Terrorism Networks and Trade: Does the Neighbor Hurt?*

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Abstract

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1 Introduction

This paper studies how global terrorist networks distort trade across countries, making 'victim' countries to trade less with close-to-terror countries and more with far-from-terror ones. We proceed in two steps to investigate the impact of the spatial diffusion of transnational terrorism on security measures and international trade. We first build a simple and original theoretical framework where the behavior of global terrorist organizations is embedded into a standard new trade theory model. Global terrorist organizations are modeled as particular multinationals extending their activity outside their borders of origin and provoking endogenous security measures. Based on this theory, we then estimate how the diffusion of transnational terrorism affects trade. Both theory and evidence suggest that the closer are countries to the source of the diffusion of terrorism, the larger is their negative spillover on trade. In

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a sharp contrast, countries located far enough from terrorism benefit from positive spillovers on trade.

These findings are important because the last few decades have seen a geographic expansion of terrorist networks. From left wing extremists to Djihadist organizations, terrorist networks have always existed in the modern history of terrorism (see Siqueira and Sandler, 2010). Over the last two decades however, while helped by the impressive development of communication devices, terrorist networks operate now in areas that are located thousands of miles away from their origin territory, such as Al-Qaeda and affiliated groups. Originally based in Saudi Arabia, Al-Qaeda extends its network as far as North Africa and the Philippines (see Figure 12 in Appendix B).[1]

As terrorist organizations extend their network the level of transnational terrorism threat raises. As a consequence, countries sourcing terrorism or hosting terrorist cells are more closely monitored. The US Department of State reports recent evidence of active monitoring in Northern Mali, where Al-Qaeda in the Islamic Maghreb (AQIM) and affiliated groups have exploited the political chaos to expand their presence. The US Department of State writes that "[they] are monitoring the actions of AQIM and other extremist and terrorist organizations in the north, and continue to work with the international community to address this evolving threat. [They] continue to enhance our work with Mali's neighbors, to increase their capacity to secure their borders, disrupt AQIM supply lines, and contain the spread of extremist groups."[2]

[1]For example, the Algerian-based Salafist Group for Preaching and Combat (SGPC) and the Libyan-based Islamic Fighting Group have joined the Al-Qaeda network in the name of a global Jihad. The SGPC has even changed his name to 'Al-Qaeda in the Islamic Maghreb' (AQIM), announcing its willingness to extend its activities to the other Maghreb countries (see Steinberg and Werenfels, 2007). Al-Qaeda's expansion is not limited to the Arab World, however. To gain visibility and logistical support, local groups in Non-Arab countries, such as Abu Sayyaf in the Philippines, are increasingly linked to the Al-Qaeda network. Recently, an Uzbek group, a sort of joint venture of Al-Qaeda and the Taliban, has expanded overseas to establish a terrorist cell in Turkey. This Turkish cell, called the Islamic Jihad Union, aims to recruit nationals and emigrants in European countries for Al-Qaeda's global Jihad (see Steinberg, 2008).

[2]The rest of the quote is also very insightful "We assist Mauritania and Niger through the Trans-Sahara Counter Terrorism Partnership, which is designed to help build long-term capacity to contain and marginalize terrorist organizations and facilitation networks; disrupt efforts to recruit, train, and provision terrorists and extremists; counter efforts to establish safe havens for terrorist organizations; and disrupt foreign fighter networks that may attempt to operate outside the region. Lasting resolution to the terrorist threat will require that the countries in the Sahel develop the

Monitoring goes hand in hand with more restrictive security measures, such as increased checks at borders, restrictions on visa allowances or immigration controls. A quick glance at the cross-country differences in the number of US nonimmigrant visas issued to foreign nationals offers evidence of this restriction. In 2002, after the September 11 attacks, almost all of the countries experienced a reduction in visa allowances but some countries, especially Muslim ones, have been more affected than others (Cainkar, 2004).[3]

Where security measures apply they are likely to increase the costs of international trade (see Anderson and Marcouiller, 2002; Anderson and van Wincoop, 2004). As a consequence, a country hosting a terrorist cell may face negative spillovers on its trade without being effectively a source of transnational terrorism. On the opposite, countries that are far from terrorist organizations gain a relative export advantage of being 'safe' from the relative cheapening of their goods.

In the first stage of our analysis, we investigate theoretically the impact of the spatial diffusion of transnational terrorism on security measures and international trade. This is our first contribution to the literature. We model a terrorist organization, as a sort of multinational institution, that spatially diffuses terrorism by implementing a terror cell abroad. This implementation is costly and the cost is increasing in the distance from the terrorist organization to the host country. The cell will be established in the host country if and only if the expected net rent from terrorism is larger than the implementing cost. The cell's aim is to gear an attack against a third country. To counter this threat, the third country's government designs security measures against the country hosting the cell. However, the security level is designed based on imperfect information about the expected net rent of terrorism. This terrorism-security game exhibits a unique Bayesian Nash equilibrium such that the diffusion of terrorism and the security level depend on the distance from the terrorist organization to the host country. Terror cells are implemented in countries close to the terrorist organization. Security measures are thus applied

capacity to counter this threat" (see `http://www.state.gov/p/af/rls/rm/2012/201583.htm`).

[3]On average, Europeans and Asians experienced a 15 and 23% decrease, respectively. Muslim countries experienced a 40% decrease with a large variance: from a - 1% for Eritrea to - 67% for Saudi Arabia.

against these countries, which face negative spillovers on their trade. In contrast, there is no diffusion of terrorism and no security measures applied against countries far from the terrorist organization. These 'safe' countries may benefit in terms of trade from an exogenous increase in security by becoming relatively cheaper.

Our second stage of investigation is empirical and leads to our second contribution. To estimate the predictions of our model, we use detailed information on transnational terrorist acts from the ITERATE database (see Mickolus *et al.* 2006).[4] Using this information, we proceed in three steps. First, we build a measure of proximity to terrorism based on the sharing of 'affinities' between countries, such as a border, a language or a religion. We argue that the more of these affinities a country shares with a source country of terrorism, the closer their neighborhood relationship and thus the higher the likelihood to host a terror cell. Second, using this measure and a theoretically founded gravity-type model of trade we estimate a negative spillover effect of neighbor terrorism. Every additional incident perpetrated by exporter's neighbors against a given importer reduces exports to this importer by a large amount, around 38%. Third, based on our preferred estimate of neighbor terrorism and the computation of inward and outward multilateral resistances, we perform counterfactual experiments to gauge how cost increases from terrorism affect international trade. Namely, we confirm contrasting spillover effects based on the distance to the source country of terrorism: exports of potentially unsafe –close-to-terror– countries are negatively hit by terrorism incidents originating from their neighbors, while 'safe' countries experience positive spillovers on their trade.

Our paper is related to the literature on trade and violence. For a given country and year, the presence of terrorism together with external and internal conflicts is equivalent to as much as a 30% tariff on trade (Blomberg and Hess, 2006). Other studies focus more specifically on transnational terrorism (Nitsch and Schumacher 2004, Mirza and Verdier, 2013, 2008 or Egger and Gassebner 2013)) and

[4]The International Terrorism: Attributes of Terrorist Events (ITERATE) defines terrorism acts as "the use, or threat of use, of anxiety-inducing, extra-normal violence for political purposes by any individual or group, whether acting for or in opposition to established governmental authority, when such action is intended to influence the attitudes and behavior of a target group wider than the immediate victims and when, through the nationality or foreign ties of its perpetrators, its location, the nature of its institutional or human victims, or the mechanics of its resolution, its ramifications transcend national boundaries."

external wars (Glick and Taylor, 2010, Martin *et al.* 2008). In those papers, controlling for endogeneity, violence between two countries reduces their bilateral trade. Among those papers, the closest to ours is Mirza and Verdier (2013). They also investigate the relationship between trade, terrorism and security measures. However, unlike this paper, in their theory terrorism organizations do not spread across countries and spillovers from terrorism are neither considered nor tested.

Besides, our theory highlights an interesting non-monotonic effect of neighbor terrorism on working through two channels: one direct effect (increase in bilateral trade costs faced by countries close to terror) and one indirect effect (increase in the remoteness of countries experiencing terror, making relative prices of exporting distant-from-terror countries lower). This indirect effect acting through the remoteness term is actually perfectly consistent with the structural gravity theory from Anderson and Van Wincoop 2003 and Anderson and Yotov 2010, which treat remoteness in an endogenous manner.

The rest of the paper is structured as follows. In section 2, we set a simple theoretical framework of endogenous spatial diffusion of terrorism and security, embedded into a new standard trade model. In section 3, we first explain the empirical strategy and present data on terrorism. Then, we present the benchmark econometric results and robustness checks. Finally, we perform counterfactual experiments to gauge how cost increases from terrorism affect international trade. In section 4, we conclude.

2 A simple model of Trade, Spatial diffusion of Terrorism and Security

In this section we present the basic elements of a simple model of trade, spatial diffusion of transnational terrorism and security. There are two types of countries that are engaged in international trade. First, there is the US (indexed by U) that is the main target of transnational terrorism. Second, there is a continuum of countries of mass 1 (indexed by z) and located on the segment $[0, 1]$. Some of them are potential sources of terrorism against the US (country U).

2.1 Trade

Each country (i.e., U and $z \in [0,1]$) produces differentiated goods under increasing returns. The utility of a representative agent in country U has a standard Dixit-Stiglitz form

$$U_U = \left[v_U x_{UU}^{(1-1/\sigma)} + \int_0^1 v_z x_{Uz}^{(1-1/\sigma)} dz \right]^{1/(1-1/\sigma)},$$

where v_k is the number of varieties produced in each country $k \in \{U, z \in [0,1]\}$. x_{Uk} is country U demand for a variety of country k. All goods produced in k are demanded in the same quantity by symmetry and $\sigma > 1$ is the elasticity of substitution. In country U, this helps define a usual consumer price index:

$$P_U = \left(v_U p_U^{1-\sigma} T_{UU}^{1-\sigma} + \int_0^1 v_z p_z^{1-\sigma} T_{Uz}^{1-\sigma} dz \right)^{1/(1-\sigma)},$$

where p_k is the mill price of products made in k and T_{Uk} are the usual iceberg trade costs between U and K. If one unit of good is exported from country k to country U only $1/T_{Uk}$ units are consumed. Trade costs are assumed to depend on geographical distance, trade restrictions and also on security measures (more on this below). As is well known the value of demand by country U from k is given by

$$m_{Uk} = v_k E_U \left[\frac{p_k T_{Uk}}{P_U} \right]^{1-\sigma} \text{ for } k \in \{U, z \in [0,1], R\}, \tag{1}$$

where E_U is the total expenditure of country U.

