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The Effects of Terror on International Air Passenger Transport: An Empirical Investigation®

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Abstract This paper presents a theoretical model (adapted from the structural gravity model by Anderson and van Wincoop, 2003) to capture the effects of terrorism on air passenger traffic between nations affected by terrorism. We then use equations derived from this model, in conjunction with alternative functional forms for trade costs, to estimate the effects of terrorism on bilateral air passenger flows from 57 source countries to 25 destination countries for the period of 2000 to 2014. We find that an additional terrorist incident results in approximately a 1.2% decrease in the bilateral air passenger transport per unit distance while doubling of the *accumulated* terrorist incidents during the past 5 years reduces it by 18%. Terrorism adversely impacts the bilateral air passenger transport per unit distance both by reducing national output and especially by increasing psychological distress, which could be an important contributing factor in perceived travel costs. Last but not the least, we show that the responsiveness of international air travel to terrorism critically depends on the nature of the terrorist attacks. Specifically, international air passenger transport is found to be extremely sensitive to fatal terrorist attacks and terrorist attacks of targets such as airports, transportation or tourists.

Keywords: air passengers, airline industry, gravity equation, international trade, terrorism

JEL: F1, F14, L93

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I. Introduction

A central factor distinguishing terrorism from other major types of violence or intimidation is that it is usually focused by the perpetrators on specific high value targets. An attack that is likely to involve targets of several nationalities is especially attractive for the terrorists because of the international press attention it is likely to garner. Such attention is exactly what the terrorist organizations seek because of a variety of reasons, including raising security concerns in multiple nations, and motivating potential future recruits in different nations who may be sympathetic to the terrorist organization's beliefs. A prime sector offering such a target is international air passenger traffic, which by its very nature, is likely to involve citizens of several nations. Accordingly, an analysis of the effects of terrorism on the international air passenger is important due to its centrality in terrorists' targeting.

By its very nature, the damages from terrorism go beyond the immediate loss of life and property.[1] When a person dies due to random gun violence in a US city, the reaction from the population is usually minor compared to a similar incident that is confirmed to be the work of a terrorist organization. There may be a variety of reasons for this, including the fact that the population may fear that more such attacks may be coming and that they may be vulnerable to those attacks. Whatever the reason for such fear, it is clear that the effects of a terrorist attack go beyond a simple calculation of the immediate economic damages. Our analysis in this paper gets at this issue to some degree, by considering how the threat of terrorism may indeed lead to economic losses, beyond the immediate loss of life and property from an attack. This is important, because only by understanding how terrorism's effects ripple through an

[1] Enders and Sandler (2012) define terrorism as "Terrorism is the premeditated use of or threat to use violence by individuals or subnational groups to obtain a political or social objective through the intimidation of a large audience beyond that of the immediate victims."

economy, can we gauge the amount of national resources we might need to commit to guard against it.

Terrorism adversely impacts international passenger flows for several reasons. First, terrorism generates a strong psychological negative effect on travellers because airlines have been frequent and the deadliest targets of terrorism for a long time. Targeting of popular tourist destinations like Istanbul also creates a strong deterrent for potential travellers. These effects are magnified by a number of factors. First, recent terrorist attacks have become more deadly because terrorists target densely populated and popular locations in major cities to maximize the impact of their attacks. Second, media coverage of terrorist incidents on a regular and repetitive basis reinforces the psychological trauma that terrorism seeks to create.[2] Finally, terrorism may also reduce international travel via general-equilibrium impacts on an economy. For example, terrorism can reduce income levels through macroeconomic disruptions (discussed in more detail in section 2 of this paper), which, in turn, are likely to reduce international travel (Czinkota, Knight, and Liesch, 2010).

We first present a model where terrorism is conceptualized as adding to trade costs. The analysis yields equations (based on various alternative functional forms for trade costs) which we use to investigate the effects of terrorism on international air passenger flows using a sample of 57 source countries and 25 destination countries for the period of 2000 to 2014. Specifically, we estimate the combined effects of terrorism occurring in the pair of source country *and* destination country or, alternatively, the separate effects of terrorism occurring in the source and the destination country on their bilateral air passenger flows. To be clear, we empirically evaluate the effects of terrorism on bilateral flows of air passengers between countries where

[2] It has been shown that people, who spent more time watching the coverage of the September 11, 2001 attacks, had more substantial stress reactions than those who watched less of that coverage (Schuster et al. (2001)). While terrorist attacks are found to have mental health effects on communities geographically distant from the attacks (Whalley and Brewin (2007)), it is also well documented that the negative psychological effects are likely to be decreasing with the distance from the location of the attacks. For example, Schuster et al. (2001) find such a correlation in the case of the 9/11 attacks.

the terrorist attacks occurred. These countries may be or may not be the countries of residence of the terrorist organizations or the countries of residence of most of the victims (Mirza and Verdier (2008)).

We find this research question important for a number of reasons. First, to the best of our knowledge there has been no study looking into the effects of terrorism on bilateral flows of air passengers for a large sample of countries and covering a long and recent period.[3] Second, air transport has been and will remain a vital industry in the global economy for decades to come. According to estimates of The Air Transport Action Group (ATAG) in 2015 the aviation industry transported close to 3.57 billion passengers and supported nearly 63 million jobs worldwide, either directly or through related tourism (9.9 million people work directly in the aviation industry). The aviation industry directly generates about $664 billion worth of value added per year, which is comparable to being ranked as the 21st country in the world in terms of GDP.[4] It is estimated that aviation industry's global economic impact (direct and indirect) in 2008 was USD 3,560 billion, equivalent to 7.5% of that year's world GDP (ATAG, 2008). Air transport has been and is expected to remain a fast and sustainably growing industry in years to come. According to the forecast by the International Civil Aviation Organization (ICAO) the annual growth in international air traffic for the 2008-2027 period is about 5% globally.[5]

The air transport industry's most important contribution, arguably, is its role in facilitating the growth of other industries. For example, air passenger transport is of critical importance for the growth of tourism, because more than 40% of international tourists travel

[3] A study by the International Air Transport Association (IATA) (2011) on the financial impact of 9/11 on aviation focuses only on the impact of 9/11 alone and the aviation industry in general.
[4] More details on the importance of the aviation industry can be found from Facts & Figures of The Air Transport Action Group (ATAG), which are available online at: http://aviationbenefits.org/ and http://www.atag.org/facts-and-figures.html. It is estimated that aviation *indirectly* currently helps sustain $2.4 trillion in economic activity and these figures will more than double in 20 years' time (IATA (2015)).
[5] See Gillen (2009) for more details.

by air (ATAG 2008). Air transport also has positive supply-side spillovers on investment, innovation and productivity. Transport links are an important factor that determines companies' investment, while transport services, including air passenger transport services, help in penetrating distant markets. For example, air passenger transport facilitates face-to-face networking and collaboration between businesses and companies located in different places around the world, which also enhances firm productivity. It is estimated that for the European Union as a whole, the impact of overall air transport usage over the 1994-2004 decade raised the level of underlying productivity by 2.0% and is predicted to raise it by another 0.6% by 2025 (Cooper and Smith (2005)).[6] Finally, since human beings are directly involved in air passenger transport, this sector is most likely to attract terrorists. Accordingly, use of bilateral air passenger flows is most pertinent to the identification of the effects of terrorism on the global airline industry.[7]

We find that terrorism has a particularly strong negative effect on bilateral air passenger transport for long distances. Specifically, an additional *contemporaneous* terrorist incident within a country pair results in approximately a 1.2% decrease in bilateral air passenger transport per unit distance, while doubling of the *accumulated* terrorist incidents in the past 5 years reduces it by 18%. We also find robust evidence that terrorism in the destination country as well as separately in the source country adversely impact the bilateral air passenger transport per unit distance via their negative effects on national output, increased psychological distress, higher costs of bilateral trade and through counter-terrorism related costs. We also show that the responsiveness of international air passenger transport to terrorism critically depends on

[6] Air transport also generates negative environmental impacts such as low air quality, noise and congestion in the vicinity of airports. Yet, these negative effects of air transport are considered to be largely outweighed by its positive spillover effects. Cooper and Smith (2005) referred to these positive effects as the "catalytic effects" of air transport industry.

[7] According to a study by IATA (2011) on the effects of the 9/11 attacks on global aviation, the industry suffered a 6% drop of $22 billion in its revenue between 2000 and 2001. While the 9/11 tragedy was unique and much more severe in terms of its consequences relative to most other terrorist incidents, these estimates clearly reveal the extent to which aviation in general and air passenger transport in particular, can be adversely influenced by terrorism.

the type of terror that hits a country. In particular, we find that the bilateral air passenger transport per unit distance is extremely sensitive to fatal terrorist attacks and to terrorist attacks of targets such as airports, transportation or tourists.

In the next section we provide a review of the related literature. Section III provides a theoretical framework for our empirical analysis. Section IV discusses the data. We discuss our econometric method and analyse the regression results in Section V. Section VI concludes.

II. Related Existing Literature

The literature on the economic consequences of terrorism is extensive. Abadie and Gardeazabal (2008) find that terrorism in a nation leads to significant diversion of foreign direct investment (FDI) to other potential hosts for FDI. They find that a one standard deviation increase in the intensity of terrorism produces a 5 % fall in the net FDI position of the country. Dreher et al. (2011) find that terrorism triggers skilled emigration, while Nitsch and Schumacher (2004), and Blomberg and Hess (2006), find substantial trade reducing effects. For example, a doubling in the number of terrorist incidents over the period 1960 to 1993 is found to be associated with a decrease in bilateral trade among 200 countries by about 4% (Nitsch and Schumacher (2004)) while the presence of terrorism together with internal and external conflict in 177 countries from 1968 to 1999 is found to be equivalent to as much as a 30% tariff on trade (Blomberg and Hess (2006)). Egger and Gassebner (2015) also look at the terrorism-trade nexus, and find much more modest effects, if any.

Terrorism also has significant adverse spillover effects on neighboring nations. Using a sample of bilateral import data from 1970 to 2014 and using different measures of terrorism Pham and Doucouliagos (2016) find that terrorist attacks and accumulated past terrorist attacks in a nation have robust negative spillover effects on its neighbouring nations' imports.

Studies that are closest to our paper are those that look into the effects of terrorism on tourism. Using data for Greece, Italy and Austria, Enders et al. (1992) find that terrorists deter tourism in these countries, and an incident in one nation acts to reduce tourism in neighbouring nations. Using a consumer-choice model Drakos and Kutan (2003) find that, for the period 1996-1999, the tourism industry in Greece and especially Turkey and Israel was sensitive to terrorism and that there were also significant regional contagion effects of terrorism. Arana and Leon (2007) relied on a discrete choice experimental approach and survey data to evaluate the impact of 9/11 attacks on the welfare of tourists. They find that the 9/11 attacks caused a significant decrease in tourists' utility for those deciding upon travel plans for a set of Mediterranean destinations and Canary Islands. They argue that this decrease in utility might be explained by the state of anxiety surrounding the tourism industry. In a recent study Neumayer and Plumper (2016) analyse spatial spillover effects in international tourism as a consequence of transnational terrorist attacks executed in Islamic countries on citizens from Western countries. They find that terrorist attacks on tourist destinations in a country reduce tourist flows to the targeted tourist destinations, and also reduce tourist flows from nations whose citizens have been attacked. In addition, tourism flows from other similar source countries (of tourists) to the same destination countries are negatively affected. .

Although there is some ambiguity, as in the recent work of Egger and Gassebner (2015), the overall message of the literature is that terrorism reduces international trade in goods and also international tourism to varying degrees. However, in spite of its centrality in terms of targeting by the terrorists, the impact of terrorism on international air passenger transport is yet to be carefully analysed. Using the structural gravity approach to trade in services, pioneered by Anderson, Milot and Yotov (2014), itself and extension of Anderson and van Wincoop (2003), we attempt to fill this gap, and complement the extant literature on the economics of terrorism.

III. Theoretical Framework

The theory is adapted from Anderson and van Wincoop (2003), Anderson and Yotov (2010), and Anderson, Milot and Yotov (2014) to the case of passenger air transport services, with trade cost depending on the incidence of terrorism. While the main goal of the paper is to empirically estimate the impact of terrorism on international air travel, the value added of this section is to guide our empirical work in a relatively structural fashion. We arrive at our theoretical predictions (that are empirically investigated in later sections) by performing comparative static exercises on international passenger air transport with respect to terrorist activities in the origin and destination countries.

