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State Failure, Violence, and Trade: Dangerous Trade Routes in Colombia[*]

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Abstract

We investigate the effect of domestic armed violence brought about by political instability on the geography of distance frictions in freight mobility and the resulting differential access of regions to global markets. The Colombian transportation system has been found to be impeded by deficiencies in landside transport infrastructure and institutions, and by fragmented political environments. The micro-level analysis of U.S.-bounded export shipping records corroborates that export freight shipping from inland regions is re-routed to avoid exposures to domestic armed violence despite greatly extended landside and maritime shipping distances. We exploit the trajectories of freight shipping from Colombian regions and spatial patterns of violent armed conflicts to see how unstable geopolitical environments are detrimental to freight shipping mobility and market openness. The discrete choice model shows that the shipping flow is greatly curbed by the extended re-routing due to domestic armed violence and that inland regions have restricted access to the global market. The perception of risk and re-routing behavior is found heterogeneous across shipments and conditional to shipment characteristics, such as commodity type, freight value and shipper sizes. The results highlight that political stability must be accommodated for improved freight mobility and export-oriented economic development in the global South.

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Fallas del estado, violencia y comercio: rutas comerciales peligrosas en Colombia

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Palabras clave: violencia, comercio internacional, modelos de elección discreta, Colombia.
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Resumen

En este documento se investiga el efecto de la violencia armada doméstica provocada por la inestabilidad política sobre las fricciones de la distancia en la movilidad de carga. Además, el efecto de esas fricciones sobre el acceso diferencial de las regiones a los mercados globales. Se concluye que el sistema de transporte colombiano se ve obstaculizado por deficiencias en la infraestructura e instituciones de transporte terrestre y por entornos políticos fragmentados. El análisis a nivel micro de los registros de exportaciones hacia Estados Unidos corrobora que el envío de carga de exportación desde las regiones del interior se redirige para evitar exposiciones a la violencia armada doméstica a pesar de las amplias distancias de envío marítimo y terrestre existentes. Aprovechamos las trayectorias del transporte de carga desde las regiones colombianas y los patrones espaciales de los conflictos armados violentos para ver cómo los entornos geopolíticos inestables son perjudiciales para la movilidad del transporte de carga y la apertura del mercado. A través de un modelo de elección discreta se muestra que el flujo de envío se ve frenado por el desvío debido a la violencia armada doméstica y que las regiones del interior tienen acceso restringido al mercado global. La percepción de riesgo y comportamiento de redireccionamiento se considera heterogénea entre los envíos y está condicionada a las características del envío, como el tipo de mercancía, el tamaño y el valor del flete. Los resultados resaltan que el conseguir la estabilidad política puede ayudar a mejorar la movilidad de carga y el desarrollo económico orientado a la exportación en el Sur global.

1. Introduction

Long-distance commerce thrives under the stable and reliable operation of a global logistic chain devoid of impediments. It capitalizes on a supply chain that has accelerated mobility, speed, capacity and reliability of freight shipping, but also where security is offered door to door (Cowen 2014, Birtchnell 2016). As the 9/11 terrorist attacks escalated security concerns, security of the logistic chains is no longer the purview of a single country's policy effort like blockading borders. Instead, it has become a matter of managing and monitoring flows of goods along any segments of trade corridors spanning across countries (Bigo 2001, Haveman and Shatz 2006). In this context, governments and international organizations have become more interested in the impacts of terrorist attacks, piracy, crime, and theft on freight mobility and in appropriate prevention measures against disruptions to assure the frictionless and seamless flow of international commerce (Cowen 2014).

In the light of the unprecedented internationalization of commerce and the ensuing integration of the global market, the inclination is to hold the view that international trade flows are no longer impeded by market barriers and geographic remoteness and are fully secure. It may largely be true in trade between developed countries today, where there are adequate supply chain infrastructure and institutions for long-distance shipping and secure operations, but it could be wishful thinking for many developing countries. Latin American countries are a case in point in this respect, where poor inland transportation systems increase freight shipping costs and uncertainty in the cargo logistics chain is holding back the opening to global markets and the growth potential of inland regions (Tiller and Thill 2015, Vega *et al.* 2019). Specifically, by the early 2000, Colombia exhibited one of the lowest indicators in terms of the number of kilometers of paved roads per worker (0.4 km). Peru and Guatemala surpassed Colombia's endowment with 1.1 km per worker, followed by Chile and Brazil (2.5 kms), Venezuela (3.6 km) and Argentina (5.9 km) (Pérez-Valbuena 2005).

Even though the traditional view in the trade literature has posited that tariff, quota (Anderson and Van Wincoop 2004), landlocked-ness (Kashiha, Thill, *et al.* 2016), international borders (Kashiha, Depken, *et al.* 2016), quality of logistical infrastructure (Limão and Venables 2001) constrain export activities and international commerce, we contend that insecurity is another significant impediment to border-crossing movement of goods. As more threats to international supply chains emerged after the 9/11 terrorist attacks, a number of studies have discussed the extent to which insecurity impacts commerce and freight mobility. For example, trade activities of Latin American countries are found hindered by the low quality of institutions and legal systems, lack of personal security, and prevalence of organized crime (Anderson and Marcouiller 2002). Moreover, a drastic rise in piracy activities in the water of the failed state of Somalia has escalated concern for the expansion of trade shipping costs because of the risk of attack and hijacking on vessels (Hastings 2009). In order to curtail risk from the Somali piracy, some shipping liners and shippers decided to re-route their vessels via the Cape of Good Hope despite the longer journey (Bendall 2010). Hence, disruption and exposure to such risk in any stages of the logistics chain can cause tremendous economic fallout, hike shipping costs, and restrict trade and shipping behaviors.

In this respect, we focus on the case of Colombia in 2006-2007 to determine how insecurity during this timeframe acted as an impediment to the movement of freight shipping in international commerce, as other tariff and non-tariff factors did. Much evidence has suggested that, for a number of years, Colombia's economic growth was persistently hampered by its state failure and by the limited effectiveness of institutions to control civil conflicts and organized crime (McLean 2002, Arnson 2004, Riascos and Vargas 2011). Domestic armed conflicts were reported in the area of main highways and ports, and trucking further inland experienced frequent interruptions, which were dubbed "*pesca milagrosa* [miraculous fishing]," by bombing, armed attacks, robbery, kidnapping, blockade, and extortion of tolls for passage and ransom by guerrilla groups (Rohter 1999, Rangel Suarez 2000, Feldmann and Hinojosa 2009, BBC News 2016). Since Colombia's production activities are concentrated around the Andean mountains and far from the seaports, export shipments to ports are highly exposed to the risk of obstruction associated with domestic armed conflicts. Given the heightened cost of risk, freight mobility in Colombia could be compromised by insecurity stemming from the unstable political environment, which in turn may curtail export activities and access to the global market.

In this context, this study focuses on decisions made by shipping parties among possible shipping routes in response to insecure political environments on the landside. Matching Colombia-U.S. export shipping records and localized domestic armed conflict data in

Colombia, we study at the micro-level how the corridor of freight shipping to seaports is influenced by the geography of domestic armed conflicts. We posit that the decisions pertaining to the port of export and port of transit on the one hand and to the shipping route leading to ports on the landside on the other hand are closely intertwined. Hence, we propose the hypothesis that shipping parties would seek to reduce their exposure to domestic armed conflicts along the shipping routes by shifting to other ports that can be accessed more securely, despite extended shipping distances. Using the sequence of ports that the freight shipment traverses as a proxy for its shipping route, we formulate and estimate a discrete choice model to examine the likelihood port choice along the route is influenced by the risk from insecurity and other covariates. We demonstrate on the basis of micro-level data that shipping routes exposed to higher risk of domestic armed violence have higher freight cost and distance friction and that cargo shipping is re-routed to further ports via safer routes.

The next section reviews the literature on the relationship between insecurity and commerce and provides background on Colombia's political and economic geography with a focus on its long-term political fragmentation and underdeveloped transport system. Here we also discuss preliminary findings on spatial patterns of the trade route choices and domestic armed conflicts from U.S.-bound export shipping and local armed conflict records in Colombia. Then, we present our modeling strategy to examine how export-bound shipping routes are influenced by the risk of domestic armed violence. The next section presents and discusses our core analytical results. In addition, we compute distance equivalences of the observed risk of domestic armed conflicts to measure the cost of the re-routing and we assess the extent to which access to global markets is restricted. The last section concludes with policy implications for institutions that support the secure operation of cargo shipping logistics and foreign aid support for transportation development.

2. Background

2.1 Theoretical Background: Insecurity as Trade Impedance

The study of international and interregional trade has long sought to identify the impediments to trade. Common findings are that trade flow is constrained not only by transport costs but also by implicit factors that impose a hidden tax on international commerce (Head and Mayer 2013). Anderson and van Wincoop (2003) observed that international borders restrict trade flows more than explained by formal impediments like physical distance, tariffs, and quotas alone. Bilateral trade between the Global North and South is also observed to be much more constrained than would be expected from differences in relative factor endowments (Anderson and Marcouiller 2002). In fact, a range of geographical and policy factors have been attributed to the hidden trade barriers, such as the quality of the logistical infrastructure (Limão and Venables 2001), tariff and trade policy relationships (Baier and Bergstrand 2001), international border, and landlocked-ness of countries (Christ and Ferrantino 2011, Kashiha, Thill, *et al.* 2016, Capello *et al.* 2018), and historical and colonial legacies (Head and Mayer 2013).

Insecurity has been discussed as a main impediment to international and interregional commerce in the larger context of the literature on institutions. As economic growth can be severely curbed when states fail to support adequate institutions to control violence and enforce laws (Knack and Keefer 1995, Blomberg *et al.* 2004, Berman *et al.* 2012), Anderson and Marcouiller (2002) argued that the lack of institutions in trading countries can lead to a heavy toll on international trade, like cases of hijacking of shipments, contract breaking, corruption and bribery extortion by customs officials. Especially, any types of violence, like external and internal conflicts and terrorist attacks, can cause a serious decline in trade since trading partners would be inclined to switch to more peaceful countries to avoid risk (Blomberg and Hess 2006). Thus, incidents of violence can raise trade barriers as much as tariff, quota, and transport costs do.

Previous studies have examined different extreme cases of inadequate institutions to show that violence and insecurity have a negative effect on trade. Anderson and Marcouiller (2002) estimated that the trade volume of Latin American countries is 30% lower than European Union countries, owing to their low institutional quality, and more specifically, deficiencies in government transparency, reliability of the legal system, personal security, and fight against organized crime. Country-level gravity model results also indicated that trade volumes are significantly reduced by the threat of terrorist events (Blomberg and Hess 2006, Mirza and Verdier 2014). Blomberg and Hess (2006) estimated that terrorism and internal and external conflicts depress trade flows as much as a 30% tariff on trade.