Labor is the only factor of production in quantity L_k in country $k \in \{U, z \in [0,1]\}$. In each country, the different varieties are produced under monopolistic competition. The entry cost to produce in a monopolistic sector is supposed to be one unit of a freely tradable good which is chosen as world numeraire. This good is produced in perfect competition. This in turn fixes the wage rate to its labor productivity $a = 1$ which is assumed for simplicity to be the same across all countries and sectors. Given this, standard mark-up conditions from profit maximization give that mill prices in the monopolistic competitive sector are identical and equal to the mark-up $\sigma/(\sigma-1)$ times marginal costs (also equal to 1). On the supply side, free entry implies that $v_k = L_k/\sigma$. In equilibrium, the indirect utility of the representative consumer in country U is:

$$W_U = W_U(\mathbf{T}_U) = \frac{E_U}{\frac{\sigma}{\sigma-1}(\sigma)^{\frac{1}{\sigma-1}}} \left(L_U T_{UU}^{1-\sigma} + L \int_0^1 T_{Uz}^{1-\sigma} dz \right)^{1/(\sigma-1)},$$

with $L_z = L$ for all countries $z \in [0,1]$ and $\mathbf{T}_U$ the vector $\{T_{Uk}\}_{k\in\{U,z\in[0,1]\}}$ of bilateral iceberg costs. As is well known from this simple model, one gets bilateral imports of country U from country k as proportional to:

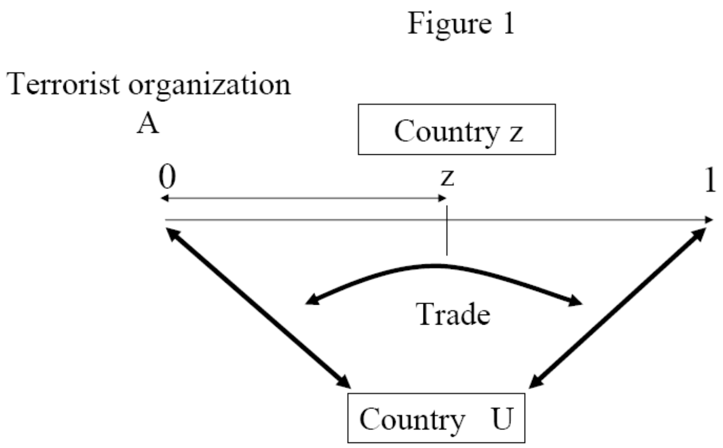
$$m_{Uk} = L_k E_U T_{Uk}^{1-\sigma} P_U^{\sigma-1}. \quad (2)$$

2.2 Terrorism and Security

Terrorist behavior and diffusion of terrorism

We assume that the headquarter of a terrorist organization A is located at $z = 0$ (see Figure 1). A is acting like a multinational terrorist network. Thus, in each country $z \in [0,1]$, A may establish a terrorist cell to gear an attack from z against country U (i.e., the US).

Figure 1: Terrorist Organization



We consider that each cell, once established, benefits from the same technology of terrorism as the headquarter. This is in a sense the intangible specific asset of the multinational terrorist network. However to capture the decentralized organizational feature of the network, we consider that each cell is maximizing her objective function independently from the other cells in the network. The objective function of a particular cell is to get visibility (which helps her capture political or economic rents).[5] More precisely a terrorist cell in country $z \in [0,1]$ maximizes

$$Max_R \, \Pi(R_z, S_z) V - \theta R_z, \tag{3}$$

where $\Pi(R_z, S_z)$ is the probability of success of a terrorist act against country U launched from country z. It depends positively on the amount of resources R_z invested by the terrorist cell and negatively on security measures S_z implemented by the government of U against z. V is the perceived visibility gain enjoyed by the terrorist cell when terrorism is successful. θ is the marginal resource cost of the terrorist network. As said, it is a specific characteristic of the terrorist network.

We introduce now a spatial dimension. We assume that to establish a cell in country z the terrorist organization A has to spend a fixed organizational resource cost $F(z)$ that depends positively on the distance between country $z = 0$ and country at distance z (i.e., $F'(z) > 0$, $F(0) = 0$, and $\lim_{z \to 1} F(z) = +\infty$). We assume that the terrorist cell will be established in country z if and only if the expected net rent from terrorism is larger than the fixed establishment cost of the cell, namely: Max_{R_z} $[\Pi(R_z, S_z) V - \theta R_z] \geq F(z)$.

We consider a specific parametric form for the probability of success $\Pi(R, S)$. More precisely, we follow Anderson and Marcouiller 2002 and take a simple asymmetric contest success function:

$$\Pi(R, S) = \frac{\varphi R}{\varphi R + S} \,,$$

with the technological parameter $\varphi > 0$ reflecting the relative efficiency of terrorism compared to security.

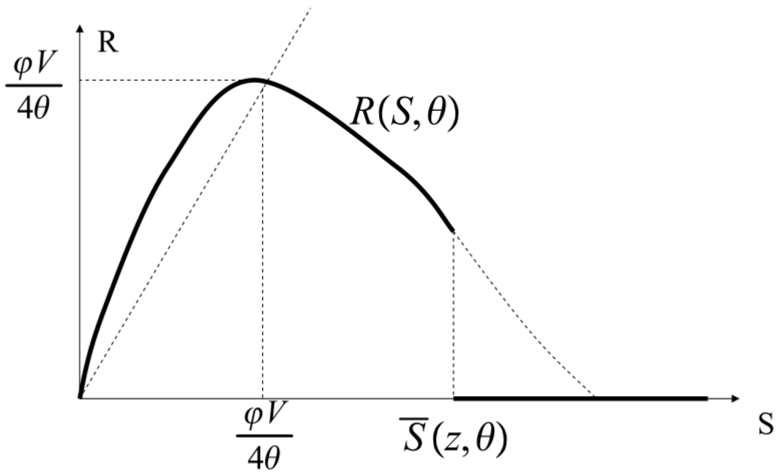
[5]We follow here a rationalist view of transnational terrorism (see Sandler *et al.* 1983).

Denoting $R'_z = \varphi R_z$, the solution of (3) gives the reaction curve of the terrorist group in country z given a certain level of security S_z imposed by country U on z:

$$R'_z = R(S_z, \theta) = \sqrt{\frac{\varphi S_z V}{\theta}} - S_z \quad \text{for} \quad S_z \leq \overline{S}(z,\theta) = \left[\sqrt{V} - \sqrt{F(z)}\right]^2 \frac{\varphi}{\theta}, \quad \text{(terror)}$$
$$= 0 \qquad \text{for} \quad S_z > \overline{S}(z,\theta).$$

Equation (terror) takes into account the fact that a terrorist cell is established in country z if and only if $Max_{R_z} \left[\Pi\left(R_z, S_z\right) V - \theta R_z\right] \geq F(z)$. The shape of the reaction curve is depicted in Figure (2). When the security level S_z imposed by U against z is below a certain threshold $\overline{S}(z,\theta)$, the transnational terrorist organization chooses to diffuse and to establish a cell in country z, engaging resources locally $R_z = R(S_z,\theta)/\varphi$ in terrorism. Above the threshold $\overline{S}(z,\theta)$, there is no transnational terrorism diffusion to country z and $R_z = 0$.

Figure 2: Terrorist Reaction Curve



Security behavior by the US

The government of country U is concerned both by the economic welfare of the representative consumer $W_U(\mathbf{T}_U)$ and the expected social cost of terrorism imposed on its citizens $E(C)$. To fix ideas, consider that he maximizes

$$G_U = LogW_U(\mathbf{T}_U) - E(C),$$

where C is the social cost of terrorism in country U when it succeeds. We assume that, because of pervasive problems of asymmetric information, the government of country U, when deciding its security level S_z against country $z \in [0,1]$, does not know the true value of the marginal resource cost θ of the terrorist network. He has beliefs on this parameter summarized by the density function $f(\theta)$ defined on an interval $\left[\underline{\theta}, \overline{\theta}\right]$. Also, the decision on security measures S_z is made simultaneously with the decision of all terrorist cells in the various countries $z \in [0,1]$. Given this, and an expectation of terrorist activity in country z, $R_z^e(\theta)$,

$$E(C) = E_\theta \left[\int_0^1 \Pi\left(R_z^e(\theta), S_z\right) dz\right] C,$$

where $E_\theta(.)$ reflects the expectation operator of government of country U on the level of terrorist resource $R_z^e(\theta)$ undertaken in country z.

Security measures $\mathbf{S} = \{S_z\}_{z\in[0,1]}$ against terrorists involve trade costs.[6] Imposing security measures against people and goods from country z is likely to increase transactions costs on trade flows (e.g. security checks, time delays, restrictions on visa allowances to business people, immigration controls) and we simply pose that

$$T_{Uz} = T(S_z) \text{ with } T'(.) \geq 0,\ T''(.) > 0 \text{ and } T'(0) = 0. \tag{4}$$

According to the type θ of the terrorist network, country U's problem is simply:

$$Max_{S_z}\ LogW_U(\mathbf{T}_U) -\ E_\theta \left[\int_0^1 \Pi\left(R_z^e(\theta), S_z\right) dz\right] C. \tag{US}$$

Given that the equilibrium wage is 1 and the labour force available for production

[6] In doing so, we neglect the budgetary costs of security measures on the welfare of the US citizen and concentrate only on the economic distortion costs of security measures. As well, the reader will also notice that in our formulation of the equilibrium number of varieties produced in any country z, we neglected the effect of the resource cost of terrorism activity on the labor force of that country. In most cases, this is reasonable as the labor force engaged into terrorist activity in any country z is certainly a small fraction of the total active labor force of that country.

in country U is L_U, country U's expenditure on consumption goods are written as $E_U = L_U$. Neglecting constant terms and noting $R^e(.) = (R^e_z(.))_{z\in(0,1)}$, the problem (US) can be rewritten as:

$$\begin{aligned} Max_S\ W(S, R^e(.)) &= Max_S\ \frac{1}{\sigma-1} Log\left(L_U T_{UU}^{1-\sigma} + L \int_0^1 T_{Uz}^{1-\sigma} dz \right) \\ &\quad -C \int_{\underline{\theta}}^{\overline{\theta}} \left[\int_0^1 \frac{\varphi R^e_z(\theta)}{\varphi R^e_z(\theta) + S_z} dz \right] f(\theta) d\theta. \end{aligned}$$

Using Fubini's theorem, the government of country U maximizes:

$$\begin{aligned} Max_S\ W(S, R^e(.)) &= Max_S\ \frac{1}{\sigma-1} Log\left(L_U T_{UU}^{1-\sigma} + L \int_0^1 T_{Uz}^{1-\sigma} dz \right) \\ &\quad -C \int_0^1 \left[\int_{\underline{\theta}}^{\overline{\theta}} \frac{\varphi R^e_z(\theta)}{\varphi R^e_z(\theta) + S_z} f(\theta) d\theta \right] dz. \end{aligned}$$