Denoting passenger transport by the superscript A (since all international passenger transport in this model is going to be by "air," even though domestic transport will be a mix of air, rail and road), let ${X_{ij}}^A$ be the value of passenger transport from country i to country j, i.e., how much passengers spend on traveling from country i to country j. In the case of international passenger transport, i.e., for $i \neq j$, we assume that all of it is air transport. However, when $i = j$, which is domestic passenger transport, a large part is road and rail. While these assumptions affect our results, they are also very realistic. Let ${E_i}^A$ be the total expenditure by passengers on passenger transport from country i to all destinations of the world and ${Y_j}^A$ be the total expenditure by all passengers in the world on travel to all destinations in country j. Note that both of these include internal travel within countries i and j respectively. In addition, let σ be the elasticity of substitution between traveling to any two destination countries. Then our CES sub-utility function for travel from and within country i is given by

$$ {U_i}^A = \sum_j \left[\left({\beta_j}^A\right)^{\left(\frac{1-\sigma}{\sigma}\right)} \left({c_{ij}}^A\right)^{\left(\frac{\sigma-1}{\sigma}\right)} \right]^{\left(\frac{\sigma}{\sigma-1}\right)} \qquad (3.1) $$

where ${c_{ij}}^A$ is the consumption of travel service in the form of traveling from country i to country j.

We denote the price of the passenger transport service bringing people to a destination country (adjusting or controlling for, i.e., net of, additional costs related to distance, security and safety and other kinds of frictions, passed on to passengers) by ${p_j}^{*A}$, while we capture those additional unit costs related to distance, security and safety and other frictions by a factor ${t_{ij}}^A$. Following Anderson and van Wincoop and Anderson and Yotov, we assume an iceberg form for these costs. Then from (3.1), based on the maximization of this subutility subject to given expenditure on passenger transport and its prices, we have

$$ {X_{ij}}^A = \left(\beta_j {p_j}^{*A} {t_{ij}}^A / {P_i}^A\right)^{1-\sigma} {E_i}^A \qquad (3.2) $$

where β_js, as we see above, are share parameters in our utility function and ${P_i}^A = \left[\sum_j \left(\beta_j {p_j}^{*A} {t_{ij}}^A\right)^{1-\sigma}\right]^{1/(1-\sigma)}$ is the CES price index of passenger travel faced by passengers traveling from country j to all world destinations. As mentioned above, this includes passenger travel to other countries (all of which is assumed to be air travel) and passenger travel within the country (that, in addition to air travel, has sizeable portions of road and rail). Market clearance implies that

$$ {Y_j}^A = \left(\beta_j {p_j}^{*A}\right)^{1-\sigma} \sum_i \left({t_{ij}}^A / {P_i}^A\right)^{1-\sigma} {E_i}^A. \qquad (3.3) $$

Let total world passenger expenditure on air travel be $Y^A = \sum_j {Y_j}^A$. Since $\sum_j {Y_j}^A = \sum_i {E_i}^A$, the market clearance condition above implies that

$$ \frac{{Y_j}^A}{Y^A} = \left(\beta_j {p_j}^{*A} {\Pi_j}^A\right)^{1-\sigma}. \qquad (3.4) $$

Here ${\Pi_j}^A = \left(\sum_i \left({t_{ij}}^A / {P_i}^A\right)^{1-\sigma} \frac{{E_i}^A}{Y^A}\right)^{1/(1-\sigma)}$. Summing up both sides, we have

$$\sum_j \left(\beta_j p_j{}^{*A} \Pi_j{}^A\right)^{1-\sigma} = 1. \tag{3.5}$$

In other words, the CES world price index of passenger travel equals 1. Substituting for $\beta_j p_j{}^{*A}$ from equation (3.4) into equation (3.2) and the formulas for the two price indices, $P_i{}^A$ and $\Pi_j{}^A$ we have the following system of equations for the structural gravity model.

$$X_{ij}{}^A = \frac{E_i{}^A Y_j{}^A}{Y^A}\left(\frac{t_{ij}{}^A}{P_i{}^A \Pi_j{}^A}\right)^{1-\sigma}, \tag{3.6}$$

$$\left(\Pi_j{}^A\right)^{1-\sigma} = \sum_i \left(\frac{t_{ij}{}^A}{P_i{}^A}\right)^{1-\sigma} \frac{E_i{}^A}{Y^A}, \tag{3.7}$$

$$\left(P_i{}^A\right)^{1-\sigma} = \sum_j \left(\frac{t_{ij}{}^A}{\Pi_j{}^A}\right)^{1-\sigma} \frac{Y_j{}^A}{Y^A}. \tag{3.8}$$

Note here that $P_i{}^A$ and $\Pi_j{}^A$ are the origin and destination "multilateral resistance" terms respectively, as explained in Anderson and van Wincoop. It is important for our analysis to note that Anderson and van Wincoop show that the same gravity equation and multilateral resistance terms can be derived if the trade costs are non-pecuniary and such costs are directly reflected in the utility function where $c_{ij}{}^A$ terms in the utility function are replaced by $\frac{c_{ij}{}^A}{t_{ij}{}^A}$. This is especially important in our specific context since many of the costs related to terrorism in the case of passenger travel can be psychic (or psychological).

So far the model has been identical to the general framework used in Anderson and van Wincoop, Anderson and Yotov and Anderson, Milot and Yotov, except that we have a specific interpretation of $t_{ij}{}^A$ where it can enter the utility function to reflect psychological costs and affects individual preferences. We now introduce some more aspects that are specifically related to the question we are studying. Let T_i be a measure of the extent of terrorism in country i and T_j be a measure of the extent of terrorism in country j, where $\frac{\partial t_{ij}{}^A}{\partial \mathrm{T}_i} > 0$ and $\frac{\partial t_{ij}{}^A}{\partial \mathrm{T}_j} > 0$. To simplify things in our analysis, let's assume that $\frac{1}{t_{ij}{}^A}\frac{\partial t_{ij}{}^A}{\partial \mathrm{T}_i} = \gamma_i > 0$ for $i \neq j$ and $\frac{1}{t_{ij}{}^A}\frac{\partial t_{ij}{}^A}{\partial \mathrm{T}_i} = \theta_i > 0$ for $i = j$ where $\theta_i < \gamma_i$. The reason for this differential impact is that domestic travel is a combination of air, road and rail, while international passenger travel is all by air in our model by assumption (and mostly by air in the real world), where it is realistic to expect both the pecuniary and non-pecuniary costs to rise proportionally less for road and rail travel than air travel as a result of increase in terrorist activities. Let's say T_i rises for a particular country i, holding the extent of terrorism fixed for all other countries. Using the formula $P_i{}^A = \left[\sum_j \left(\beta_j p_j{}^{*A} t_{ij}{}^A\right)^{1-\sigma}\right]^{1/(1-\sigma)}$, we will see $P_i{}^A$ also rise with T_i but nowhere near the same proportion as the rise in $t_{ij}{}^A$ for $i \neq j$, as $(\beta_i p_i{}^{*A} t_{ii}{}^A)^{1-\sigma}$ is an important element within the summation sign above and, as explained above, $t_{ii}{}^A$ does not rise in the same proportion as $t_{ij}{}^A$ for $i \neq j$.[8] Also, since passenger price indices of all countries enter in a weighted fashion into $\left(\Pi_j{}^A\right)^{1-\sigma} = \sum_i \left(\frac{t_{ij}{}^A}{P_i{}^A}\right)^{1-\sigma} \frac{E_i{}^A}{Y^A}$, there is going to be a negligible rise in $\Pi_j{}^A$. Thus when T_i rises for a particular country i, $\frac{t_{ij}{}^A}{P_i{}^A \Pi_j{}^A}$ also rises for all j. Thus with $\sigma > 1$, from equation (3.6) we have $\frac{\partial X_{ij}{}^A}{\partial \mathrm{T}_i} < 0$ for given $E_i{}^A$, $Y_j{}^A$ and Y^A. Similarly we can also show that $\frac{\partial X_{ij}{}^A}{\partial \mathrm{T}_j} < 0$ for given $E_i{}^A$, $Y_j{}^A$ and Y^A.

We can define the entire utility function as a function of the various subutility functions (one of them being passenger transport) as follows $V_i = \sum_K \left[(B^K)^{\left(\frac{1-\rho}{\rho}\right)}(U^K)^{\left(\frac{\rho-1}{\rho}\right)}\right]^{\left(\left(\frac{\rho}{\rho-1}\right)\right)}$, $\rho > 1$. In the case of passenger transport $K = A$. In this case we have $\frac{\partial E_i{}^A}{\partial \mathrm{T}_i} = \frac{\partial E_i{}^A}{\partial P_i{}^A}\frac{\partial P_i{}^A}{\partial \mathrm{T}_i} < 0$ since $\frac{\partial E_i{}^A}{\partial P_i{}^A} < 0$ and $\frac{\partial P_i{}^A}{\partial \mathrm{T}_i} > 0$. Thus treating $E_i{}^A$ as endogenous, we have $\frac{dX_{ij}{}^A}{d\mathrm{T}_i} < 0$ where the impact

[8] While $p_j{}^{*A}$s are all endogenous, the fall in overall passenger travel demand for each of the various destination countries will be small to negligible in a world with many countries, depending on the size of the country.

is even stronger since people switch away from travel services to other goods and services. In other words, the value of passenger transport from and within a country decreases with terrorism in the country as people there move into other goods and services and away from travel services.

Similarly $\frac{\partial Y_j{}^A}{\partial \mathrm{T}_j} = \frac{\partial Y_j{}^A}{\partial \Pi_j{}^A}\frac{\partial \Pi_j{}^A}{\partial \mathrm{T}_j} < 0$ since $\frac{\partial Y_j{}^A}{\partial \Pi_j{}^A} < 0$ and $\frac{\partial \Pi_j{}^A}{\partial \mathrm{T}_j} > 0$ and that adds to the negative impact of terrorism in the destination country on air travel. In other words, the value of passenger transport into and within a country decreases with terrorism in the country, as people all over the world move into other goods and services and decide to travel elsewhere.

Taking natural logarithms on both sides of equation (3.6), we have

$$lnX_{ij}{}^A = lnE_i{}^A + (\sigma - 1)lnP_i{}^A + lnY_j{}^A + (\sigma - 1)ln\Pi_j{}^A - (\sigma - 1)lnt_{ij}{}^A \qquad (3.9)$$

Substituting origin and destination country fixed effects, $O_i = lnE_i{}^A + (\sigma - 1)lnP_i{}^A$ and $D_j = lnY_j{}^A + (\sigma - 1)ln\Pi_j{}^A$, we have

$$lnX_{ij}{}^A = O_i + D_j - (\sigma - 1)lnt_{ij}{}^A, \qquad (3.10)$$

where we can let

$$lnt_{ij}{}^A = b_0 + b_1\ln(Distance)_{ij} + b_2(Border)_{ij} + b_3(Colony)_{ij} + b_4(Language)_{ij} + b_5(Currency)_{ij} + \varphi(\mathrm{T}_i, \mathrm{T}_j).$$

Based on the equations above, using a panel dataset on bilateral passenger air transport expenditures for several country pairs and over a few years, we can run a regression with time-varying origin and destination country fixed effects, in which case mainly country-pair-specific variables can be used. We will have time subscripts as follows.

$$lnX_{ijt}{}^A = O_{it} + D_{jt} - (\sigma - 1)lnt_{ijt}{}^A$$

Also in that case $\varphi(\mathrm{T}_{it}, \mathrm{T}_{jt})$ cannot be additively separable in T_{it} and T_{jt} since additive separability will make them perfectly correlated with the fixed effects, O_{it} and D_{jt} representing the multilateral resistance terms. For our purpose we use the following function that is not additively separable: $\varphi(\mathrm{T}_{it}, \mathrm{T}_{jt}) = a + b\ln(\mathrm{T}_{it} + \mathrm{T}_{jt})$. We can also go somewhat astructural where in place of the time-varying country fixed effects we have time-invariant origin and destination country fixed effects and the GDPs of both countries that vary over time. In such a case, we can actually have $\varphi(\mathrm{T}_{it}, \mathrm{T}_{jt}) = a + b\ln(\mathrm{T}_{it}) + c\ln(\mathrm{T}_{jt})$ or alternatively, $\varphi(\mathrm{T}_{it}, \mathrm{T}_{jt}) = a + b\mathrm{T}_{it} + c\mathrm{T}_{jt}$. We do several other things in our estimation along these lines to make sure our results are robust. We can also drop the GDP terms to see the effect of terrorism through the destruction of national output.