Weak institutions, possibly leading to endemic violence and corruption, can restrict freight mobility and impact patterns of trade shipping. The rise in Somali piracy has patently shown how violence hinders international freight shipping and trade flows. Besley *et al.* (2015) found that shippers incurred extra maritime shipping costs for the risk premium from the Somali piracy and diminished economic profit from the international trade, as the Somali government lost its state power to control pirate activities. Bendall (2010) estimated the additional freight rate levied on shipping lines to avoid the risk of piracy by re-routing via the Cape of Good Hope. Freight mobility is also discouraged by corruption. South African firms are found to be willing to re-route their shipping to more distant ports to avoid the uncertainty of bribery payments at corrupt ports despite the higher transport costs (Sequeira and Djankov 2014). These cases emphasize the importance of strong institutions as a necessary condition for freight mobility and access to the international market through port-bound and inter-port transport systems.

2.2 Context: State Failure and Transport Geography of Colombia

Colombia is known for its deep-seated history of fragmented political landscape, the prevalence of violent crimes, and lagging economic growth ruined by illegal drug trade (Richani 2007). A number of active left-wing insurgent groups emerged in the early 1960s with different political ideologies and stance vis-à-vis the national government, like *Fuerzas Armadas Revolucionarias de Colombia* [Revolutionary Armed Forces of Colombia] (FARC), *Ejército Popular de Liberación* [Popular Liberation Army] (EPL) and *Ejército de Liberación Nacional* [National Liberation Army] (ELN). Paramilitary groups like *Autodefensas Unidas de Colombia* [United Self-Defenses of Colombia] (AUC) were also organized for self-defense and protection of local landowners against the left-wing guerrilla groups.

Regardless of their political stance, all armed groups were suspected of direct involvement in numerous cases of serious violent crimes in Colombia, such as death threats, homicides, massacres, forced recruitment, hijacking, kidnapping, bombing, road blockading, and narcotrafficking (Lozano-Gracia *et al.* 2010). The rugged terrain of the Andes and the dense Amazon forest are favorable to irregular warfare, so they could take advantage of the geography in guerrilla activities (O'Sullivan 1983). Since civilians living in sporadic urban settlements could be easy targets, the insurgent groups could not only easily wage predatory acts on civilians but also efficiently react to the government's suppression attempts (Holmes *et al.* 2010). Frequent combats between insurgents, paramilitary groups, and the government armed forces had escalated a security concern and detrimental economic impact on Colombia.

With Colombia's well-known poorly managed inland transportation infrastructure, political instability and state failure have seriously degraded inland freight mobility. Moreover, the lack of dual carriageways or the poor condition and the obsolescence of the land roads represent additional costs to the trucking companies and, in turn, disadvantages in the competitiveness of the country (Yepes *et al.* 2013, García-García *et al.* 2015). According to Ramírez-Giraldo *et al.* (2021), transport infrastructure in Colombia suffers from institutional failures of planning, regulation and corporate governance that hinder the development of this sector, which in turn have led to a historical lag in transportation infrastructure in comparison to the international context. The Colombian government have not guaranteed security and enforced the rule of law along inland trade corridors, and inland freight shipping from the Golden Triangle Area cannot avoid the risk of disruption. A number of violent crime and conflicts are reported on main highways and in ports, such as road blockading, truck hijacking, bombing, attacks, robbery, and combats between armed groups (see Selsky 2002, Associated Press Archive 2003, 2005, Associated Press News 2003, EFE News Services 2004, 2006, 2009a, 2009b, 2009c, de Leon 2006, Cambio Weekly 2009). Guerrilla groups were reported to weight transportation companies' freights and to force them to pay irregular tolls on highways and rivers (Rangel Suarez 2000). If the companies were reluctant to pay tolls, they threatened to destroy and impound the companies' vehicles.

Insecurity around ports is also a great concern with freight shippers. In particular, the port of Buenaventura, the only gateway container port to the Pacific, has experienced extreme insecurity. A union of Colombian insurance companies reported that Buenaventura has been the port that generates the highest number of payments for events related to theft than any other port in the country (Sierra 2013). Even though Buenaventura is the most straightforward port to export from the Golden Triangle Area distance-wise, the operation of export through Buenaventura has frequently been obstructed by crime and violence. Buenaventura has been exploited as one of the main channels of illicit trade for cocaine export, and the city has remained a hub of gang activities tied to narcotrafficking (Zeiderman

2016, McVeigh 2018). Despite the Colombian government's attempt to demobilize paramilitary groups, the remaining bands have persisted in controlling local residents, imposing forced recruitment and preying on local businesses (Schoening 2014). The countryside of Buenaventura has frequently fallen under the control of the FARC (Zeiderman 2016). The city even experienced a massive attack on the infrastructure that resulted in a citywide power outage (AFP 2015).

2.3 Empirical Setting: Spatial Patterns of Domestic Armed Conflicts and Freight Shipping

A. Colombia-U.S. Freight Shipping Data

To study export shipping patterns from Colombia to the U.S., we retrieved records of maritime cargo shipping between these countries from the Port Import Export Reporting Services (PIERS) database. The PIERS database consists of bills of lading of freight imported through ports where the U.S. Customs and Border Protection offices are located. Each record has details on the shipping process from the origin to the U.S. destination port, including addresses of shippers, forwarding ports of exporting countries, intermediate ports before entering the U.S., commodity types described by the Harmonized Commodity Description Coding System (HS) codes, volume and weight of the cargo. The shipping records were recoded to clearly indicate their shipping trajectories, by identifying the location of shippers, forwarding ports in Colombia, intermediate transfer ports, and U.S. destination ports. We first collected 28,656 bill-of-lading records of cargo imported through U.S. ports from July 2006 to June 2007, right after Colombian domestic armed conflicts had intensified. Idiosyncratic shipment cases are excluded, such as empty containers, non-containerized cargo, cargo with no information on the estimated freight value or weight, and cargo transshipped at remote ports in East Asia and Europe. This produces a dataset of 26,109 bill-of-lading records of containerized cargo. Shipments of non-containerized cargo or bulk products, such as coal and oil, are not considered in the study because their production origins are limited in a few locations and their shipments are captive to a specialized port where bulk products can be handled.

We should note that Colombia's geography has a distinctive setting as far as export shipping patterns are concerned. Colombia faces both the Pacific Ocean and the Caribbean Sea, but ports on the Pacific coast and on Caribbean coast are physically disconnected by the Darién

Gap, an extremely dense rainforest and watershed area with very sparse human settlement. No road infrastructure exists in the Darién Gap, so inland shipping routes to the Pacific and Caribbean ports are completely separated. By passing the Panama Canal, cargo shipping from Colombia to the U.S. follows any of a number of routes, from inland areas via Colombian ports on either the Pacific or Caribbean coast and the Panama Canal, finally to U.S. ports on the Pacific, the Atlantic or the Gulf coast (Figure 1). For example, between July 2006 and June 2007, cargo originating in Bogotá was shipped to the U.S. along with a number of different maritime routes, in fact, 202 unique combinations of forwarding, intermediate, and U.S. ports trade routes. All cargoes from Colombia were processed through 318 different maritime routes. Examining various possible trade routes allows us to see how shipping route choices are made among broad choice sets and how shipping is re-routed in response to differentiated levels of exposure to the risk of domestic violence.

Colombia's land-based transportation system is configured in such a way that enables us to directly observe the relationship between freight mobility and the incidence of unstable domestic environments, without any interferences of political relationships with third countries or shipping across the territory of third countries. The inland segment of cargo shipping from Colombia to the U.S. is confined by the Colombia's domestic transport system. Between July 2006 and June 2007, all Colombia-U.S. export cargo was forwarded exclusively to Colombian ports without crossing the border into a neighboring country. Also, cargo sources are overwhelmingly concentrated in the Golden Triangle Area, deep in the Andean region, rather than in the coastal areas. According to the PIERS data used in this study, 10,920 out of 26,109 U.S.-bounded shipments from July 2006 to June 2007 were shipped from Bogotá, Medellín and Cali, and accounted for 40,643.57 TEUs or 52.33% of the total freight cargo. Most freight is hauled by truck because of the low quality of railway and waterway infrastructures (Vega *et al.* 2019), and inland shipping to ports is therefore highly susceptible to influences from Colombia's political and transport geography. Notice that by the early 2000, only 15% of the road network in Colombia was paved among the total 166,233 km (Cárdenas *et al.* 2005). Those factors may explain why "internal transport costs exceed international transport costs, a counterintuitive result for a country where the distances traveled internally are less than those traveled in maritime transport" (García-García *et al.* 2017).

Even though the Pacific and Caribbean coasts are topographically separated by Panama and the Darién Gap, shipping through each coastal range of ports is not necessarily tied to the corresponding range in the U.S. Our dataset reveals that a significant volume of cargo is cross-shipped to the other side via the Panama Canal (Figure 2). Even though municipalities in the Golden Triangle Area are much closer to Buenaventura on the Pacific coast, a disproportionate number of U.S.-bound exports is forwarded through Caribbean ports, like Cartagena, Barranquilla, Turbo and Santa Marta (84.92%), rather than Buenaventura (13.82%). Even when the final destinations are U.S. West Coast ports, 53.05% of the freight is forwarded through ports on the Caribbean, despite considerably extended maritime voyages through the Panama Canal. This implies that Pacific ports starkly lagged behind ports on the Caribbean Coast in handling freight, and that freight mobility on the Pacific coast is severely restricted. Possibly, Buenaventura's lower efficiency in logistic operations may cause this, yet the underperformance of Pacific ports is still notable.