Equilibrium

We now look for the Bayesian Nash equilibrium of the terrorism-security game. More precisely a Bayesian Nash equilibrium

$$\left(S^N, R^N(\theta)\right) = \left(\left\{S^N_z\right\}_{z\in[0,1]}, \left\{R^N_z(\theta)\right\}_{z\in[0,1]} \right),$$

is, for each country $z \in [0,1]$, a security level S^N_z and a terrorist activity function $R^N_z(.)$ defined on $\left[\underline{\theta}, \overline{\theta}\right]$ and characterized by the two following conditions:

$$(i)\ S^N = Arg\max_S\ W(S, R^N(.)),$$

$$(ii) \begin{cases} R^N_z(\theta) = R(S^N_z, \theta) = \dfrac{1}{\varphi}\left[\sqrt{\dfrac{\varphi V}{\theta}} \sqrt{S^N_z} - S^N_z \right] & \text{for } \theta \text{ such that } S^N_z \leq \overline{S}(z,\theta), \\ \quad = 0 & \text{for } \theta \text{ such that } S^N_z > \overline{S}(z,\theta). \end{cases}$$

We can equivalently redefine the Bayesian Nash equilibrium as a couple (S^N, θ^N), with $S^N = (S^N_z)$ and $\theta^N = (\theta^N_z)$ such that

$$(i)\ S^N = Arg\max_S \left[\begin{array}{l} \frac{1}{\sigma-1} Log\left(L_U T_{UU}^{1-\sigma} + L \int_0^1 T_{Uz}^{1-\sigma} dz \right) \\ -\ C \int_0^1 \left[\int_{\underline{\theta}}^{\theta^N_z} \frac{\varphi R^N_z(\theta)}{\varphi R^N_z(\theta) + S_z} f(\theta) d\theta \right] dz \end{array} \right], \tag{5}$$

$$(ii)\begin{cases} R_z^N(\theta) = \dfrac{1}{\varphi}\left[\sqrt{\dfrac{\varphi V}{\theta}}\sqrt{S_z^N} - S_z^N\right] & \text{for } \theta < \theta_z^N, \\ \quad = 0 & \text{for } \theta \geq \theta_z^N, \end{cases} \tag{6}$$

and the equilibrium thresholds θ_z^N for all $z \in [0,1]$ are defined by

$$\overline{S}(z, \theta_z^N) = S_z^N. \tag{7}$$

Given that $\overline{S}(z,\theta) = \left[\sqrt{V} - \sqrt{F(z)}\right]^2 \frac{\varphi}{\theta}$, inverting (7) provides a threshold function $\widetilde{\theta}(.)$ such that[7]

$$\theta_z^N = \widetilde{\theta}\left(S_z^N, z\right).$$

For a given threshold θ_z, the first order condition of problem (5) writes as:

$$MC(S_z, \widetilde{T}) = \frac{LT_{Uz}^{-\sigma}}{\widetilde{T}^{1-\sigma}}\frac{dT_{Uz}}{dS_z} = C\int_{\underline{\theta}}^{\theta_z} \frac{\varphi R_z^N(\theta)}{\left[\varphi R_z^N(\theta) + S_z\right]^2} f(\theta)d\theta,$$

where $\widetilde{T}$ is a trade friction cost index proportional to the aggregate price index of country U:

$$\widetilde{T}^{1-\sigma} = \left(L_U T_{UU}^{1-\sigma} + L\int_0^1 T_{Uz}^{1-\sigma}dz\right).$$

The left hand side of equation (2.2) is the marginal cost $MC(S_z, \widetilde{T})$ of security measures S_z applied against country z. It is simply the marginal distortion cost of imposing security measures on bilateral trade flows between U and z. $MC(S_z, \widetilde{T})$ is increasing in S_z when $T_{Uz}(.)$ is convex enough in S_z. We noted also its dependence on the aggregate trade friction cost index $\widetilde{T}$ of country U. The larger this index, the larger the volume that country U imports from country z and the more costly it is at the margin to impose trade frictions between U and z. Hence the larger the marginal cost $MC(S_z, \widetilde{T})$ of security measures S_z between U and z.

[7] The threshold function $\widetilde{\theta}(.)$ is defined by

$$\widetilde{\theta}(S,z) = Max\left[Min\left(\frac{\left[\sqrt{V} - \sqrt{F(z)}\right]^2\varphi}{S}; \overline{\theta}\right); \underline{\theta}\right],$$

and is also defined for all distance z such that $\sqrt{V} - \sqrt{F(z)} \geq 0$ (i.e., $z \leq \widetilde{z} = F^{-1}(V)$) takes into account that $\widetilde{\theta}(S,z)$ takes values in the interval $\left[\underline{\theta}, \overline{\theta}\right]$. For $z > \widetilde{z}$, it is never optimal for a transnational terrorist organization to diffuse to country z and we simply pose in that case $\widetilde{\theta}(S,z) = \underline{\theta}$.

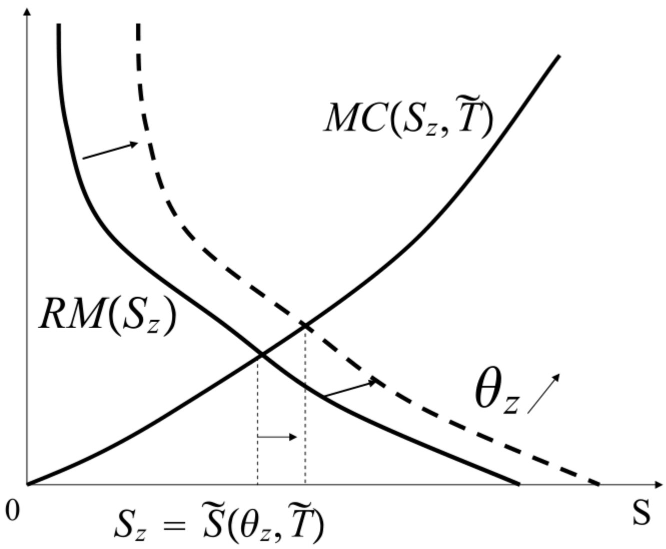
The right hand side of (2.2) is the marginal benefit $RM(S_z)$ of security measures on the probability of no occurrence of a terrorist act emanating from z. It depends on the beliefs that the government of U has on the amount of resources $R_z^N(\theta)$ spent by a terrorist cell in z. It is easy to see that $RM(S_z)$ is decreasing in S_z.

Substituting (6) into the first order condition we get

$$MC(S_z, \widetilde{T}) = C \int_{\underline{\theta}}^{\theta_z} \left(\frac{\sqrt{\theta}}{\sqrt{\varphi V}} \frac{1}{\sqrt{S_z}} - \frac{\theta}{\varphi V} \right) f(\theta) d\theta. \tag{8}$$

This is illustrated in Figure (3). The right hand side of (8) is the marginal benefit of security $RM(S_z)$. It is shifted up with the threshold θ_z. In other words, the larger the set of parameters θ such that transnational terrorism diffuses to country z, the larger the marginal gain to impose security against that country. Simple inspection shows that (8) has a unique solution $S_z = \widetilde{S}(\theta_z, \widetilde{T})$ which is increasing in the threshold θ_z, decreasing in $\widetilde{T}$ and such that $\widetilde{S}(\underline{\theta}, \widetilde{T}) = 0$.

Figure 3: Optimal Security Measure



We get easily the following proposition:

Proposition 1 *There is a unique Bayesian Nash equilibrium of the transnational terrorism-security game such that:*

i) For $z > \widetilde{z}$, there is no diffusion of terrorism and no security measure applied against country z (i.e., $R_z^N(\theta) = 0 \; \forall \theta \in \left[\underline{\theta}, \overline{\theta}\right]$, $\theta_z^N = \underline{\theta}$ and $S_z^N = 0$).

ii) For $z \leq \widetilde{z}$, there is a unique threshold $\theta_z^N \in]\underline{\theta}, \overline{\theta}]$ such that terrorism diffuses to country z if and only if the terrorist resource cost θ is less than θ_z^N. The level of security applied against country z is S_z^N and the level of terrorist resources engaged in country z is:

$$R_z^N(\theta) = R(S_z^N, \theta) = \frac{1}{\varphi}\left[\sqrt{\frac{\varphi V}{\theta} S_z^N} - S_z^N\right] \quad \textit{for} \quad \theta < \theta_z^N,$$
$$= 0 \qquad\qquad \textit{for} \quad \theta \geq \theta_z^N.$$

iii) The equilibrium expected probability of occurrence of a terrorist action originating from country z is given by : $\Pi_z = 0$ for $z > \widetilde{z}$ and

$$\Pi_z = \int_{\underline{\theta}}^{\theta_z^N} \left(1 - \sqrt{\frac{\theta}{\varphi V}} \sqrt{S_z^N}\right) f(\theta) d\theta \;\; \textit{for} \; z \leq \widetilde{z}.$$

Characterization of the Bayesian equilibrium is illustrated in Figure (4) for $z \leq \widetilde{z}$.

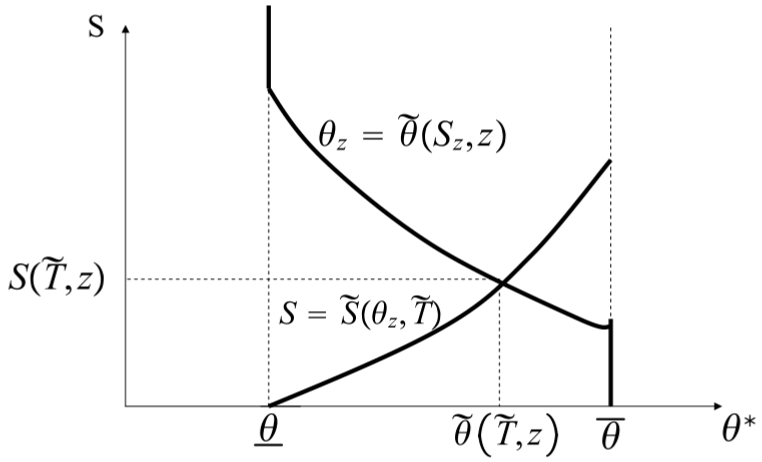
The security curve $S = \widetilde{S}(\theta_z, \widetilde{T})$ is an upward sloping curve of the threshold θ_z. The larger the threshold below which transnational terrorism diffuses, the larger the benefits of security measures imposed by country U against country z. The threshold curve $\theta_z = \widetilde{\theta}\,(S_z, z)$ on the other hand is decreasing in S_z. A larger level of security against country z reduces the profitability of establishing a terrorist cell in that country. This establishment requires indeed a higher level of efficiency (i.e., a lower value of θ). The intersection of these two curves gives a solution $S_z = S(\widetilde{T}, z)$ and $\theta_z = \widetilde{\theta}\left(\widetilde{T}, z\right)$. On appendix A we show that there is a unique $\widetilde{T}$ consistent with these solutions and therefore a unique Bayesian Nash equilibrium.