IV. Data

Data on bilateral air passenger transport between 57 source countries and 25 destination countries for the period 2000-2014 are from the UN Service Trade Database. Those are the source and destination countries for which the data of air passenger transport *and* control variables of the gravity equation is available. Specifically, the data on the transport of bilateral air passenger corresponds to code 211 in the 2010 Extended Balance of Payment Services Classification (EBOPS). Note that EBOPS code 211 of Air Passenger Transport belongs to the EBOPS services that are exchanged between residents and non-residents through Mode 1 (cross-border supply).[9]

Data on terrorism are constructed based on the Global Terrorism Database (GTD) of the University of Maryland.[10] The database includes systematic data on domestic as well as transnational and international terrorist incidents that have occurred during the period 1970 to

[9] For more details on the classifications of different categories of service trade see WTO (2010).
[10] The link to the database is the following: http://www.start.umd.edu/gtd/about/.

2014. Data on standard gravity variables are available from CEPII's gravity dataset. [11] Data on whether the pair of trading partners has a common currency or a common free trade agreement are available from De Sousa's database. [12] Finally, data on military spending of countries in the sample as percentage of their GDPs are available from the World Bank Development Indicator Database.

V. Effects of Terrorism on the International Air Passenger Transport

The gravity specification of bilateral air passenger flows

For our purpose, we rely on the following modified gravity model of bilateral air passenger flows between source country *i* and destination country *j*: [13]

$$Log\left(\frac{AirPassenger_{ijt}}{Distance_{ij}}\right) = \alpha_0 + \alpha_1 Border_{ij} + \alpha_2 Language_{ij} + \alpha_3 Colony_{ij}$$

$$+\alpha_4 FTA_{ijt} + \alpha_5 Currency_{ijt} + \alpha_6 Log(Terror_{ijt}) + \alpha_{jt} + \alpha_{it} + \varepsilon_{1ijt} \quad (5.1)$$

where our explanatory variable of interest is constructed as follows:

$$Log(Terror_{ijt}) = Log(Terror_{it} + Terror_{jt}) \quad (5.2)$$

For gravity specification (5.1), along with the country-pair-specific terror variable as defined by (5.2), we use two measures of *Terror*: the number of terrorist attacks *or* the number of people killed in terrorist attacks in the source country *and* in the destination country. The

[11] The dataset is available from the following link of CEPII, a French Center of Research on the World Economy: http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=8. Based on a method similar to the method CEPII's researchers used we however need to compute bilateral distances between Serbia and Russia and other countries for which the data is not available from the CEPII's database. For this purpose we use the information on the bilateral distance between cities in the world from the following link: http://www.distancefromto.net/.

[12] The link to de Sousa's gravity data on common currency and free trade agreements is the following: http://jdesousa.univ.free.fr/data.htm.

[13] Empirically, the gravity model has been found to be successful in explaining the volume of bilateral trade in services in numerous studies. (Kimura & Lee, 2006 & Anderson et al., 2014). Specifically, Kimura and Lee (2006) rely on the gravity equation to investigate what determines bilateral goods and services trade between 10 OECD member countries and other economies for the years 1999 and 2000, while Anderson et al. (2014) estimate geographical barriers to trade in nine service categories for Canada's provinces from 1997 to 2007. An alternative gravity specification is to include the year dummies and both measures of terrorism in the source country and in the destination country. Egger and Gassebner (2015) use this specification to investigate trade flows in their paper. We later use a modified version of this alternative gravity specification in order to investigate the direct and indirect effect of terrorism on the international air passenger transport.

notations used for these two measures are $Log(Incidents_{ijt})$ and $Log(PeopleKilled_{ijt})$, respectively.[14] It is important to note the following important feature of the data on terrorist incidents from the Global Terrorism Database: 49.64% or 70473 of the total of 141965 terrorist attacks reported by the Global Terrorism Database have zero death toll. As a result, the flow measure of terrorism in logarithm, based on the number of people killed in terrorist incidents in the source country and the destination country (i.e. $Log(PeopleKilled_{ijt})$), is not defined and results in substantial reduction of sample size. This feature of the data needs to be taken into account later when we analyse the results.[15]

As for the dependent and other explanatory variables of gravity equations (5.1) they are defined as follows:

$AirPassengers_{ijt}/Distance_{ij}$: the ratio of value of bilateral air passenger transport between source country i to destination country j to the bilateral distance between them. This is the expenditure on bilateral air travel normalized by distance.

Gdp_{it} and Gdp_{jt} : the Gross Domestic Products of the source country and the destination country in year t.

$Distances_{ij}$: the bilateral distance between the source country of the air passenger flows and the destination country of the air passenger flows.

$Border_{ij}$: the dummy on whether the source country and the destination country share a common border.

$Colony_{ij}$: the dummy on whether the source country and the destination country share a common colonial relationship.

$Language_{ij}$: the dummy on whether the source country and the destination country speak the same language.

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[14] Specifically, using equation (5.2) our main explanatory variables on terrorism are constructed as follows: $Log(Incidents_{ijt})=Log(Incidents_{it} + Incidents_{jt})$ and $Log(PeopleKilled_{ijt})= Log(PeopleKilled_{jt}+ PeopleKilled_{jt})$.

[15] In order to keep observations for which the measure of terrorism in level is zero later in our analysis we also apply gravity specification (5.1) in which a very small number, 0.001, is added to our measure of terrorism.

FTA_{ijt}: the dummy on whether the source country and the destination country are members of a free trade agreement in year *t*.

$Currency_{ijt}$: the dummy on whether the source country and the destination country are members of a common currency area in year *t*.

$Milspending_{it}$ and $Milspending_{jt}$: the military spending as percentage of GDP of the source country *i* and the destination country *j*.

Some discussion of gravity equation (5.1) is warranted. First, we choose as our dependent variable, the value of bilateral air passenger transport per unit of bilateral distance. In other words, we have expenditure normalized by distance on the left-hand side. The use of this dependent variable is reasonable because the effect of terrorism on air passenger transport is likely to be smaller for short distances, since passengers might believe that long distances result in longer flight durations that give terrorists more time to implement their plans. Also, the expenditure per person on a flight increases with distance. Holding constant the number of trips taken, the expenditure on air travel is therefore expected to increase with distance. However, air travel is more easily substitutable by other modes of transport (for example, road, rail or river) for close destinations than for farther destinations, which results in the impact of terrorism to go down with distance. In the absence of data on control variables that can accurately control for the substitution of air transport by other modes of transport the use of expenditure for air passenger transport by distance allows us to address the potential issue of omitted variable bias regarding those control variables.[16] Because of the various forces in play going in different directions leading to an expected lack of a systematic relationship with distance, we decided not to throw in distance on the right-hand side and just have it in the denominator of the left-hand side. By virtue of distance being in the denominator of the left-

[16] The dummy variable on sharing a common border only partially controls for the fact that passengers are more likely to substitute air transport for other types of transport when the destinations are neighbouring countries.

hand side, using distance on the right-hand side as well can show a trivial relationship, which we want to avoid. Note that distance is also expected to be uncorrelated with any of our other right-hand side variables, so that its absence is not expected to bias any other parameter estimates.[17]

Second, in the literature on the gravity model α_{it} *and* β_{jt} account respectively for the multilateral resistances associated with source country *i* and destination country *j* (Feenstra (2004)). The inclusion of these terms reduces the omitted variable bias to the extent that destination-year specific factors or source-country-year specific factors may correlate with the explanatory variables of interest, i.e. the terrorism in the source country *and* terrorism in the destination country.

Flow and Stock Measures of Terrorism

For our purpose, we use both the *flow* measure and the *stock* measure of terrorist incidents taking place in the source country of and the destination country for air passenger flows. The flow measure corresponds to the total number of terrorist attacks or the number of terrorism-related human casualties in year *t* while the stock measure is the accumulated terrorist incidents or the accumulated terrorism-related human casualties in year *(t-5)* to year *(t-1)*.

Specifically, we construct flow and stock measures of terrorism using the number of total confirmed fatalities including all victims and attackers who died as a direct result of the incident (*People Killed*) or the number of terrorist incidents (*Incidents*).[18] We use the following formula to compute the *stock* measures of terrorism in the source country and in the destination country for the international air passenger flows, respectively:

[17] We however show that the use of the expenditure for air passenger transport as our dependent variable, with distance on the right-hand side, yields very similar results.

[18] For robustness we also construct flow and stock measures of terrorism using the following information: the number of terrorist incidents/attacks in which the primary effects are caused by either high or low explosives (including a dirty bomb) but does not include a nuclear explosive device; the number of terrorist attacks in which arms are used or the number of terrorist incidents/attacks in which either biological or chemical weapon or explosives/bombs or firearms are used.

$$Stock\_Terror_{v,(t-1)} = \sum_{i=1}^{i=5}(1.2 - 0.2 * i)Terror_{v,(t-i)}$$

where v denotes either the source country or the destination country. Thus, terrorist incidents of years (t-5) to year (t-1) are accumulated in the stock measure of terrorism with a discount rate of 20%.[19] It is reasonable to argue here that the accumulated past terrorist incidents up to year (t-1) taking place in the neighbors of a country have effects on its bilateral travels that are likely to be psychological. The reason is that people usually have short memories and that the media broadcast more recent terrorist incidents than older ones, and hence it is expected that recent terrorist incidents have a larger adverse impact on bilateral air passenger flows.[20] As a robustness check, we later accumulate the terrorist incidents of the past 10 years with a discount rate of 10%.

Terrorism in the World from 1970 to 2014

Figure 1 presents the evolution of terrorism from 1970 to 2014 in two categories: the total number of terrorist incidents and the total number of people killed in the world. A noticeable pattern is that from the start of our sample, 2003, and especially from 2010, terrorism has become much more frequent. Specifically, the number of terrorist incidents has increased approximately by a factor of five from 2003 to 2014. The number of people killed in terrorism related incidents also has been increasing exponentially. Table 2 shows that in 2014 the world recorded more than 16000 terrorist attacks, which was by far the highest number of terrorist attacks for the period 1970 to 2014. In 2014 more than 43500 people were killed in terrorism related attacks, which is 4 times (or more) the global death toll in any year during the period

[19] Using *monthly* data of trade and international terror Egger and Gassebner (2015) give equal weight to all the years when they compute their stock measure of terrorism. As a robustness check we later construct our stock measure of terrorism in the same way as Egger and Gassebner (2015) and the regression results remain essentially the same.

[20] As a robustness check we later compute the stock measures of terrorism by accumulating terrorist incidents of the last ten years with a discount rate of 10%. The regression results remain essentially the same.

2003-2010. Figure 2 shows that terrorism generally has become more deadly over time. The number of people killed per terrorist attack has been following an upward trend. Finally, Figure 3 graphically shows the annual number of terrorist attacks on the world map. We compute this number as the averages of the period 1970 to 2014. The map shows that regions in which terrorism has been active the most are the Middle East, India, Pakistan as well as the United States and Russia.

Effects of Terrorism on Bilateral Flows of Air Passengers: Analysis of the Regression Results

Our regression results of the gravity specification (5.1) are presented in columns 1 to 4 of Table 3. The first two columns report results using the flow measures of terrorism: the logarithm of the sum of terrorist attacks or of the sum of people killed in the source country *and* the destination country. The results show that the gravity specification performs well. Factors such as sharing a common border, having a common colonial relationship, and being members of a regional free trade agreement, have a positive and statistically significant effect on the bilateral passenger transport per unit of distance.

The results show that both the flow and the stock measures of terrorism based on the number of terrorist incidents taking place in the source country and the destination country together have a statistically significant negative effect on the value of bilateral air passenger transport per unit distance. The flow and the stock measures of terrorism based on the number of people killed in the terrorist attacks have a negative but not statistically significant effect on the value of bilateral air passenger transport. As expected, the number of observations is substantially reduced in this case, which potentially explains the reduction in the precision of the regression estimates of the effect of terrorism.

When the estimates of terrorism on the bilateral air passenger transport are found to be negative and statistically significant the regression results mean specifically that a 100% increase in the number of terrorist incidents results in a 13.6% reduction in the value of bilateral air passenger transport per unit bilateral distance. Equivalently, an additional terrorist incident causes the bilateral air passenger transport per unit distance to decrease by 1.2%. [21] Similarly, a 100% increase in the *accumulated* terrorist incidents in the past 5 years or equivalently 34 additional accumulated terrorist incidents results in an 18% decrease in the value of bilateral air passenger transport per unit of bilateral distance.[22]

Next, we estimate a slightly modified version of gravity specification (5.1) with the standard bilateral air passenger transport as our dependent variable and the bilateral distance in log as an added explanatory variable. We want to show that this slightly modified gravity specification yields results that are qualitatively very similar to the results obtained earlier using our preferred gravity specification (5.1). The results presented in Online Appendix Table 1 strongly support our argument. [23] Bilateral distance reduces the value of bilateral air passenger flow. Both contemporaneous terrorist attacks and accumulated terrorist attacks adversely and significantly impact the bilateral air passenger transport. The coefficient estimate of the dummy on common border is smaller with the bilateral distance being included than with the bilateral distance being excluded. This is in line with our expectation because a country is generally located at closer distance to its neighbours than non-neighbours ones. As a result when the variable on the bilateral distance is excluded the coefficient estimate of the variable on common border picks up also some positive effect of closer bilateral distance on air passenger transport per unit distance.

