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# Epidemic Travel Bans and Trade: Evidence from Ebola in Western Africa<sup>\*</sup>

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## Abstract

Recent crises have highlighted the role of public health policies in mitigating the economic impact of epidemics or pandemics. We use the case of Ebola to identify this effect in African developing countries. This paper analyzes the impact on trade of restrictions on inflows of persons implemented against Western African countries affected by Ebola. We use monthly bilateral trade data at a sectoral level (HS6) and focus on Guinea, Liberia, Nigeria, and Sierra Leone, the four countries most affected by the restrictions. Using both OLS and PPML estimation with high-dimension fixed effects, we find a significant negative impact of Ebola-related restrictions on the exports of these four countries (-42.8%). The effect is more pronounced for fresh product exports (-47.6%) compared to durable products (-38.5%). We do not observe any significant impact on imports. Our results are robust to considering the number of Ebola cases and including landlocked countries.

Keywords: Entry Restrictions, Epidemics, Ebola, International trade, Gravity model.

JEL classification: F14, F51, F68, I15

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# 1 Introduction

Between December 2013 and January 2016, the Ebola epidemic spread across Western Sub-Saharan African (SSA) countries. Guinea, Liberia, Sierra Leone, and, to a lesser extent, Nigeria, were particularly affected. As stressed by The Economist: ” *The inadequacies of the health-care systems in this region help to explain how the Ebola outbreak became so deadly*” (Economist(The), 2016). Individual health expenditures are particularly low in SSA. For instance, annual health care expenditures in Sierra Leone are ten times lower than in Spain. Guinea, Liberia, and Sierra Leone are ranked among the poorest countries and are plagued by instability (Economist(The), 2014).

Epidemics negatively impact economic outlooks by harming and killing people, and creating fear that disrupts economic activities. The effects of epidemics on growth and inequalities have been widely analyzed (Barro et al. (1996); Bloom and Mahal (1997); Couderc and Ventelou (2005)). However, the question remains whether the impact occurs through a supply or demand effect. Therefore, we study the effect of epidemics on trade to analyze both supply responses (through exports) and domestic demand responses (through imports). Additionally, using bilateral trade data allows us to check for a shift effect, indicating a change in trade partners after the epidemics. Finally, as we focus on developing countries with highly specialized production, the role of trade is crucial, justifying our emphasis on external relations.

Recent health crises have highlighted the crucial role of robust health systems and sound public health policies in mitigating adverse economic impacts. In this paper, we use the case of Ebola to identify this effect for African developing countries for two reasons. First, since the epidemic was confined to specific African countries, we can isolate the effect. Second, we aim to analyze the vulnerability and higher exposure of poor and developing countries to health shocks.

More precisely, we evaluate the effect of Ebola-related entry restrictions on international trade. Using monthly trade data, we cover the period from January 2011 to December 2018, even though the outbreak occurred only from August 2014 to January 2016. We study 13 West African countries, some of which were not infected. Our aim is to measure the impact of increased trade costs during epidemics on international trade, making it essential to control for years without epidemics and for countries not affected by the disease. These entry restrictions represent a specific channel through which Ebola affects trade, as they form barriers to the transport of goods and hinder face-to-face business meetings between trading partners.

We build our own database on the implementation of restrictions to prevent the spread of Ebola, following the method proposed by Rhymer and Speare (2017). We collect information

from surveys, research working papers, and newspapers. For each of the 135 trading partners of our four SSA-infected countries, we visited an average of thirty websites. Then, we identify the type, scale, and duration of these entry restrictions on people.

Given that we are studying Western African countries with already low trade flows, we anticipate a dramatic effect of entry restrictions on their trading flows. To the best of our knowledge, there has been no study yet on the effect of Ebola-related restrictions on the international trade of infected countries.

Our study fits into three strands of the literature. Firstly, we address international trade by analyzing monthly bilateral trade of SSA countries. Secondly, our work is related to health economics through the study of restrictions on the movement of persons coming from countries affected by the Ebola epidemic. Finally, we also propose policy recommendations on how to handle sanitary crises, which refer to the normative vision of trade and trade policy.

Our contribution is fourfold. First, we rely on monthly trade data rather than annual statistics, as the Ebola epidemic is a short-term phenomenon. Data with higher frequency allow us to improve the measurement of the change in trade related to the epidemic. Second, despite many countries in Western Africa being affected by Ebola, we focus our analysis on only four countries: Liberia, Sierra Leone, Guinea, and Nigeria, as the restrictions were specifically imposed against these four countries. This allows us to isolate the impact of impediments to trade linked to Ebola. Third, we use disaggregated trade data to conduct a more fine-grained analysis, including a product dimension (HS6 product level). We distinguish between fresh products and durable goods. We analyze trade with all trading partners, not only regional trade. Finally, we construct a representative database of restrictions on the movement of natural persons imposed on Ebola-infected countries. Then, we assess the effect of these impediments on the external trade of affected countries.

We find that restrictions on the movement of people reduce exports of Ebola-infected countries, while no impact shows up on imports. The intensity of restrictions matters: the impact is higher for total bans than for delays or when partial entry is still allowed (partial bans). Fresh products are more affected than durable goods. Finally, the depressive effect on exports is higher for landlocked countries.

The remainder of this paper is organized as follows: Section 2 provides a brief overview of the literature, Section 3 presents some stylized facts on the Ebola epidemic and the associated entry restrictions, Section 4 describes the methodology and the data. Section 5 is dedicated to the results. Section 6 proposes some robustness checks. Finally, Section 7 concludes.

## 2 Related literature

The literature can be split into three fields: the impact on trade of restrictions on the movement of people, the impact of epidemics/pandemics on trade in general, and the specific effect of Ebola on trade.

### 2.1 Entry restrictions on people and international trade

Insofar as we study the impact on trade of impediments to the movement of people implemented after Ebola, we consider the literature dealing with the relation between entry restrictions and trade. The literature highlights a strong positive correlation between international travel and trade (see the seminal paper of [Kulendran and Wilson \(2000\)](#)).

Trade often requires face-to-face meetings to negotiate and conclude trade deals. [Cristea \(2011\)](#) highlights the preference for face-to-face meetings to transmit complex information needed for trade. Using US business class travel data as a proxy for in-person business meetings, he finds a strong positive correlation between the demand for business class air travel and the volume of exports of differentiated products.

In order to analyze distance-related trade frictions, [Startz \(2016\)](#) makes simulations proposing travel as a solution to address these frictions. Using panel data on transactions with Nigerian importers of consumer goods, the results of the simulations show that easy access to travel services would increase Nigerian imports by 29%. In the context of an epidemic where trade actors face travel restrictions, in-person meetings in foreign countries to verify the quality of products are no longer possible, and this negatively impacts bilateral trade.

Other studies show the fundamental role of international travel in generating trade. [Poole \(2010\)](#) uses US data from a survey of all outbound travelers on international flights and demonstrates the effect on trade. He highlights that business travel to the US by non-residents has a positive impact on US exports. Regarding the negative effect of travel restrictions on trade, studies find that developing countries (DCs) have lower trade flows than developed countries because most of their destinations require visas, which create trade frictions ([Umana-Dajud \(2019\)](#), [Akman \(2016\)](#)).

### 2.2 Relationship between epidemics/pandemics and international trade

Recent literature concentrates mainly on three epidemics/pandemics: cholera, the 2003 Severe Acute Respiratory Syndrome (SARS-2003), and COVID-19.

The negative effect of health crises on international trade was highlighted at the beginning of the 21st century. [Kimball et al. \(2005\)](#) study the impact of the restrictions imposed by the

European Union (EU) after the cholera epidemic of 1997 on fish exports from Uganda, Tanzania, Kenya, and Mozambique, at the initiative of the World Trade Organization (WTO). They find that these impediments to trade have cost more than 332 million US dollars between 1998 and 2002.

Using quarterly trade data on Chinese firms, [Zanin et al. \(2020\)](#) measure the impact of the SARS-2003 outbreak on the trade of Chinese firms. They show that firms in regions affected by SARS experienced lower import and export growth compared to firms in unaffected regions. This effect persisted for more than two years after the outbreak. [Kostova et al. \(2020\)](#) study the effect of SARS-2003 on merchandise exports from the US to EAP (East Asia-Pacific) countries. Their findings reveal a USD 29 billion decline in US merchandise exports to the high SARS-bearing countries of this region, which experienced the bulk of the epidemic's transmission in 2003.

More recently, [Hassani and Shahwali \(2020\)](#) use a computable general equilibrium (CGE) model with two scenarios (short- and long-term containment) to measure the effect of COVID-19 on the level of world trade. Results of their simulations show that the short- and long-term containment scenarios would result in a decline in world trade of USD 905 billion and USD 2,095 billion, respectively. [Hayakawa and Mukunoki \(2021\)](#) rely on a gravity model to measure the impact of COVID-19 on monthly world trade data from January to August in 2019 and 2020. Regardless of the measures used to quantify COVID-19, the effect of the pandemic on international trade is significantly negative for both exports and imports. Other recent studies confirm the negative effect of COVID-19 on international trade ([Zhang et al. \(2021\)](#); [Bricongne et al. \(2021\)](#); [Baldwin and Tomiura \(2020\)](#); [Gruszczynski \(2020\)](#)).

All these papers examine the direct economic effect of epidemics/pandemics. To the best of our knowledge, very few articles analyze the indirect impact of political decisions related to infectious diseases.

Using a two-economy, two-goods trade model embedded in a micro-founded SIR model<sup>1</sup> of infection dynamics, [Acharya et al. \(2020\)](#) analyse the relationship between international trade and health coordination during a pandemic. Their results show that coordination between countries during pandemics mitigates the effects of an epidemic on international trade. In the same vein, [Agarwal and Chonzi \(2020\)](#) show that protectionist trade policies adopted by developed countries during COVID-19 pandemic have a negative impact on African developing countries because of their high dependence on trade and low diversification.

Our contribution builds on the latter work as we analyze the impact of restrictions on

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<sup>1</sup>SIR allow to model the effects of epidemics by splitting population into three classes: (S) susceptible individuals, (I) infected individuals, (R) recovered individuals.

people's entry, implemented in reaction to Ebola, on the trade of West African (WA) countries. However, we differ from them and go beyond. Specifically, we focus on a specific group of four countries to assess the effects of these impediments.

### 2.3 Specific relationship between Ebola and international trade

Few studies have analyzed the relationship between the Ebola epidemic and international trade. They all focus on the direct economic impact of Ebola on the trade of partner or infected countries.

[Bambery et al. \(2018\)](#) utilize the World Bank's estimates of the Ebola outbreak in West Africa for the period 2014-2016 (3.3% and 16.1% reduction in gross domestic product in 2014 and 2016, respectively) to determine the impact on US exports. They find that such a scenario would result in the loss of between 1,500 and nearly 1.4 million US export-related jobs. [Adegun \(2014\)](#) examines the effect of Ebola on the economies of West African countries through the channel of international trade by analyzing intra-regional exports and imports of countries affected by the epidemic. The simulations show that the virus would affect several sectors, including agriculture, mining, health, transportation, education, and hospitality. [Abban \(2020\)](#) uses the international trade gravity model with annual panel data from 2000 to 2017 to assess the effect of the Ebola pandemic on intra-regional trade in the Economic Community of West African States (ECOWAS). Their results indicate that Ebola virus disease reduces the share of trade between infected countries and their intra-regional partners by half.