We can now derive our two main comparative statics:

a) How does distance to the terrorist organization headquarter influence transnational terrorism diffusion, bilateral security and trade flows across countries?

b) How does an exogenous shock on security measures (due to the occurrence of

Figure 4: Bayesian Equilibrium



increased terrorist action against the US or a higher sensitivity of the US to terrorism) affect trade flows across countries?

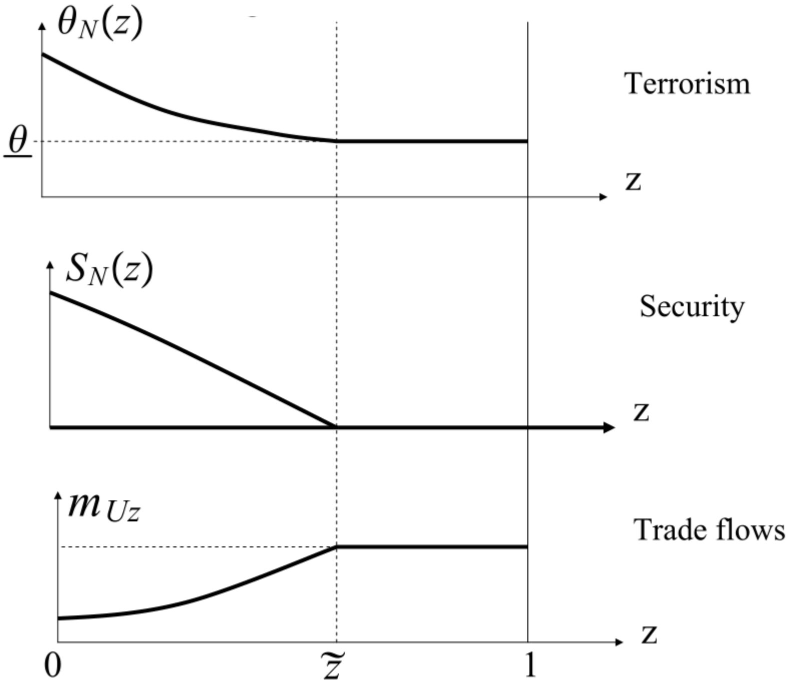
Let us consider the first comparative static. Simple inspection of Figure (4) shows immediately how the equilibrium outcome varies with distance z to the terrorist organization headquarter.

Proposition 2 *Whenever transnational terrorism diffuses, (i.e., for $z \leq \widetilde{z}$), we get that: i) θ_z^N is a decreasing function of z, ii) S_z^N is a decreasing function of z.*

Hence both the incentives for diffusion of transnational terrorism and the level of security applied to country z tend to decrease with the distance z to the terrorist organization headquarter. In other words, as distance z increases the organizational cost to establish a terrorist cell, the perceived probability of diffusion of terrorist activity decreases. This in turn reduces the level of bilateral security imposed by country U. These two effects are summarized in the first two panels of Figure (5).

The effect of terrorism diffusion on trade flows between country U and country

Figure 5: Effect of Distance



z is easily deduced from the equation characterizing their bilateral trade:

$$m_{Uz} = \frac{LL_U T(S_z^N)^{1-\sigma}}{(\widetilde{T}^*)^{1-\sigma}}. \tag{9}$$

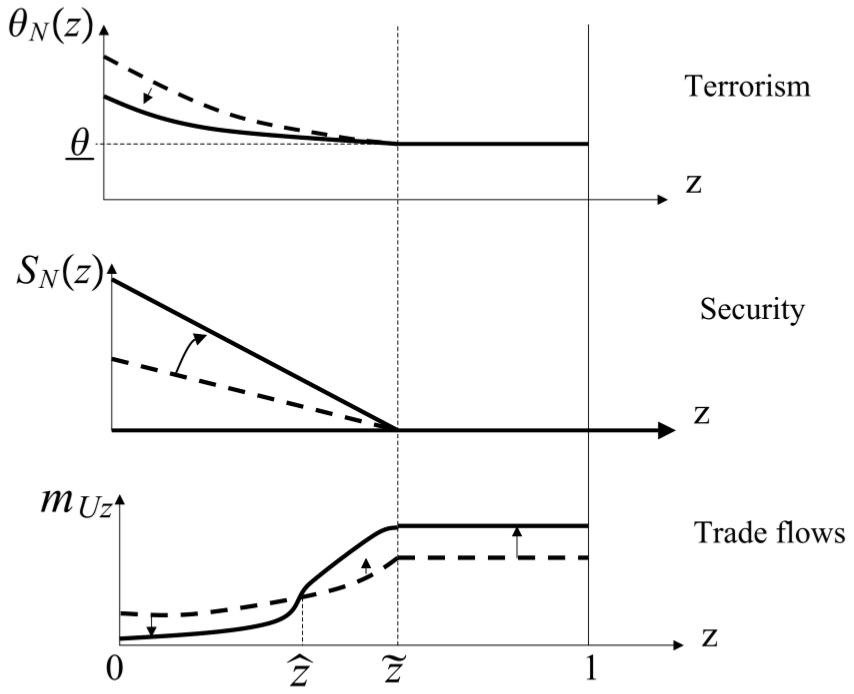
It is easily verified that:

Proposition 3 *m_{Uz} is strictly increasing in z for $z \leq \widetilde{z}$ and $m_{Uz} = const.$ for $z > \widetilde{z}$ (i.e., is unaffected by terrorism).*

Proposition (3) says that transnational terrorism has some local negative spillover effects on bilateral trade (m_{UZ}). The closer the location of country z is to the terrorist organization headquarter in 0, the lower is trade between countries U and z. This effect is depicted in the bottom panel of Figure (4).

Consider now the second comparative static, i.e., the effect of an exogenous shock on security measures. As can be seen on (8), this shock will increase the value of bilateral security $S = \widetilde{S}(\theta_z, \widetilde{T})$. It can be shown that the equilibrium value S_z^N will increase for $z \leq \widetilde{z}$ and remain constant ($S_z^N = 0$) for $z > \widetilde{z}$. The security function S_z^N rotates around point $z = \widetilde{z}$ (recall that $\widetilde{z}$ is independent from C). In turn, it can be shown that a larger level of security requires a higher level of efficiency (i.e., a lower value of θ). Hence the equilibrium threshold value θ_z^N will decrease for $z \leq \widetilde{z}$ and remain constant $\theta_z^N = \underline{\theta}$ for $z > \widetilde{z}$. These two effects are depicted in the first two panels of Figure (6).

Figure 6: Effect of Shock on Terrorist Cost C



Two effects on trade volumes can be distinguished. They are summarized in the bottom panel of Figure (6). First, it can be shown that the increase in security shifts up the trade friction cost index $\widetilde{T}^*$. Consequently, all countries benefit from an increase in the (inward) multilateral trade resistance of U. So, the trade flow of z to U is increased by high trade cost from other suppliers to U as captured by inward multilateral resistance. On the other hand, countries with $z \leq \widetilde{z}$ also suffer from increased bilateral security measures which penalize their trade with U. The overall effect will depend on the location of z to the terrorist organization headquarter at $z = 0$. Trade with country U will increase for countries with $z > \widetilde{z}$, as they only face the positive multilateral resistance effect. However, countries close to $z = 0$ will face a decrease in their volume of trade with U (i.e., m_{U0} goes down), as such countries are more affected by the negative bilateral effect than the positive multilateral resistance effect due increased security.[8] In other words, for countries z close enough to the terrorist headquarter (i.e., $z \leq \widehat{z} \leq \widetilde{z}$), their trade with country U is smaller after the shift in C, while for countries further away from U, (i.e., $z > \widehat{z}$) their trade with country U is larger. The preceding discussion can be summarized in the following proposition:

Proposition 4 *An exogenous increase in the cost of terrorism C reduces trade flows m_{Uz} with country U for countries such that $z \leq \widehat{z}$ and increases m_{Uz} for countries such that $z > \widehat{z}$.*

3 Empirical analysis

The aim of our empirical analysis is to assess the impact of neighbor terrorism on trade patterns. Before embarking on regressions and conterfactual experiments, we present the data on transnational terrorism and the way we construct the proximity measure to terrorism. In lieu of direct measures of increased security, that are unfortunately unavailable, we use terrorist incidents that are assumed (backed by the theory) to induce increased security targeted at perpetrating locations of terrorist acts and their near neighbors.

3.1 Data description on transnational terrorism

ITERATE database. Data on transnational terrorist incidents come from the ITERATE database set-up by Mickolus, Sandler, Murdock and Flemming (2006). This data set is available for the years 1968-2011, but we only use the years 1993-2006 because this is the period for which our explained variable, bilateral sectoral trade, and the principal explanatory variables are available on a large scale.

ITERATE is an event-based data set that lists all of the incidents in the world that have been reported in the medias since 1968 onwards. It provides information on the date, the country of location of the attack, and the nationalities of terrorists and victims. This helps us to define the target and the source (or origin) countries of terrorism.

[8] This can be shown when the transport cost function $T(S)$ is convex enough in S.

Source country of terrorism. The country is coded as a source of terrorism when it represents that of the main nationality of the attacking force. Three potential issues are here worth mentioning.[9] First, we may be concerned that there is no one main nationality in the attacking group but different equally-sized nationalities. However, as noted by Blomberg and Rosendorff (2009), 98% of incidents are reported with only one source country. Second, the nationality of the attacking force may not represent the view of the country with which it is associated. We abstract from this problem as long as the target countries implement security measures against a country hosting attacking forces, regardless of the representativeness of the terrorist's views. Moreover, "this problem is no less severe than what we encounter when we try to measure any international variable" [Blomberg and Rosendorff, 2009] such as investment or trade. Third, the source country might not be the country of location of the incidents, defined as the place where the incidents have taken place. However, we observe in the data that in most cases the source country is also the country of location of the incident, e.g. this is the case in 96% of the incidents perpetrated against the US.

Based on the ITERATE data, we identify 115 source countries, that have been at the source of at least one transnational terrorist incident between 1993 and 2006. Table (3) reports the number of incidents per source country (mean, 13 incidents; standard deviation, 27.69). The top ten source countries of transnational terrorism are Colombia, Turkey, Palestine, Iraq, Somalia, Algeria, Pakistan, Yemen, Egypt and Iran. On average, these ten countries have perpetrated more that 80 transnational incidents each between 1993 and 2006.

Our final sample for estimation includes 113 countries (see Table 4 in appendix for the list of countries). This sample is constrained by the availability of the dependent and explanatory variables. Thus, not all countries, included in the final sample, have been a source of terrorism and not all source countries are included in the final sample. Only the countries indicated with a star in Table (3) are included in the final sample for estimation.

[9]Note that one third of total incidents have been perpetrated by unknown groups with which no source country has been associated.

Target country of terrorism. The country is coded as a target of terrorism when it represents that of the main nationality of the victims.[10] Nearly 80% of the victims are associated with only one nationality. Consequently, we could assign in a relatively confident way only one target country to an incident. We also consider that the target country can be hit at home or abroad. As an illustration, when an US embassy is hit abroad, the US is coded as the target country.