B. Colombian Domestic Armed Conflict Data

We use the Uppsala Conflict Data Program (UCDP)'s Georeferenced Event Data (GED), which contains point-based geolocated armed conflict records to see the empirical trend in domestic armed conflicts in Colombia. UCDP has collected worldwide armed conflict cases annually since 1989 from global newswire and local media reporting, non-governmental and intergovernmental organization reports, and field reports (Sundberg and Melander 2013, Högbladh 2019). The geographical coordinates are identified by the place or administrative division names reported in the sources. We use detailed information about domestic armed conflicts in UCDP GED, such as the total number of fatalities, warring parties, start and end dates of the events. It is important to clarify that such detailed information helps us to improve the identification of the effects that are being estimated in the document. There are alternative sources that report cases of conflict and land piracy, but they are aggregated by municipality[1]. Notwithstanding, when comparing with other sources we find that there is a high correlation between homicides, road piracy, robberies in general, and kidnappings. One could argue that any of those events may deter exporters to send merchandises if the incidence of such events

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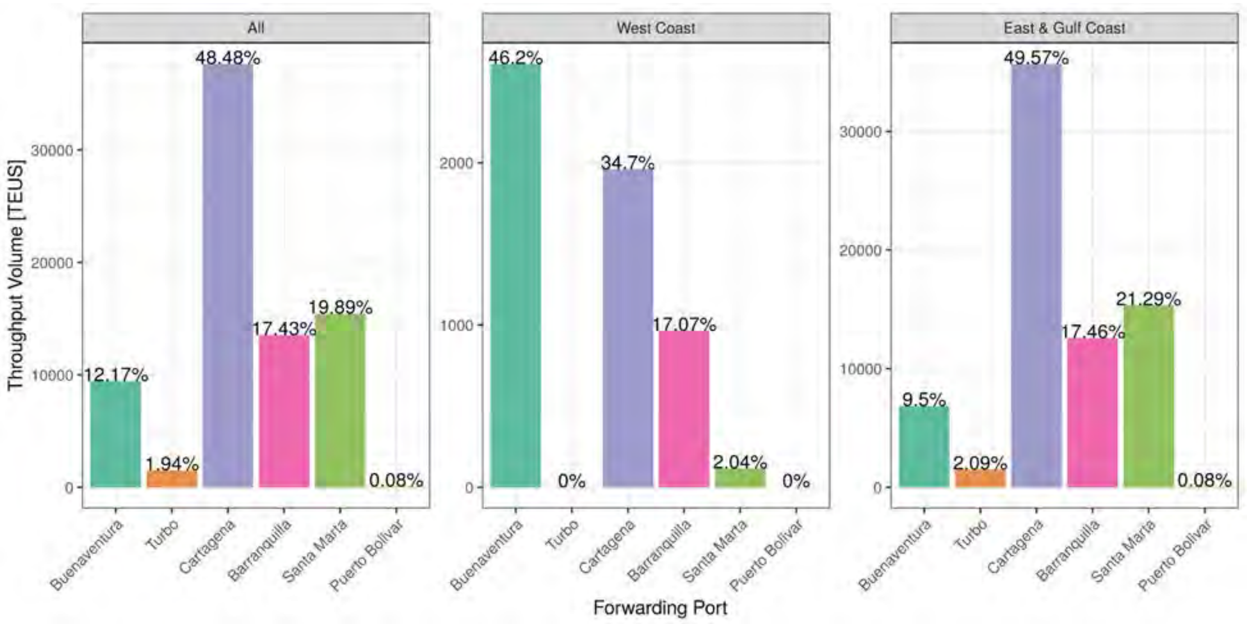
[1] See for instance the dataset by Universidad de Los Andes on conflict and violence, https://datoscede.uniandes.edu.co/es/catalogo-de-microdata.

is high. We are using however the data on the number of fatalities as this one may be more accurately reported. Thefts or piracy, for instance, may be reported depending on the value of the merchandise involved.

Figure 1. Spatial distribution of U.S.-bound freight shipping departure points (July 2006–July 2007)

Figure 2. Port forwarding patterns of U.S.-bound freight shipping from Colombia (July 2006–June 2007)

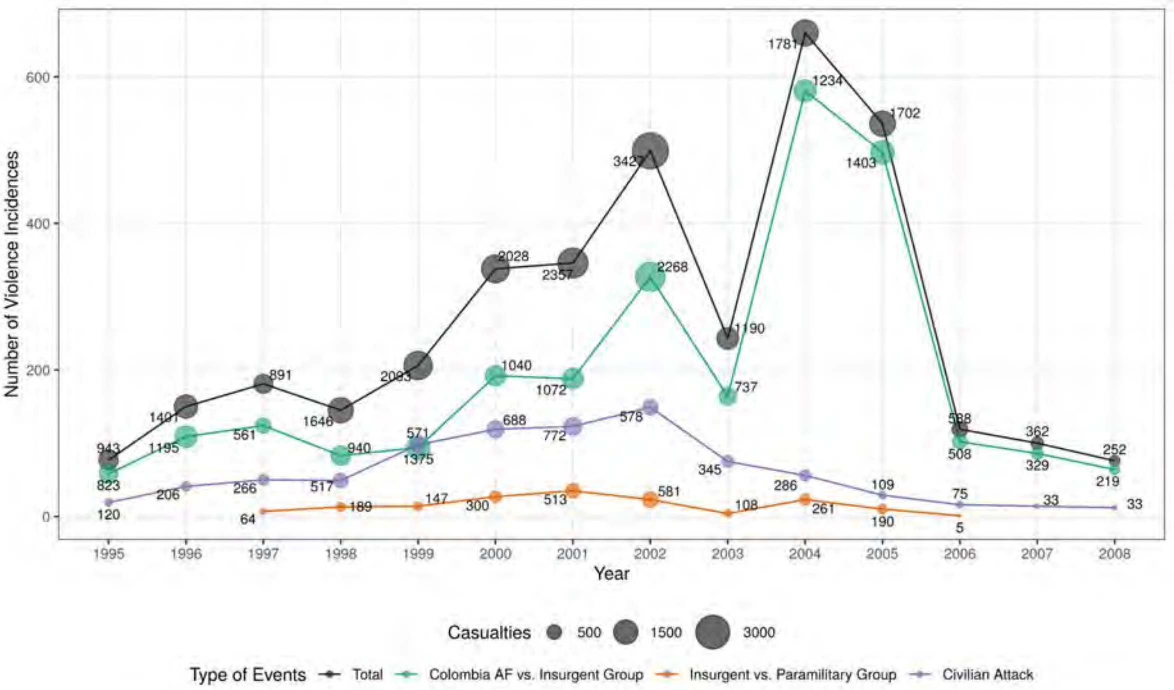


Source: calculations by the authors.

In the 2000s, Colombia experienced an high level of violence between Colombian armed forces, insurgent, and paramilitary groups, as shown by the time-series trend of the armed conflicts (Figure 3). While the Uribe administration (2002–2008) expanded counterinsurgency operations, the number of casualties and violence incidences reached their peak in 2002 and 2004, respectively (Dube and Naidu 2015). The preponderance of violent incidents and casualties came from combats between Colombia armed forces and insurgent groups, but the number of civilian attacks was also quite high. The incidence of civilian attacks was most severe in 2002, but the number of casualties of civilian attacks remained large until 2006. The violence between paramilitary and insurgent groups faded away in 2006, when AUC was demobilized by the Colombian government.

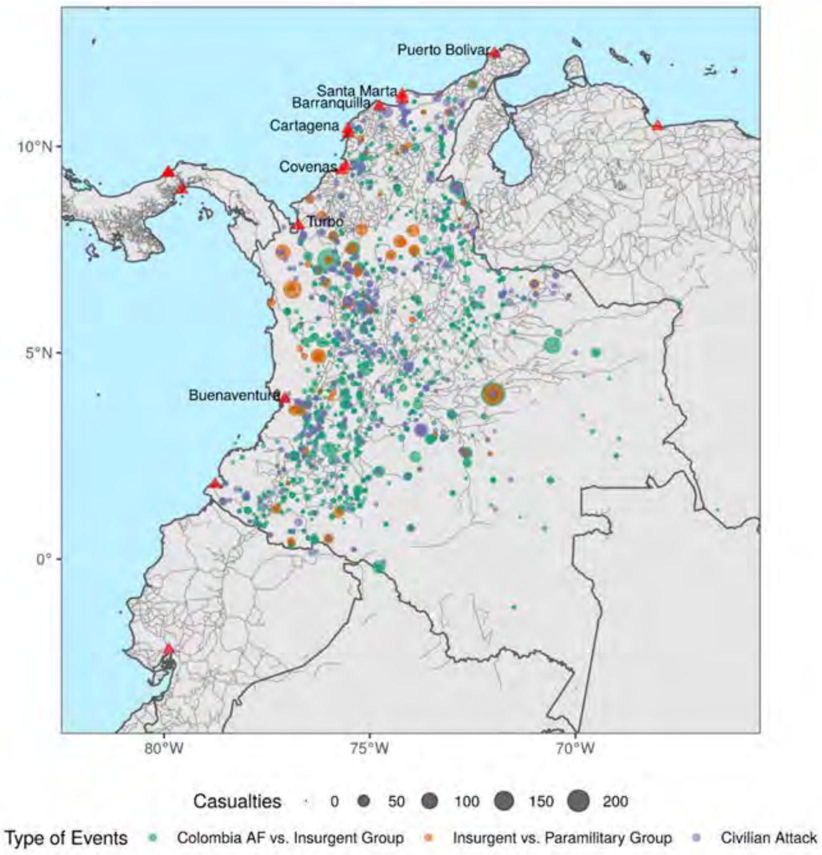
The mapping of domestic armed conflicts between 2002 and 2007, when a counterinsurgency campaign was initiated, and domestic armed conflicts reached their peak, shows that the events were disproportionately clustered in the central part of the Andean region (Figure 4). Since the area is mountainous but also the most populated, its geography provides an environment favorable to the guerrilla warfare of the insurgent groups (O'Sullivan 1983). This area is also the epicenter of Colombia's economy, where Bogotá, Medellín, and Cali are located, so civilians and businesses are easy targets of insurgent groups, as seen by the concentration of civilian attacks in this area. The mapping confirms that armed conflict events tended to occur along roads and near populated areas rather than deep in the Amazon forest. This implies that the exports starting from or passing through the central part of the Andean region could be exposed to insecurity from the armed conflict events.

Figure 3. Time-series trend of domestic armed conflicts in Colombia (1995–2008)



Source: calculations by the authors.

Figure 4. Spatial pattern of domestic armed conflicts in Colombia (2002–2007)



Source: authors' elaboration.

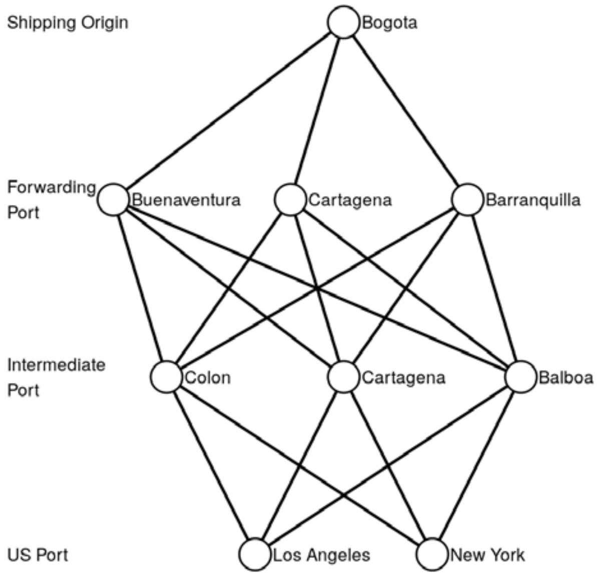
3. Research Design and Implementation Issues

3.1 Discrete Choice Model of Port Pairs aligned with Shipping Routes

To restate our objective, we study the effect of Colombia's domestic armed conflicts on commerce. We do so by analyzing export shipping routes across land and water over a twelve-month period in the form of switches between alternatives in response to localized risks of human and material loss and of transit delays brought about by violent events. On the premise that decisions pertaining to the choice of ports and to the port-bound routing on the landside are made at once, and given the configuration of Colombia's land-based transportation systems, we argue that the re-routing of shipments for safety reasons would also entail using the services of other ports. Hence, the analysis focuses on the choice of ports along the logistics chain of shipments from a Colombian source to the U.S.