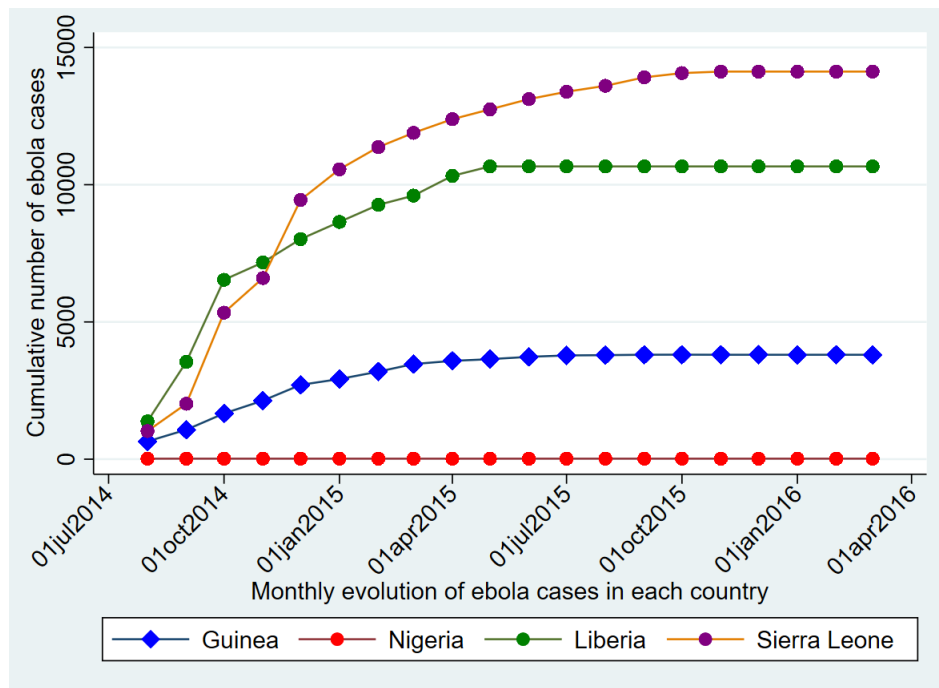
Our contribution adds to these papers in two ways. First, by studying the indirect impact of quotas or prohibitions on the movement of people originating from countries affected by Ebola, we propose an analysis of the indirect effects of political economy measures. Second, by focusing the analysis on four poor and developing countries in West Africa, we can isolate the impact of the epidemic.

## 3 Stylised facts

The Ebola outbreak began in Guinea in December 2013 and subsequently spread to Sierra Leone and Liberia. The virus also affected other African countries such as Nigeria, Mali, and Senegal before spreading to countries outside the African continent, including the United States, the United Kingdom, Spain, and Italy. In addition to the loss of human life, the epidemic severely damaged the affected economies. This damage encompasses not only the costs associated with eradicating the health crisis but also its negative impacts on production and trade.



Figure 1: Monthly change of the cumulative number of Ebola cases in each country

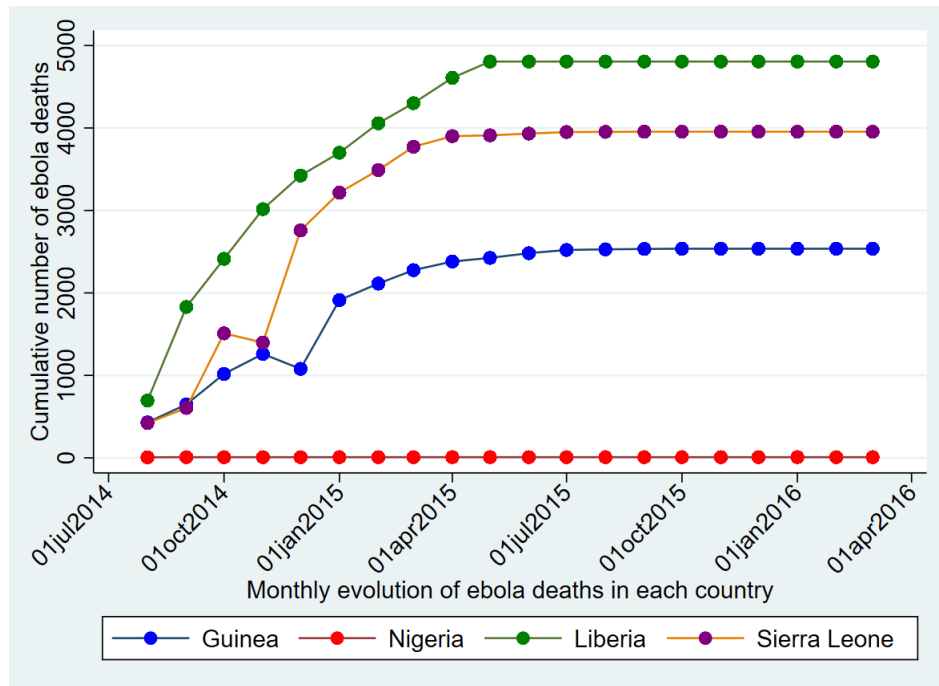


**Source:** Author's compilations from World Health organisation database on Ebola.

During the Ebola epidemic, the main entry restrictions were implemented against Guinea, Liberia, Sierra Leone, and Nigeria. Figure 1 illustrates the monthly change in the cumulative number of Ebola cases in each of these four countries. The highest cumulative number of cases was recorded in Sierra Leone in March 2016, with almost 15,000 cases, showing a sharp increase from around 2,000 cases in September 2014 to almost 10,000 cases in January 2015. Following Sierra Leone, Liberia had over 10,000 cases, then Guinea with over 3,000 cases. Nigeria was the least affected country. Despite the relatively low and stable number of cases in Nigeria over the period, the country faced limitations on external mobility due to its proximity to and business interactions with heavily infected countries. From April 2015 onward, the number of recorded cases gradually stabilized for all countries. By June 2015, it remained relatively stable for all countries except Sierra Leone, which experienced a slight increase until March 2016. The quarantine measures implemented by the governments of affected countries facilitated this reduction and ultimately halted the epidemic.

Figure 2 illustrates the monthly evolution of the cumulative number of deaths caused by Ebola in each of the four infected countries. The highest number of deaths was recorded in Liberia in May 2015, with almost 5,000 deaths, showing a sharp increase from nearly 1,000 deaths in August 2014 to almost 5,000 deaths in May 2015. Following Liberia, Sierra Leone had around 4,000 deaths, Guinea slightly more than 2,500 deaths. Nigeria experienced a relatively low and stable number of deaths from August 2014 to March 2016. There was also a sharp

Figure 2: Monthly variation of the cumulative number of Ebola deaths in each country



Source: Author's compilations from World Health organisation database on Ebola.

increase in the number of deaths in Sierra Leone from October 2014 to April 2015, rising from nearly 700 deaths to almost 4,000 deaths. From April 2015 onwards, the number of recorded deaths gradually started to stabilize, with a slight increase in Sierra Leone and Guinea until March 2016. This stabilization was facilitated by the quarantine measures implemented by the governments of affected countries to stop the spread of the disease.

To address epidemics declared as global emergencies, the World Health Organization (WHO) established a system to prevent and control future outbreaks: the International Health Regulations (IHR), first adopted in 1969. Considering the increase in international travel and trade, the IHR regulate the handling of the adverse effects of the emergence and spread of epidemics on the economy, particularly on international trade.<sup>2</sup>

The Ebola outbreak in West Africa was declared an international health emergency on August 8, 2014, by the WHO. The IHR adopted recommendations for infected countries and all other member countries to halt the proliferation of the epidemic while avoiding negative effects on international trade. For countries affected by the epidemic, these measures include:

- Surveillance of clusters of unexplained febrile cases or deaths due to febrile illness.

<sup>2</sup>The latest revision of the IHR was adopted in 2005, following the SARS pandemic (2002-2003), and now has 196 signatory countries. The IHR implement public health actions that are proportionate and limited to the risks to public health, while avoiding unnecessary barriers to international traffic and trade.

- Introduction of access to qualified laboratories for the diagnosis of Ebola virus disease.
- Training of health workers on control and implementation of prevention procedures.
- Establishment of rapid response teams with the capacity to investigate and manage Ebola virus disease cases and their contacts.

For other countries around the world, the same surveillance guidelines were recommended by the IHR. Additionally, based on scientific reports showing that the risk of transmission through air travel, for example, was very low, the IHR strongly advised against travel restrictions and any other border closure measures that would have a negative effect on trade.<sup>3</sup>

Unfortunately, some countries did not follow these IHR recommendations, including the main trading partners of Ebola-infected countries. As the number of cases and deaths began to reach thousands, many governments panicked. Due to the fear of Ebola, they implemented restrictions to prevent individuals residing in Ebola-infected countries from traveling to their countries. These measures affected air, sea, and land travel.<sup>4</sup>

The measures implemented against Ebola-infected countries primarily focused on restrictions on the entry of people. However, these impediments were not limited to human travel but also included the transport of goods. Several countries, including the US, Argentina, Brazil, China, Panama, and the UK, established increased surveillance of shipments from West Africa and screened crew members for infection. US ports required ships to report the last five or more ports of call. Additionally, countries like Brazil and Canada refused to allow Western African ships to dock or unload cargo at any port for a 21-day quarantine period after a call in an Ebola-affected Western African country. These measures resulted in delivery delays and additional transaction costs. [Rhymer and Speare \(2017\)](#) identified that some restrictions were still in place over the period from March to April 2015.