Between 1993 and 2006, Table (4) reports that 89 out of our 113 countries in the final sample have been a target of a least one terrorist incident from the above source countries. We also observe that the US has been by far the country that is most hit by transnational terrorism attacks during our period of investigation: 819 incidents against 176 for Great-Britain, 169 for Turkey and 120 for France.

Construction of the proximity measure to terrorism. To assess empirically the impact of neighbor terrorism on trade patterns, we construct a measure of proximity to terrorism. We proceed in two steps. First, we define neighbor relationships among countries. Neighborhood definitions are based on the sharing of different characteristics between countries such as a land border, an official (or primary) language and/or a religion.[11] We argue that the more of these characteristics countries share, the closer their neighborhood relationship. For each definition, we count the number of neighbor countries $n = 0, 1, ..., N$ of a given country z. As an illustration, let us consider two different definitions. The first one is based on the sharing of a border, a language *and* a religion.

Using this definition, Sudan shares a border, a language and a religion with three neighbor countries n in our sample, namely Chad, Egypt and Libya. The second definition is based on the sharing of a border only. Using this definition, Sudan has seven contiguous neighbors n in our sample, namely Central African Republic, Chad, Democratic Republic of the Congo, Egypt, Ethiopia, Kenya, Libya and Uganda.

In the second step, using the different combinations of characteristics shared by z

[10] ITERATE defines victims as "those who are directly affected by the terrorist incident by the loss of property, lives, or liberty."

[11] We consider that two countries share a religion when a common religion is practiced by at least 50% of the population in each country. Our results appear to be robust to the use of a different threshold, namely 10 and 20%.

and its neighbors n,[12] we construct a proximity to terrorism variable, $Proxim_{dzt}(n)$. For each combination of characteristics, $Proxim_{dzt}(n)$ sums the number of terrorist incidents perpetrated by the neighbor(s) n of z against a target (or destination) country d in a year t. Formally, for a given year and a given combination of characteristics between n and z:

$$\text{Proxim}_{dz}(n) = \sum_{n=1}^{N} \left(\text{Terror Incidents}_{nd} \times \text{Neighbor Dummy}_{nz}\right), \tag{10}$$

where Terror Incidents_{nd} is the number of terrorist incidents perpetrated by neighbor countries $n = 0, 1..., N$ against the target d; and Neighbor Dummy_{nz} is equal to one if countries n and z are neighbors, zero otherwise. As an illustration, in 1993, Sudan's neighbors, with whom it shares a border, a language and a religion in our sample (i.e., Chad, Egypt and Libya), perpetrated 4 terrorists incidents against the target country $d = \{\text{United States}\}$.

$Proxim_{dz}(n)$ measures the proximity to terrorism of a country z against a country d. Thus, for a given combination of common characteristics, the higher the number of terrorist incidents perpetrated by z's neighbor(s) against d, the closer is z to terrorism against d. Defining neighborhood based on the share of a border, a language and a religion, the distribution of $Proxim_{dzt}(n)$ in our sample of 1,207,475 bilateral trade observations, spanning from 1993 to 2006, is tabulated in Table (1).

Based on the observation of Table (1), we can summarize the $Proxim_{dzt}(n)$ variable by an indicator $I_{dz}(n)$, that will be incorporated in the trade specification. $I_{dz}(n)$ equals one if $Proxim_{dzt}(n) > 0$, and 0 otherwise. A bit less than one percent of bilateral relationships are affected by terrorism from neighbors (i.e., $I_{dz} = 1$).

3.2 The direct effect of proximity to terrorism on trade

Building on the above measure of proximity to terrorism and using a gravity equation consistent with our theory (albeit more general), we first estimate the direct effect of neighbor terrorism on trade. Together with all other trade cost estimates we can then compute inward and outward multilateral resistances. Finally, from the

[12] We use seven different combinations: {border, language, religion}, {border, language}, {border, religion}, {language, religion}, {border}, {language} and {religion}.

Table 1: Neighbor incidents against target countries (1993-2006)

Number of Neighbor Incidents$_{dz}(n)$	Number of Observations$_{dz}$
0	1,197,830
1	6,283
2	1,299
3	706
4	375
5	171
6	226
7	149
8	52
9	106
10	135
11	18
12	24
14	25
15	23
16	19
88	34
Total	1,207,475

Notes: Col. 1: Number of incidents perpetrated by neighbor(s) n of country z against a target country d. Col 2: Number of bilateral observations between the importer (target) country d and the exporter country z.

direct neighbor effects and the multilateral resistances, we perform a counterfactual experiment to gauge an interesting non-monotonic *total* effect of neighbor terrorism on trade (i.e. direct+indirect one).

To get a reliable estimate of the effect of neighbor terrorism on trade, we adapt the theoretical gravity equation (2) for empirical estimation of a multi-country model. This adaptation is in line with the now standard structural gravity model methods (see Anderson, 2011). Our sample includes 113 exporter and importer countries, of which various source and target countries of terrorism (see Table 4 in appendix for the list of countries). Using time subscripts, we get

$$m_{dzt} = \frac{Y_{zt}E_{dt}}{Y_t}\left(\frac{T_{dzt}}{P_{dt}\Pi_{zt}}\right)^{1-\sigma}, \qquad (11)$$

where m_{dzt} is imports of country d from country z in year t and Y is the nominal value of world output. Equation (11) defines a structural gravity-like model of trade (Anderson and van Wincoop, 2003 and Anderson and Yotov, 2010). The expression $\left(\frac{Y_{zt}E_{dt}}{Y_t}\right)$ is the frictionless trade ratio. It relates bilateral trade to the economic size of both partners, i.e., the sales of goods at destination prices from country z to all destinations (Y_{zt}) and the expenses of country d from all origins (E_{dt}). The expression $\left(\frac{T_{dzt}}{P_{dt}\Pi_{zt}}\right)$ is the *trade cost friction ratio*. Thus, bilateral trade is also related to bilateral trade costs T_{dzt}, as well to the outward Π_{zt} and inward P_{dt} multilateral resistances:

$$\Pi_{zt}^{1-\sigma} = \sum_{d} \left(\frac{T_{dzt}}{P_{dt}}\right)^{1-\sigma} \frac{E_{dt}}{Y_t}, \tag{12}$$

$$P_{dt}^{1-\sigma} = \sum_{o} \left(\frac{T_{dzt}}{\Pi_{zt}}\right)^{1-\sigma} \frac{Y_{zt}}{Y_t}. \tag{13}$$

We now fit the equation (11) to the data as follows. First, for a given year, we posit that trade costs are a stochastic log-linear function of observables

$$T_{dz} = \prod_{m=1}^{M} (\ell_{dz}^{m})^{\gamma_m} \; \tau_{dz}(n) \; \exp(u_{dz}), \tag{14}$$

where u_{dz} is a random error, which captures all the unobserved linkages between d and z that affect bilateral trade costs. Normalizing such that $\ell = 1$ measures zero trade barriers associated with a given variable m, $(\ell_{od}^{m})^{\gamma_m}$ is equal to one plus the tariff equivalent of trade barriers associated with this variable (Anderson and van Wincoop, 2004). As in many empirical applications, the list of observable arguments ℓ_{od}^{m} will include among others geodesic distance, common language, adjacency and border effects. The argument $\tau_{dz}(n)$ is related to the spillovers of neighbor terrorism. We argue that there is no negative spillover on trade of proximity to neighbor country n if $\tau_{dz}(n) = 1$, $z \neq n$ and there is a negative spillover in region R if $\tau_{dz}(n) > 1$, $n, z \in R$. More specifically, we assume that $\tau_{dz}(n) = \tau^{I_{dz}(n)}$, $n, z \in R$, where $I_{dz}(n)$ is an indicator variable that equals unity if $Proxim_{dz}(n) > 0$ and zero if $Proxim_{dz} = 0$ (see above). Thus, this indicator variable equals one if a neighbor n of country z has perpetrated at least one terrorist incident against d. In that case, $\tau_{dzt}(n) = \tau$ is the effect of proximity to terrorism on trade.

Second, we use disaggregated trade data. This presents some advantages. The first advantage is that bilateral and multilateral frictions may be different by sectors. The second advantage is to cope with differences in specialization between developing and developed countries. Using trade data at the sector level (3-digit) allows us to control for the relative specialization of countries which might be correlated both with *aggregate* trade and terrorism activities (see Anderson 2008 and Mirza and Verdier 2013). This is because a country's openness to trade might shift resources away from informal sectors, increasing the opportunity cost of engaging in terror activities and pushing labor to more formal sectors. We use sectoral trade data to mitigate this potential endogeneity, which might be not to severe in our analysis. Indeed, our strategy is not to estimate the direct terrorism between d and z but the effect of the *indirect* terrorism through the neighbors.

The third step to get an estimable equation is to model the monadic z (Y_z, Π_z) and d (E_d, P_d) terms in equation (11). Such monadic terms include size effects and multilateral resistance indices. We use the simplest unbiased estimator that consist to replace monadic terms by exporter and importer country fixed effects.[13] It follows

$$m_{dzt} = \exp(\alpha_{zt} + \alpha_{dt})(T_{dzt})^{1-\sigma}, \tag{15}$$

where $\alpha_{zt} = \Pi_{zt}^{1-\sigma}\frac{Y_{zt}}{Y_t}$ is a year-exporter fixed effect for z and $\alpha_{dt} = P_{dt}^{1-\sigma}\frac{E_{dt}}{Y_t}$ is year-importer fixed effect for d.

Using the trade cost specification (14), we obtain for a given sector

$$m_{dzt} = \exp\left(\alpha_{zt} + \alpha_{dt} + \sum_{m=1}^{M} \lambda_m \ln z_{dzt}^m + \beta I_{dzt}(n) + u_{dzt}\right), \tag{16}$$

where $\lambda_m = (1-\sigma)\gamma_m$. The estimate of interest is $\beta = (1-\sigma)\ln\tau$, given that the *ad-valorem* tax equivalent of terror is $\tau - 1 = \exp\left(\frac{\gamma}{1-\sigma}\right) - 1$.

Results.

To run our analysis, we use a constructed data set from de Sousa, Mayer and Zignago (2012) of 26 International Standard Industrial Classification (ISIC Revision 2) 3-digit industries, 113 exporting and importing countries on the period 1993-2006. The list of countries and industries are tabulated in Tables (4) and (5) in Appendix E. Data sources are described in Appendix C.

[13] Among others, this approach is adopted by Anderson and van Wincoop (2003) and Eaton and Kortum (2002).

We estimate equation (16) with the Poisson pseudo-maximum likelihood (PPML) estimator advocated by Santos Silva and Tenreyro (2006). This estimator addresses two typical problems in estimating gravity equations with the Ordinary Least Square (OLS) when log-transforming the dependent variable: sample selection and inconsistency. The sample selection results from converting the zero values of the nontrading pairs to missing values. The OLS inconsistency comes from the fact that the expected value of the log-linearized error will depend on covariates.