International freight shipping involves multimodal logistic processes, such as land-based and maritime shipping and transshipment at ports on the cargo's voyage. For our purpose, we conceptualize the route of a shipment as a sequence of three segments (Figure 5): land-based segment (shipping origin–forwarding port), initial maritime segment (forwarding port–intermediate port), and final maritime segment (intermediate port–U.S. port of entry). In our micro-level trade dataset, the shipping route choices are represented by tripartite joint choices of forwarding, intermediate, and U.S. ports of entry. Since the PIERS data do not provide a detailed record of the spatial trajectory that a shipment took, we use the sequence of traversed ports as a proxy for the shipping route.

Figure 5. Illustration of the tripartite join choice of ports along the route: An example of possible shipping routes from Bogota, Colombia



Source: authors' elaboration.

PIERS data do not provide sufficiently reliable information on the U.S. consignee location; hence, the last location on an observed shipping route that can reliably be used is the U.S. port of entry. Since the choice of the port of entry heavily depends on the shipment's ultimate destination, we do not analyze the choice of the U.S. port of entry but include it instead as an exogenous variable in the model. Given that the shipment source and final U.S. port of entry are given and taken as exogeneous, the shipping route choice problem boils down to a choice of the two nodes of forwarding and intermediate ports. Our focus being on the choice of traversed ports along the route, the choice set is then formed of all possible combinations of forwarding and intermediate ports. By doing so, we do not consider the choice of mode nor the specific set of transportation links traversed between two ports.

Here we assume that a port pair choice along each shipment's route is made independently of all the others. The utility of routing a shipment i on route j formed of a pair of traversed forwarding and intermediate (transshipping) ports is defined as follows:

$$U_{ij} = V_{ij} + \varepsilon \tag{1}$$

where U_{ij} is the utility of shipment i gained from choosing alternative j, V_{ij} is the deterministic part of the utility, and ε is the random component. When the shipment source and the U.S. port of entry l are given exogenously, the shipper of i will choose the alternative whose utility is the largest among all alternatives in the choice set J. Following a standard logit formula (Train 2009, Ortúzar and Willumsen 2011), the probability of choosing the route j^* can be expressed as follows:

$$P\left(y_{ij^*} = 1\right) = \frac{\exp\left(U_{ij^*}\right)}{\sum_J \exp\left(U_{ij}\right)} \tag{2}$$

where y_{ij^*} is a dummy variable indicating that trade route j^* is chosen among the choice set J and $\sum_J y_{ij} = 1$.

3.2 Model Specification: Utility Function of Shipping Route Choice

To test our hypothesis on the effect of domestic armed violence on commerce, we specify the utility of a shipping route alternative with a number of factors, including the core variable of risk of domestic armed conflicts, as control variables such as shipping distance, port features, and hinterland and foreland geography along the spatial extent of the shipping routes. We should note two additional assumptions made because of the limitations of the PIERS data. First, the shippers are assumed to send their cargo to Colombia's forwarding ports by truck. Inland container cargo is predominantly shipped by this mode in Colombia because of the low quality or absence of railway and waterway infrastructures (Vega *et al.* 2019). Since the PIERS data do not specify how cargo was hauled to ports before sailing off at the forwarding ports, this assumption is the best approximation to reality. Second, land-based shipping is assumed to follow the shortest path between the source and the forwarding port. Likewise, in our data, we can only locate the nodal points of forwarding and intermediate ports along the trade routes with sufficient precision, not the whole detailed trajectories of cargo movements. To measure geographical proximity between nodal points, we use the shortest-path distances along with the inland road network and maritime voyage network, respectively. Even though the shortest path routes may not be the actual routes taken, they can indicate how shipping from one point is geographically accessible to other points.

Following basic model specifications of traditional port choice studies (Malchow and Kanafani 2001, 2004, Steven and Corsi 2012, Kashiha, Thill, *et al.* 2016), we define the deterministic part of the utility function as follows:

$$V_{ij} = V_{ij}\left(r_{ij}, \boldsymbol{D}, \boldsymbol{X}\right) \tag{3}$$

where r_{ij} is the risk of domestic armed conflicts along the land-based shipping route between the shipping origin and the forwarding port when the shipment takes route j, $\boldsymbol{D}$ is the covariates of either shortest-path trucking or maritime voyage distances, and $\boldsymbol{X}$ is a vector of other shipment- and alternative-specific control covariates.

We first specify the linear effects of the shipping distances and of the risk on the utility:

$$V_{ij} = \gamma_1 d_{ij1} + \gamma_2 d_{j2} + \gamma_3 d_{ij3} + \phi r_{ij} + \eta_{ij} \tag{4}$$

where d_{ij1} is the shortest-path trucking distance from the shipping origin to the forwarding port, d_{j2} and d_{ij3} are the shortest-path maritime voyage distances between forwarding and intermediate ports and between intermediate port and the U.S. port of entry when shipment i takes route j, respectively, and η_{ij} is the error term. Each parameter γ captures a linear distance friction effect or unit freight cost per distance, and ϕ denotes the linear effect of the risk on the utility. In addition to the linear effects, we capture the interaction effects between the risk and other covariates as discussed hereafter.

The error term η_{ij} in Equation (4) can be decomposed into three parts as follows:

$$\eta_{ij} = \eta_{ij}\left(r_{ij}, \boldsymbol{D}, \boldsymbol{X}\right) = u_i\left(r_j, \boldsymbol{X}_i\right) + v_j\left(\boldsymbol{X}_j\right) + w_{ij}\left(\boldsymbol{D}, \boldsymbol{X}_i, \boldsymbol{X}_j\right) \tag{5}$$

where u_i captures additional marginal effects of the risk interacted with the shipment-specific covariates $\boldsymbol{X}_i$, v_j accounts for the effects of the alternative-specific control covariates $\boldsymbol{X}_j$, w_{ij} denotes the effects of the other control covariates interacted with the distance terms. We specify the additional marginal effects of the risk in Equation (5) by interacting with the unit value of the shipment as follows:

$$u_i = \lambda \times r_{ij} \times \pi_i \tag{6}$$

where π_i is the unit value of shipment i. To account for the effects of the alternative-specific controls, $v_j\left(\boldsymbol{X}_j\right)$, we looked at a range of port-related variables or route-related characteristics, like port capacity and throughput, port efficiency indicators, transshipment, and crossing of the Panama Canal. However, due to the limited availability of port- and route-related information, we control alternative-specific fixed effects by using dummy terms for each alternative j, $v_j\left(\boldsymbol{X}_j\right) = v_j$, instead. This ensures the estimation captures sufficiently well the unobserved time-invariant route-related characteristics and therefore attenuates the possible omitted variable bias. Since the distance between forwarding and intermediate ports, d_{j2}, is specific to alternative j, the distance effect $\gamma_2 d_{j2}$ in Equation (4) is absorbed in the alternative-specific fixed effect term, v_j, and it is thus removed from the utility function in Equation (5).

For the remaining part, w_{ij} in Equation (5), the specification serves to control shipper- and port-specific covariates. Since $\boldsymbol{X_i}$ and $\boldsymbol{X_j}$ are case-specific (shipment-specific) and alternative-specific variables, respectively, we cannot directly estimate their linear effects, but instead we capture them by interacting with the landside trucking and port-to-port voyage distances. Hence, we specify the w_{ij} term as follows:

$$w_{ij} = d_{ij1} \times \boldsymbol{X_1} \times \boldsymbol{\beta}_1 + d_{j2} \times \boldsymbol{X_2} \times \boldsymbol{\beta}_2 + d_{ij3} \times \boldsymbol{X_3} \times \boldsymbol{\beta}_3 \tag{7}$$

where $\boldsymbol{X_1}$, $\boldsymbol{X_2}$ and $\boldsymbol{X_3}$ are shipment- and alternative-specific covariates interacted with landside distance, maritime distances d_{j2} and d_{ij3} between forwarding and intermediate ports and between intermediate ports and U.S. ports of entry, respectively, and $\boldsymbol{\beta}_1$, $\boldsymbol{\beta}_2$ and

$\boldsymbol{\beta}_3$ are the corresponding coefficients. We treat the shipment volume and the unit value as covariates for all three distances. Also, to account for additional costs that may arise from economies of scale stemming from the size of shippers, from transshipment at intermediate ports and from crossing the Panama Canal, we added the shipper size, dummy variables for transshipment, for crossing the Panama Canal westward (from the Colombian Caribbean to the U.S. Pacific Coast), and eastward (from the Colombian Pacific to the U.S. East and Gulf Coast) as covariates in $\boldsymbol{X_1}$.[2]

After substitutions, the final model synthesizing Equations (4) – (7) is given by:

$$\begin{aligned} V_{ij} &= \gamma_1 d_{ij1} + \gamma_3 d_{ij3} + \phi r_{ij} + \lambda \times r_{ij} \times \pi_i + v_j \\ &+ d_{ij1} \times \boldsymbol{X_1} \times \boldsymbol{\beta}_1 + d_{j2} \times \boldsymbol{X_2} \times \boldsymbol{\beta}_2 + d_{ij3} \times \boldsymbol{X_3} \times \boldsymbol{\beta}_3 \end{aligned} \tag{8}$$

The key variables in this model are the risk r_{ij}, landside distance d_{ij1} and maritime distance d_{ij3}, and the main coefficients of interest are ϕ, γ_1 and γ_3.

We should note several important considerations regarding the estimation of this discrete choice model. First, owing to the structure of the choice set, the assumption of independence of irrelevant alternatives (IIA) is generally not going to hold. The IIA assumption is an important basis for the conditional logit model to provide consistent estimation of the effects regardless of how the choice set is built. However, the IIA assumption is not likely to hold in our shipping route problem because choice alternatives are pairs of forwarding and intermediate ports, and some alternatives may be correlated by sharing either a forwarding port or an intermediate port. We can relax the IIA assumption by estimating a mixed logit model instead. This model does not depend on the IIA assumption, because the ratio of mixed logit probabilities depends on all alternatives, regardless of how the full choice set is defined (Train 2009). Also, the mixed logit model estimates individual-specific coefficients by allowing random taste variation across individual cases, so we can see how the distance friction and route risk effects vary across shipments. With the mixed logit model, we impose

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[2] The shipper size, transshipment and Panama Canal crossing dummy variables exhibit high collinearity with the alternative-specific fixed effect dummy variables when they are interacted with the two maritime distances, d_{j2} and d_{ij3}. These variables interacted with d_{j2} and d_{ij3} are therefore left out of the model specification.

individual-specific (shipment-specific) coefficients to the risk and the two distance terms as follows,

$$\begin{aligned} V_{ij} &= \gamma_{i1} d_{ij1} + \gamma_{i3} d_{ij3} + \phi_i r_{ij} + \lambda \times r_{ij} \times \pi_i + v_j \\ &+ d_{ij1} \times \boldsymbol{X_1} \times \boldsymbol{\beta}_1 + d_{j2} \times \boldsymbol{X_2} \times \boldsymbol{\beta}_2 + d_{ij3} \times \boldsymbol{X_3} \times \boldsymbol{\beta}_3 \end{aligned} \tag{9}$$

Note that, in this formulation, γ_{i1}, γ_{i3} and ϕ_i replace γ_1, γ_3 and ϕ in Equation (8). We use the triangular distribution for estimating shipment-level coefficients γ_{i1}, γ_{i3} and ϕ_i to avoid having extreme outliers around the mean, like with the normal or log normal distributions (Train 2009, León and Miguel 2017).