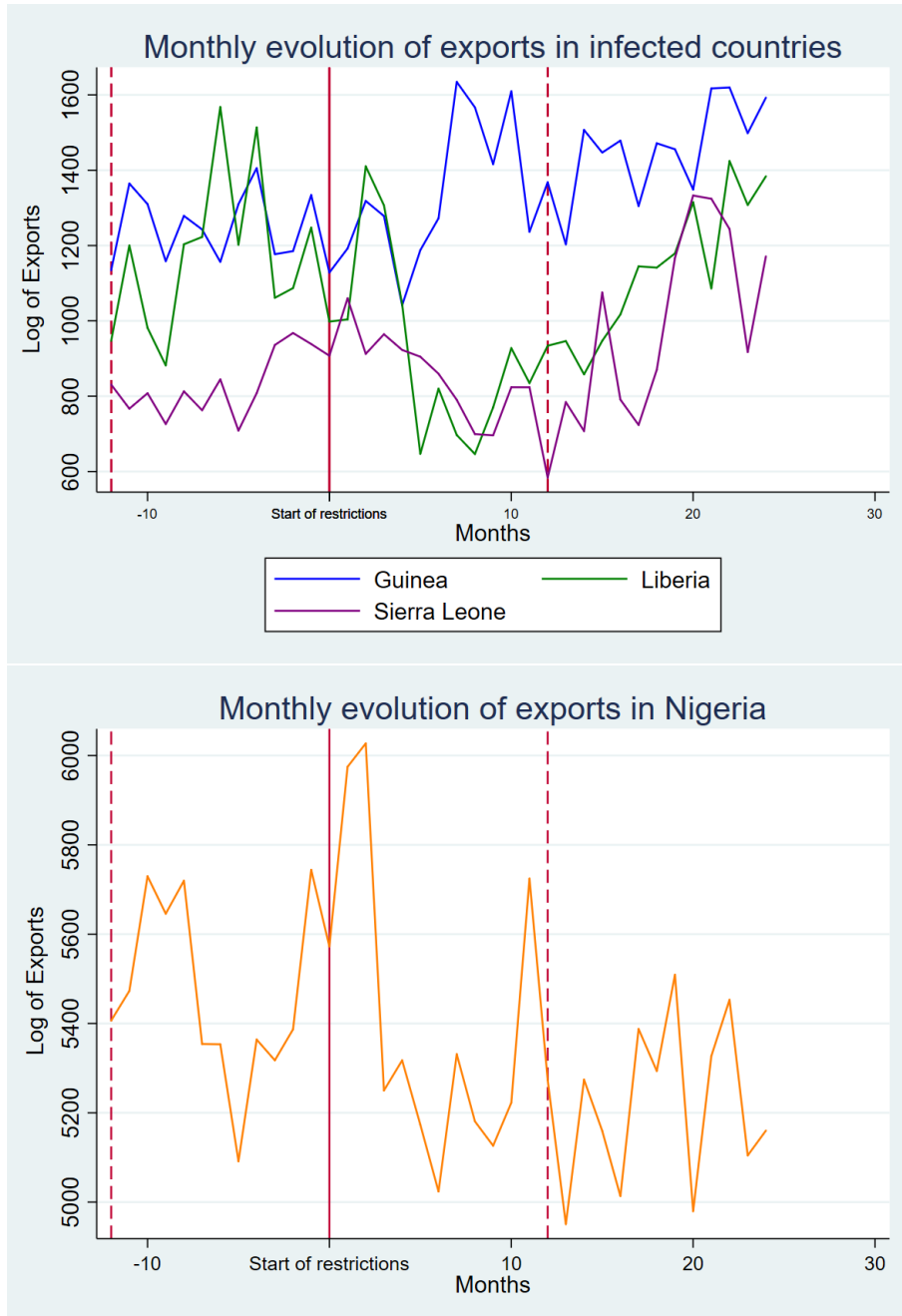
Protection measures take the form of entry restrictions, which have affected the travel of incoming citizens from countries or areas infected by Ebola. These restrictions have had a negative impact on the transport of goods from Ebola-infected countries, by air, sea, and land. Consequently, exports of products from these infected countries have declined. Partial bans,

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<sup>3</sup>The virus is only transmitted through direct contact with body fluids such as blood, saliva, urine, breast milk, semen, sweat, faeces, and vomit of infected persons, whether dead or alive.

<sup>4</sup>Canada canceled and suspended visa processing in September 2014 for foreign citizens who had visited Ebola-affected states in the three months prior to the date of their visa application. Canada also stopped processing visa applications for foreign citizens intending to travel to Ebola-affected states. Australia announced on October 28, 2014, the temporary suspension of all visa application assessments for citizens of Ebola-affected countries and the possible cancellation of visas for individuals who were outside Australia and had been in an Ebola-affected country. During the same period, the USA restricted the entry of citizens from Ebola-infected countries to five airports to better control their entry and quarantine suspected cases. Similar measures were implemented at seaports. Other countries, such as China, Thailand, and Peru, issued similar restrictions on the entry of individuals from Ebola-infected countries into their territories.

Figure 3: **Export changes before and after restrictions (Guinea, Liberia, Sierra Leone, Nigeria)**



**Source:** Author's calculations from UN Comtrade databases.

**Note:** The two graphs above display export changes in countries under restrictions. A decline in exports is evident a few months post-restriction initiation (August 2014, depicted by the continuous straight-line) in each country. Importantly, this decline isn't seasonal, as seen in the variations post-August 2013 and August 2015 (represented by dotted lines).

such as conditional entry, have resulted in additional trade costs due to delays in the delivery of goods. For instance, restricting the arrival of ships to fewer ports, as the USA decided, likely led to additional transport costs for countries that could previously dock at closer ports. Trade also relies on the movement of persons, such as businessmen. When restrictions on international mobility of people are imposed, the traveling of trade actors is limited or forbidden, which affects trade between the affected country and the implementing country.

Figure 3 illustrates the evolution of exports before and after the implementation of restrictions in Guinea, Liberia, Sierra Leone, and Nigeria. A clear drop in exports is observed in these four countries a few months after the restrictions began. The observations cover a period of 12 months before and 24 months after the start of the restrictions. The lowest export levels during these 36 months are reached shortly after the restrictions began. This decrease cannot be attributed to seasonal variation, as evidenced by the trends over the compared periods (dotted lines). Thus, the restrictions had a significant impact on bilateral trade between these countries and their trading partners.

## 4 Methodology and data

We first present and justify the choice of our econometric method before explaining our specification.

### 4.1 Methodology

#### 4.1.1 The econometric method

We rely on a gravity model of international trade to perform our estimations. The gravity equation can be expressed as follows:

$$X_{ij} = \frac{Y_i E_j}{Y} \left( \frac{t_{ij}}{\pi_i P_j} \right)^{1-\sigma} \quad (1)$$

Where  $X_{ij}$  is the volume of trade between partners  $i$  and  $j$ ;  $Y_i$  is the GDP of the country of origin  $i$ ;  $E_j$  represents the level of total expenditure in the country of destination  $j$ ;  $t_{ij}$  represents the trade costs between the country of origin  $i$  and the country of destination  $j$ ; and  $P_j$  is an index measuring domestic multilateral resistance in the country of destination  $j$ .<sup>5</sup> The equation can be decomposed into two terms. The first term,  $Y_i E_j / Y$ , represents the size of the countries, and the second term,  $(t_{ij} / \pi_i P_j)^{1-\sigma}$ , corresponds to the trade costs.

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<sup>5</sup>Multilateral resistance measures the tendency of two countries isolated from the rest of the world (like Canada and the US) to trade more than two countries with many other neighbors (like France and Germany).

The trade costs term has three main components.  $t_{ij}$  represents the total set of bilateral trade costs between the origin country  $i$  and the destination country  $j$ , proxied by the bilateral distance between  $i$  and  $j$  and regional trade agreements. The structural term  $P_j$ , or the multilateral internal resistance, represents the ease of market access for importer  $j$ . The structural term  $\Pi_i$ , defined as the external multilateral resistance, measures the ease of market access for exporter  $i$  (Anderson and Van Wincoop, 2003).

#### 4.1.2 Empirical model specification

To assess the effect of Ebola-related entry restrictions on exports and imports from infected countries, we use the gravity model of international trade with a non-linear specification. For both sides of trade (exports and imports), we run two different types of regressions. First, we measure the average effect of restrictions on trade and then, decompose the effect of restrictions distinguishing total from partial bans effects.

We choose a Poisson Pseudo Maximum Likelihood (PPML) estimator for three reasons. Firstly, applying the PPML estimator to the gravity model in a multiplicative form allows us to control for the heteroscedasticity that often affects trade data (Silva and Tenreyro, 2006). Secondly, the PPML estimator enables us to consider the information contained in zero trade flows. Thirdly, the PPML estimator provides gravity fixed effects that are identical to their corresponding structural terms. Additionally, the PPML estimator can be used to calculate general equilibrium effects of theory-consistent trade policies (Anderson et al., 2015; Larch and Yotov, 2016).

We consider two versions for our specification. First, we estimate the basic gravity model with the usual dyadic dummy variables to proxy trade costs. Our specification is defined as follows:

$$Trade_{ij,t} = \exp \left[ \beta_1(Restriction_{ij,t}) + \beta_2 \ln(Dist_{ij}) + \beta_3 \ln(GDP_{i,t}) + \beta_4 \ln(GDP_{j,t}) + \beta_5(Comlang_{ij}) + \beta_6(Colony_{ij}) + \beta_7(Contig_{ij}) + \beta_8(RTA_{ij,t}) \right] \times \mu_{ijt} \quad (2)$$

Where  $\mu_{ijt}$  is the idiosyncratic error assumed to be independent and identically distributed. The dependent variable  $Trade_{ij,t}$  represents the volume of trade between countries  $i$  and  $j$  at date  $t$ . This variable will take two values:  $Exports_{ij,t}$  for exports from country  $i$  and  $Imports_{ij,t}$  for imports into country  $i$  at period  $t$ .  $Restriction_{ij,t}$  represents a dummy variable indicating entry restrictions imposed by country  $j$  on country  $i$  at date  $t$ . We distinguish between total bans and partial bans.

The distance ( $Dist_{ij}$ ) between countries  $i$  and  $j$  is expected to deter trade. We use usual dummy variables to assess the proximity of countries, which favor trade: common border ( $Contig_{ij}$ ), language ( $Comlang_{ij}$ ), and having belonged to the same colonial empire ( $Colony_{ij}$ ).

$GDP_{i,t}$  and  $GDP_{j,t}$  represent the GDP of countries  $i$  and  $j$ , respectively, in period  $t$ . We anticipate a positive impact on trade (exports and imports), as posited by the gravity model.

Finally,  $RTA_{ij,t}$  assesses whether the two countries participate in the same regional trade agreements (RTAs), and a positive effect is expected.

We rely on panel data at a monthly frequency covering the period from January 2011 to December 2018 (T=84). The trade data pertain to 13 ECOWAS countries ( $i$ ) and 135 trade partners ( $j$ ). The monthly data encompass trade and restrictions. For variables such as GDP and RTA, we used annual values, as these data were not available on a monthly basis.

The use of panel data to estimate the gravity model was recommended by [Piermartini and Yotov \(2016\)](#) for two main reasons. First, it improves the efficiency of the estimates. Second, the size of a panel data allows the application of country pair fixed effects methods to address the issue of endogeneity of trade policy variables such as regional trade agreements.<sup>6</sup> In addition, incorporating country time (monthly) fixed effects allows to tackle unobserved changes in trade specific to each trading partner for a given month, in particular seasonal variations. According to [Anderson and Van Wincoop \(2003\)](#), exporter and importer fixed effects control for non-observable multilateral resistances (informal sector effect on competitiveness of ECOWAS countries).

Using country pair fixed effects has advantages; it can capture the endogeneity of trade policy variables [Baier and Bergstrand \(2007\)](#). For [Egger and Nigai \(2015\)](#), dyadic fixed effects provide a flexible and comprehensive report of the effects of all time-non-varying bilateral trade costs.

Considering these recommendations, we perform our estimations using high dimensional fixed effects by including exporter and importer time fixed effects, and also country pair fixed effects. This leads to the following equation:

$$Trade_{ij,t} = \exp \left[ \beta_1 (Restriction_{ij,t}) + \beta_2 (RTA_{ij,t}) + \lambda_{it} + \varphi_{jt} + \tau_{ij} \right] \times \epsilon_{ijt} \quad (3)$$

Where  $\lambda_{it}$  is the exporter time fixed effects,  $\varphi_{jt}$  is the importer time fixed effects and  $\tau_{ij}$  represents country pair fixed effect. We test a PPML estimator. Equation (3) is our baseline scenario.

Our database contains many zero values for trade data ( $trade_{ij,t} = 0$ ). To distinguish

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<sup>6</sup>This was also recommended by [Baier and Bergstrand \(2007\)](#).

between zero trade and missing flows, we analyzed the redundancy of the data. For instance, it is unlikely that Nigeria exports cocoa to Saudi Arabia in December. Transactions like these, representing zero trade, are excluded from our analysis. Thus, for each product, particularly seasonal crops, traded between a pair of countries for only a few months each year, we remove the months without bilateral trade of that product from the database. This approach enables us to address the seasonality inherent in agricultural products, which are typically traded after harvest periods.