We next carry out a number robustness checks and the results are presented in Table 4. Columns 1 to 4 present the results when we use lagged values of our measures of terrorism as

[21] Note that according to Table 1 the mean of the number of terrorist incidents in the source country *and* the destination country, $Incidents_{ijt}$, is 11.51212 (i.e. $e^{2.4434}$). Thus, an increase of $Incidents_{ijt}$ by 100% or by 11.51212 results in a 13.6% decrease in the air passenger transport per unit distance or equivalently an additional terrorist incident is associated with approximately a 1.2% (i.e. 13.6/11.51212) decrease in the air passenger transport per km.

[22] According to Table 1 the mean of accumulated past terrorist incidents during the past five years is $e^{3.5306} \approx 34$.

[23] The online appendix is available at http://faculty.maxwell.syr.edu/dmitra/PMB_OnlineAppendix.pdf.

our explanatory variable. Columns 5 to 8 present the regression results when the main explanatory variable of interest is the flow and stock measures only of terrorist attacks with the use of explosive, bombs and dynamite or the flow and stock measures of human casualties from this type of terrorist attacks. In general, the gravity estimates are sensible. Terrorism generally is found to reduce the value of bilateral air passenger transport per unit distance. As before, lagged terrorist incidents, or, the accumulated terrorist incident of the last five years, in the source country *and* the destination country, is found to reduce the value of bilateral air passenger transport by unit distance.

As already mentioned, the use of the measure of terrorism in log, substantially reduces the sample of data used for our analysis. In order to check the sensitivity of our results to sample sizes as an additional robustness check, we also estimate gravity specification (5.1) when we add a small value of 0.001 to our measure of terrorism. The new set of results which is presented in Online Appendix Tables 2 and 3 show that the effects of contemporaneous terrorist attacks and especially accumulated past terrorist attacks remain significant.

Exploring Possible Channels via Which Terrorism Impacts Bilateral Air Passenger Transport

As already mentioned, gravity specification (5.1) represents an evident methodological advantage. It helps to address issues of the endogenous relationship between terrorism and bilateral air passenger transport. Note that there exist two major sources of endogeneity in the relationship between terrorism and the value of air passenger transport per unit distance. The first source of the endogenous relationship between terrorism and bilateral air passenger transport results from the fact that countries for which international air passenger transport accounts for a larger component of their GDP are likely to have a larger incentive to increase their counter-terrorism spending, and to adopt counter-terrorism measures in their fight against terrorism. As the second source of endogeneity, terrorists are likely to have a greater incentive to target countries that engage in more economic activity. This includes tourism activity, and hence these nations are major destinations for or/and major sources of air passenger transport.. The inclusion of source country-year dummies and destination country-year dummies (i.e. α_{it} *and* α_{jt}) in gravity specification (5.1) takes care of these two sources of endogeneity.[24] Yet, the advantage inherent in gravity specification (5.1) due to the inclusion of α_{it} and α_{jt} comes at the cost of limits that are imposed on applicable econometric strategies that can explore channels via which terrorism affects bilateral air passenger transport. We next explore how terrorism affects bilateral air passenger transport (partially) through its impact on economic activity, and also whether the impact of terrorism on air passenger transport depends on the levels of development of the source country and the destination country. For example, does terrorism reduce the bilateral air passenger transport via the negative effect it has on the GDPs of the source and the destination countries or/and separately via other negative effects originating from increasing psychological distress and bilateral trade costs? Does the impact of terrorism on bilateral air passenger transport per unit distance depending on the GDP per capita (level of development) of the source and/or the destination country? For example, richer countries can afford greater counterterrorism and national security expenditures.

In order to further investigate how the effects of terrorism operate we apply the following slightly modified versions of gravity specification (5.1):

$$Log\left(\frac{AirPassenger_{ijt}}{Distance_{ij}}\right) = \beta_0 + \beta_1 Log(GDP_{jt}) + \beta_2 Log\big(GDPC_{jt}\big) + \beta_3 Border_{ij}$$
$$+\beta_4 Language_{ij} + \beta_3 Colony_{ij} + \beta_4 FTA_{ijt} + \beta_5 Currency_{ijt}$$
$$+\beta_6 MilitarySpending_{jt} + \beta_7 Incidents_{jt} + \ \beta_8 * Log(GDPC_{jt}) * Incidents_{jt}$$
$$+\beta_{it} + \varepsilon_{3ijt} \tag{5.3}$$

[24] In the literature of the gravity equation both α_{it} and α_{jt} are said to control for the multilateral resistances that may correlate with the exporter-specific measure of terrorism and the importer-specific measure of terrorism.

$$Log\left(\frac{AirPassenger_{ijt}}{Distance_{ij}}\right) = \delta_0 + \delta_1 Log(GDP_{it}) + \delta_2 Log(GDPC_{it}) + \delta_3 Border_{ij}$$

$$+\delta_4 Language_{ij} + \delta_3 Colony_{ij} + \delta_4 FTA_{ijt} + \delta_5 Currency_{ijt}$$

$$+\ \delta_6 MilitarySpending_{it} + \delta_7 Incidents_{it} +\ \delta_8 * Log(GDPC_{it}) * Incidents_{it}$$

$$+\delta_{jt} + \varepsilon_{4ijt} \qquad (5.4)$$

where GDP, GDPC denote Gross Domestic Product and Gross Domestic Product per capita, respectively and β_{it} and δ_{jt} are source country-year dummies and destination country–year dummies, respectively.

Gravity specifications (5.3) and (5.4), which are more flexible forms in some respects than gravity specification (5.1), allow us to achieve a number of goals. First, we can estimate both gravity specifications (5.3) and (5.4) with and without *Log(GDP$_{jt}$)* (or *Log(GDP$_{it}$)*) and *Log(GDPC$_{jt}$)* (or *Log(GDPC$_{it}$)*) in order to explore if the effect of terrorism operates through the destruction of national output. Second, gravity specifications (5.3) and (5.4) include an interaction between our measure of terrorism with GDP per capita in log of the source country or the destination country, which allows us to explore if the effect of terrorism depends on the level of their development. Note that our measure of terrorism is the number of terrorist incidents in the source country or in the destination country. Given the presence of observations with zero terrorist attacks we here use the variable in levels in order to have a large sample size.[25]

With the exclusion of destination country-year dummies, β_{jt} , and the source country-year dummies, δ_{it}, in gravity specifications (5.3) and (5.4), respectively we need to address the two sources of the endogenous relationship between terrorism and the bilateral air passenger

[25] Most studies on the effects of terrorism on international trade use measures of terrorism in level. As a robustness check we also use the number of terrorist attacks in log when we include a small value of 0.001 to preserve our zero observations. The results are presented in Online Appendix Table 4.

transport. It is our econometric strategy to control for the first source of endogeneity by including, as an additional explanatory variable, military spending as percentage of GDP of the destination country (i.e. $MilitarySpending_{jt}$) or the source country ($MilitarySpending_{it}$).[26] Note that military spending is a reasonably good proxy for counter-terrorism spending to the extent that counter-terrorism, by definition, incorporates the practice, military tactics, techniques, and strategy that government, military, law enforcement and intelligence agencies use to combat of prevent terrorism.[27]

While we leave unaddressed the first source of endogeneity, we are comforted by the fact that if terrorists have a greater incentive to attack countries more actively taking part in international air passenger transport, this source of endogeneity results in a downward bias of the effects of terrorism on our estimates.[28] In other words, our estimates are likely to provide the lower bounds of the true effects of terrorism on the international air passenger transport.

The new set of results is presented in Table 5. All the coefficient estimates on standard gravity variables are expected and sensible. Military spending of the source country or the destination country helps to increase its bilateral air passenger transport per unit distance. Terrorist attacks, in flow or in stock, significantly and adversely impact the dependent variable at levels of GDP per capita below a certain threshold (as captured by the positive coefficient of the interaction between terrorism and GDP per capita in the presence of a negative coefficient estimate of the pure level term in terrorism). Abstracting from interaction with the level of development (focusing on the component of the impact of terrorism that is completely

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[26] Using lagged values of military spending as one of our robustness check we later obtain very similar results.

[27] Note also that the advantage of using data on military spending is that it is available for all countries and years of our sample. As a robustness check we also use data on government expenditure of OECD countries for public order and safety. The data is available only for a smaller sub-sample of our data. The online link to the OECD database is: https://stats.oecd.org/Index.aspx?DataSetCode=SNA_TABLE11.

[28] See Appendix A3 for an illustration of why the second source of endogeneity will provide lower bounds for estimates of the negative effect of terrorism.

autonomous of income), an additional terrorist attack in the destination country results in close to a 17.6% reduction in the bilateral air passenger transport per unit distance (column 2). However, using the upper bound of per capita income for low income countries ($1000), the effect, incorporating the interaction term, gives an effect of an additional terrorist attack of 4% reduction in the value of passenger air travel per unit distance. For lower middle income countries ($1000-$4000), the effect lies in the range of 2-4%.

Importantly, a comparison of the regression results (abstracting from the interaction term and focusing on the impact that is autonomous of income) shows that the effects of terrorism (abstracting from the interaction term) indeed are larger when GDP and the level of per capita GDP of the source country or of the destination country are excluded. For example, columns (1) and (2) in Table 5 show that the coefficient estimate on the pure level term of the flow measure of terrorism in the destination country is -0.472 compared to -0.176, when GDP and the per capita GDP are included. The effects of terrorism on the ratio of bilateral air passenger transport to bilateral distance remain statistically and economically significant. In other words, terrorism reduces bilateral air passenger transport via both its destructive effect on the GDP as well as through channels such as negative effects of increasing psychological distress, increasing trade costs due to counter-terrorism measures etc. That is why introducing GDP and GDP per capita reduces the size of the coefficient of the terrorism variable, which nevertheless still remains significant.

The results in Table 5 also show the coefficient estimates on the interaction of our variable of terrorism with per capita GDP or the source country or the destination country is positive and statistically significant at 1% level. This suggests that the negative effects of terrorism are decreasing in per capita GDP or the level of development of the source country or the destination country.[29]

In order to check the sensitivity of our regression results in Table 5, we carry out two robustness checks. First, we also apply regressions (5.3) and (5.4) when a small value of 0.001 is added to our measure of terrorism. These regression results, which are presented in Online Appendix Table 4 are strongly in line with our findings earlier. Terrorism in the destination country is found to substantially reduce its bilateral normalized air passenger transport. As our second robustness check, we run regressions (5.3) and (5.4) for a subsample of source and destination OECD countries for which data on government expenditure on public order and safety are available. Note that with the data on government expenditure on public order and safety, the sample size decreases substantially by almost 45%. The regression results which are presented in Online Appendix Table 5 show that the negative effects of destination country terrorism found earlier remain. However, we don't find evidence of negative effects of source country terrorism, a result that can be explained by the reduction in sample size.

Next, we make additional efforts in order to improve the identification of the effects of terrorism. First, we focus on estimating the effects of terrorist attacks with targets that are likely to impact the behaviour of air passengers the most or the least. First, we look into the impact of terrorist attacks with the use of bombs and explosive devices as the attack types. If terrorist attacks adversely impact the air passenger transport, it must be true for this type of terrorist incidents. The results show that those attacks indeed reduce the bilateral air passenger transport. Bombs and explosive devices are likely to generate significant destructive effects on the direct

[29] This is probably due to increases in counterterrorism expenditures and efforts that rise with incomes. At high income levels the overall partial derivative of passenger air transport with respect to terrorism can turn positive, which means that the increase in counterterrorism and national security efforts and expenditures in response to terror can more than offset the direct impact of terror on air transport. In other words, the reassurance provided to passengers through these efforts more than makes up for the impact of terror and this happens more and more as we move to richer and richer countries.

targets of the terrorist attacks, including people and facilities. In addition, such damages will also have serious indirect psychological effects on air passengers. The first set of regression results using this measure of terrorism is presented in Table 6. To save space, we choose to report only the coefficient estimates on our main variable of terrorism and its interaction with per capita GDP of the source country or of the destination country.[30] The results show that terrorist attacks with the use of bombs and explosive devices adversely impact bilateral air passenger transport (at below threshold levels of source and destination country GDPs). This result is robust and holds whether terrorism is measured in flow or in stock. Again, the pure level term coefficient estimates of terrorism on the air passenger transport per unit distance in the destination country, are much larger than those corresponding to the source country. As expected, the negative effects of terrorism with the use of bombs and explosive devices on the bilateral air passenger transport per unit distance is larger than the negative effects of terrorist attacks in general.