3.3 Risk-to-Distance Equivalence: Trade-off between Risk and Distance

What is the price of exposure to risk? How much is a shipper willing to extend its landside or maritime shipping distance to avoid the risk of violent acts or delinquency? Taking an approach similar to the value of statistical life by León and Miguel (2017), we compute risk-to-distance equivalences (RDE) that measure the trade-off relationship between the risk and landside or maritime shipping distance. RDE is formally defined as follows:

$$RDE_i \equiv -\frac{\Delta d_i}{\Delta r_i} \tag{10}$$

where Δd_i is the change in landside or maritime shipping distance to reduce the risk Δr_i along the land-based or maritime shipping route. For the sake of the tractability of RDE estimation, we remove terms interacted with r_{ij}, d_{i1} and d_{i3} and leave all others as in Equation (9) and get:

$$V_{ij} = \gamma_{i1} d_{ij1} + \gamma_3 d_{j3} + \phi_i r_{ij} + v_j + d_{j2} \times \boldsymbol{X_2} \times \boldsymbol{\beta}_2. \tag{11}$$

Setting all variables other than the landside shipping distance d_{j1} and risk r_{ij} fixed in Equation (11) to facilitate the comparative statics, the change in utility is expressed by total differentiation as follows, when the shipment is switched from one alternative to another:

$$\Delta U_i = \gamma_{i1} \Delta d_{i1} + \phi_i \Delta r_i. \tag{12}$$

If $\Delta U_i = 0$,

$$\frac{\phi_i}{\gamma_{i1}} = -\frac{\Delta d_{i1}}{\Delta r_i} = RDE_{i1} \tag{13}$$

where RDE_{i1} denotes the landside RDE. A similar formulation can be applied to the maritime RDE:

$$\frac{\phi_i}{\gamma_{i3}} = -\frac{\Delta d_{i3}}{\Delta r_i} = RDE_{i3} \tag{14}$$

where RDE_{i3} indicates the maritime RDE. By estimating the coefficients of Equation (11) through the mixed logit model, the mean landside and maritime RDEs are given by the estimated mean coefficients γ_1, γ_3 and ϕ, which allows us to estimate the overall trade-off relationship, but we can also obtain the distribution around these mean measures by estimating the landside and maritime RDEs of each individual shipment from individual coefficients γ_{i1}, γ_{i3} and ϕ_i. Given that the landside and maritime shipping distances have a negative effect on the probability of choosing a route, if the risk also has a negative effect, landside and maritime RDEs would have a positive value. A higher value of the risk effect ϕ_i would return higher value of RDE.

3.4 Data, Variables and Measurements

Our model investigates records of export shipping from Colombia to the U.S. and their route trajectories retrieved from the PIERS database. We collected bill of lading records imported through U.S. ports from July 2006 to June 2007. The choice pair of forwarding and intermediate ports in each bill of lading is extracted and used as a dependent variable. We exclude cases when shipments are transshipped at ports on other continents (e.g., South Korea, Germany, Spain, and Belgium), are not containerized, or consist of empty containers. Our shipping data include 26,109 bills of lading, 77,661.67 TEUs (Twenty-foot Equivalent Units), from 79 municipalities, 6 Colombian forwarding ports, 24 intermediate ports of Colombia and other foreign countries, and 26 U.S. ports of entry.

For the risk of domestic armed conflicts r_{ij}, the domestic armed conflict cases recorded in UCDP GED are used. We measure the total casualty counts of domestic armed conflicts within 20 km buffers around the shortest-path landside shipping routes. Since our focus is to detect the change in route choice patterns in response to risk, only armed conflict cases that occurred between July 2005 and June 2006 are considered. The shipping route and port choice is a long-term decision that accompanies the corporate contracts between shippers, shipping lines, and port authorities (Tongzon 2009), so they cannot be changed promptly right after a violent event has occurred. Hence, it is more appropriate to consider the cases with a time lag before shipping occurs. Other sources report on armed conflict cases, like the Centro de Estudios sobre Desarrollo Económico [Center for Economic Development Studies, CEDE] (2013), but their data are released after aggregation at the municipality level. Since UCDP data show strong correlation with CEDE armed events and similar spatial distributions, while also being more spatially disaggregated, UCDP data are deemed to be the best dataset to measure the route-level risk in our study.

For the landside shipping distance d_{ij1}, we measure shortest-path distances between shipment source and forwarding port along the road network from the Global Roads Open Access Dataset (CIESIN-ITOS 2013). Since Colombia has a rugged terrain that potentially degrades the speed and efficiency of trucking, we use a distance measure penalized according to slope, following an approach similar to Tao *et al*. (2016). We first split each road link by 5-km segments and compute a penalized distance by weighting the 5km segment by impedance factors according to the slope between the two endpoints (Table A1). The shortest-path distance is calculated by summing the penalized network distances of segments. The slope information is calculated from the USGS Digital Elevation SRTM Dataset (USGS 2020). The maritime voyage distances d_{j2} and d_{ij3} are measured by the port-to-port shortest-path network distances from the Global Shipping Lane Network Dataset (Oak Ridge National Laboratory 2000).

The alternative-specific control covariates $\boldsymbol{X}_j$ include three dummy variables indicating whether transshipment takes place, whether the shipment should cross the Panama Canal westward (from the Colombian Caribbean coast to the U.S. West coast) and eastward (from the Colombian Pacific coast to the U.S. East coast) to reach the U.S. port of entry. The shipment-specific control covariates $\boldsymbol{X}_i$ include unit value of the shipment, reported shipment value by weight (\$/kg), and shipper size (TEU), collected or computed from the bills of lading from July 2006 to June 2007. The shipper sizes are measured by the total freight shipment volume (TEU) by shippers in the dataset. When running models on subsets of the full dataset by commodity type, we use the first two-digit HS codes and reclassify them into 10 categories by the commodity characteristics (Table A2). Descriptive statistics are reported in Table A3.

4. Empirical Results

4.1 Main Results

We start with reporting our main regression results based on the full dataset (Table 1). As presented in Equation (9), we include four types of explanatory variables: landside and maritime shipping distances, risks, alternative-specific fixed-effects, and alternative- and shipment-specific controls interacted with distance terms. To check the model robustness and omitted variable bias, we run four models that either include or exclude 1) route risk interacted with unit value of the shipment and 2) a set of shipment-specific controls interacted with the three shipping distance terms, respectively. Thus, column 1 excludes both, and column 4 includes all, while column 2 only includes the route risk interacted with the unit value, and column 3 only includes alternative- and shipment-specific controls interacted with the shipping distance terms. With this testing design, we confirm that the effects of the route risk and of the marginal route risk by the unit value are consistent across model specifications.

In line with the literature, we find significant effects of distance impedance on port pair choice and by the same token on the shipping route. Both landside and maritime shipping distances commonly exhibit an inverse effect, implying a strong preference for shorter shipping distances throughout both stages of shipping. However, the magnitude of these friction effects is found fairly different across land and water. Estimation results (Column 4 in Table 1) indicate that the odds of choosing a port pair are decreased by 2.43% if the landside shipping distance is increased by 1 km ($e^{-2.4609/100} - 1 = -2.43\%$), while 1 km extension of the final maritime shipping distance has a much smaller effect, namely a 0.06% decrease in the odds ($e^{-0.0568/100} - 1 = -0.06\%$), all other effects being held constant. This indicates that the landside shipping segment accounts for a far greater portion of the total shipping cost than the maritime shipping segment despite shorter distance, which is consistent with a wide body of literature on this matter, such as García-García *et al.* (2017) and Vega *et al.* (2019).

Table 1. Port pair choices and perceived risk: Main results of the mixed logit model

		(1)	(2)	(3)	(4)
Distances	Landside Distance§	-2.2177^{***}	-2.2670^{***}	-2.3270^{***}	-2.4609^{***}
	(d_{ij1}, Origin – Forwarding Port)	(0.0314)	(0.0319)	(0.0352)	(0.0364)
	Maritime Distance 2§	-0.0576^{***}	-0.0574^{***}	-0.0573^{***}	-0.0568^{***}
	(d_{ij3}, Intermediate – U.S. Port of Entry)	(0.0037)	(0.0037)	(0.0050)	(0.0050)
Perceived Risk	Route Risk§	-0.1357^{***}	-0.0893^{***}	-0.1105^{***}	-0.0264^{**}
		(0.0089)	(0.0088)	(0.0090)	(0.0080)
	Route Risk × Unit Value		-0.0059^{***}		-0.0091^{***}
			(0.0009)		(0.0008)
Alternative-Specific Controls (Interacted with distances)	Landside Distance × Transshipping			-0.1011^{***}	-0.0999^{***}
	(Transshipping – 1: Yes, 0: No)			(0.0056)	(0.0056)
	Landside Distance × Panama-Crossing (W)			-0.3855^{***}	-0.3298^{***}
	(Panama-Crossing (Westward) – 1: Yes, 0: No)			(0.0296)	(0.0315)
	Landside Distance × Panama-Crossing (E)			-0.4853^{***}	-0.7104^{***}
	(Panama-Crossing (Eastward) – 1: Yes, 0: No)			(0.0542)	(0.0562)
Shipment-Specific Controls (Interacted with distances)	Landside Distance × Shipper Size			0.0001^{***}	0.0001^{***}
				(0.0000)	(0.0000)
	Landside Distance × Unit Value			0.0216^{***}	0.0285^{***}
				(0.0009)	(0.0010)
	Maritime Distance 1 × Unit Value			-0.0015^{**}	-0.0015^{**}
	(d_{j2}, Forwarding – Intermediate Port)			(0.0005)	(0.0005)
	Maritime Distance 2 × Unit Value			0.0016^{**}	0.0014^{*}
				(0.0006)	(0.0006)
	Landside Distance × Shipping Volume			-0.0443^{***}	-0.0469^{***}
				(0.0025)	(0.0027)
	Maritime Distance 1 × Shipping Volume			0.0003	0.0003
				(0.0006)	(0.0006)
	Maritime Distance 2 × Shipping Volume			0.0000	0.0000
				(0.0008)	(0.0008)
	Alternative-Specific Fixed Effects	Yes	Yes	Yes	Yes
	AIC	83265.088	83165.139	80355.436	80160.618
	Log Likelihood	-41582.544	-41531.570	-40117.718	-40019.309
	McFadden's Pseudo-R^2	0.1913	0.1923	0.2198	0.2217
	Number of Observations	26109	26109	26109	26109
	Number of Alternatives	45	45	45	45

Notes: *** $p < 0.1\%$; ** $p < 1\%$; * $p < 5\%$; § Random coefficients; Standard errors in parentheses.