For missing data that are not redundant—meaning they do not repeat for a given pair of countries over the same months each year—we consider them as a lack of trade information and keep them with a value of zero. However, when, for a given product, no bilateral trade is observed in any month of the period under review, we remove the data entirely. For example, this might occur with oil not traded between Nigeria and Saudi Arabia.

In addition to countries affected by Ebola-related restrictions, we include ECOWAS (Economic Community of West African States) countries not affected by Ebola-related restrictions in our estimations. This approach allows us to assess the impact of epidemic-related restrictions by comparing affected economies with similar (twin) nations. The list of these countries is available in Appendix [B12](#).

## 4.2 Data

We combine two types of data: measures of bans on trade and travel with infected countries, which we have built from information in official sources and media [\[4.2.1\]](#); and variables related to monthly trade at the product level and the usual determinants of trade used in the literature [\[4.2.2\]](#).

### 4.2.1 Construction of restriction’s dataset

There is no database for the entry restrictions imposed on Ebola-infected countries during the period from 2014 to 2016, which were implemented in violation of the IHR. Therefore, we construct our own measure by gathering information from various sources, following the method developed by [Rhymer and Speare \(2017\)](#).

This method consists of collecting information on the date and the countries implementing restrictions from the Google search engine. We search through surveys, research, and newspapers, keeping only non-contradictory information. Once this type of information is identified, we look for its confirmation by checking various sources. For the information gathered, priority is given to official government websites of the countries under review, followed by travel and



news websites.<sup>7</sup>

In practice, we first identify the list of trading partners that have issued restrictions against Ebola-infected countries. For each of the 135 trading partners of these economies, we visited at least 30 different information sources to collect accurate information on the type of restrictions. We then identify the type, scale, and period over which the restrictions were in force (see Appendix B9).<sup>8</sup>

We could thus identify several types of restrictions implemented against infected countries. These impediments to trade were mainly restrictions on the entry of persons and sometimes goods produced in and imported from Ebola-infected countries. These barriers varied depending on the trading partner, ranging from outright entry denial to limited entry permissions under certain conditions. These measures were eased by some trading partners over time (see Appendix B9), but most countries kept them constant until March 2016, when the WHO officially declared the end of the Ebola epidemic as a global public health emergency. Out of a total of 135 trading partners (both for the infected countries and a control group of ECOWAS countries<sup>9</sup>), 38 countries (28.1%) imposed entry restrictions on citizens from Ebola-infected countries during the period from August 2014 to January 2016.

We then construct the representative variable of restrictions by considering the intensity of the barriers. Due to the lack of precise information concerning restrictions on goods transportation, we focus on the limitations on people's entry.<sup>10</sup> We then split the restrictions into three broad categories and assign different values depending on their intensity. The values assigned are: "0" when there are no restrictions between the infected country and its trading partner, "1" when there are partial restrictions or partial bans (conditional entry) between the infected country and its trading partner, and "2" when there are total restrictions or total bans (categorical refusal of entry) between the infected country and its trading partner. Table B1 shows the frequency of observations related to each type of restriction in our database.

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<sup>7</sup>This method of information collection has been approved by James Cook University in Australia.

<sup>8</sup>Appendix A4 shows that 50% of the top 10 export trading partners of Ebola-infected countries have issued restrictions against them. This demonstrates the impact of restrictions on the share of exports between Ebola-infected countries and their trading partners.

<sup>9</sup>We also introduce ECOWAS countries non-affected by Ebola restrictions in our estimations. We aim to control for the impact of the epidemic by comparing affected economies with similar nations. The list of the control group is available in Appendix B12.

<sup>10</sup>Details regarding the duration and extent of restrictions on goods transportation vary across sources. To mitigate biases in our analysis due to this lack of precise information, we construct our indicator of restrictions by including only those related to travel bans for individuals, for which we have more precise data confirmed by multiple sources.

### 4.2.2 Data on trade and its usual determinants

The aim of this paper is to measure the effect of restrictions on international trade. Our dependent variables are trade variables representing bilateral exports and imports between ECOWAS countries (both affected and unaffected by Ebola restrictions) and their trading partners. We use statistics from UN Comtrade at the HS6 product level. We make two types of estimations. First, we consider all sample products. Second, we focus on fresh products and durable goods. We expect a higher impact than average on fresh products, which are perishable and must be consumed immediately after their production and cannot be stocked, and a lower impact on durable goods, which can wait to be traded. In both cases, we then select only the average of the ten most commonly exported products by ECOWAS countries both affected and unaffected by restrictions.

We consider monthly bilateral trade data from January 2011 to December 2018 to compare trade before and after the epidemic with its level during the health crisis. At the product level, disaggregated trade data include durable products (such as textiles, cotton, vehicles, machinery, equipment) and fresh products (such as fruit, vegetables, meat, fishery products).

In equation (2), the usual dyadic variables of distance, contiguity, common language, or colony are sourced from the Gravity database of the CEPII (Centre d’Etudes Prospectives et d’Informations Internationales). Data on GDP for countries  $i$  and  $j$  are collected from the World Bank’s Development Indicators (WDI) platform. Information on regional trade agreements is recorded annually and obtained from Larch’s Regional Trade Agreements Database. We extracted the annual data for our study period (2011 to 2018) from this database.<sup>11</sup>

Table B3, in the appendix, presents descriptive statistics on trade data. Standard deviations reveal significant heterogeneity in the volume of exports and imports between ECOWAS countries  $i$  and their trading partners  $j$ . Exports have an average value of approximately USD 52 million with a standard deviation of USD 314 million. Imports, on the other hand, have an average value of USD 9 million with an approximate standard deviation of USD 32 million. This heterogeneity can be explained primarily by the differences in the types of products traded by the countries involved. For example, products such as oil are exported only by countries in the sample with oil-rich sub-soils. Additionally, large countries tend to import and export more than small countries, according to the gravity model.

In Table B3, we see significant heterogeneity in the usual determinants of bilateral trade. The countries differ in size. The average annual GDP in exporting/origin countries amounts to USD 91 billion with a standard deviation of USD 159 billion. In destination country  $j$ , the

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<sup>11</sup>A summarized presentation of all variables can be found in table B2, in the appendix.

average annual GDP is USD 1,930 billion with a standard deviation of USD 3,680 billion.

## 5 Results and discussion

We begin by analyzing the impact of bans on total bilateral trade (for all products), then focusing on the diverging effects on fresh and durable goods.

### 5.1 Effect of restrictions on trade of all products

Table 1: PPML estimation of restrictions' effect on trade for all sample products

	[1]	[2]	[3]	[4]
Dependent variables: Trade <sub>(ij,t)</sub>	Exports <sub>(ij,t)</sub>		Imports <sub>(ij,t)</sub>	
Restrictions <sub>(ij,t)</sub>	-0.558*** (0.166)		0.070 (0.058)	
Total bans <sub>(ij,t)</sub>		-1.115** (0.478)		0.119 (0.135)
Partial bans <sub>(ij,t)</sub>		-0.559*** (0.193)		0.091 (0.090)
Regional Trade Agreements <sub>(ij,t)</sub>	0.002 (0.183)	0.002 (0.184)	-0.449** (0.193)	-0.449** (0.193)
Constant	20.368*** (0.065)	20.368*** (0.065)	17.794*** (0.062)	17.793*** (0.062)
Observations	207,036	207,036	205,216	205,216
Pseudo R-squared	0.961	0.961	0.914	0.914
Exporter time FE	Yes	Yes	Yes	Yes
Importer time FE	Yes	Yes	Yes	Yes
Pair FE	Yes	Yes	Yes	Yes

**Source:** Author's calculations.

**Note:** Robust standard errors in parentheses \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . Estimations based on PPML. Average effect includes total and partial bans' effect in the same variable named Restrictions. Decomposed effect shows the individual effect of total and partial bans. The two types of regressions include importer-time, exporter-time, and country pair fixed effects. This table presents restrictions' effect on bilateral trade (exports and imports) from Ebola-infected countries that were subjected to restrictions, to their trading partners. Estimations include all traded products.

We first assess the effect of entry restrictions on total trade (all products) using our baseline scenario with equation (2). Table 1 displays the effect of restrictions on exports and imports. As hypothesized, we observe a negative effect of restrictions on exports (see column 1, table 1). The greater the level of restrictions imposed by trading partners, the fewer exports from Ebola-infected countries to these partners.<sup>12</sup> On average, restrictions lead to a drop in exports

<sup>12</sup>More detailed estimates (see Appendix A5) show that the negative effect of restrictions on exports is persistent

of -42.8%.<sup>13</sup> Regarding the decomposed effect of restrictions, we find a stronger impact of total bans compared to partial bans when distinguishing restrictions by their intensity. Total bans lead to a drop in bilateral exports of 67.2%, while for partial bans, the drop in exports is 42.8% (see column 2, table 1).

We replicate the same estimations for imports from countries affected by Ebola. Interestingly, we find no significant effect of restrictions on imports from infected countries (see columns 3 and 4, Table 1), as expected, given that restrictions primarily focus on the entry of people into the importing (non-infected) country, rather than exit. Despite the reduction in exports from infected countries due to restrictions, the need for imports persisted, especially considering the dependency of these countries on imports (e.g., manufacturing imports).

The delay between production and use varies significantly among products. Therefore, we analyze fresh products and durable goods separately to assess whether the impact of Ebola differs among different types of goods.

## 5.2 Effect of restrictions on fresh products trade

We now assess the impact of restrictions on the trade of fresh products, given their perishable nature and the necessity for consumption shortly after production. As restrictions may result in exceeding delivery deadlines, we anticipate a stronger effect on the exports of non-durable products, particularly fresh ones. Here, fresh products are defined as those with a maximum shelf life of 30 days. Table 2 provides an overview of the effect of restrictions on the trade of fresh products, including both exports and imports.

We selected fresh products traded by both the infected countries (subjected to restrictions) as the treated group and the other ECOWAS countries (not subjected to restrictions) as the control group. We then retained only the ten most commonly exported products by both groups of nations (see Appendix B10). This selection allows us to establish a comparison between a treated group (fresh products subjected to restrictions) and a non-treated group (fresh products not subjected to restrictions) for identical products. Thus, we can accurately assess the impact of restrictions on the trading of fresh products. Our results confirm our hypotheses of a much stronger effect of restrictions on fresh product exports.

The first column of Table 2 illustrates the effect of restrictions on fresh product exports from Ebola-infected countries. We observe a greater impact of restrictions on fresh product exports compared to all products. Restrictions lead to a 47.6% decrease in fresh product exports and significant up to 8 months after the start of restrictions.

<sup>13</sup>From Table 1, in the fixed effect PPML model, we find a total negative effect of restrictions on exports of -0.558 (column 1). A higher level of restrictions leads to a decrease in exports of  $[(\exp(-0.558) - 1)] \times 100 = -42.77\%$ .