In Table 2, we report results for equation (16), using different combinations of the measure of proximity to terrorism. All specifications include a full set of year-exporter, year-importer and sector-specific (3-digit) dummies. Standard errors are clustered at the country-pair level to address potential problems of heteroskedasticity and autocorrelation in the error terms.

Before discussing the neighbor terrorism estimates, notice that, in all regressions, the traditional bilateral trade costs variables included in equation (14), like geodesic distance, common language, contiguity and home appear with the expected signs. The elasticity of trade to distance is negative and in line with the mean elasticity of 0.9 found in the literature (see Disdier and Head 2008). The contiguity variable, which is set to one if the two countries are contiguous, and the "common language" variable, which is set to one if a language is spoken by at least 9% of the population in both countries, have expected positive estimates. The home dummy is equal to one for intranational trade (i.e., $d = z$), and zero otherwise. The Home estimate in column (1) implies that each country traded, on average, around 12 times more [exp(2.48)] within its national borders than with another country of the world. This high border effect is not so much surprising since McCallum (1995) (see also de Sousa, *et al.* 2012).

The Neighbor Terror is a dummy variable which is unity if neighbors of country z have perpetrated at least one terrorist incident against country d. The estimate of the Neighbor Terror variable is not significant in the first three regressions, while it is statistically and economically significant in the last two columns. Regression in column (5) implies that imports from d decrease by about 38% [$(\exp(-0.48)-1)*100$] due to neighbor terrorism. The estimate in column (4) is a bit higher but does not

Table 2: Trade and proximity to transnational terrorism

Dependent variable	Imports$_{dzkt}$				
	(1)	(2)	(3)	(4)	(5)
Definition of proximity to transnational terrorism	Linguistic	Religious	Contiguous	Contiguous & Linguistic	Contiguous & Linguistic & Religious
ln(Distance)$_{dz}$	-0.91^a	-0.91^a	-0.91^a	-0.91^a	-0.91^a
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Language dummy$_{dz}$	0.36^a	0.35^a	0.36^a	0.37^a	0.36^a
	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
Contiguity dummy$_{dz}$	0.37^a	0.37^a	0.36^a	0.36^a	0.36^a
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Home dummy$_{dz}$	2.48^a	2.50^a	2.48^a	2.48^a	2.48^a
	(0.11)	(0.12)	(0.11)	(0.11)	(0.11)
Neighbor Terror dummy$_{dzt}$	-0.01	0.05	-0.02	-0.60^a	-0.48^b
	(0.09)	(0.1)	(0.18)	(0.22)	(0.22)
Fixed Effects:					
Exporter-Year	yes	yes	yes	yes	yes
Importer-Year	yes	yes	yes	yes	yes
Sector k (3-digit)	yes	yes	yes	yes	yes
# of Observations	1,207,475	1,207,475	1,207,475	1,207,475	1,207,475

Notes: In parentheses: heteroskedastic-robust standard errors, clustered by country pairs. ^{a} and ^{b} denote significance at the 1% and 5% level respectively. Constant and fixed effects are not reported.

appear to be significantly different from the one in column (5). Both estimates confirm the importance of negative local spillovers on trade as backed by the theory.

The stark difference between neighbor estimates, in columns (1-3) vs columns (4-5), is in line with the reasonable assumption that the more characteristics a country z shares with its neighbors, as in columns (4) and (5), the closer their neighborhood relationship. In that case, neighbor terrorism is assumed to be more detrimental to trade between d and z, because security measures against z will be increased to prevent any potential direct attack from the terror cell. Recall that increased security is assumed to more intensively impose costs on trade from more likely sources of terrorism.

The difference between neighbor terror estimates is reassuring if we consider that security measures are not designed randomly but use 'profiling'. A given country z could indeed share the language of a source country of terror while being geographically far remote from z, with a low probability to host a terrorist cell. This could explain why the Neighbor Terror estimate is not significant in column (1), when proximity to terrorism is only defined on a linguistic basis. *Mutantis mutandis*, the same is true when defining neighborhood only on a religious basis. The result in regression (3) is more surprising since contiguous countries are at least close in terms of geographic distance, but their contiguity does not imply that they share other common characteristics, which increase the probability of implementing a terror cell. They could be at war for instance.

3.3 A non-monotonic effect of proximity to terrorism on trade

We perform a counterfactual experiment to gauge how cost increases from terrorism affect international trade. Proposition (4) highlights an interesting non-monotonic effect of increased security whereby near neighbors to a terrorist incident have trade reduced by enhanced security measures while further away countries benefit from the relative cheapening of their goods due to the security induced increase in the inward multilateral resistance of the US. We design an empirical strategy to investigate this non-monotonic effect.

Empirical strategy. The non-monotonic effect of neighbor incidents is investigated through the estimation of the trade cost friction ratio (see eq. 11), comprising bilateral trade costs, outward (OMR) and inward (IMR) multilateral resistances:

$$OMR_d = \widehat{\Pi}_d^{1-\sigma} = \sum_z \left(\frac{\widehat{T}_{zd}}{\hat{P}_z} \right)^{1-\sigma} \frac{E_z}{Y}, \tag{17}$$

$$IMR_d = \widehat{P}_d^{1-\sigma} = \sum_z \left(\frac{\widehat{T}_{dz}}{\hat{\Pi}_z} \right)^{1-\sigma} \frac{Y_z}{Y}. \tag{18}$$

$$\widehat{T}_{dz}^{1-\sigma} = \exp\left(\widehat{\lambda}_1 \ln(\text{dist})_{dz} + \widehat{\lambda}_2 \text{border}_{dz} + \widehat{\lambda}_3 \text{lang}_{dz} + \widehat{\lambda}_4 \text{home}_{dz} + \widehat{\lambda}_5 I_{dz}(n)\right) \tag{19}$$

Inward and outward multilateral resistance indexes are calculated by solving system (17) - (18).[14] To solve this system, we need data on individual country expenditures (E_z) and outputs (Y_z) from 1993 to 2006 (see data source details in Appendix C). Unfortunately, we lack such data for a large number of countries, especially for the developing countries where transnational terrorism is prevalent. Thus, to keep a maximum number of countries, we average manufacturing expenditures and outputs over the period 1993-2006 at country level. Moreover, we compute the bilateral trade cost $\widehat{T}_{dz}$ based on the equation (19) and the estimates of the trade cost variables reported in column (5) of Table (2). Finally, for each country pair, we sum over the period 1993-2006 the number of terrorist incidents perpetrated by neighbors' exporter against the importer.[15]

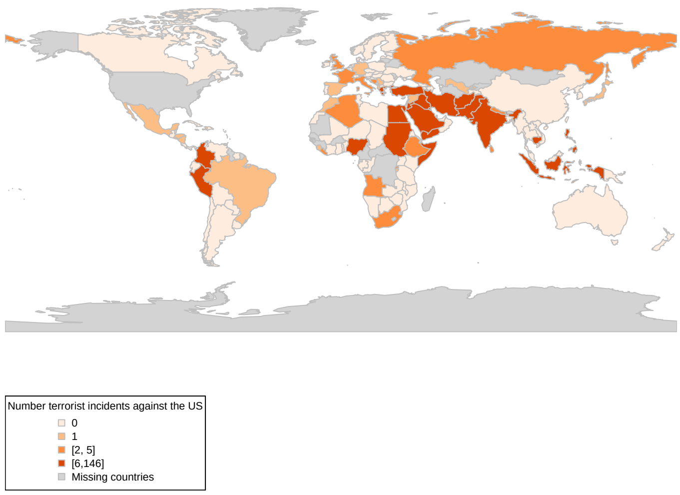
Proposition (4) has been derived with a continuum of countries potentially hosting terror cells. However, for tractability reasons, only one importing (target) country, the US, has been considered. As in the previous empirical section, we consider a multi-country model, but our counterfactual experiment is designed to isolate the effects of neighbor terror against the US, via its representative authorities, its army or its civilians anywhere in the world. This choice is empirically motivated by the fact that the US has been by far the country that is most hit by transnational

[14] We thank Scott Baier for providing us a draft of the R code to solve this system.

[15] We define here neighbor relationships based on the sharing of a border, a language and a religion between countries.

terrorism attacks during our period of investigation (see Table 4). Moreover, the distribution of incidents against the US is spread over a large number of different source countries. This pattern is depicted in Figure (7). We use this cross-section variation of terrorism to investigate the effect of neighbor terror on US imports. During our period of investigation, 40 exporter countries in our sample for estimation have neighbors perpetrating incidents against the US (see Table 6). It is worth noting that 11 out of those 40 countries do not perpetrate direct incidents against the US.

Figure 7: Transnational terrorism against the United States (1993-2006)



Results. We analyze the counter-factual experiment of switching on neighbor terrorism against the US, i.e. a switch from "No neighbor terror" to "Neighbor terror" against the US. Our counter-factual experiment confirms an interesting non-monotonic effect of terror on trade that can be decomposed in three parts, corresponding to the three arguments of the trade cost friction ratio in Eq. (11). First, the 40 near neighbors of terrorism (see Table 6) have seen their bilateral trade costs with the US increasing from an unweighted average of 6.9% to a weighted average of 17.7%. The weight is the number of neighbor terrorist incidents against the US.

Second, switching on neighbor terror against the US leads to a 2% increase in the inward multilateral resistance (IMR) of the US. So, as expected, near neighbors to a terrorist incident have trade reduced by enhanced trade costs while further away countries benefit from the relative cheapening of their goods due to the increase in the IMR of the US (that benefits to all countries). Third, the multicountry model allows to compute the outward multilateral resistance (OMR) and IMR changes of all the countries, i.e. their buyer and seller incidence (see Anderson and Yotov, 2010). We find that the 40 near neighbors have increased their OMR by 1.6% on average, while further away countries have reduced their OMR by .28% (see bottom of Table 6). This difference is significant (p=0.00). Moreover, those 40 countries have decreased their IMR by 2.16% on average, versus an increase of .5% for the further away countries (see bottom of Table 6). Interestingly enough, the largest variations in OMR are found in countries geographically close to the US, such as Canada (+1.2%) and Bahamas (+1.27%) versus Mexico (-2.18%) and Guatemala (-2.45%) (see Table 6).

The three parts of the non-monotonic effect, related to trade cost and multilateral resistance changes, can be decomposed graphically. Figure (8) represents the changes in bilateral trade cost between z and the US by switching on neighbor terrorism against the US. Multilateral resistances are unchanged. The solid red line shows the discontinuity of trade cost changes for the 72 countries far from terrorism vs the 40 countries near terrorism. The latter face a negative spillover on trade with the US. This negative spillover is identical for all those countries because the solid line does not account for the number of incidents perpetrated by their neighbors.