On average, a shipment is found to avoid a port pair and the associated shipping route whose landside segment is exposed to higher risk of armed violence. Coefficients of the landside route risk are in the range of -0.03 to -0.14 across models. These estimates show a highly significant and sizable effect of the landside route risk on the, routing choice of shipments. Column 4 in Table 1 shows that one additional death per 100km from domestic armed conflicts along a landside shipping route diminishes the odds of choosing the associated port pair by 2.61% ($e^{-0.0967} - 1 = -2.61\%$). Furthermore, the route risk term interacted with unit value captures an additional route risk effect that is dependent on the unit value of the shipment; we find here how shippers respond to exposure to risk according to the value of shipped cargos. The negative sign of the coefficients in columns 2 and 4 confirms that freight of higher value is more likely to be routed away from higher risk landside routes. If the value of freight is $1 per kg higher, there is additional deterrence to use a high-risk route. Specifically, the odds of choosing a certain port pair contract by 0.91% ($e^{-0.0091} - 1 = -0.91\%$) in favor of another that entails a less hazardous route. Thus, shipments with higher value are more averse to armed violence risk *en route* to their forwarding port.

These results strongly confirm the detrimental consequences of the inability of institutions to control civil conflicts in commercial terms, especially in the context of international freight shipping. This certainly further validates other studies that have focused on the heightened shipping cost of passing through the waters of Somalia due to frequent piracy activities (Besley *et al.* 2015) and the shipping behaviors deterred by bribery corruption at ports of South Africa (Sequeira and Djankov 2014), as well as the increasing costs of cargo theft on the economy of São Paulo (Justus *et al.* 2018).

Using the model specification of Equation (9) for subsets of the shipping data with different categories of HS commodity codes, we check if the exposure to violence risk has a differential effect across commodity types (Table 2). The analysis confirms that route risk, in general, has a negative impact on the movement of shipments by rerouting to another forwarding port along a safer route. Also, we find that the magnitude and statistical significance of these effects vary by commodity type and shipment unit value. The baseline route risk has a strongly negative effect on shipments of light manufacturing products (F); the effect is not statistically significant at 5% for the other commodity types, except fresh fruits and vegetables (A). The additional effects of the route risk by shipment unit value are also found to vary across commodity types. The baseline effect on shipments of fresh fruits and vegetables (A) is shown to have a positive effect, but the total effect becomes negative just if the unit value of products is more than \$1.27 per kg. Even though the baseline route risk has no statistical significance at the 5% level for shipments of textile and clothing products (E), the total risk effect is negative and stronger as more expensive products are shipped. The route risk effect is invariant with unit value when shipping other commodity types at the 5% significance level. We will discuss the heterogeneity in the risk effect across commodity type in more detail later.

4.2 Risk-to-Distance Equivalence

We quantify the price of the state's failure to control domestic armed conflicts on freight mobility by estimating the shipping distance equivalence of the additional risk of armed violence along landside shipping routes. As indicated earlier, the magnitude of the route risk can be measured with landside and maritime distance terms by using the random coefficients estimated in the mixed logit model. The landside and maritime RDEs are estimated based on the model specification given in Equations (11), (13), and (14). For comparison between the landside and maritime RDEs, we consider different scales of landside and maritime shipping distances and unit freight costs. We compute maritime RDEs converted to the landside distance scale by multiplying the maritime RDEs by a proportion of maritime to landside trucking unit freight cost (\$ per km-ton). We take the 2012 landside unit freight cost data estimated by the Colombia Ministry of Transport (2012)[3]. The maritime unit freight cost data are taken from Vega *et al*. (2019). The average landside and maritime unit freight rates are computed by averaging pairwise landside freight rates by summing the landside shipping distances and pairwise maritime freight rates from Colombian ports to Los Angeles as the sum of maritime shipping distances, respectively. By doing so, we obtain a conversion factor of 0.102.

Given the sensitivity of route and port choices detected for different commodity types, our approach consists in segmenting the shipping data according to the commodity types used

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[3] 2012 is closest among available records to the time period of our shipping data.

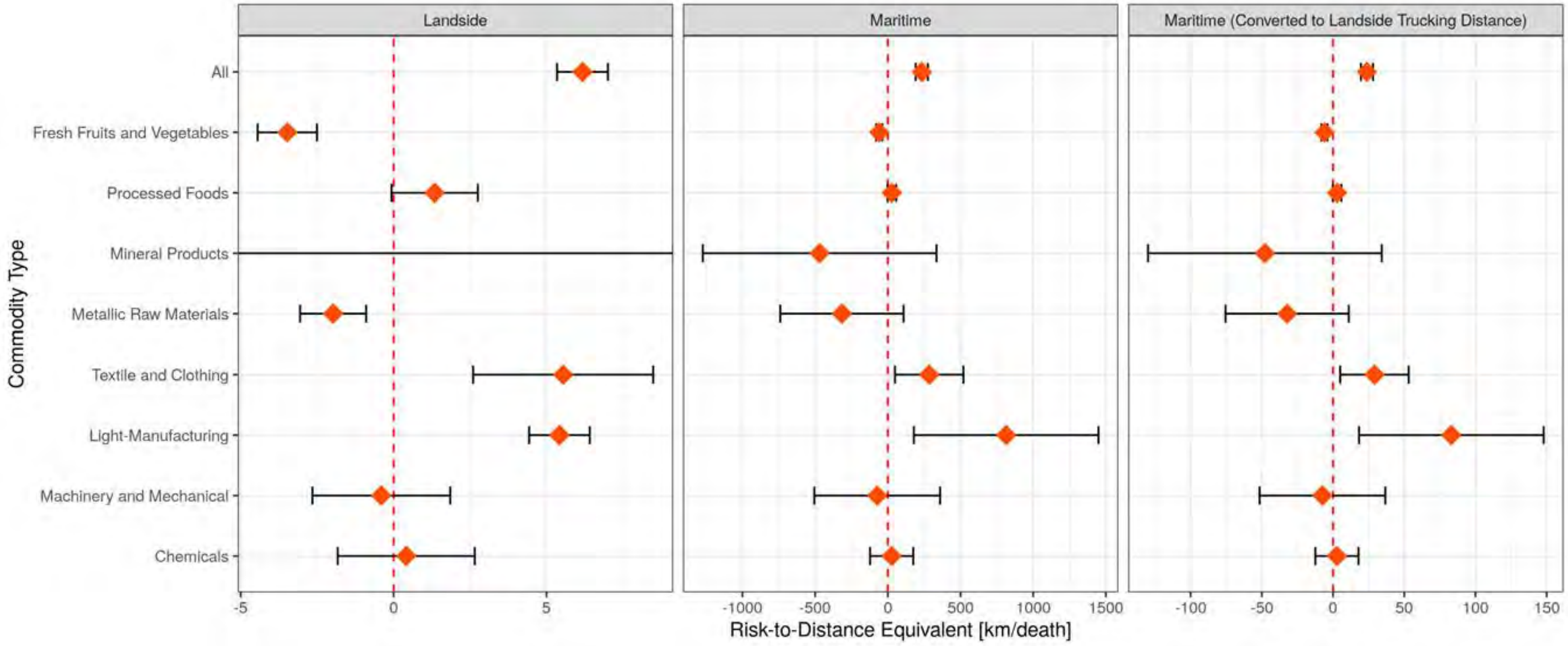
earlier to allow for the associated variation of risk-to-distance equivalence. Estimated RDEs are reported in Table A4 and Figure 6. The analysis shows that the violence risk along landside routes significantly degrades freight mobility of the majority of exported products (positive RDE), but the effect is not necessarily consistent across commodity types. The RDEs estimated for shipments of all commodity types indicates that an additional death per 100 km is equivalent to extending the landside shipping distance by 6.18 km and the maritime shipping distance by 233.62 km (or 23.85 km on the landside distance scale by conversion). If a product is shipped through a landside route with an average level of risk, that is 17.41 deaths per 100 km, it generates the same effect as an extension of the landside shipping route by 107.53 km and of the maritime shipping route by 4,066.37 km (or 415.04 km on the landside distance scale). This means that higher risk of armed violence along shipping routes has the same effect on route and port choice as extending both landside and maritime shipping distance and therefore the shipping costs. Shippers would trade-off a port reachable on a riskier route for ports located further away from the shipping origin, provided that the access route has lower risk. Also, they would be willing to take a safer landside shipping route to ports over a riskier one, even though the maritime segment of the associated shipping distance to the U.S. port of entry is quite extended. Logistically, the extension of the maritime shipping route by 4,066.37 km is equivalent to 415.04 km on the landside distance scale, indicating a greater sensitivity of shippers to armed violence risk on the maritime segment than on the landside segment.

Table 2. Port pair choices and perceived risk across commodity types: Mixed logit model results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	A	B	C	D	E	F	G	H
	Fresh Fruits & Vegetables	Processed Foods	Mineral Products	Metallic Raw Materials	Textile & Clothing	Light Manufacturing	Machinery & Mechanical	Chemicals
Landside Distance§	-1.1841***	-1.7044***	-1.5739	-4.1292***	-2.7809***	-2.5593***	-3.4972***	-3.2125***
(d_{ij1}, Origin – Forwarding Port)	(0.0967)	(0.0934)	(0.9158)	(0.1566)	(0.2193)	(0.0702)	(0.4113)	(0.3157)
Maritime Distance 2§	-0.0205	-0.0736***	0.1673	-0.0391	-0.0500	-0.0300**	-0.0198	-0.0493
(d_{ij3}, Intermediate – U.S. Port of Entry)	(0.0140)	(0.0147)	(0.1423)	(0.0283)	(0.0335)	(0.0102)	(0.0238)	(0.0422)
Route Risk§	0.1956***	-0.0204	-0.9582	0.0468	-0.0323	-0.1461***	0.0192	-0.0053
	(0.0211)	(0.0194)	(1.1216)	(0.0530)	(0.0528)	(0.0166)	(0.0538)	(0.0426)
Route Risk × Unit Value	-0.1538***	-0.0003	-0.1157	-0.0140	-0.0083**	-0.0073**	-0.0001	-0.0018
	(0.0172)	(0.0030)	(1.3210)	(0.0088)	(0.0031)	(0.0023)	(0.0023)	(0.0045)
Alternative-Specific Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Alternative-Specific Control (Interacted with distances)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Shipment-Specific Control (Interacted with distances)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AIC	19118.2254	11400.7023	452.9127	3081.9684	4094.8164	24120.6729	2723.5349	1640.7495
Log Likelihood	-9507.1127	-5653.3511	-199.4563	-1500.9842	-2015.4082	-12014.3364	-1323.7674	-785.3747
McFadden's Pseudo-R^2	0.2279	0.2366	0.4324	0.4735	0.3719	0.2161	0.2429	0.4159
Number of Observations	5067	3329	239	1909	2777	10471	1126	877
Number of Alternatives	36	31	11	24	16	30	22	19

Notes: *** $p < 0.1\%$; ** $p < 1\%$; * $p < 5\%$; § Random coefficients; Standard errors in parentheses.
Source: calculations by the authors.