Table 2: **PPML estimation of restrictions' effect on fresh products trade**

	[1]	[2]	[3]	[4]
Dependent variables: Trade <sub>(ij,t)</sub>	Exports <sub>(ij,t)</sub>		Imports <sub>(ij,t)</sub>	
Restrictions <sub>(ij,t)</sub>	-0.647*** (0.189)		0.043 (0.080)	
Total bans <sub>(ij,t)</sub>		-1.352** (0.532)		0.032 (0.173)
Partial bans <sub>(ij,t)</sub>		-0.613*** (0.202)		0.104 (0.121)
Regional Trade Agreements <sub>(ij,t)</sub>	-0.136 (0.192)	-0.138 (0.194)	-0.294* (0.162)	-0.294* (0.162)
Constant	20.178*** (0.070)	20.176*** (0.069)	17.308*** (0.060)	17.306*** (0.060)
Observations	50,585	50,585	49,791	49,791
Pseudo R-squared	0.960	0.960	0.900	0.900
Exporter time FE	Yes	Yes	Yes	Yes
Importer time FE	Yes	Yes	Yes	Yes
Pair FE	Yes	Yes	Yes	Yes

**Source:** Author's calculations.

**Note:** Robust standard errors in parentheses: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . PPML estimations are employed. The average effect encompasses both total and partial bans' impact within the variable named Restrictions. The decomposed effect distinguishes between the individual effects of total and partial bans. Both types of regressions incorporate importer-time, exporter-time, and country pair fixed effects. This table explores the impact of restrictions on bilateral trade (exports and imports) from Ebola-infected countries to their trading partners, focusing solely on fresh products.

exports. Regarding the decomposed effect, we also find that total bans have a greater negative impact on fresh product exports compared to all products (comparing columns 2 of Table 2 and 1). The imposition of total bans led to a decrease in the export of fresh products by 74.1% (see column 2, Table 2). Since fresh products are non-durable, attempting to export them to trading partners that have imposed outright refusal restrictions on entry into their territories (total bans) would result in product degradation and financial losses. To mitigate these losses, Ebola-infected countries have likely ceased the export of fresh products to countries with total bans.

Partial bans have had a greater impact on the exports of fresh products compared to all products. Increased control measures on cargoes and visa restrictions, which have caused delays in the delivery of goods, have negatively affected the export of fresh products due to their non-durability. This resulted in a drop of 45.8% (see column 2, Table 2).

Partial bans still allow exports, albeit to a lesser extent. Consequently, some infected countries have implemented new methods to preserve fresh products for longer periods. During the

Ebola crisis, the issue of food security was raised in countries such as Liberia, Sierra Leone, and Guinea due to border closures. These countries implemented corrective actions to prevent a food crisis resulting from a decline in local production due to reduced exports. Measures included preserving products for extended periods to prevent food shortages. These preservation methods may have enabled them to continue exporting fresh products only to trading partners that have imposed partial bans. This could explain the weaker effect of partial bans compared to total bans on fresh product exports.

From columns 3 and 4 of Table 2, we observe that, similar to the case with all products, restrictions did not have any significant effect on fresh product imports. This outcome can be explained by the fact that restrictions only penalized the exit of products from, and not the entry into, infected countries.

### 5.3 Effect of restrictions on durable products trade

We also estimate the effect of restrictions on trade in durable products. We want to verify whether restrictions have affected durable products to the same extent as all goods or fresh products. We expect a smaller impact on the former. Durable products do not deteriorate quickly and therefore will not incur the costs associated with deterioration due to delivery delays, unlike fresh products. Table 3 presents the results of the effect of restrictions on trade in durable goods, including exports and imports. Using the same method as for fresh products, we selected durable products traded by both the infected and uninfected ECOWAS countries. We retained the fourteen most commonly exported durable goods for the region's countries (see Appendix B11). This resulted in a treated group (banned durable goods) and a non-treated group (non-banned durable goods) composed of identical products. This approach allows us to identify the true effect of restrictions on trade in durable products.

Table 3 presents the effect of restrictions on exports from Ebola-infected countries that have been subjected to restrictions. There is a negative relationship between restrictions and exports of durable goods, resulting in a 38.5% drop in exports. This effect is smaller compared to fresh products (columns 1, Tables 3 and 2, respectively). The disparity with fresh products is also evident in the breakdown of the effect of restrictions on exports. The intensification of total bans led to an approximate 62.7% decrease in the export of durable products (Table 3), compared to a 74.1% decrease in the export of fresh products (columns 2, Tables 3 and 2, respectively). Partial bans resulted in a 38.1% decrease in the export of durable products, compared to a 45.8% decrease in the export of fresh products (columns 2, Table 3 and Table 2, respectively). This confirms our hypothesis of a stronger effect of restrictions on the export of fresh products.

Table 3: PPLM estimation of restrictions' effect on durable products trade

	[1]	[2]	[3]	[4]
Dependent variables: Trade <sub>(ij,t)</sub>	Exports <sub>(ij,t)</sub>		Imports <sub>(ij,t)</sub>	
Restrictions <sub>(ij,t)</sub>	-0.486*** (0.177)		-0.039 (0.078)	
Total bans <sub>(ij,t)</sub>		-0.986** (0.487)		-0.116 (0.163)
Partial bans <sub>(ij,t)</sub>		-0.479** (0.212)		-0.006 (0.116)
Regional Trade Agreements <sub>(ij,t)</sub>	-0.161 (0.187)	-0.161 (0.188)	-0.393** (0.163)	-0.392** (0.163)
Constant	20.205*** (0.070)	20.205*** (0.070)	17.294*** (0.057)	17.293*** (0.057)
Observations	46,675	46,675	46,127	46,127
Pseudo R-squared	0.960	0.960	0.894	0.894
Exporter time FE	Yes	Yes	Yes	Yes
Importer time FE	Yes	Yes	Yes	Yes
Pair FE	Yes	Yes	Yes	Yes

**Source:** Author's calculations.

**Note:** Robust standard errors in parentheses: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . PPML estimations are utilized. The average effect incorporates both total and partial bans' impact within the variable named Restrictions. The decomposed effect distinguishes between the individual effects of total and partial bans. Both types of regressions include importer-time, exporter-time, and country pair fixed effects. This table examines the impact of restrictions on bilateral trade (exports and imports) from Ebola-infected countries to their trading partners, focusing exclusively on durable products.

Columns 3 and 4 of Table 3 demonstrate that there is still no significant effect of bans on the imports of the infected countries.

## 6 Robustness Checks

We conduct three types of robustness checks: (i) running the estimation with another econometric method (OLS), (ii) controlling for the intensity of the Ebola disease (the number of cases), and (iii) considering the heterogeneity of countries (controlling for landlocked countries).

- Alternative estimation methods

Our baseline model utilizes a non-linear approach with PPML estimation, incorporating high-dimensional fixed effects. Additionally, we conduct PPML estimations without including any fixed effects and provide the results with OLS and fixed effects. Our objective is to determine whether restriction effects persist regardless of the estimation method used. Tables B4, B5,

and [B6](#), in the appendix, present the results of these two estimation methods for all products, fresh products, and durable goods, respectively. For both specifications, restrictions consistently exhibit a negative and significant effect on exports across all types of products. However, when comparing the OLS and PPML estimators with the same set of fixed effects, we observe that the effect of restrictions is much stronger in the PPML model than in the OLS for all products (comparing columns 1 of Tables [1](#) and [B4](#)), fresh products (comparing columns 1 of Tables [3](#) and [B5](#)), and durable goods (comparing columns 1 of Tables [1](#) and [B4](#)). These differences are further illustrated in Figure [A1](#), which compares the magnitude of the impact of restrictions on exports using PPML (darker color) and OLS (lighter color) for all types of goods (see the upper bars for total products). Figures [A2](#) and [A3](#) replicate the same trends for fresh products and durable goods, respectively.

The impacts now exhibit similar magnitudes for fresh products and durable goods when comparing columns 1 in Table [B5](#) and [B6](#) for OLS, and columns 2 in the same tables for PPML without fixed effects.

When considering the intensity of the implemented measures, we observe a stronger impact of restrictions on the reduction of exports for total bans compared to partial bans with OLS for all products (see column 3 of Table [B4](#)). With PPML estimation without individual fixed effects only (equation (2)), we find an impact of restrictions only for total bans, while exports remain unchanged by partial bans (see column 4 of Table [B4](#)). This result also holds for durable goods (see columns 3 and 4 of Table [B6](#) for OLS and PPML, respectively, with individual fixed effects only), whereas for fresh products, partial bans are non-significant in both specifications (see columns 3 and 4 of Table [B5](#)). These results are consistent with the possibility of bypassing partial bans, as previously stated.

- Impact of the number of Ebola cases

Except for Nigeria, the countries in our study were severely affected by the Ebola epidemic, with thousands of cases reported. This prompted the authorities of the affected countries to implement internal quarantine measures to contain the spread of the infectious fever. The decline in exports could be attributed to a decrease in the productivity of the infected countries due to these internal quarantine measures, the severity of which was linked to the number of cases. To ensure that the drop in exports we observe is indeed related to the restrictions, we conduct a robustness check by controlling for the number of persons infected. The effect of restrictions on exports remains negative and significant, and stronger with PPML estimation compared to OLS (see columns 1 and 3 of Table [B7](#) for PPML and OLS specifications, respectively).



- Landlocked countries

The ECOWAS countries in our study, both treated and non-treated groups, are geographically diverse, with some being landlocked while others have access to the sea. Countries with access to the sea benefit from harbors, allowing for direct transportation of goods by sea without the need to pass through other countries. To account for this geographical difference, we include the landlocked variable in our analysis to ensure the effect of restrictions is accurately captured. The effect of restrictions remains negative and significant even after controlling for the landlocked variable. We observe an additional negative impact for landlocked countries in both the PPML and OLS specifications for all impediments (columns 1 and 3 of Table [B8](#) for OLS and PPML, respectively). This negative impact persists when the restrictions are further examined; however, only total bans now have a depressive impact on exports (see columns 2 and 4 of Table [B8](#) for OLS and PPML, respectively).

## 7 Conclusion

We analyze the impact on trade of prohibitions and limitations on the movement of persons following an epidemic. We find a negative effect of restrictions on exports from Ebola-infected countries and no effect on imports from trading partners. Since impediments were only imposed on the entry of people into importing (non-infected) countries and not on exit, these different outcomes have a clear explanation. The restrictions resulted in additional trade costs due to delays in the delivery of goods in general, and the deterioration of fresh products in particular. The effect is stronger for total bans than for partial limitations and sharper for fresh products than for durable goods.

Our results are derived from OLS and PPML estimations, which remain robust even when controlling for the number of Ebola cases in a country. This allows us to disentangle the effects of the disease from those of the restrictions. Furthermore, this outcome persists even after introducing a dummy variable to isolate landlocked countries, which are often more affected than the entire sample.

In light of our findings, we recommend that countries strictly adhere to the International Health Regulations (IHR) during pandemics. Additionally, fostering cohesion between states during such crises can mitigate the negative economic impacts of epidemics. Especially for developing countries, governments should prioritize increased investment in healthcare to better manage future health crises. This paper contributes to the literature by highlighting the importance of international coordination and the development of robust health infrastructures in

mitigating the adverse economic effects of pandemic shocks.