We now examine the extent to which terrorist attacks adversely impact the bilateral air passenger transport depending on the death toll. To the extent that air passenger transport involves passengers moving by air from one place to another, these passengers may be the direct targets of terrorism. Consequently, international air passengers are likely to be sensitive to the severity of terrorist attacks or their death toll. For this purpose, we make a distinction between fatal terrorist attacks and non-fatal terrorist attacks. A terrorist attack is considered to be fatal if it has any human casualties. As already mentioned, almost half of the terrorist incidents have zero death toll.

The regression results on the effects of non-fatal terrorist attacks and fatal terrorist attacks in Table 6 show that the negative effect of terrorism is robust and significant regardless

[30] Coefficient estimates on standard gravity variables are robust, sensible and qualitatively very similar to those we obtain in Table 6. They are available upon request from the authors.

of its death toll. Importantly, the coefficient size of fatal terrorism is three to four times than that of non-fatal terrorism. This is especially the case for fatal terrorist attacks in the destination country. This finding of a much larger effect of fatal terrorist attacks confirms our expectation that passengers are very sensitive to the human casualties of terrorist attacks. Taken together, all the results suggest that the psychological factor is an important determinant of the bilateral air passenger transport.

We next evaluate the impact of terrorist attacks with use of biological and chemical weapons. To the extent that terrorist attacks of this type not only may cause high death toll but also generate psychological effects on those who may not be the direct targets of these attacks we expect to find evidence of negative effects of terrorist incidents with the use of biological and chemical weapons The new set of results in Table 6, when we focus on the income-autonomous part of the impact (thereby focusing on countries below a threshold level of income), shows that terrorist attacks with these weapons significantly reduce the bilateral air passenger transport by unit distance.

As our last effort to identify potential channels via which terrorist attacks adversely impact the bilateral air passenger transport, we now examine the extent to which terrorist attacks of sensitive targets such as airports, transportation and tourists influence the international air passenger transport. It is our expectation that air passengers pay much more attention to terrorist attacks of those targets than others. The reason is that air passengers are more likely to become victims of terrorist attacks if these attacks are directed against these targets. The new set of results is presented in the last part of Table 6 is very much in line with our expectation. Focusing once again on the autonomous part of the income, the results show that terrorist attacks of those targets substantially reduce international air passenger transport. This is especially true in the case of terrorism occurring in the destination country whether we use the flow measure or the stock measure of terrorism. It is important to note that the coefficient estimates on negative effect of this category of terrorist attacks is largest in magnitude. This finding suggests that terrorist attacks directed at locations such as airports and tourists are likely to cause the most harm to the world airline industry.

It is important to note that throughout Table 6 we find a positive estimated coefficient of the interaction between per capita income and the incidence of terrorism, As discussed in the case of Table 5, this indicates that the negative effect of terrorism goes down with income due probably to increases in counterterrorism expenditures and efforts that rise with incomes.[31]

VI. Conclusion

This paper presents a model of the effects of terrorism on international flow of air passenger traffic. The empirical analysis uses the model's structure to estimate an augmented gravity model. We include both the source country-year dummies and the destination country-year dummies and empirically evaluate the effects of terrorism in the pair of source country *and* the destination country combined on their bilateral air passenger transport per unit distance. We find that terrorism measured as the number of contemporaneous terrorist incidents occurring in the source country and the destination country combined or the number of accumulated past incidents in that country pair adversely and significantly impacts the value of bilateral air passenger transport (per unit distance). An additional terrorist incident reduces it by 1.2%. Similarly, a 100% increase in the *accumulated* terrorist incidents in the past 5 years or equivalently 34 additional accumulated terrorist incidents results in an 18% decrease in our bilateral air passenger transport variable. In other words, our results suggest that while terror

[31] As discussed in a previous footnote (in the context of Table 5 results), at high enough income levels the overall partial derivative of passenger air transport with respect to terrorism can turn positive, which means that the increase in counterterrorism and national security efforts and expenditures in response to terror can more than offset the direct impact of terror on air transport. As discussed above, the reassurance provided to passengers through these efforts more than makes up for the impact of terror and this happens more and more as we move to richer and richer countries.

clearly reduces bilateral air passenger transport, this effect is especially pronounced for pairs of the source country and destination country that are geographically located further away from each other.

This paper also attempts to look into potential channels via which terrorism adversely impacts the bilateral air passenger transport per unit distance. We find that terrorism reduces it both by its negative effect on national output and by psychological negative effects or the effect of terrorism on bilateral trade costs. Our findings suggest that both channels are equally important. While terror both in the source country and the destination country significantly and adversely impacts its air passenger transport, the destination country impact is stronger. Importantly, we find the adverse effects of terror on bilateral air passenger transport is decreasing on the level of development of the source and destination countries. More in-depth future research needs to be done to explore specific factors behind this finding.

Last but not the least, we show that the identification of the effects of terrorist attacks critically depends on the severity of their death toll and on the nature of their targets. Specifically, bilateral air passenger transport is much more sensitive to fatal terrorist attacks than to non-fatal terrorist attacks. This is consistent with the widespread sense of vulnerability, at least in the short run, amongst tourists contemplating trips to prominent destinations such as Paris or Istanbul where high profile fatal terrorist attacks have occurred in the recent past. Along similar lines, we also find strong evidence that air passenger flows per unit distance are much more adversely impacted by terrorist attacks with targets such as airports, transportation and tourists than by terrorist attacks of other types.

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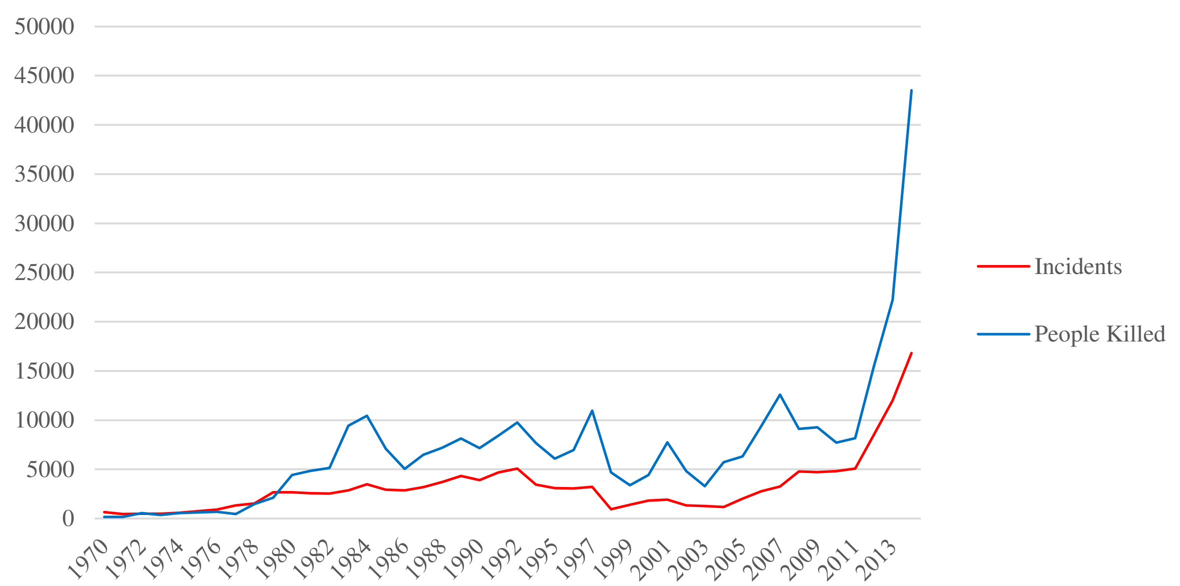
Figure 1: Terrorism in the World 1970-2014



Notes: (1) The statistics are computed by the authors based on Global Terrorism Database (GTD).
(2) *Incidents* denotes the number of terrorist incidents/attacks taking place anywhere in the world. *People Killed* denotes the number of total confirmed fatalities including all victims and attackers who died as a direct results of the incident.