Figure 6. The landside and maritime risk-to-distance equivalences by commodity type (From Table A4)



(Note: For comparison with the landside RDEs, the panel on the right-hand side reports the maritime RDEs converted to the landside distance scale, by multiplying them by 0.118, the average proportion of maritime to landside trucking unit freight cost ($ per km-ton). The unit freight cost data are taken from Colombia Ministry of Transport (2012) and Vega et al. (2019)).

Source: calculations by the authors.

However, the RDEs differ notably by commodity type. When shipping textile and clothing, and light manufacturing products, additional risk is found equivalent to a longer landside shipping distance. However, the 95% confidence intervals of the landside and maritime RDEs of processed foods, mineral products, machinery and mechanical products, and chemical products include zero, indicating the lack of statistical evidence that additional risk is equivalent to an extension of the landside and maritime shipping distance when these types of products are shipped. It is also notable that the 95% confidence interval of the landside and maritime RDEs of mineral products have a particularly wide range between -78.86 and 181.55 km and between -1,272.55 and 335.07 km, respectively, which points to the highly uncertain effect of violence risk on route and port choice for these products. It is possible that the product's origin is associated with the differential RDE across commodity type, and we will discuss this later in the analysis.

When shipping fresh fruits and vegetables and metallic raw materials, the landside RDE is found negative, indicating that their shipments are more sensitive to landside distance than to the risk of armed violence on the route. As for the maritime RDE, it is found negative only when shipping fresh fruits and vegetables but not significant when shipping metallic raw materials. This means that, for shipments of fresh fruits, reducing both landside and maritime shipping distance is far more important than avoiding the route risk. Considering that fresh fruits and vegetables are perishable goods, it is more pressing to ship to closer forwarding ports and routes with a shorter maritime voyage to preserve the quality of products and reduce shipping cost, rather than following a longer but safer export route. For shipments of metallic raw materials, reducing landside shipping distance is found more important than avoiding the risk of violence, while shippers are rather indifferent between maritime shipping distance and route risk. Since metallic raw materials are heavy and are subject to a greater freight cost, the analysis suggests that shipments tend to take place to closer forwarding ports to reduce the landside shipping distance rather than avoid the route risk. However, such a tendency does not hold on to the maritime segment, possibly due to high efficiency in maritime shipping. We can find that, for shipments of metallic raw material, the coefficient of the landside distance is highest among all commodity types; however, the coefficient of the maritime distance is not significant at the 5% significance level, confirming the expensive landside shipping cost of metallic raw materials.

4.3 Heterogeneity in Risk Effect

The variance in RDEs across commodity types suggests that heterogeneity in the risk effect exists across shipments. To confirm the sources of this heterogeneity, we estimate how the variances in RDEs are explained by the unit value, commodity types of shipments and other shipment-specific characteristics. The following steps are used to this end. From the random coefficients estimated through the mixed logit model on the full dataset (Table A4, column 1), we obtain shipment-specific landside RDE estimates by dividing the shipment-specific coefficient of the route risk by that of the landside shipping distance (Equation (13)). We regress the shipment-specific RDE estimate on a number of hypothesized predictors, namely its unit value, commodity type dummy variables, shipment volume, shipper size and a dummy variable indicating whether the U.S. port of entry is on the West Coast, while controlling for the origin-specific fixed effects with origin municipality dummy variables. We proceed in the same way with the maritime RDE on the basis of Equation (14).

Table 3 reports that all the variables listed above contribute to the heterogeneity in the landside and maritime RDEs across shipments. It should be noted that the model includes origin-specific dummy variables to control the origin-specific fixed effects and the possible association between the product origin and the RDEs. The positive signs of the unit value coefficients confirm that shipments of higher value have higher RDEs, meaning that they are more likely to have their landside and maritime shipping distances extended to avoid insecurity and potential risk along landside shipping routes. While larger-volume shipments are found to have lower landside and maritime RDEs and, therefore, to be more sensitive to risk, larger shippers tend to have higher RDEs and to be more sensitive to risk. Freight shipped to the U.S. West Coast is found to have a lower landside RDE but a higher maritime RDE than those to the U.S. East Coast. Since all commodity type dummy variables of the result on the landside RDE are statistically significant, we can also confirm that the mean landside RDEs are statistically different across commodity types at the 99% significance level. Even though the maritime RDEs of only processed foods, textile and clothing, light manufacturing, and chemical products are statistically different from that of fresh fruits and vegetables, there is still significant heterogeneity in the maritime RDE across commodity types. These two results show that the effect of the commodity type accounts for a substantial part of the variance in individual RDEs, even when the unit value is controlled for.

Table 3. Heterogeneity in individual risk-to-distance equivalent estimates

	(1) Landside RDE	(2) Maritime RDE
Intercept	7.4654***	243.9149***
	(0.2926)	(11.3235)
Unit Value	0.0142***	0.7116***
	(0.0021)	(0.0822)
Shipment Volume	-0.0193***	-0.6486***
	(0.0015)	(0.0589)
Shipper Size	0.0001***	0.0037***
	(0.0000)	(0.0003)
U.S. Port of Entry on the West Coast	-0.3929***	3.4096*
(1: Yes, 0: No)	(0.0404)	(1.5639)
Commodity: B. Processed Foods	-0.2317***	-19.3639***
(1: Yes, 0: No)	(0.0470)	(1.8203)
Commodity: C. Mineral Products	0.7628***	5.0838
(1: Yes, 0: No)	(0.1286)	(4.9773)
Commodity: D. Metallic Raw Materials	0.5239***	1.8247
(1: Yes, 0: No)	(0.0543)	(2.1014)
Commodity: E. Textile and Clothing	0.7366***	6.0476**
(1: Yes, 0: No)	(0.0558)	(2.1607)
Commodity: F. Light-Manufacturing	0.5337***	-4.5778***
(1: Yes, 0: No)	(0.0351)	(1.3601)
Commodity: G. Machinery & Mechanical	0.5421***	-3.4916
(1: Yes, 0: No)	(0.0672)	(2.5998)
Commodity: H. Chemical Products	0.8894***	16.1218***
(1: Yes, 0: No)	(0.0735)	(2.8449)
Commodity: O. Miscellaneous	0.4550	4.0820
(1: Yes, 0: No)	(0.3004)	(11.6270)
Origin-Specific Fixed Effects	Yes	Yes
Adjusted R^2	0.1896	0.1602
Number of Observations	26109	26109

Notes: *** $p < 0.1\%$; ** $p < 1\%$; * $p < 5\%$; Standard errors in parentheses. The baseline category of commodity types is A. Fresh Fruits and Vegetables.
Source: calculations by the authors.

Various estimation results in Tables 1, 2, 3, and Figure 6 consistently confirm that the route risk effect and RDEs are heterogeneous across commodity types. These results imply that shippers may have different shipping behaviors in response to potential risk along the landside routes. We can provide several reasons for this. First, certain products can easily be reproduced and replaced when they are damaged or lost, or the shipment is disrupted. In this case, shippers may choose to ship through shorter routes, even if riskier, rather than pay more freight costs by taking safer but extended shipping routes. In this respect, fresh fruits and vegetables have negative landside and maritime RDEs, metallic raw materials have negative landside RDEs, and processed foods have lower landside and maritime RDEs than textile and clothing, and light manufacturing products do. Given that it takes relatively longer to reproduce textile and clothing and light-manufacturing products once they are lost, we argue the difference in RDE values may be explained by such considerations.

Second, the shipping of certain commodities may exhibit inflexibilities that severely constrain the choice of ports and of the associated landside shipping route to them. If a product is more susceptible to shipping delays on alternate shipping routes, hauling through the least-cost port may be the preferred option, even if the risk of potential disruption along this route is high. On a similar note, a product that requires specialized handling facilities and storage at the forwarding port may be captive to ports that have such facilities, therefore being unable to switch to another port in spite of the risk differential. For instance, metallic raw materials are shown to have a negative landside RDE, while the maritime RDE is not statistically significant at 5%. Shipments of metallic raw materials may not be flexible against the risk because the shipments require specialized logistic and storage facilities and are expensive due to their heavy weight, as indicated by the higher value of the landside distance coefficient (Table 2, column 4). Also, we see that fresh fruits and vegetables have negative landside and maritime RDEs, while processed foods have the second smallest RDE among all commodity types with positive RDEs. Given that food products are perishable and that freshness is the highest priority in shipping, shippers may prefer to avoid taking extended landside shipping routes to arrive at port facilities without delay, even if this means following a riskier route. In contrast, the shipment of other non-perishable and durable goods may have more flexible shipping schedules, which makes it more possible to avoid risks of violence and cargo loss along shorter routes.

Third, outlaw groups may show discriminatory behavior in their actions towards freight trucks in the territories they control. They may target trucks that potentially bring them more financial benefit. They could target only freight that is easily transferrable for their own use, that is more durable so that value is maintained high enough for market resale, or for which they can charge higher bribery or tolls from shippers or shipping companies. Sierra (2013) mentioned that electronics, electrical appliances, and textiles are most likely subject to theft along the shipping corridors in Colombia. In Aceh, Indonesia, corrupted officials showed discriminatory behaviors in charging bribery payment to trucks at checkpoints for passage, and the payment was higher for higher-value cargo, higher for steel, and lower for processed goods (Olken and Barron 2009).

In a similar but different context, Ibáñez and Vélez (2008) found that Colombian rebel groups are more likely to victimize and force civilians whom they can easily prey upon, such as landowners, young individuals and households with lower economic privileges. If this is the case also in shipping textile and light manufacturing products would indicate that illegal groups prefer targeting and extorting shippers of those products due to higher expected profit from market resale, bribery, and tolls. This is quite probable since these products are non-perishable and durable, so they undergo less depreciation for market resale than other products. It is notable that larger shippers tend to have higher RDEs (Table 3), indicating that they are more sensitive to risk and more likely to follow longer landside shipping routes. It is highly likely that illegal groups expect higher value of bribery or tolls from a larger shipper than a smaller one and that a larger shipper's freight would be a more tempting target to them. The positive sign of the shipper size coefficient in Table 3 may therefore reflect that shippers adjust their route choices against outlaw groups' discriminatory actions towards shipments of larger shippers. This implies that shippers are impacted differently by the risk of the route to ports and therefore respond by adjusting their freight mobility choices differently according to the type of commodity being exported and to shipper size.