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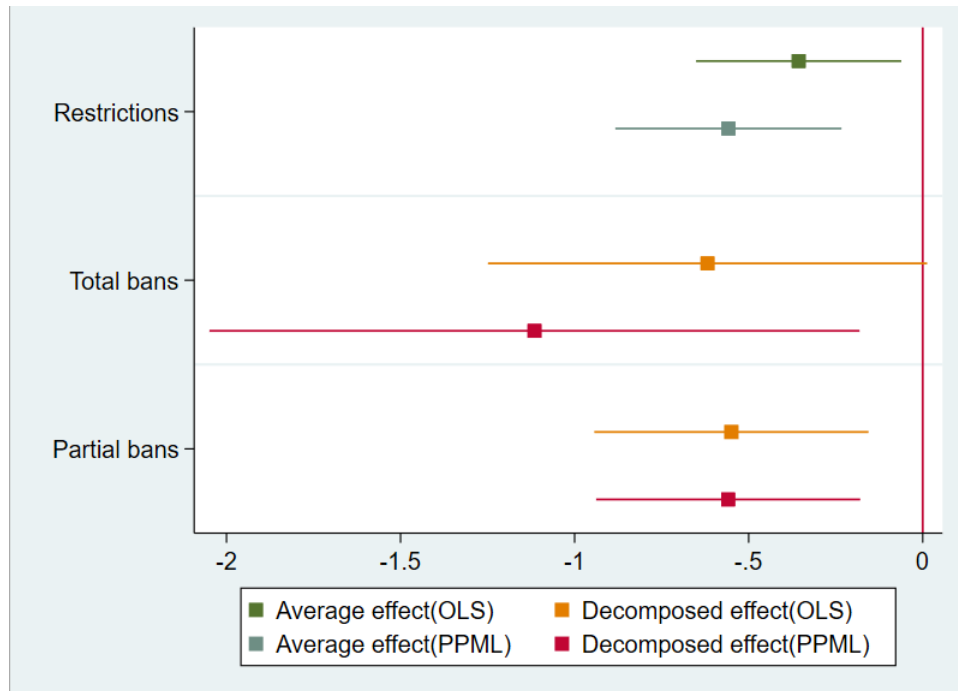
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# APPENDIX

## A Figures

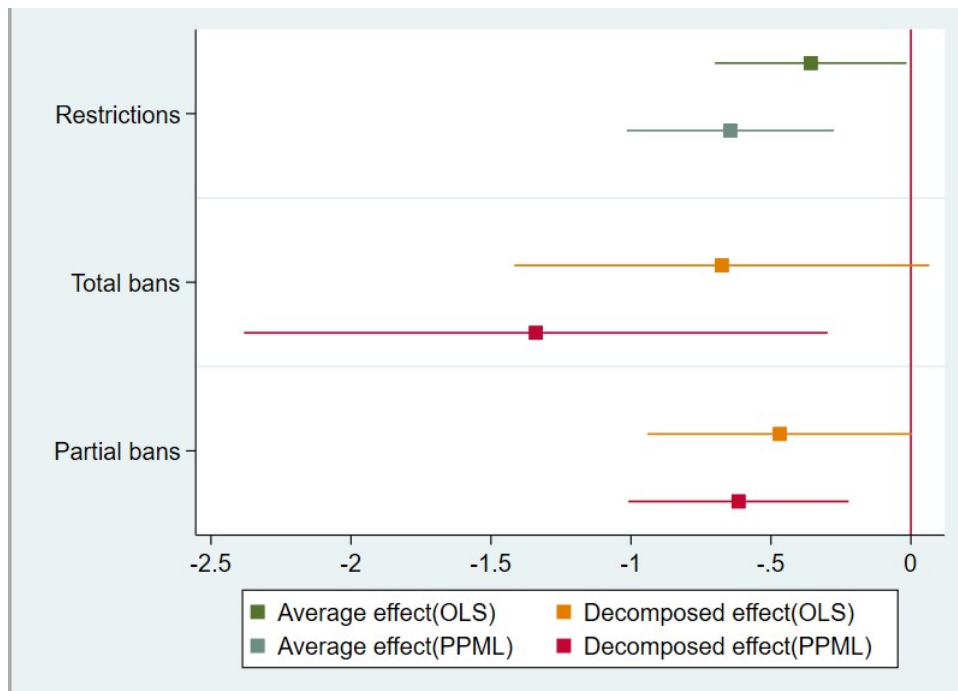
Figure A1: Restrictions' effect on exports for all sample products (Linear Vs PPML)



**Source:** Author's compilations.

**Note:** OLS represents the linear model estimation, and PPML represents the non-linear model estimation. The average effect includes total and partial bans under the variable Restrictions. The decomposed effect distinguishes the individual impacts of total and partial bans. This graph compares the effects of linear (OLS) and non-linear (PPML) estimators, both including importer-time, exporter-time, and country-pair fixed effects.

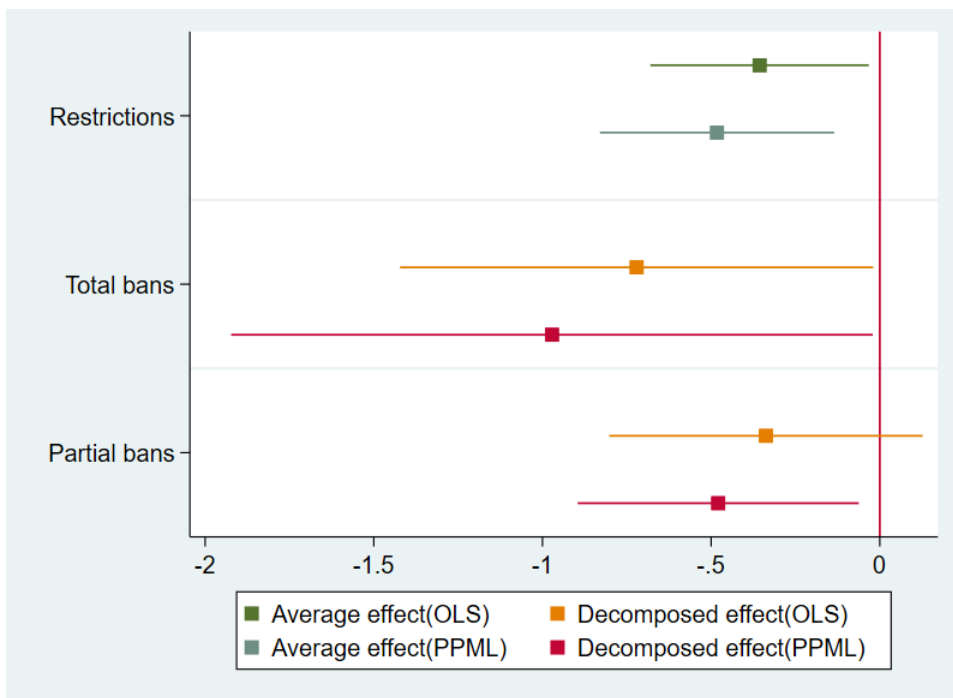
Figure A2: Restrictions' effect on fresh product exports (Linear Vs PPML)



**Source:** Author's compilations.

**Note:** OLS is the estimation method for the linear model, while PPML is used for the non-linear model. The average effect includes the combined impact of total and partial bans under the variable 'Restrictions.' The decomposed effect distinguishes the individual impacts of total and partial bans. This graph compares the effects of linear (OLS) and non-linear (PPML) estimators, both incorporating importer-time, exporter-time, and country-pair fixed effects.

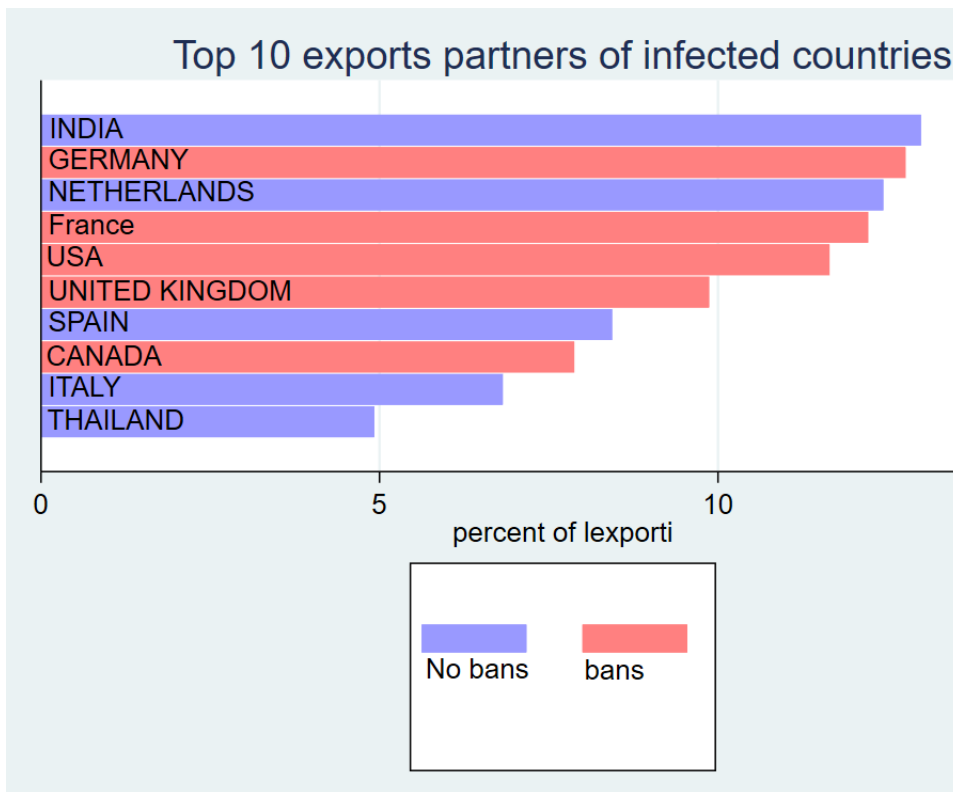
Figure A3: Restrictions' effect on durable product exports (Linear Vs PPML)



**Source:** Author's compilations.

**Note:** OLS is used for the linear model and PPML for the non-linear model. The average effect combines total and partial bans under 'Restrictions,' while the decomposed effect shows their individual impacts. This graph compares the effects of OLS and PPML estimators, both incorporating importer-time, exporter-time, and country-pair fixed effects.

Figure A4: Share of restrictions in Exports

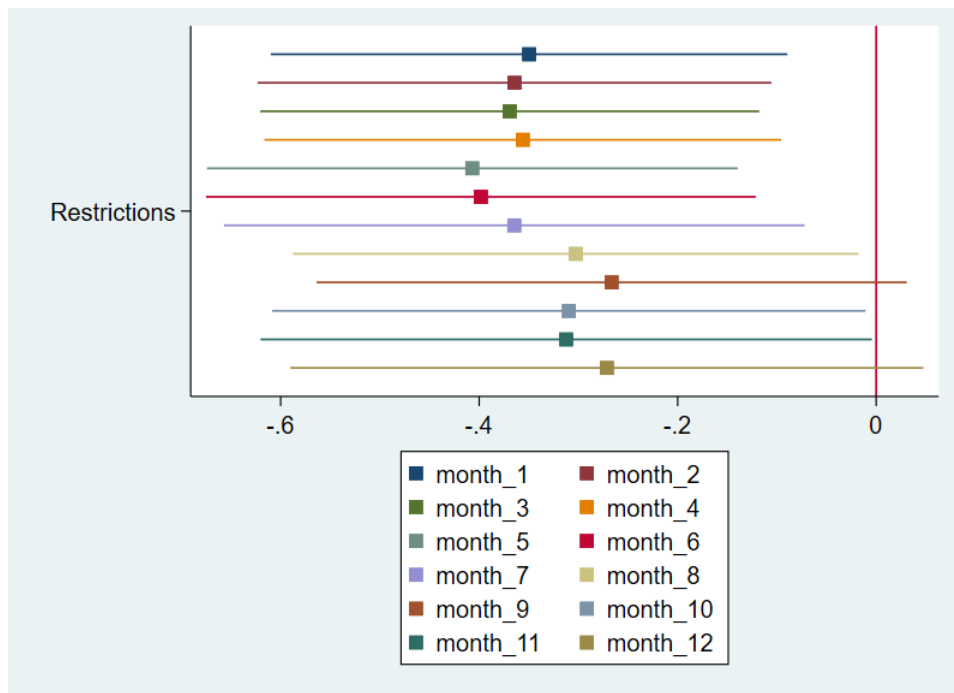


**Source:** Author's calculations from UN Comtrade databases and restriction surveys.

**Note:** The graph above shows the top 10 export trading partner countries subjected to restrictions. These trading partners have the largest share in the exports of the treated countries. Notably, half of these partners have imposed restrictions against the treated countries, highlighting the significant impact of these restrictions on their trade.