Figure 2: Number of People Killed per Terrorist Attack

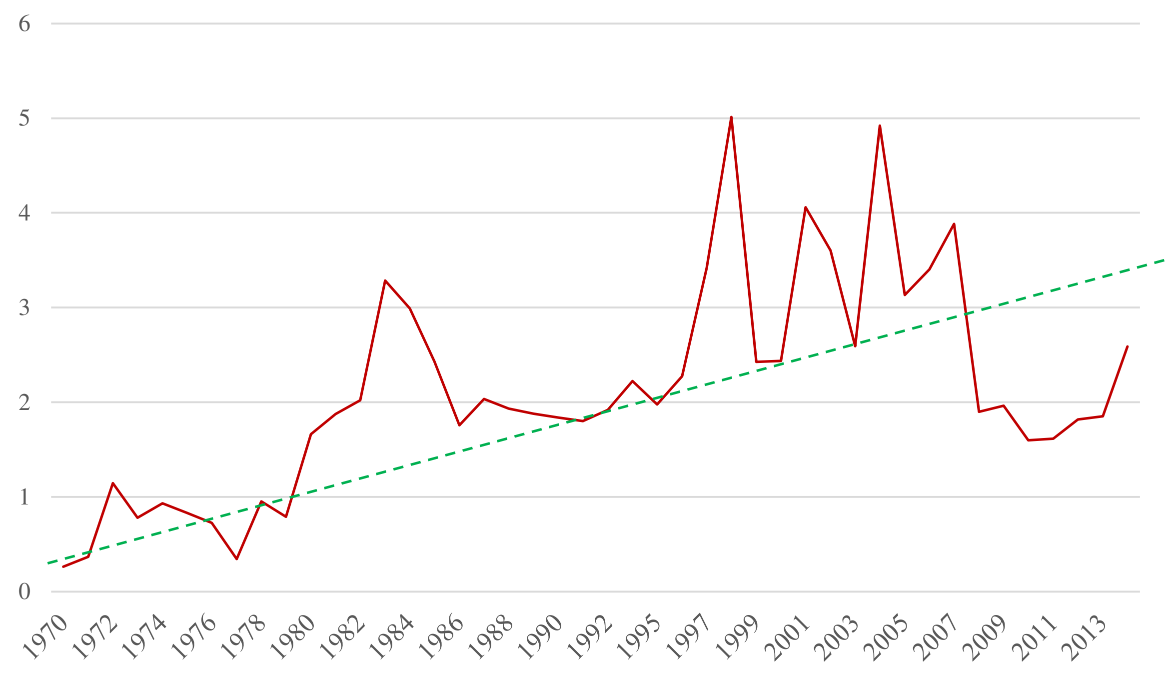


Figure 3: World Map of Terrorism Intensity

Annual averages of the number of terrorist incidents for the 1970-2014 period

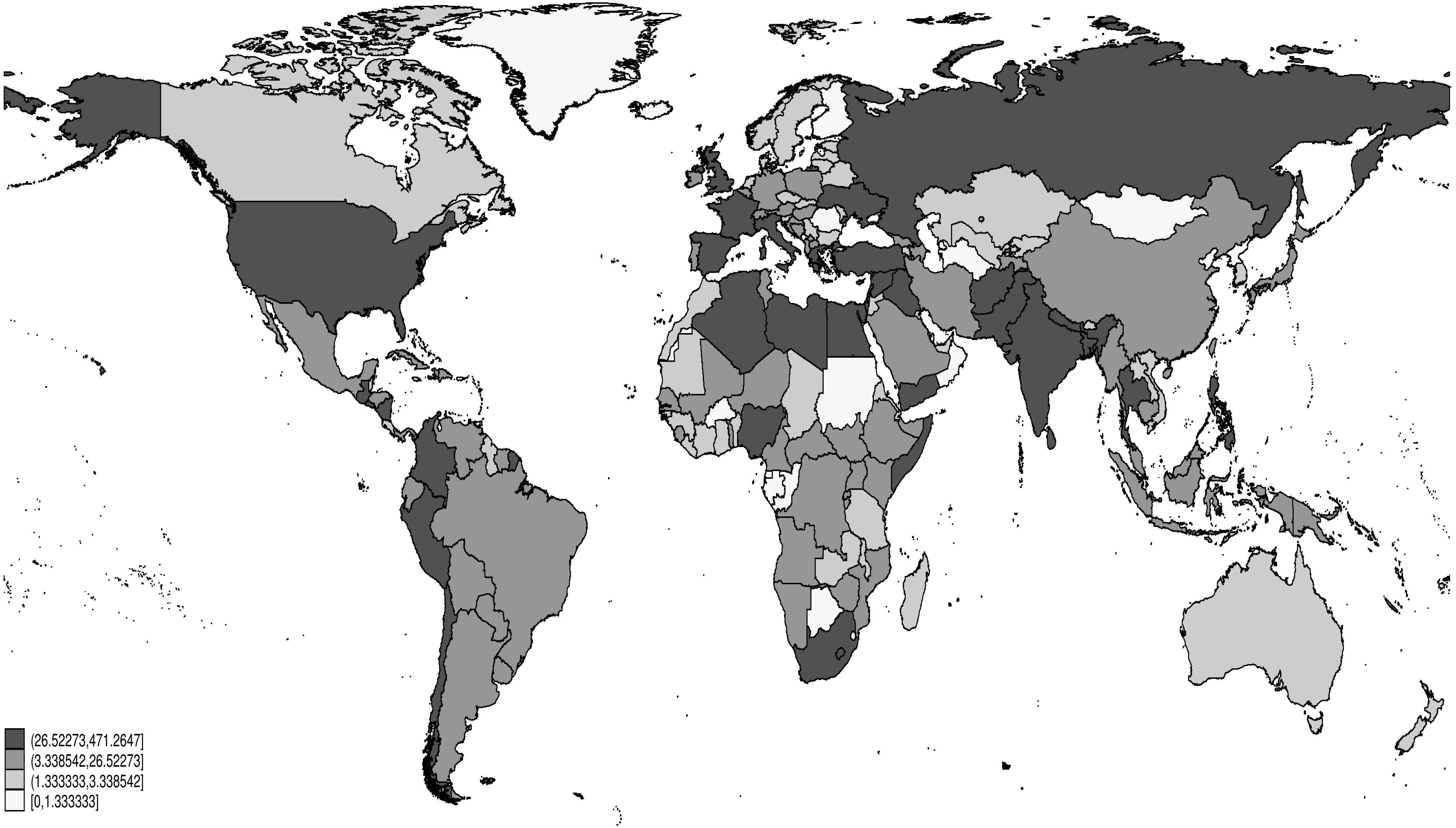


Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Log(Air/Passenger$_{ijt}$)	8,182	7.40151	3.00306	-0.5386	14.6538
Log(GDP$_{it}$)	8,166	26.5777	1.56998	22.1935	30.315
Log(GDP$_{jt}$)	8,182	26.5354	1.76199	22.5856	30.315
Log(GDPCit)	8,125	9.67207	1.12558	6.31389	11.3636
Log(GDPC$_{jt}$)	8,182	9.82432	0.80633	8.14906	10.8336
RTA$_{ij}$	8,182	0.60902	0.488	0	1
Common Currency$_{ijt}$	8,182	0.1067	0.30875	0	1
Border$_{ij}$	8,182	0.09631	0.29503	0	1
Language$_{ij}$	8,182	0.04889	0.21565	0	1
Colony$_{ij}$	8,182	0.05488	0.22775	0	1
Military Spending$_{jt}$	8,182	1.82797	0.78228	0.75	4.67
Military Spending$_{it}$	7,880	1.81455	1.13052	0.12	8.55
Log(Incidents$_{ijt}$)	6.68	2.4434	1.6927	0	6.8167
Log(Stock_Incidents$_{ijt}$)	6,824	3.5306	1.7979	-1.6094	7.8143
Log(PeopleKilled$_{ijt}$)	3,768	2.7581	2.168	0	8.9587
Log(Stock_PeopleKilled$_{ijt}$)	6,824	2.593	2.5944	-1.6094	8.2436
Incidents$_{jt}$	8,182	12.5291	34.4015	0	251
Incidents$_{it}$	8,182	25.438	88.8808	0	859
Stock_Incidents$_{jt}$	8,835	40.037	95.331	0	546.8
Stock_Incidents$_{it}$	9,015	57.8816	184.301	0	1967.4

Table 2: Terrorism in the World from 1970 to 2014

Year	$Incidents^{F}_{World}$	$Peoplekilled^{F}_{World}$	Death Toll per Terrorist Incident
1970	651	171	0.262672811
1971	470	173	0.368085106
1972	494	566	1.145748988
1973	473	370	0.782241015
1974	580	542	0.934482759
1975	741	617	0.83265857
1976	923	672	0.728060672
1977	1318	454	0.344461305
1978	1526	1455	0.953473132
1979	2661	2101	0.7895528
1980	2663	4428	1.662786331
1981	2585	4851	1.876595745
1982	2546	5149	2.02238806
1983	2871	9435	3.28631139
1984	3494	10449	2.990555238
1985	2917	7085	2.428865273
1986	2861	5031	1.758476057
1987	3185	6480	2.034536892
1988	3721	7192	1.93281376
1989	4322	8121	1.878991208
1990	3887	7149	1.839207615
1991	4683	8429	1.799914585
1992	5077	9746	1.919637581
1994	3459	7691	2.223474993
1995	3083	6095	1.976970483
1996	3058	6955	2.274362328
1997	3204	10955	3.419163546
1998	933	4677	5.012861736
1999	1396	3388	2.426934097
2000	1814	4422	2.437706725
2001	1907	7738	4.057682223
2002	1332	4799	3.602852853
2003	1262	3271	2.591917591
2004	1161	5713	4.920757967
2005	2014	6311	3.133565045
2006	2751	9362	3.403126136
2007	3241	12586	3.88336933
2008	4788	9093	1.899122807
2009	4722	9271	1.963362982
2010	4819	7697	1.59721934
2011	5065	8176	1.614215202

2012	8491	15427	1.816864916
2013	11999	22211	1.851070923
2014	16818	43512	2.58722797

Table 3: Effects of Contemporaneous Terrorist Incidents on the International Air Passenger Transport

	Log($Passengers_{ijt}$/$Distance_{ij}$)			
	(1)	(2)	(3)	(4)
$Border_{ij}$	1.601^{c}	1.486^{c}	1.858^{c}	1.547^{c}
	(0.204)	(0.223)	(0.056)	(0.209)
$Language_{ij}$	0.317	0.291	0.223	0.245
	(0.247)	(0.286)	(0.265)	(0.264)
$Colony_{ij}$	0.721^{c}	0.433^{a}	0.774^{c}	0.700^{c}
	(0.231)	(0.272)	(0.249)	(0.236)
RTA_{ijt}	0.488^{b}	0.649^{b}	0.689^{c}	0.748^{c}
	(0.264)	(0.307)	(0.254)	(0.265)
$Currency_{ijt}$	0.051	0.089	0.067	0.020
	(0.197)	(0.224)	(0.189)	(0.198)
Log($Incidents_{ijt}$)	-0.136^{b}			
	(0.073)			
Log($PeopleKilled_{ijt}$)		-0.100		
		(0.107)		
Log($Stock\_Incidents_{ij(t-1)}$)			-0.185^{c}	
			(0.056)	
Log($Stock\_PoepleKilled_{ij(t-1)}$)				-0.041
				(0.067)
Gravity equation includes				
Exporter-Year FE (α_{it})	Yes	Yes	Yes	Yes
Importer-Year FE (α_{jt})	Yes	Yes	Yes	Yes
No. of Obs.	6680	3768	8735	6625
Adj. R^2	0.73	0.75	0.75	0.76

Notes: (i) Robust standard errors adjusted for the clustering of exporter pairs are in parentheses.
^{a}, ^{b} and ^{c} denote 10%, 5% and 1% level of significance, respectively.

Table 4: Effects of Contemporaneous Terrorist Incidents on the International Air Passenger Transport – Robustness Checks

	Log(Passengers$_{ijt}$/Distance$_{ij}$)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Border$_{ij}$	1.584[c]	1.426[c]	1.604[c]	1.443[c]	1.584[c]	1.459[c]	1.898[c]	1.788[c]
	(0.202)	(0.227)	(0.207)	(0.217)	(0.250)	(0.332)	(0.241)	(0.270)
Language$_{ij}$	0.307	0.160	0.301	0.182	0.255	0.274	0.241	0.075
	(0.250)	(0.309)	(0.249)	(0.290)	(0.250)	(0.497)	(0.270)	(0.353)
Colony$_{ij}$	0.721[c]	0.539[b]	0.717[c]	0.532[b]	0.636[c]	0.395	0.715[c]	0.703[b]
	(0.233)	(0.273)	(0.237)	(0.256)	(0.235)	(0.417)	(0.255)	(0.310)
RTA$_{ijt}$	0.519[b]	0.528[a]	0.574[b]	0.533[b]	0.559[b]	0.438	0.680[c]	0.804[c]
	(0.264)	(0.306)	(0.254)	(0.272)	(0.274)	(0.345)	(0.256)	(0.294)
Currency$_{ijt}$	0.018	0.071	-0.016	0.046	0.037	0.299	0.014	0.013
	(0.196)	(0.242)	(0.196)	(0.226)	(0.208)	(0.354)	(0.200)	(0.256)
Log(Incidents$_{ij(t-1)}$)	-0.129[a]							
	(0.076)							
Log(PeopleKilled$_{ij(t-1)}$)		-0.159[a]						
		(0.093)						
Log(Incidents$_{ij(t-2)}$)			-0.130[a]					
			(0.076)					
Log(PeopleKilled$_{ij(t-2)}$)				-0.096				
				(0.094)				
Log(Bombings_Incidents$_{ijt}$)					-0.129[a]			
					(0.075)			
Log(Bombings_PeopleKilled$_{ijt}$)						-0.228[b]		

						(0.120)		
Log(Stock_Bombings_Incidents$_{ij(t-1)}$)							-0.149[c]	
							(0.058)	
Log(Stock_Bombings_PeopleKilled$_{ij(t-1)}$)								-0.045
								(0.092)
Gravity equation includes								
Exporter-Year FE (α_{it})	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer-Year FE (α_{jt})	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of Obs.	6542	3691	6507	3832	5650	2505	8129	4798
Adj. R^2	0.73	0.76	0.74	0.76	0.74	0.72	0.76	0.75

Notes: (i) Robust standard errors adjusted for the clustering of exporter pairs are in parentheses. (ii) *Bombings_Incidents$_{ijt}$* denotes the number of terrorist incidents/attacks with use of bombings or explosive while *Bombings_PeopleKilleds$_{ijt}$* denotes the number of human casualties in terrorist attacks with use of bombings or explosives.

[a], [b] and [c] denote 10%, 5% and 1% level of significance, respectively.