5. Conclusions

As international freight transportation becomes unprecedently more inexpensive and faster than ever, the frictionless and seamless flow of commerce has been regarded as axiomatic and infallible. It has been taken for granted that the global logistic chain is operated with full security anywhere, and the disruption of international freight shipping has been out of one's mind. Our study posits that failure to control armed violence along trade routes severely impedes freight shipping, increases the cost of doing business, and greatly limits access to the global market, potentially discouraging export-oriented economic activities.

We focused on the case of Colombia in 2006-2007, when state failure led to frequent domestic armed conflicts between insurgents, paramilitary groups, and government forces, to show how exposure to risk is a heavy tax on freight shipping. Colombia is widely known as a country whose economic growth has been impeded by the state failure of its state institutions and by frequent violence, and this paper presented that the country's freight shipping system has been severely affected. Through micro-level analysis matching bills of lading records from PIERS and georeferenced domestic armed conflict data from UCDP, we found strong evidence from Colombia in a period of heightened political violence in 2006-2007 that risk of violence along landside shipping routes results in altered geography of freight mobility, with least-cost ports and landside access corridor being avoided in favor of other, safer options. Our mixed logit modeling results suggest that more exposure to risk along trade routes has a negative effect on the odds of choosing pairs of forwarding and intermediate ports on the way to foreign markets. The average level of violence along landside trade routes (17.41 deaths per 100 km) is estimated to be a 105.82 km and 4,066.37 km extension of the landside and maritime shipping distance, respectively. This points to the rerouting of shipments to further ports to avoid armed violence risk and the consequent rise in impediments to freight mobility. We also confirmed that the effect of risk of armed violence varies across shipping instances. All other things being equal, shipments tend to reroute further in response to risk when textile and clothing, light-manufacturing products, and higher-value products are shipped, or when shipments originate from larger shippers. The heterogeneity in the risk effect implies that guerrilla rebel groups or paramilitary groups exhibit discriminatory behaviors vis-a-vis shipments passing through their territories, and that shipments have different levels of flexibility in changing routes against risk.

Our study points to important implications in terms of interregional and international trade-oriented development policies. First, it is important for countries to design and implement policies to guarantee full security in any segments of trade routes and provide a secure environment for freight transportation. Only in the absence of concern about potential death threats, blockade, and extortion of tolls, will shippers be able to make effective decisions to minimize their freight shipping cost for interregional and international export activities and only then can efficient operation of freight transportation systems be achieved. Along this line of thought, it would be useful for future research to assess the economic impact of restricted freight mobility and calculate the welfare lost by the route change forced by the political instability on municipalities, especially port areas like Buenaventura.

Second, disruptions in any segment of the trade routes can be a great cost for freight haulage; hence, efforts from trading partners to control domestic armed violence is a key to lowering the friction of commodity flows and to increasing the mutual benefit from trade. Promoting frictionless bilateral trade flow is not just a matter of economic and diplomatic relationships between trading partners, but also of how they establish a stable domestic geopolitical environment and maintain security in freight transportation without undue disruption. Thus, international cooperation is necessary to maintain the efficient operation of the logistic chain system.

Third, investment in supply chain infrastructure should be made with careful consideration of geopolitical environments to guarantee the full security of freight transportation. Foreign aid programs to developing countries have largely focused on investment in improving road and rail infrastructure and port systems without appropriate consideration for the lack of institutions to control internal violence and its potential impact on efficient operation of the transportation systems (Ali *et al.* 2015). No matter how considerable are the resources invested in supply chain infrastructure to promote access to global markets, such financial support can readily be offset by disruptions to cargo flows by violence in developing countries without proper institutions. Foreign aid support for transportation development should be accompanied by appropriate measures and dispositions to remedy political instability.

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Appendix

Table A1. Terrain slope's influence on speed and impedance factor to distance (Source: Tao *et al.* (2016, p. 418))

Slope (degree)	Difficulty	Slope's Impact on Travel Speed	Impedance Factor to Distance
< 5	Easy	100%	× 1
5 – 10	Moderate	50%	× 2
10 – 20	Hard	20%	× 5
20 – 40	Difficult	10%	× 10
> 40	No-go	0%	× ∞

Source: authors' elaboration.

Table A2. Classification of commodity types

Class	Label	First 2-digit HS Code
A	Fresh Fruits and Vegetables	06, 07, 08, 09, 10, 11, 12, 13, 14
B	Manufactured Agricultural and Animal Products	01, 02, 03, 04, 05, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24
C	Mineral Products	25, 26
D	Metallic Raw Material	72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 83
E	Textile and Clothing	41, 42, 43, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67
F	Light Manufacturing Products	39, 40, 44, 45, 46, 47, 48, 49, 68, 69, 70, 71, 82, 94, 95, 96, 97
G	Machinery and Mechanical Products	84, 85, 86, 87, 88, 89, 90, 91, 92, 93
H	Chemical Products	28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38
O	Petroleum Oil	27
Z	Miscellaneous Products	00, 98, 99

Source: authors' elaboration.

Table A3. Descriptive statistics

Variable	Unit	Mean	Standard Deviation	Min	Max
Landside Distance, d_{ij1} (Origin – Forwarding Port)	100 km	6.779	3.498	0.078	20.113
Maritime Distance 1, d_{j2} (Forwarding – Intermediate Port)	100 km	19.465	15.828	0	64.636
Maritime Distance 2, d_{ij3} (Intermediate – U.S. Port of Entry)	100 km	37.385	21.069	2.046	139.606
Route Risk	Death / 100 km	17.406	9.176	0	89.281
Unit Value	USD / kg	4.208	7.345	0	134.231
Shipment Volume	Twenty-foot Equivalent Units	2.975	9.183	0	210
Shipper Size	Twenty-foot Equivalent Units	1,251.44	2,085.36	0.01	13,622.64
Port Throughput (Forwarding ports)	Twenty-foot Equivalent Units	17,668.87	11,780.41	60.36	37,654.24
Port Throughput (Intermediate ports)	Twenty-foot Equivalent Units	4,240.50	7,260.14	1.13	26,604.57
Transshipping	Dummy variable (1: Yes, 0: No)	0.133	0.340	0	1
Panama-Crossing (Westward)	Dummy variable (1: Yes, 0: No)	0.068	0.251	0	1
Panama-Crossing (Eastward)	Dummy variable (1: Yes, 0: No)	0.318	0.466	0	1

Notes: Sample includes 1,174,905 observations (= 26,109 × 45 [Bills of Lading × Alternatives])
Source: calculations by the authors.

Table A4. Estimation of the risk-to-distance equivalence across commodity types

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		A	B	C	D	E	F	G	H
	All	Fresh Fruits & Vegetables	Processed Foods	Mineral Products	Metallic Raw Material	Textile & Clothing	Light-Manufacturing	Machinery & Mechanical	Chemicals
Mean Landside RDE [km]	6.1784	-3.4777	1.3429	51.3445	-1.9776	5.5463	5.4244	-0.4009	0.4126
2.5% Percentile	5.3457	-4.4486	-0.0690	-78.8593	-3.0583	2.6002	4.4333	-2.6550	-1.8293
97.5% Percentile	7.0111	-2.5067	2.7548	181.5483	-0.8969	8.4925	6.4155	1.8532	2.6545
Mean Maritime RDE [km]	233.6189	-58.9562	27.8119	-468.7412	-315.5131	284.8190	814.1510	-72.7627	26.6743
2.5% Percentile	191.7749	-80.3982	-2.2044	-1272.5501	-739.4648	49.3665	179.1762	-505.3321	-121.6863
97.5% Percentile	275.4630	-37.5143	57.8282	335.0678	108.4386	520.2715	1449.1258	359.8067	175.0349
Mean Maritime RDE#[km]	23.8445	-6.0174	2.8386	-47.8425	-32.2031	29.0703	83.0971	-7.4266	2.7225
2.5% Percentile	19.5737	-8.2059	-0.2250	-129.8840	-75.4742	5.0386	18.2878	-51.5772	-12.4200
97.5% Percentile	28.1154	-3.8289	5.9023	34.1990	11.0679	53.1020	147.9064	36.7240	17.8651
Landside Distance§	-2.1928***	-1.3281***	-1.7532***	-2.4028	-4.4086***	-2.8246***	-2.8627***	-3.6484***	-3.6398***
(d_{ij1}, Origin – Forwarding Port)	(0.0311)	(0.0425)	(0.0688)	(2.1433)	(0.1036)	(0.1698)	(0.0694)	(0.3262)	(0.3348)
Maritime Distance 2	-0.0580***	-0.0783***	-0.0847***	0.2632*	-0.0276	-0.0550**	-0.0191**	-0.0201	-0.0563
(d_{ij3}, Intermediate – U.S. Port of Entry)	(0.0037)	(0.0077)	(0.0095)	(0.1122)	(0.0170)	(0.0202)	(0.0074)	(0.0172)	(0.0327)
Route Risk§	-0.1355***	0.0462***	-0.0235	-1.2337	0.0872***	-0.1567***	-0.1553***	0.0146	-0.0150
	(0.0088)	(0.0072)	(0.0125)	(1.0541)	(0.0252)	(0.0356)	(0.0134)	(0.0427)	(0.0407)
Alternative-Specific Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Alternative-Specific Control (Interacted with distances)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Shipment-Specific Control† (Interacted with distances)	Yes†	Yes†	Yes†	Yes†	Yes†	Yes†	Yes†	Yes†	Yes†
AIC	83012.7322	20619.9076	11570.7480	497.8945	3178.9743	4181.2498	24634.1743	2790.8262	1658.9673
Log Likelihood	-41454.3661	-10266.9538	-5747.3740	-230.9472	-1558.4872	-2067.6249	-12280.0872	-1366.4131	-803.4836
McFadden's Pseudo R^2	0.1938	0.1661	0.2239	0.3428	0.4534	0.3557	0.1988	0.2186	0.4024
Number of Observations	26109	5067	3329	239	1909	2777	10471	1126	877
Number of Alternatives	45	36	31	11	24	16	30	22	19

Notes: *** $p < 0.1\%$; ** $p < 1\%$; * $p < 5\%$; § Random coefficients; † Include shipment-specific controls interacted only with maritime distance 1 (d_{j2}, Forwarding–Intermediate Ports); # (Note: For comparison with the landside RDEs, the maritime RDEs and their 95% confidence intervals are converted to the landside distance scale, by multiplying them by 0.118, the average proportion of maritime to landside trucking unit freight cost ($ per km-ton). The unit freight cost data are taken from Colombia Ministry of Transport (2012) and Vega et al. (2019); Standard errors in parentheses; The standard errors and 95% confidence intervals of the RDEs are estimated with the delta method.

Source: calculations by the authors.