Figure A5: Average persistence effect of restrictions over time



**Source:** Author's calculations based on PPML estimations.

**Note:** The graph above illustrates the average persistence effect of restrictions over time, showing that the impact persists for 8 months after the restrictions are imposed.

## B Tables

Table B1: **Frequency of restrictions**

Variables	Frequency	Percentage	Cumulative Percentage
<b>Restrictions</b>	204.558	96.68	96.68
<b>Total bans</b>	4.525	2.14	98.82
<b>Partial bans</b>	2.507	1.18	100

**Source:** Author's calculations from official sources and media websites.

**Note:** Restrictions data come from surveys we conducted visiting at least 30 information sources per country. The information was gathered from official sources and the medias. These are restrictions applied against countries such as Liberia, Sierra Leone, Guinea and Nigeria during the Ebola epidemic. The restrictions cover on average over the monthly period from August 2014 to March 2016

Table B2: **Summary of main variables**

Variable	Frequency of observations	Sources
Exports from country i to country j	Jan. 2011 - Dec. 2018	UN Comtrade
Imports of country i from country j	Jan. 2011 - Dec. 2018	UN Comtrade
GDP in i	2011 - 2018	WDI World bank
GDP in j	2011 - 2018	WDI World bank
Regional trade agreements between i and j	2011 - 2018	Mario Larch's RTA Database
Contiguity between i and j	2011 - 2018	CEPII
Language between i and j	2011 - 2018	CEPII
Colonial story between in and j	2011 - 2018	CEPII
Distance between i and j	2011 - 2018	CEPII
Travel bans from j against i	Jan. 2011 - Dec. 2018	Constructed by the authors
Total bans from j against i	Jan. 2011 - Dec. 2018	Constructed by the authors
Partial bans from j against i	Jan. 2011 - Dec. 2018	Constructed by the authors

**Source:** Author's compilations from official sources and media websites.

Table B3: **Descriptive statistics of main variables**

Variables	N	Mean	Sd	Min	Max
Exports of i to j (in USD million)	211590	52.4	314	0	14300
Imports of i from j (in USD million)	211590	9.4	31.7	0	1040
GDP in i (in USD Billion)	211590	91.4	159	0.989	547
GDP in j (in USD Billion)	211590	1930	3680	0.28	20600
Regional trade agreements between i and j	211590	0.2661184	0.441928	0	1
Contiguity between i and j	211590	0.0591758	0.2359539	0	1
Language between i and j	211590	0.30095	0.4586721	0	1
Colonial story between in and j	211590	0.072442	0.2592189	0	1
Distance between i and j	211,538	5964.208	3321.48	237.7669	19027.26
Travel bans from j against i	211590	0.0450825	0.02583547	0	2
Total bans from j against i	211590	0.0118484	0.1082038	0	1
Partial bans from j against i	211590	0.0213857	0.1446667	0	1

**Source:** Author's calculations from databases of WDI, CEPII and on restrictions after Ebola.

Table B4: OLS and simple PPML estimations of restrictions' effect on exports for all sample products

Dependent Variable $(ij,t)$	[1]	[2]	[3]	[4]
	OLS Log of Exports	PPML Exports	OLS Log of Exports	PPML Exports
Restrictions $(ij,t)$	-0.353** (0.150)	-0.353** (0.176)		
Total bans $(ij,t)$			-0.610* (0.321)	-1.366*** (0.349)
Partial bans $(ij,t)$			-0.548*** (0.201)	-0.237 (0.255)
Logarithm of GDP $(i,t)$		0.987*** (0.095)		0.984*** (0.093)
Logarithm of GDP $(j,t)$		0.807*** (0.080)		0.801*** (0.078)
Logarithm of Distance $(ij)$		-0.615*** (0.212)		-0.621*** (0.210)
Colony $(ij)$		-0.288 (0.310)		-0.304 (0.316)
Common Language $(ij)$		0.119 (0.318)		0.126 (0.321)
Contiguity $(ij)$		-1.388** (0.663)		-1.394** (0.652)
Regional Trade Agreements $(ij,t)$	0.114 (0.166)	1.078*** (0.384)	0.117 (0.166)	1.067*** (0.378)
Constant	13.850*** (0.048)	-24.480*** (3.223)	13.860*** (0.048)	-24.190*** (3.045)
Observations	168,387	211,538	168,387	211,538
R-squared	0.839	0.229	0.839	0.229
Exporter time FE	Yes	No	Yes	No
Importer time FE	Yes	No	Yes	No
Pair FE	Yes	No	Yes	No

**Source:** Author's calculations.

**Note:** Robust standard errors in parentheses \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. : This table shows OLS and PPML (with individual fixed effects) estimations of the effect of restrictions on exports from Ebola infected countries.

Table B5: OLS and simple PPML estimations of the restrictions' effect on fresh product exports

Dependent variable $(i,j,t)$	[1]	[2]	[3]	[4]
	OLS Log of Exports	PPML Exports	OLS Log of Exports	PPML Exports
Restrictions $(i,j,t)$	-0.357** (0.165)	-0.308* (0.167)		
Total bans $(i,j,t)$			-0.721** (0.358)	-1.180*** (0.369)
Partial bans $(i,j,t)$			-0.338 (0.237)	-0.200 (0.243)
Logarithm of GDP $(i,t)$		1.019*** (0.094)		1.017*** (0.094)
Logarithm of GDP $(j,t)$		0.960*** (0.074)		0.956*** (0.073)
Logarithm of Distance $(ij)$		-0.860*** (0.223)		-0.863*** (0.223)
Colony $(ij)$		(0.290) -0.358		(0.301) -0.364
Common Language $(ij)$		0.143 (0.379)		0.145 (0.380)
Contiguity $(ij)$		-0.911 (0.676)		-0.911 (0.671)
Regional Trade Agreements $(i,j,t)$	-0.012 (0.208)	1.038*** (0.376)	-0.012 (0.208)	1.030*** (0.372)
Constant	11.960*** (0.055)	-27.710*** (2.925)	11.960*** (0.053)	-27.500*** (2.804)
Observations	34,292	50,366	34,292	50,366
R-squared	0.826	0.205	0.826	0.204
Exporter time FE	Yes	No	Yes	No
Importer time FE	Yes	No	Yes	No
Pair FE	Yes	No	Yes	No

**Source:** Author's calculations.

**Note:** Robust standard errors in parentheses \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . This table shows OLS and PPML (with individual fixed effects) estimations of the effect of restrictions on exports from Ebola infected countries.

Table B6: OLS and simple PPML estimations of restrictions' effect on durable product exports

Dependent variable $(i,j,t)$	[1]	[2]	[3]	[4]
	OLS Log of Exports	PPML Exports	OLS Log of Exports	PPML Exports
Restrictions $(i,j,t)$	-0.356** (0.174)	-0.309* (0.169)		
Total bans $(i,j,t)$			-0.672* (0.378)	-1.199*** (0.380)
Partial bans $(i,j,t)$			-0.468* (0.241)	-0.197 (0.245)
Logarithm of GDP $(i,t)$		1.015*** (0.096)		1.013*** (0.095)
Logarithm of GDP $(j,t)$		0.975*** (0.074)		0.970*** (0.072)
Logarithm of Distance $(ij)$		-0.856*** (0.223)		-0.858*** (0.224)
Colony $(ij)$		-0.304 (0.376)		-0.315 (0.381)
Common Language $(ij)$		0.110 (0.384)		0.111 (0.385)
Contiguity $(ij)$		-0.855 (0.691)		-0.853 (0.687)
Regional Trade Agreements $(i,j,t)$	0.089 (0.200)	1.018*** (0.380)	0.09 (0.200)	1.009*** (0.376)
Constant	12.150*** (0.053)	-28.050*** (2.875)	12.150*** (0.053)	-27.830*** (2.756)
Observations	36,869	54,022	36,869	54,022
R-squared	0.821	0.201	0.821	0.200
Exporter time FE	Yes	No	Yes	No
Importer time FE	Yes	No	Yes	No
Pair FE	Yes	No	Yes	No

**Source:** Author's calculations.

**Note:** Robust standard errors in parentheses \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . This table shows OLS and PPML (with individual fixed effects) estimations of the effect of restrictions on exports from Ebola infected countries.

Table B7: OLS and PPML estimation controlling with the number of Ebola cases

	[1]	[2]	[3]	[4]
	OLS	OLS	PPML	PPML
Dependent variable $(ij,t)$	Log of exports	Log of exports	exports	exports
Restrictions $(ij,t)$	-0.364**		-0.427***	
	-0.153		-0.130	
Total bans $(ij,t)$		-0.664*		-1.007**
		(0.356)		(0.494)
Partial bans $(ij,t)$		-0.479**		-0.381***
		(0.196)		(0.141)
Logarithm of GDP $(i,t)$	1.433***	1.433***	2.984***	2.980***
	-0.431	-0.431	-0.589	-0.59
Regional Trade Agreements $(ij,t)$	0.018	0.019	0.093	0.092
	(0.168)	(0.168)	(0.170)	(0.171)
Ebola cases $(i,t)$	0.914E-05	1.08E-05	-3.14E-05	-3.17E-05
	(1.63E-05)	(1.60E-05)	(3.22E-05)	(3.22E-05)
Constant	-22.370**	-22.370**	-57.800***	-57.700***
	(10.380)	(10.380)	(15.340)	(15.360)
Observations	36,889	36,889	50,749	50,749
R-squared	0.810		0.810	
Pseudo R-squared		0.947		0.947
Exporter time FE	No	No	No	No
Importer time FE	Yes	Yes	Yes	Yes
Pair FE	Yes	Yes	Yes	Yes

**Source:** Author's calculations.

**Note:** Robust standard errors in parentheses \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . This table presents robustness check results concerning the effect of restrictions on exports from Ebola infected countries by controlling for number of Ebola cases. We make this robustness by using both OLS and PPML estimations.