Table 5: Potential Channels via Which Terrorism Affects Bilateral Air Passenger Transport

	Dependent Variable: Log(Passengers$_{ijt}$/Distance$_{ij}$)								
	Panel A: Terrorism in the destination country					Panel B: Terrorism in the source country			
	(1)	(2)	(3)	(4)		(1)	(2)	(3)	(4)
Log(GDP$_{jt}$)		1.001^{c}		1.049^{c}	Log(GDP$_{it}$)		0.521^{c}		0.545^{c}
		(0.041)		(0.041)			(0.033)		(0.033)
Log(GDPC$_{jt}$)		-0.115		0.016	Log(GDPC$_{it}$)		0.193^{c}		0.234^{c}
		(0.097)		(0.094)			(0.051)		(0.052)
Border$_{ij}$	1.721^{c}	1.549^{c}	1.959^{c}	0.730^{c}	Border$_{ij}$	1.911^{b}	0.180	2.181^{c}	0.337^{c}
	(0.217)	(0.197)	(0.232)	(0.221)		(0.193)	(0.187)	(0.131)	(0.195)
Language$_{ij}$	1.693^{c}	0.758^{c}	1.459^{c}	0.748^{c}	Language$_{ij}$	0.431	0.259	0.315	0.100
	(0.289)	(0.224)	(0.318)	(0.219)		(0.285)	(0.238)	(0.288)	(0.242)
Colony$_{ij}$	0.321	0.805^{c}	0.338	0.904^{c}	Colony$_{ij}$	0.640^{b}	0.821^{c}	0.645^{b}	0.929^{c}
	(0.281)	(0.233)	(0.301)	(0.239)		(0.276)	(0.229)	(0.282)	(0.232)
RTA$_{ijt}$	1.225^{c}	1.098^{c}	1.988^{c}	1.097^{c}	RTA$_{ijt}$	1.957^{c}	0.192	2.181^{c}	0.281^{c}
	(0.253)	(0.212)	(0.273)	(0.230)		(0.134)	(0.166)	(0.131)	(0.165)
Currency$_{ijt}$	1.121^{b}	0.301^{a}	0.855^{c}	0.177	Currency$_{ijt}$	0.754^{a}	0.147	0.774^{b}	0.125
	(0.234)	(0.181)	(0.250)	(0.182)		(0.183)	(0.138)	(0.183)	(0.140)
Military spending$_{jt}$	0.151	-0.179^{b}	0.266^{b}	0.335^{c}	Military spending$_{it}$	0.078	0.070^{a}	0.139^{c}	0.129^{c}
	(0.108)	(0.082)	(0.133)	(0.095)		(0.055)	(0.038)	(0.059)	(0.047)
Incidents$_{jt}$	-0.472^{c}	-0.176^{c}			Incidents$_{it}$	-0.0390^{c}	-0.0207^{c}		
	(0.025)	(0.021)				(0.004)	(0.0039)		
Incidents$_{jt}$*Log(GDPC$_{jt}$)	0.054^{c}	0.019^{c}			Incidents$_{it}$*Log(GDPC$_{it}$)	0.0054^{c}	0.0029^{c}		
	(0.003)	(0.002)				(0.0006)	(0.00054)		
Stock_Incidents$_{j(t-1)}$			-0.174^{c}	-0.061^{c}	Stock_Incidents$_{i(t-1)}$			-0.023^{c}	-0.009^{c}
			(0.010)	(0.009)				(0.0024)	(0.0021)

$Stock\_Incidents_{j(t-1)}$ $*Log(GDPCjt)$			0.019^{c}	0.006^{c}	$Stock\_Incidents_{i(t-1)}$ $*Log(GDPC_{it})$			0.0032^{c}	0.00125^{c}
			(0.0011)	(0.0009)				(0.00034)	(0.00029)
Gravity equation includes					Gravity equation includes				
Exporter-Year FE (α_{it})	Yes	Yes	Yes	Yes	Exporter-Year FE (α_{it})	No	No	No	No
Importer-Year FE (α_{jt})	No	No	No	No	Importer-Year FE (α_{jt})	Yes	Yes	Yes	Yes
No. of Obs.	8182	8182	8843	8443	No. of Obs.	8213	8213	8288	8288
Adj. R^2	0.41	0.68	0.44	0.52	Adj. R^2	0.58	0.73	0.62	0.68

Notes: (i) T-statistics computed based on the robust standard errors are in parentheses. The regression allows for the clustering of exporter pairs.
[a], [b] and [c] denote 10%, 5% and 1% level of significance, respectively.

Table 6: Potential Channels via Which Terrorism Affects Bilateral Air Passenger Transport – Additional Results

Dependent Variable: Log(Passengers$_{ijt}$/Distance$_{ij}$)									
	Panel A: Terrorism in the destination country					Panel B: Terrorism in the source country			
	(1)	(2)	(3)	(4)		(1)	(2)	(3)	(4)
Measure of Terrorism 1: Terrorist Incidents with bombs or explosions as the attack types									
Incidents$_{jt}$	-0.561^{c}	-0.219^{c}			Incidents$_{it}$	-0.053^{c}	-0.025^{c}		
	(0.034)	(0.029)				(0.0079)	(0.008)		
Stock_Incidents$_{j(t-1)}$			-0.241^{c}	-0.087^{c}	Stock_Incidents$_{i(t-1)}$			-0.034^{c}	-0.0128^{c}
			(0.015)	(0.0134)				(0.0042)	(0.004)
Measure of Terrorism 2: Not-Fatal Terrorist Incidents									
Incidents$_{jt}$	-0.467^{c}	-0.199^{c}			Incidents$_{it}$	-0.0560^{c}	-0.0276^{c}		
	(0.0281)	(0.0248)				(0.0058)	(0.0054)		
Stock_Incidents$_{j(t-1)}$			-0.416^{c}	-0.193^{c}	Stock_Incidents$_{i(t-1)}$			-0.0378^{c}	-0.0156^{c}
			(0.049)	(0.035)				(0.0031)	(0.0031)
Measure of Terrorism 3: Fatal Terrorist Incidents									
Incidents$_{jt}$	-2.075^{c}	-0.565^{c}			Incidents$_{it}$	-0.0538^{c}	-0.0488^{c}		
	(0.141)	(0.102)				(0.0117)	(0.0115)		
Stock_Incidents$_{j(t-1)}$			-0.771^{c}	-0.193^{c}	Stock_Incidents$_{i(t-1)}$			-0.0216^{b}	-0.0152^{c}
			(0.066)	(0.0356)				(0.0057)	(0.0056)
Measure of Terrorism 4: Terrorist Incidents with the use of biological and chemical weapons									
Incidents$_{jt}$	-0.512^{c}	-0.185^{c}			Incidents$_{it}$	-0.0402^{c}	-0.0239^{c}		
	(0.027)	(0.0234)				(0.0054)	(0.0051)		
Stock_Incidents$_{j(t-1)}$			-0.211^{c}	-0.070^{c}	Stock_Incidents$_{i(t-1)}$			-0.0226^{c}	-0.010^{c}
			(0.0114)	(0.0102)				(0.0028)	(0.0026)

	Measure of Terrorism 5: Terrorist Incidents Targeting Sensitive Targets such as Airports, Transportation and Tourists								
$Incidents_{jt}$	-3.254[c]	-1.239[c]			$Incidents_{it}$	-0.499[c]	-0.287[c]		
	(0.184)	(0.0149)				(0.0591)	(0.0551)		
$Stock\_Incidents_{j(t-1)}$			-2.741[c]	-0.968[c]	$Stock\_Incidents_{i(t-1)}$			-0.254[c]	-0.126[c]
			(0.132)	(0.1145)				(0.0336)	(0.0317)
All Gravity equations include									
Exporter-Year FE (α_{it})	Yes	Yes	Yes	Yes		No	No	No	No
Importer-Year FE (α_{jt})	No	No	No	No		Yes	Yes	Yes	Yes
Other control variables	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes

Notes: (i) Robust standard errors adjusted for the clustering of exporter pairs are in parentheses. (ii) All regressions include the same set of control variables as in gravity specifications (5.3) and (5.4). The coefficient estimates on those variables are sensible and similar to those we obtain in Table 5. We choose not to report them to save space. But they are available upon request from the authors. (iii) Regression results in columns (1) and (3) are obtained when we exclude GDPs and per capita GDPs of the source country or the destination country while columns (2) and (4) are obtained when GDPs and per capita GDPs are included.

[a], [b] and [c] denote 10%, 5% and 1% level of significance, respectively.

Online Appendices for

"The Effects of Terror on International Air Passenger Transport: An Empirical Investigation"

By

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January 28, 2017

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Appendix A1: List of 57 Source Countries

Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, China Hong Kong Special Administrative Region (SAR), Croatia, Cyprus, Czech Republic, Denmark, Egypt, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Mexico, Morocco, Netherlands, New Zealand, Nigeria, Norway, Philippines, Poland, Portugal, Rep. of Korea, Russian Federation, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, United Kingdom, United States and Venezuela.

Appendix A2: List of 25 Destination Countries

Austria, Belarus, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Netherlands, Poland, Russian Federation, Slovakia, Slovenia, Sweden, USA and United Kingdom.

Appendix A3:

The Endogenous Relationship between Terrorism and Bilateral Air Passenger Transport and the Direction of Bias of the Coefficient Estimate of Terrorism

Assume that there exist two sources of endogeneity in the relationship between terrorism (*Terror*$_i$) and air passenger transport (*AirPassengerTransport*$_i$). The first source of endogeneity results from the reverse causality running from bilateral air passenger flows to terrorism in the source country or in the destination country. Terrorists are likely to have a greater incentive to attack a source country and/or a destination country of air passenger flows if these countries have higher economic activity and are more important source countries and destination countries for air passenger transport. The reason is straightforward: by targeting those countries that have a lot of economic activity including air passenger transport terrorists hope that their attacks can cause more negative consequences to their targets and that they can better achieve their political or ideological goals as a result. As a second source of endogeneity countries for which international air passenger transport accounts for a large share of their national output have a greater incentive to have larger counter-terrorism budget to fight terrorism.

In sum the two sources of endogeneity bias the coefficient estimates of terrorism in two opposite directions: terrorists may have greater incentive to attack countries involved more in air transport passenger activities while more of these activities may motivate the government to fight terrorism harder, which in turn reduce the risk of terrorist attacks.

The two sources of endogeneity can be illustrated by the following two equations:

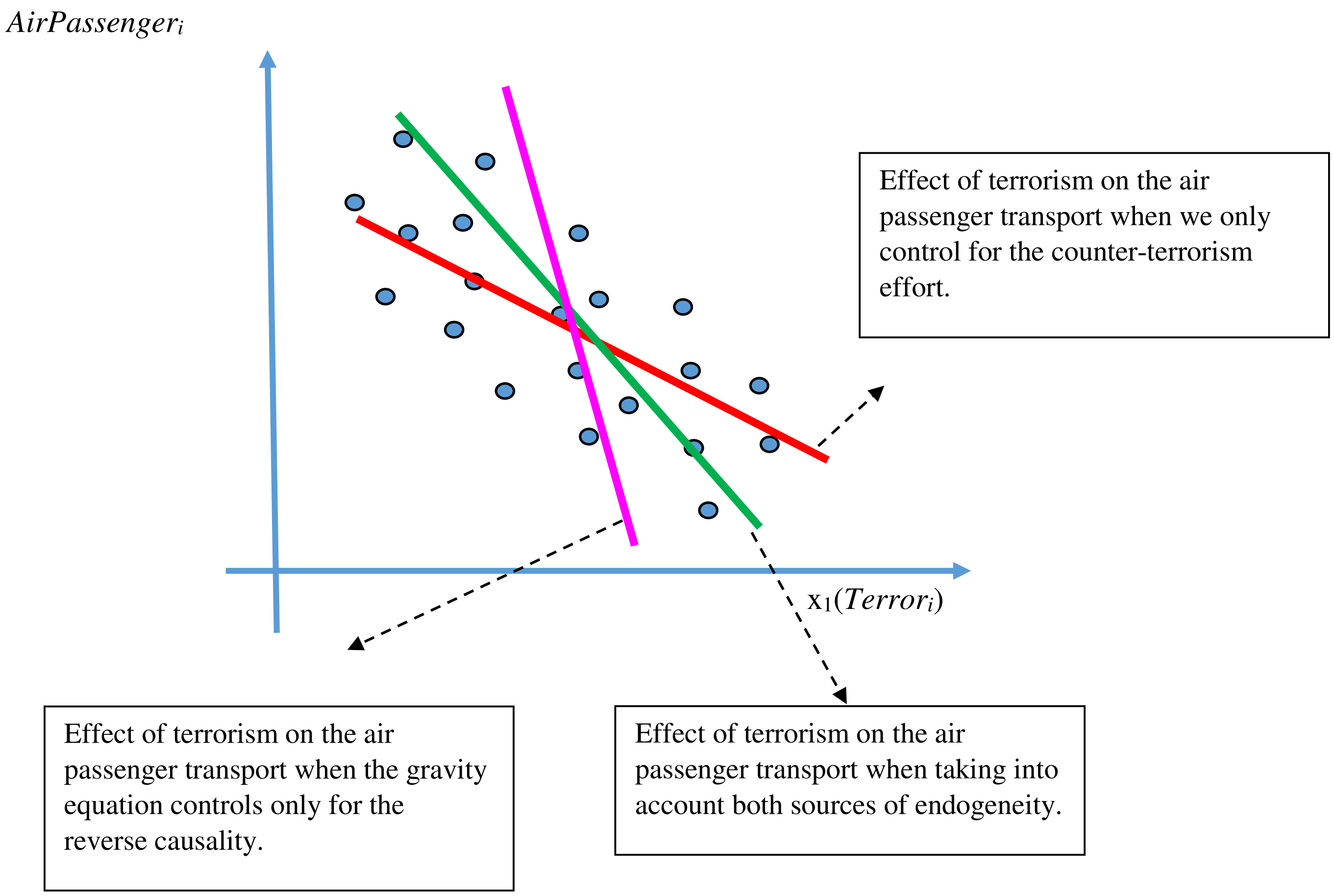
$$AirPassenger_i = \alpha_0 + \alpha_1 Terror_i + e_{1i} \quad \text{(A3.1)}$$

$$Terror_i = \beta_0 + (\beta_1 + \beta_2) AirPassenger_i + e_{2i} \quad \text{(A3.2)}$$

where e_1 and e_2 are valid standard error terms.

