant adverse effect on inbound flows but a positive one for outbound flows. The incidence of diseases at destination discourages inbound tourists but only the incidence of tuberculosis discourages outbound tourists. Reasonably, the vaccination rate is important for both inbound and outbound tourists. Moreover, higher ethnic fractionalization at destination discourages tourist inflows whilst linguistic and religious fractionalization have the opposite effect due to higher tolerance conditions. Finally, higher levels of political democracy encourage both inbound and outbound tourist flows. Economic freedom encourages inbound tourist flows but discourages outbound flows. In contrast, dual citizenship encourages both flows. These findings confirm out baseline results and, for the most part, corroborate those of previous studies.

Table 3
Further robustness checks: Role of economic, health, social and political conditions.

	Macroeconomic conditions (1)		Health conditions (2)		Social conditions (3)		Political conditions (4)	
	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound
ESR	0.410***	0.276***	0.259*	0.484**	0.500***	0.136	0.512***	0.149
	(0.122)	(0.106)	(0.151)	(0.189)	(0.094)	(0.111)	(0.127)	(0.112)
GDPCAP	0.044***	0.003						
	(0.009)	(0.009)						
CREDIT	0.248***	0.162***						
	(0.034)	(0.044)						
GINI	−0.272***	1.135***						
	(0.046)	(0.143)						
MALARIA			0.004	−0.092				
			(0.010)	(0.066)				
TUBERCULOSIS			−0.001**	−0.005***				
			(0.001)	(0.001)				
IMMUNITY			0.005**	0.001**				
			(0.002)	(0.001)				
FRAETHN					−7.257***	−7.401***		
					(0.736)	(0.808)		
FRALING					2.952***	0.184		
					(0.351)	(0.301)		
FRARLG					3.786***	2.130***		
					(0.256)	(0.167)		
POLITY							2.466***	3.736***
							(0.431)	(0.528)
FREEDOM							0.941***	−1.415***
							(0.149)	(0.203)
DUAL							9.864***	10.168***
							(1.968)	(1.440)
Control effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.722	0.783	0.775	0.779	0.782	0.783	0.781	0.782
F-test	1628.228	1123.672	1058.083	1407.491	2835.164	2752.283	2111.141	2672.609
N	1252	923	1005	636	1810	1250	1608	1197

Notes. The table reports the marginal effects of the baseline model after accounting for the impact of country-level factors. The outcome variables are the number of inbound tourists (log), TOURINB, and outbound tourists (log), TOUROUT, respectively. The key explanatory variable is the index of epidemiological susceptibility risk, ESR. The parentheses show heteroscedasticity-robust standard errors. The pool sample period is 2000–2018. We use an OLS model. We do not report the fixed effects and the baseline control effects. The signs *, **, *** correspond to $p < 0.1$, $p < 0.05$, $p < 0.01$, respectively.

Conclusions

Global tourist flows have increased rapidly in the recent decades, but so have the outbreak and spread of infectious diseases. The drivers of epidemic risk are likely to continue, whilst additional drivers associated with ecological change and global warming are also likely to exacerbate the risk. The outbreak and worldwide spread of infectious diseases cause tremendous social and economic costs for the global economy and the tourism sector in particular. Epidemics affect the tourists' decisions to travel and their choice of destinations by affecting their perception of travel risk and safety. Given the costs of epidemics, tourists need to assess whether destination countries can identify and manage these risks adequately to improve travel safety. It appears that many destinations remain unprepared to manage epidemiological risks. This paper responds to this challenge by constructing a country-level index of epidemiological susceptibility risk, which it subsequently uses to predict tourist flows around the world. The index uses objective and reproducible information on key factors that are relevant to assess epidemiological susceptibility risk: health infrastructure; environmental safety infrastructure; communications infrastructure; demographics; economic activity; and governance institutions. It captures structural conditions that may affect epidemiological contagion. Previous studies have shown that these factors enter the tourists' decisions on whether and where to travel. Higher index values imply lower epidemiological susceptibility risk, better perceptions of travel safety and therefore stronger tourist flows. Thus, the key channel of influence is through the tourists' perception of risk. The ESR index is a positive and significant predictor of inbound tourist flows, but a weak predictor of outbound flows. The effect on inbound tourist flow is stronger in larger countries relative to smaller ones and weaker in the case of outbound flows. The index effect remains robust after applying several sensitivity tests, endogeneity analysis and various economic and non-economic controls. The index could therefore provide a useful tool for predicting the implications of epidemiological episodes, such as the devastating and ongoing COVID-19 pandemic, on the tourism industry around the world and for managing their consequences on the tourism activity.

CRediT authorship contribution statement

Charilaos Mertzanis: contributed the concept development and methodology.
Avraam Papastathopoulos: contributed in the literature review and presentation.

Declaration of competing interest

The authors have no known conflicts of interest with respect to the content of the paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.annals.2020.103095.

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