Table B8: **OLS and PPML estimation of restrictions' effect on exports controlling with lanlocked**

Dependent variable $(ij,t)$	[1] OLS Log of exports	[2] OLS Log of exports	[3] PPML exports	[4] PPML exports
Restrictions $(ij,t)$	-0.404** (0.175)		0.136 (0.211)	
Total bans $(ij,t)$		-0.804* (0.431)		-0.870* (0.457)
Partial bans $(ij,t)$		-0.407 (0.291)		0.343 -0.228
Logarithm of GDP $(i,t)$	1.030*** (0.060)	1.030*** (0.060)	1.002*** (0.108)	0.999*** (0.107)
Logarithm of Distance $(ij)$	1.805*** (0.467)	1.805*** (0.467)	3.061** (1.471)	3.026** (1.447)
Colony $(ij)$	-0.332 (0.513)	-0.332 (0.512)	-0.013 (0.388)	0.002 (0.386)
Common Language $(ij)$	-0.291 (0.255)	-0.291 (0.254)	-0.143 (0.323)	-0.151 (0.320)
Contiguity $(ij)$	1.587*** (0.460)	1.587*** (0.461)	1.892* (1.094)	1.768 (1.075)
Regional Trade Agreements $(ij,t)$	0.841*** (0.200)	0.841*** (0.200)	0.529*** (0.186)	0.526*** (0.183)
Landlocked $(i)$	-2.305*** (0.235)	-2.305*** (0.235)	-1.307*** (0.427)	-1.313*** (0.425)
Constant	-26.240*** (4.568)	-26.230*** (4.568)	-33.100** (15.160)	-32.740** (14.940)
Observations	168,538	168,538	209,710	209,710
R-squared	0.641		0.641	
Pseudo R-squared		0.870		0.870
Exporter time FE	No	No	No	No
Importer time FE	Yes	Yes	Yes	Yes
Pair FE	No	No	No	No

**Source:** Author's calculations.

**Note:** Robust standard errors in parentheses \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . This table presents robustness check results concerning the effect of restrictions on exports from Ebola infected countries by controlling for landlocked. We make this robustness by using both OLS and PPML estimations.

Table B9: List of trading partners that applied entry restrictions to citizens of Ebola-infected countries between 2014 and 2016.

Country	Travel restrictions	Period of restrictions	Sources
Algeria	Entry refused if no medical certificates, Mandatory quarantine	Aug 2014- (no precise information on the end)	Bulletin of WHO (2017), Rhymer (travel website)
Antigua and Barbuda	Entry refused	Oct 2014-Mar 2016	Bulletin of WHO (2017), Rhymer (Government website)
Argentina	Mandatory quarantine for suspected cases	Aug 2014- (no precise information on the end)	Latina American science
Australia	Entry refused	Oct 2014-Mar 2016	Bulletin of WHO (2017), Rhymer (Government website), BBC News, public health research and practice
Bahrain	Entry refused	Aug 2014- Mar 2016	Bulletin of WHO (2017), Rhymer (Government website)
Belize	Entry refused	Oct 2014-Feb 2016	Bulletin of WHO (2017), Rhymer (Government website), Reuters
Brazil	Entry refused if no medical certificates	Oct 2014-Mar 2016	News website (Reuters, Bal Global,)
Cabo Verde	Entry refused	Aug 2014-Mar 2016	Bulletin of WHO (2017), Rhymer (travel website)
Canada	Entry refused	Aug 2014-Mar 2016	Bulletin of WHO (2017), Rhymer (Government website), Cambridge university press (2017)
Cameroon	Entry Refused and after entry conditioned by medical check-up	Aug 2014-Mar 2016	BSI supply chain solution, AA (news website)
Central African Rep.	Entry refused	Aug 2014- (no precise information on the end)	Bulletin of WHO (2017), Rhymer (travel website)
Colombia	Entry refused	Oct 2014- (no precise information on the end)	Bulletin of WHO (2017), Rhymer (Government website), Reuters
Côte d'Ivoire	Entry refused and after Entry refused if no medical certificates	Aug 2014-Mar 2016	News website (BBC News, Reuters, BAL Global, ...)
China	Entry conditioned by a medical check-up and Quarantine of suspect cases	Aug 2014-Mar 2016	News website (BAL Global, Wiley Online Library, ...)
Dominican Rep.	Entry refused	Oct 2014-Mar 2016	Bulletin of WHO (2017), Rhymer (Government website), Reuters
France	Entry conditioned by a medical check-up and Quarantine of suspect cases	Oct 2014-Mar 2016	Santé Publique France



Greece	Entry conditioned by a medical check-up and Quarantine of suspect cases	Oct 2014-Mar 2016	Government Website, Greek Reporter
Guyana	Entry refused	Sept 2014- Mar 2016	Bulletin of WHO (2017), Rhymer (News Website), Reuters
India	Mandatory Quarantine	Oct 2014-Mar 2016	News website (BBC news, Down to earth, . . .)
Indonesia	Entry conditioned by a medical check-up and Quarantine of suspect cases	Aug 2014-Mar 2016	Journal of clinical and diagnostic research, Bulletin of WHO (2017), Wendy Rhymer (Email correspondence with embassy)
Kazakhstan	Entry refused if no medical certificate	Oct 2014- (no precise information on the end)	Bulletin of WHO (2017), Rhymer (Email correspondence with embassy)
Kenya	Entry refused	Aug 2014- Mar 2016	Bulletin of WHO (2017), Rhymer (Travel Website), Reuters, BAL Global, BBC news
Maldives	Entry refused	Aug 2014-Fev 2016	Bulletin of WHO (2017), Rhymer (Government Website), relief web
Mauritius	Entry refused	Oct 2014- (no precise information on the end)	Bulletin of WHO (2017), Rhymer (Government Website)
New Zealand	Entry conditioned by medical check-up	Oct 2014- Mar 2016	BAL Global
Nicaragua	Mandatory Quarantine	Oct 2014- Mar 2016	Bulletin of WHO (2017), Rhymer (Travel Website), News websites
Panama	Entry refused	Aug 2014 - (no precise information on the end)	Bulletin of WHO (2017), Rhymer (Government Website)
Peru	Entry refused if no medical certificates	Oct 2014- Mar 2016	Bulletin of WHO (2017), Rhymer (Government Website)
Philippines	Mandatory quarantine	Aug 2014-Mar 2016	Bulletin of WHO (2017), Rhymer (Travel Website)
Qatar	Entry refused	Sept 2014-Mar 2016	Bulletin of WHO (2017), Rhymer (News Website), BAL Global
Rep. of Korea	Entry refused and after Mandatory quarantine	Oct 2014-Mar 2016	Bulletin of WHO (2017), Rhymer (Government Website), Reuters

Rwanda	Entry refused	Aug 2014- (no precise information on the end)	Bulletin of WHO (2017), Rhymer (Government Website)
Saint Kitts and Nevis	Entry refused	Oct 2014- Feb 2016	Bulletin of WHO (2017), Rhymer (Government Website)
Saint Vincent and the Grenadines	Entry refused	Oct 2014-Mar 2016	Bulletin of WHO (2017), Rhymer (Government Website), Reuters
Sao Tome and Principe	Entry refused	Aug 2014-Mar 2016	Bulletin of WHO (2017), Rhymer (Travel Website)
Saudi Arabia	Entry refused	Oct 2014-Mar 2016	Bulletin of WHO (2017), Rhymer (Government Website), news websites
Senegal	Entry refused and after conditioned by medical check-up	Aug 2014- Mar 2016	Reuters, BAL Global, Jeune Afrique
Seychelles	Entry refused	Aug 2014-Mar 2016	Bulletin of WHO (2017), Rhymer (Government Website), Reuters
Sri Lanka	Entry refused	Oct 2014- (no precise information on the end)	BAL Global
United Kingdom	Entry Refused and after conditioned by medical check up	Aug 2014-Mar 2016	BBC News
USA	Entry Limited and conditioned by a medical check-up and Quarantine of suspect cases	Oct 2014-Mar 2016	Centres for Disease Control and Prevention, BAL Global
Thailand	Entry refused if no medical certificates	Aug 2014-Mar 2016	Journal of Clinical and Diagnostic and Research
Singapore	Entry conditioned by a medical check-up and Quarantine of suspect cases	Oct 2014-Mar 2016	Journal of Clinical and Diagnostic and Research, BAL Global
Zambia	Entry refused and after conditioned by medical check up	Aug 2014- Mar 2016	Reuters (News website)

**Source:** Author's survey on restrictions.

**Note** Restrictions data come from surveys we conducted visiting at least 30 information sources per country. The information was gathered from official sources and the medias. These are restrictions applied against countries such as Liberia, Sierra Leone, Guinea and Nigeria during the Ebola epidemic. The restrictions cover on average over the monthly period from August 2014 to March 2016.

Table B10: **Group of Fresh products used for the analysis**

<b>Commodity</b>	<b>Frequency</b>	<b>Percent</b>
Fish and crustaceans, molluscs and other aquatic invertebrates	11187	22.12
Fruit and nuts, edible; peel of citrus fruit or melons	17081	33.77
Meat and edible meat offal	3961	7.83
Milk and cream; not concentrated nor containing added sugar or other sweetening matter	478	0.95
Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit, industrial or medicinal plants; straw and fodder	9184	18.16
Prepared foods obtained by swelling, roasting of cereals or cereal products (eg corn flakes); cereals, other than maize (corn), in grain form, pre-cooked or otherwise prepared	461	0.91
Tomatoes; fresh or chilled	93	0.18
Vegetable oils; olive oil and its fractions, virgin, whether or not refined, but not chemically modified	188	0.37
Vegetables and certain roots and tubers; edible	7875	15.57
Vegetables; fruits of the genus capsicum or of the genus pimenta	68	0.13
<b>Total</b>	<b>50576</b>	<b>100</b>

**Source:** Author's compilations from UN Comtrade monthly trade databases

Table B11: **Group of durable products used for analysis**

<b>Commodity</b>	<b>Frequency</b>	<b>Percent</b>
Cotton	9023	8.38
Diamonds, whether or not worked, but not mounted or set	2168	2.01
Electro-mechanical domestic appliances; with self-contained electric motor	656	0.61
Line telephony or line telegraphy apparatus; including such apparatus carrier-current line systems	5190	4.82
Machines and appliances; instruments or apparatus of chapter 90; parts and accessories n.e.s. in chapter 90	237	0.22
Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes	12381	11.5
Motor vehicles; parts and accessories, of heading no. 8701 to 8705	3881	3.61
Pharmaceutical products	8834	8.21
Plastics and articles thereof	19180	17.82
Plastics; articles of apparel and clothing accessories (including gloves)	344	0.32
Rubber and articles thereof	18071	16.79
Tobacco and manufactured tobacco substitutes	1145	1.06
Vaccines; for human medicine	505	0.47
Wood and articles of wood; wood charcoal	26021	24.17
<b>Total</b>	<b>107636</b>	<b>100</b>

**Source:** Author's compilations from UN Comtrade monthly trade databases

Table B12: **List of Origin Countries i including countries affected by Ebola-related restrictions and Control Group**

<b>Country</b>	<b>Frequency</b>	<b>Percent</b>
Benin	13746	6.5
Burkina Faso	11775	5.57
Cameroon	19457	9.2
Congo	14569	6.89
Côte d'Ivoire	22000	10.4
Ghana	28236	13.34
Guinea	13888	6.56
Guinea-Bissau	5460	2.58
Liberia	14021	6.63
Mali	12932	6.11
Niger	9380	4.43
Nigeria	34200	16.16
Sierra Leone	11926	5.64
Total	211590	100

**Source:** Author's compilations from databases