How does a higher sensitivity of the US to terrorism affect US trade flows across countries? To analyze empirically this question, investigated theoretically in proposition 4, we account for the number of terrorist incidents perpetrated by the neighbors over the period. This weight reflects the sensitivity of the US to terrorism. Security is assumed to more intensively impose costs on trade from more likely sources of terrorism against the US. This likelihood is higher the greater the number of neighbor incidents against the US. The dashed green line translates this idea into a higher negative spillover on trade.

Figure 8: The non-monotonic effect of neighbor terror against the US (1st part)

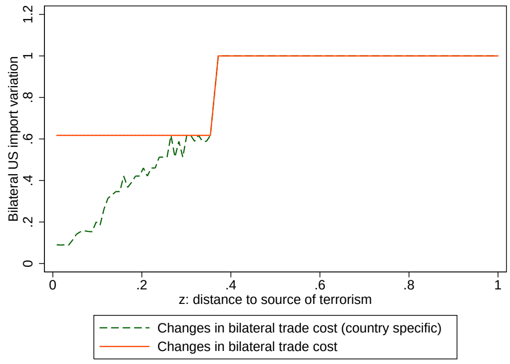
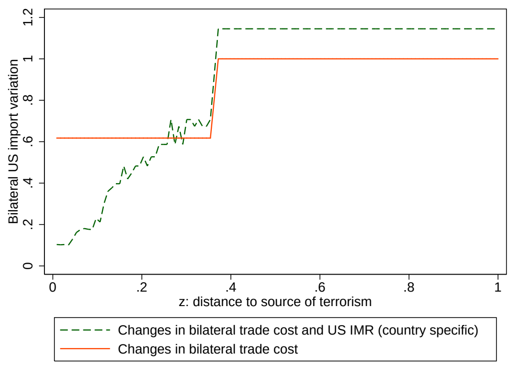


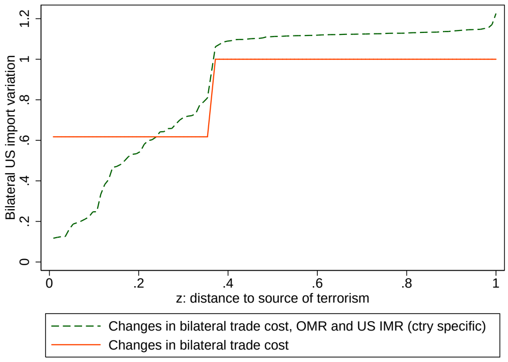
Figure (9) adds the second part of the non-monotonic effect, i.e., the change in the US IMR. As expected, this change benefits to all the exporters and the dashed line is shifted up compared to Figure (8). Figure (9) mimics the Figure (6) derived theoretically from proposition (4) (where the US is the only importing country and exporters' OMR changes cannot be accounted for).

Figure 9: The non-monotonic effect of neighbor terror against the US (2nd part)



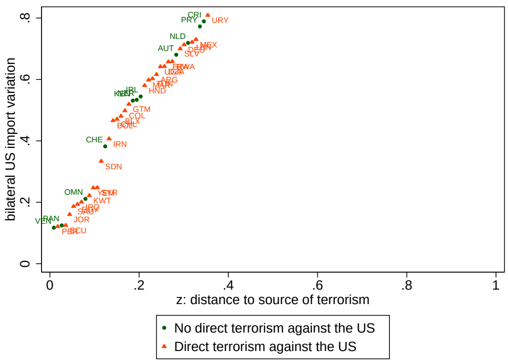
The three changes of the non-monotonic effect of neighbor terror are finally represented in Figure (10). This figure incorporates the additional change in exporters' OMR when switching on neighbor terrorism against the US. This effect is absent from our theory because for the sake of tractability the only importing country is the US. The empirical multi-country model allows for the response of partner costs or their complement, outward multilateral resistances, to increases in security measures directed at near neighbors of terrorist perpetrators. This figure confirms the interesting non-monotonic effect of increased security whereby near neighbors to a terrorist incident have trade reduced by enhanced security measures while further away countries benefit from the relative cheapening of their goods due to the security induced increase in the inward multilateral resistance of the US.

Figure 10: The non-monotonic effect of neighbor terror against the US (3rd part)



Finally, Figure (11) zooms on the near neighbors of terror. We distinguish among those who do perpetrate terrorism against the US from those who don't. Both groups face negative spillovers on trade from neighbor terror independently of their own potential terrorist acts against the US.

Figure 11: Negative spillover on near neighbors of terror



4 Conclusion

In this paper we have examined the impact of transnational terrorism diffusion on security and international trade. To counter the diffusion of transnational terrorism, governments implement comprehensive security measures. These measures are directed both against the source countries of terror and their neighbor countries where terrorism may diffuse. By raising trade costs, these measures may affect international trade.

We set up a simple theoretical model predicting an interesting non-monotonic effect: the closer a country is to a source of terrorism, the higher the negative spillovers on its trade. In contrast, countries located far from terror could benefit from an increase in security by trading more. We investigate the empirical validity of these implications with a large data set of international trade relationships and transnational terrorist incidents on the 1993-2006 period. We find a direct negative impact of transnational terrorism on trade and confirm the non-monotonic effect of neighbor terror on trade.

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Appendices

A Existence of the Bayesian Nash equilibrium

A Bayesian Nash equilibrium $\left(S_z^N, \theta_z^N\right)$ of the terrorism-security game is characterized by the set of equations such that for all $z \in [0,1]$:

$$\begin{aligned} S_z^N &= \widetilde{S}(\theta_z^N, \widetilde{T}), \\ \theta_z^N &= \widetilde{\theta}\left(S_z^N, z\right), \end{aligned}$$

and

$$\widetilde{T}^{1-\sigma} = \left(L_U T_{UU}^{1-\sigma} + L\int_0^1 T(S_z^N)^{1-\sigma} dz\right).$$

Inspection of Figure 3b shows that $S(\widetilde{T}, z)$ is decreasing in $\widetilde{T}$ while $\widetilde{\theta}\left(\widetilde{T}, z\right)$ is increasing in $\widetilde{T}$.[16] From this, it follows that

$$\begin{aligned} H(\widetilde{T}) &= L_U T_{UU}^{1-\sigma} + L\int_0^1 T(S_z)^{1-\sigma} dz \\ &= L_U T_{UU}^{1-\sigma} + L\int_0^1 T(S(\widetilde{T}, z))^{1-\sigma} dz, \end{aligned}$$

is an increasing function of $\widetilde{T}$. Now the equilibrium value of $\widetilde{T}$ has to satisfy the following equation

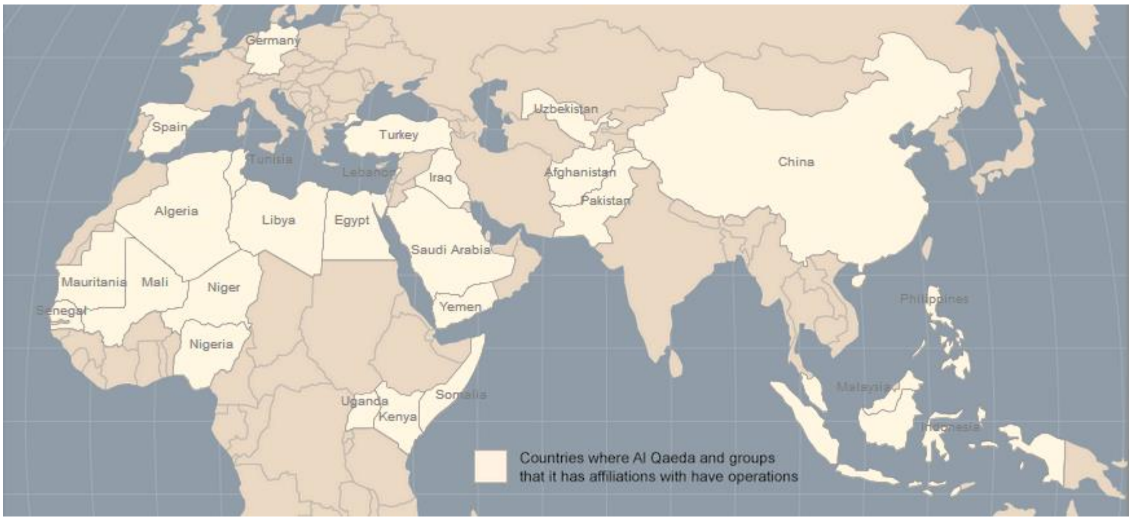
$$\widetilde{T}^{1-\sigma} = H(\widetilde{T}). \tag{20}$$

The left hand side of this equation is a decreasing function of $\widetilde{T}$ (for $\sigma > 1$) going from $+\infty$ to 0 as $\widetilde{T}$ goes from 0 to $+\infty$. As $H(\widetilde{T})$ is an increasing function of $\widetilde{T}$ with $H(0) \geq 0$ and $\lim_{\widetilde{T}\to\infty} H(\widetilde{T}) > 0$, it follows that equation (20) has a unique solution $\widetilde{T}^*$. Substitution gives immediately $S_z^N = S(\widetilde{T}^*, z)$ and $\theta_z^N = \widetilde{\theta}(\widetilde{T}^*, z)$ for $z \leq \widetilde{z}$.

[16] Note that $\widetilde{T}$ is also endogenous in the model as, in turn, it depends on the level of security measures imposed on all countries $z \in [0,1]$ (see equation 4).

B Terrorism figures

Figure 12: Al Qaeda and affiliated groups



Source: http://www.nytimes.com/interactive/2011/05/12/world/12aqmap.html

C Data sources

The study covers the period 1993-2006. To run our analysis, we use a constructed data set from de Sousa, *et al.* (2012) of 26 International Standard Industrial Classification (Revision 2) 3-digit industries, 113 exporting countries and 113 importing countries. The data sets provides bilateral trade and production figures in a compatible industry classification for developed and developing countries. Manufacturing expenditures (absorption) are calculated as total production plus imports minus exports. Data on distance, contiguity and language come from the CEPII (http://www.cepii.fr/anglais-graph/bdd/distances.htm).

D Source countries of terrorism

Table (3) lists the source countries of transnational terrorism from 1993 to 2006.