We have α_1<0 because terrorist attacks in the source country and the destination country are expected to reduce the air passenger flows between the source country and the destination country. Equation (A3.2) illustrates in a simplified way the two sources of endogeneity. Note that the first source of endogeneity is represented by β_1>0 Equation (A3.1) because terrorists are likely have a greater incentive to attack the source or/and the destination of air passenger flows if the volume of air passenger flows between them is higher. The second source of endogeneity is represented by $\beta_2 < 0$ because countries for which air passenger transport is important for their economies are expected to deploy greater counter-terrorism efforts. These counter-terrorism efforts in turn will reduce the risk of terrorist attacks.

Figure A1



Using (A3.1) and (A3.2) to solve for the reduce form yields the following:

$$(1-\beta_1\alpha_1-\beta_2\alpha_1)AirPassenger_i=\beta_0+\beta_1\alpha_0+\beta_2\alpha_0+(\beta_1+\beta_2)e_1+e_2 \qquad \text{(A3.3)}$$

Equation (A3.3) clearly shows that Cov($AirPassenger_i$;e_1) $=\frac{(\beta_1+\beta_2)}{(1-\alpha_1(\beta_1+\beta_2))}$. Since we have α_1<0; β_1>0 and $\beta_2<0$, the numerator and the denominator can take any sign. The sign of Cov($AirPassenger_i$;e_1) depends on the sign of $(\beta_1+\beta_2)$ and consequently on which source of endogeneity dominates. Figure A1 graphically illustrates the direction of bias of the coefficient estimate on the effects of terrorism when we control for one or both sources of endogeneity. If our gravity specification controls for the counter-terrorism effort $\beta_2$becomes zero and we have Cov($AirPassenger_i$;e_1) $=\frac{\beta_1}{(1-\alpha_1\beta_1)}$>0. Gravity specifications (5.3) and (5.4) correspond to this case and consequently are likely to provide lower bound estimates of the effect of terrorism on the bilateral air passenger transport.

Online Appendix Table 1: Effects of Contemporaneous Terrorist Incidents on the International Air Passenger Transport

	Dependent Variable: Log($Passengers_{ijt}$)			
	(1)	(2)	(3)	(4)
Log($Distance_{ij}$)	-0.392^{c}	-0.040	-0.542^{c}	-0.334^{b}
	(0.070)	(0.093)	(0.157)	(0.149)
$Border_{ij}$	0.588^{c}	0.757^{c}	0.647^{c}	0.566^{c}
	(0.096)	(0.135)	(0.241)	(0.235)
$Language_{ij}$	0.092	0.113	-0.088	0.006
	(0.099)	(0.147)	(0.262)	(0.264)
$Colony_{ij}$	0.734^{c}	0.519^{c}	0.789^{c}	0.743^{c}
	(0.101)	(0.146)	(0.243)	(0.235)
RTA_{ijt}	-0.294^{b}	0.103	-0.093	0.021
	(0.134)	(0.171)	(0.286)	(0.301)
$Currency_{ijt}$	-0.092	-0.015	-0.088	-0.116
	(0.088)	(0.141)	(0.174)	(0.189)
Log($Incidents_{ijt}$)	-0.076^{b}			
	(0.040)			
Log($PeopleKilled_{ijt}$)		-0.028		
		(0.062)		
Log($Stock\_Incidents_{ij(t-1)}$)			-0.110^{c}	
			(0.053)	
Log($Stock\_PoepleKilled_{ij(t-1)}$)				-0.002
				(0.065)
Gravity equation includes				
Exporter-Year FE (α_{it})	Yes	Yes	Yes	Yes
Importer-Year FE (α_{jt})	Yes	Yes	Yes	Yes
No. of Obs.	6680	3768	8735	6824
Adj. R^2	0.70	0.73	0.73	0.74

Notes: (i) Robust standard errors adjusted for the clustering of exporter pairs are in parentheses. [a], [b] and [c] denote 10%, 5% and 1% level of significance, respectively.

Online Appendix Table 2: Effects of Contemporaneous Terrorist Incidents

	Log($Passengers_{ijt}$/$Distance_{ij}$)			
	A Small value, 0.001, is added to the measure of terrorism			
	(1)	(2)	(3)	(4)
Log($Incidents_{ijt}$)	-0.035[b]			
	(0.015)			
Log($PeopleKilled_{ijt}$)		-0.019		
		(0.019)		
Log($Stock\_Incidents_{ij(t-1)}$)			-0.089[c]	
			(0.033)	
Log($Stock\_PoepleKilled_{ij(t-1)}$)				-0.029
				(0.024)
Gravity equation includes				
Exporter-Year FE (α_{it})	Yes	Yes	Yes	Yes
Importer-Year FE (α_{jt})	Yes	Yes	Yes	Yes
Other control variables	Yes	Yes	Yes	Yes
No. of Obs.	8546	7589	9033	9033
Adj. R^2	0.73	0.75	0.75	0.79

Notes: (i) Robust standard errors adjusted for the clustering of exporter pairs are in parentheses.
[a], [b] and [c] denote 10%, 5% and 1% level of significance, respectively.

Online Appendix Table 3: Effects of Contemporaneous Terrorist Incidents on the International Air Passenger Transport – Robustness Checks

	Log(Passengers$_{ijt}$/Distance$_{ij}$)							
	(1)	(2)	(3)	(4)	(5)	(5)	(7)	(8)
	A Small value, 0.001, is added to the measure of terrorism							
Log(Incidents$_{ij(t-1)}$)	-0.045^{c}							
	(0.015)							
Log(PeopleKilled$_{ij(t-1)}$)		-0.024						
		(0.019)						
Log(Incidents$_{ij(t-2)}$)			-0.060^{b}					
			(0.026)					
Log(PeopleKilled$_{ij(t-2)}$)				-0.028^{a}				
				(0.019)				
Log(Bombings_Incidents$_{ijt}$)					-0.050^{c}			
					(0.016)			
Log(Bombings_PeopleKilled$_{ijt}$)						-0.027		
						(0.029)		
Log(Stock_Bombings_Incidents$_{ij(t-1)}$)							-0.051^{c}	
							(0.016)	
Log(Stock_Bombings_PeopleKilled$_{ij(t-1)}$)								-0.038
								(0.028)
Gravity equation includes								
Exporter-Year FE (α_{it})	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer-Year FE (α_{jt})	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Other control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of Obs.	8346	7642	8346	7668	8346	7719	8346	7712
Adj. R^2	0.77	0.72	0.73	0.72	0.73	0.71	0.73	0.75

Notes: (i) Robust standard errors adjusted for the clustering of exporter pairs are in parentheses. (ii) All regressions include the same set of control variables as in gravity specifications (5.3) and (5.4). The coefficient estimates on those variables are sensible and similar to those we obtain in Table 5. We choose not to report them to save space. Yet they are available upon request from the authors.

[a], [b] and [c] denote 10%, 5% and 1% level of significance, respectively.

Online Appendix Table 4: Potential Channels via Which Terrorism Affects Bilateral Air Passenger Transport

	Dependent Variable: Log($Passengers_{ijt}$/$Distance_{ij}$)								
	Panel A: Terrorism in the destination country					Panel B: Terrorism in the source country			
	(1)	(2)	(3)	(4)		(1)	(2)	(3)	(4)
	A Small value, 0.001, is added to the measure of terrorism								
$Incidents_{jt}$	-0.472^{c}	-0.176^{c}			$Incidents_{it}$	-0.039^{c}	-0.022^{c}		
	(0.025)	(0.021)				(0.004)	(0.004)		
$Incidents_{jt}$*Log($GDPC_{jt}$)	0.054^{c}	0.019^{c}			$Incidents_{it}$*Log($GDPC_{it}$)	0.005^{c}	0.003^{b}		
	(0.003)	(0.002)				(0.001)	(0.0006)		
$Stock\_Incidents_{j(t-1)}$			-0.173^{c}	-0.059^{c}	$Stock\_Incidents_{i(t-1)}$			-0.023^{c}	-0.011^{c}
			(0.010)	(0.009)				(0.002)	(0.002)
$Stock\_Incidents_{j(t-1)}$ *Log(GDPCjt)			0.019^{c}	0.006^{c}	$Stock\_Incidents_{i(t-1)}$ *Log($GDPC_{it}$)			0.0032^{c}	0.0017^{c}
			(0.001)	(0.001)				(0.0003)	(0.0003)
Gravity equation includes					Gravity equation includes				
Exporter-Year FE (α_{it})	Yes	Yes	Yes	Yes	Exporter-Year FE (α_{it})	No	No	No	No
Importer-Year FE (α_{jt})	No	No	No	No	Importer-Year FE (α_{jt})	Yes	Yes	Yes	Yes
Other control variables	Yes	Yes	Yes	Yes	Other control variables	Yes	Yes	Yes	Yes
No. of Obs.	8182	8182	7860	7860	No. of Obs.	8213	8213	8289	7759
Adj. R^2	0.48	0.64	0.58	0.64	Adj. R^2	0.61	0.64	0.62	0.68

Notes: (i) Robust standard errors adjusted for the clustering of exporter pairs are in parentheses. (ii) All regressions include the same set of control variables as in gravity specifications (5.3) and (5.4). The coefficient estimates on those variables are sensible and similar to those we obtain in Table 5. We choose not to report them to save space. Yet they are available upon request from the authors. (iii) Regression results in columns (1) and (3) are obtained when we exclude GDPs and per capita GDPs of the source country or the destination country while columns (2) and (4) are obtained when GDPs and per capita GDPs are included.
[a], [b] and [c] denote 10%, 5% and 1% level of significance, respectively.

Online Appendix Table 5: Potential Channels via Which Terrorism Affects Bilateral Air Passenger Transport

	Dependent Variable: Log($Passengers_{ijt}$/$Distance_{ij}$)								
	Panel A: Terrorism in the destination country					Panel B: Terrorism in the source country			
	(1)	(2)	(3)	(4)		(1)	(2)	(3)	(4)
	Control for counter-terrorism effort by using government expenditure of OECD countries for public order and safety								
$Incidents_{jt}$	-2.199[c]	-1.211[c]			$Incidents_{it}$	-0.311[c]	-0.013		
	(0.304)	(0.234)				(0.0087)	(0.077)		
$Incidents_{jt}$*Log($GDPC_{jt}$)	0.032	0.115[c]			$Incidents_{it}$*Log($GDPC_{it}$)	-0.010	-0.008		
	(0.029)	(0.022)				(0.009)	(0.0076)		
$Stock\_Incidents_{j(t-1)}$			-0.811[c]	-0.276[c]	$Stock\_Incidents_{i(t-1)}$			-0.151[c]	-0.00138
			(0.039)	(0.039)				(0.042)	(0.036)
$Stock\_Incidents_{j(t-1)}$ *Log(GDPCjt)			0.081[c]	0.027[c]	$Stock\_Incidents_{i(t-1)}$ *Log($GDPC_{it}$)			-0.016[c]	0.00013
			(0.004)	(0.039)				(0.004)	(0.0035)
Gravity equation includes					Gravity equation includes				
Exporter-Year FE (α_{it})	Yes	Yes	Yes	Yes	Exporter-Year FE (α_{it})	No	No	No	No
Importer-Year FE (α_{jt})	No	No	No	No	Importer-Year FE (α_{jt})	Yes	Yes	Yes	Yes
Other control variables	Yes	Yes	Yes	Yes	Other control variables	Yes	Yes	Yes	Yes
No. of Obs.	5258	5258	5497	5479	No. of Obs.	4264	4264	4182	4182
Adj. R^2	0.47	0.63	0.51	0.65	Adj. R^2	0.61	0.66	0.64	0.68

Notes: (i) Robust standard errors adjusted for the clustering of exporter pairs are in parentheses. (ii) All regressions include the same set of control variables as in gravity specifications (5.3) and (5.4). The coefficient estimates on those variables are sensible and similar to those we obtain in Table 5. We choose not to report them to save space. Yet they are available upon request from the authors. (iii) Regression results in columns (1) and (3) are obtained when we exclude GDPs and per capita GDPs of the source country or the destination country while columns (2) and (4) are obtained when GDPs and per capita GDPs are included.

[a], [b] and [c] denote 10%, 5% and 1% level of significance, respectively.