Table 3: Source countries of transnational terrorist incidents by income level

High	# of incidents	Upper-middle	# of incidents	Lower-middle	# of incidents	Low	# of incidents
Australia*	2	Argentina*	2	Albania*	10	Afghanistan	29
Austria*	1	Bahrain	7	Algeria*	57	Angola	26
Belgium and Lux.*	1	Brazil*	2	Bolivia*	1	Azerbaijan*	2
Cyprus*	1	Chile*	1	Bosnia-Herzegovina	14	Burundi	6
Denmark*	1	Croatia	1	China*	14	Bangladesh*	1
France*	9	Gabon*	1	Colombia*	224	Côte d'Ivoire*	1
Germany*	14	Korea*	2	Costa Rica*	1	Congo	2
Greece*	27	Lebanon*	8	Cuba	8	Ethiopia*	9
Ireland*	8	Malaysia*	1	Dominican Rep.	1	Georgia*	6
Israel*	4	Mexico*	2	Ecuador*	2	Haiti*	2
Italy*	14	Poland*	1	Egypt*	42	Indonesia*	28
Japan*	4	Saudi Arabia*	35	El Salvador*	5	India*	17
Kuwait*	9	Slovakia*	1	Guatemala*	6	Cambodia*	31
Netherlands*	1	South Africa*	5	Honduras*	2	Liberia	8
Norway*	1	Trinidad-Tobago*	1	Iran*	40	Mali	1
Portugal*	1	Uruguay*	1	Iraq*	68	Burma	5
Singapore*	2	Venezuela*	4	Jamaica	1	Nigeria*	32
Spain*	14			Jordan*	15	Nicaragua	7
Sweden*	1			Latvia*	1	Nepal*	4
Taiwan*	2			Macedonia*	1	Pakistan*	52
U.A. Emirates	1			Morocco*	9	Rwanda*	7
U.S.A*	5			Papua New Guinea	1	Sudan*	13
United Kingdom*	14			Peru*	15	Sierra Leone*	29
				Philippines*	36	Somalia	61
				Romania*	1	Chad	2
				Russia*	19	Togo	1
				Serbia-Montenegro	5	Tajikistan*	5
				Sri Lanka*	19	Uganda*	6
				Syria*	5	Ukraine*	2
				Tunisia*	1	Uzbekistan	4
				Turkey*	129	Yemen*	48
						Zimbabwe*	1
						Palestine	88
Total: 23	137	17	75	31	753	33	536

Note: The study covers the period 1993-2006. The star indicates the countries in the sample for estimation. High, Upper-middle, Lower-middle and Low refer to the World Bank classification of countries by income level in 2001. # of incidents: number of incidents from the source country. The country is coded as a source of terrorism when it represents that of the main nationality of the attacking force.

E List of industries and countries in the sample for estimation

Tables (4) and (5) report (1) the list of source countries of transnational terrorism, and (2) the list of countries in the sample for estimation with the number of transnational terrorist incidents recorded against them, respectively.

Table 4: List of countries in the sample for estimation by income level and recorded transnational terrorist incidents against them (1993-2006)

High	# of incidents	Upper-middle	# of incidents	Lower-middle	# of incidents	Low	# of incidents
Australia	18	Argentina	7	Albania	3	Armenia	0
Austria	7	Brazil	9	Algeria	4	Azerbaijan	1
Bahamas	0	Chile	3	Bolivia	3	Benin	0
Belgium and Lux.	26	Czech Republic	1	Bulgaria	13	Bangladesh	7
Canada	26	Estonia	1	China	20	Côte d'Ivoire	0
Cyprus	0	Gabon	0	Colombia	11	Eritrea	0
Denmark	6	Hungary	10	Costa Rica	2	Ethiopia	4
Finland	2	Korea	15	Ecuador	3	Georgia	1
France	120	Lebanon	3	Egypt	9	Ghana	1
Germany	25	Malaysia	4	El Salvador	4	Gambia	1
Greece	15	Malta	1	Fiji	2	Haiti	0
Hong Kong	0	Mexico	10	Guatemala	5	Indonesia	9
Ireland	9	Oman	1	Honduras	0	India	41
Israel	66	Panama	5	Iran	9	Kenya	3
Italy	86	Poland	14	Iraq	3	Cambodia	0
Japan	22	Saudi Arabia	6	Jordan	7	Laos	0
Kuwait	0	Slovakia	2	Latvia	1	Mozambique	1
Netherlands	23	South Africa	10	Macedonia	0	Malawi	1
New Zealand	4	Trinidad-Tobago	0	Morocco	4	Niger	0
Norway	8	Uruguay	7	Paraguay	2	Nigeria	5
Portugal	6	Venezuela	28	Peru	2	Nepal	4
Singapore	2			Philippines	17	Pakistan	3
Slovenia	1			Romania	6	Rwanda	1
Spain	29			Russia	38	Sudan	4
Sweden	8			Sri Lanka	5	Sierra Leone	0
Switzerland	23			Suriname	0	Tajikistan	0
Taiwan	3			Syria	0	Tanzania	1
U.S.A	819			Thailand	11	Uganda	0
United Kingdom	176			Tunisia	1	Ukraine	6
				Turkey	169	Viet Nam	0
						Yemen	0
						Zambia	1
						Zimbabwe	0
Total: 29	1530	21	137	30	354	33	95

Note: The sample includes 113 countries. High, Upper-middle, Lower-middle and Low refer to the World Bank classification of countries by income level in 2001. # of incidents: number of incidents recorded against the country. The country is coded as a target when it represents that of the main nationality of the victims.

Table 5: List of the 26 ISIC 3-digit industries included in the sample

Code	ISIC (International Standard Industrial Classification) Rev. 2 3-digit
31	**Food, Beverages and Tobacco**
311-312	Food
313	Beverage
314	Tobacco
32	**Textile, Wearing Apparel and Leather Industries**
321	Textiles
322	Wearing apparel, except footwear
323	Leather and products of leather, leather substitutes and fur
324	Footwear, except vulcanized or moulded rubber or plastic footwear
33	**Wood and Wood Products, Including Furniture**
331	Wood and cork products, except furniture
332	Furniture and fixtures, except primarily of metal
34	**Paper and Paper Products, Printing and Publishing**
341	Paper and paper products
342	Printing, publishing and allied industries
35	**Chemicals and Chemical, Petroleum, Coal, Rubber and Plastic Products**
351	Industrial chemicals
352	Other chemical products
353	Petroleum refineries
355	Rubber products
356	Plastic products not elsewhere classified
36	**Non-Metallic Mineral Products, except Products of Petroleum and Coal**
361	Pottery, china and earthenware
362	Glass and glass products
369	Other non-metallic mineral products
37	**Basic Metal Industries**
371	Iron and steel basic industries
372	Non-ferrous metal basic industries
38	**Fabricated Metal Products, Machinery and Equipment**
381	Fabricated metal products, except machinery and equipment
382	Machinery except electrical
383	Electrical machinery apparatus, appliances and supplies
384	Transport equipment
385	Professional and scientific, and measuring and controlling equipment not elsewhere classified, and of photographic and optical goods

F Counter-factual experiment (1993-2006)

Table 6: Neighbor terror against the US and multilateral resistance changes

No Neighbor Terror	Δ OMR	Δ IMR	Neighbor Terror	Δ OMR	Δ IMR
Albania	-0.31	0.53	Argentina	0.71	-1.26
Armenia	-0.26	0.46	Austria	0.13	-0.36
Australia	-0.29	0.55	Belgium and Lux.	-0.06	-0.34
Azerbaijan	-0.12	0.46	Bolivia	2.33	-3.06
Benin	-0.22	0.59	Switzerland	0.85	-2.65
Bangladesh	-0.25	0.41	Chile	2.47	-3.05
Bulgaria	-0.43	0.52	Colombia	2.48	-3.09
Bahamas	-0.68	1.27	Costa Rica	2.28	-2.44
Brazil	-0.33	0.35	Germany	0.13	-0.17
Canada	-0.56	1.20	Algeria	1.31	-1.85
China	0.32	-0.15	Ecuador	3.08	-3.75
Côte d'Ivoire	-0.30	0.59	Egypt	1.44	-2.16
Cyprus	-0.21	0.49	France	-1.02	0.58
Czech Republic	0.03	0.32	Guatemala	2.14	-2.45
Denmark	-0.06	0.34	Honduras	2.68	-2.91
Eritrea	-0.21	0.64	Ireland	0.47	-0.66
Spain	-1.08	0.88	Iran	1.09	-1.67
Estonia	-0.27	0.53	Iraq	1.56	-2.08
Ethiopia	-0.19	0.65	Jordan	3.23	-3.77
Finland	-0.08	0.42	Kenya	1.38	-1.96
Fiji	-0.71	0.81	Kuwait	3.46	-3.48
Gabon	-0.26	0.54	Lebanon	0.98	-0.86
United Kingdom	-0.92	0.86	Morocco	1.84	-2.63
Georgia	-0.16	0.48	Mexico	0.47	-2.18
Ghana	-0.38	0.74	Niger	1.45	-2.30
Gambia	-0.58	0.77	Netherlands	0.24	-0.27
Greece	-0.21	0.49	Oman	2.55	-3.23
Hong Kong	-0.24	0.28	Panama	2.76	-3.20
Haiti	-0.60	0.86	Peru	2.50	-2.98
Hungary	-0.10	0.43	Paraguay	1.97	-2.04
Indonesia	-0.18	0.38	Rwanda	1.67	-1.84
India	-0.30	0.43	Saudi Arabia	2.10	-3.54
Israel	-0.77	0.64	Sudan	1.51	-2.65
Italy	-0.60	0.58	El Salvador	2.56	-2.58
Japan	-0.35	0.36	Syria	2.26	-3.46
Cambodia	-0.27	0.40	Tunisia	1.95	-2.73
Korea	0.01	0.04	Uganda	1.29	-1.54
Laos	-0.10	0.33	Uruguay	1.95	-2.06
Sri Lanka	-0.36	0.46	Venezuela	1.84	-2.76
Latvia	-0.32	0.51	Yemen	1.07	-1.08
Macedonia	-0.30	0.52			
Malta	-0.61	0.68			
Mozambique	-0.16	0.53			
Malawi	-0.38	0.67			
Malaysia	0.01	0.26			
Nigeria	-0.41	0.71			
Norway	-0.18	0.50			
Nepal	-0.15	0.38			
New Zealand	-0.54	0.76			
Pakistan	0.08	0.49			
Philippines	-0.43	0.49			
Poland	-0.37	0.41			
Portugal	-0.15	0.57			
Romania	-0.36	0.50			
Russia	-0.02	0.41			
Singapore	-0.40	0.43			
Sierra Leone	-0.51	0.76			
Suriname	0.98	-0.90			
Slovakia	-0.24	0.45			
Slovenia	-0.23	0.47			
Sweden	-0.28	0.44			
Thailand	-0.24	0.33			
Tajikistan	-0.21	0.44			
Trinidad-Tobago	-0.35	0.51			
Turkey	-0.54	0.50			
Taiwan	0.11	0.02			
Tanzania	0.02	0.66			
Ukraine	-0.14	0.49			
Viet Nam	-0.03	0.32			
South Africa	-0.28	0.59			
Zambia	-0.35	0.69			
Zimbabwe	-0.41	0.67			
Average change:	-.28	.50		1.63	-2.16

Note: No Neighbor Terror (72 countries) and Neighbor Terror (40 countries) refer to countries with or without neighbor terrorism against the US. Δ is the change in multilateral resistances when switching on vs switching off neighbor terrorism against the US.