

An evidence base for international health regulations: quantitative measurement of the impacts of epidemic disease on international trade

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Submitted for publication: 13 July 2004

Accepted for publication: 4 May 2005

Summary

When cholera broke out in Mozambique, Kenya, Tanzania and Uganda in 1997, an urgent measure was filed with the Sanitary and Phytosanitary Committee of the World Trade Organization, by the European Union, citing the protection of human health, to limit imports of fish products. The authors analysed import data on specified products over time to quantify the trade impact of this measure. Using previous specific trade trends, the authors modelled expected trade flows and compared observed imports with expected imports to calculate the potential cost of lost trade. The conclusion of this analysis was that the impact of European restrictions on fish exports from Mozambique, Kenya, Tanzania and Uganda on the economies of these African countries was at least US\$332,217,415 for the years 1998 to 2002. Insights from such quantitative studies will be important in making policy choices under the revised International Health Regulations of the World Health Organization and should inform the discussion about the adoption of these regulations.

Keywords

Epidemic disease – International health – Trade embargo – Trade impact – World Health Organization.

Background

The International Health Regulations (IHR) are in the final stages of revision by the World Health Organization (WHO). The regulations address the measures that may and may not be implemented by member states to protect themselves from infectious diseases, and they are the only

such regulations backed by the weight of international treaty law. The development of an evidence base for evaluating the potential impact of policies embodied within these regulations has not kept pace with the proposed changes or with the decisions now being taken by governments in the face of epidemics. Specifically, there are few studies that examine the direct impacts of trade

restrictions that have been implemented to limit contagion, so the costs of these measures are not known.

This article addresses the impact of infections and embargoes on the direct flow of goods among trading nations. The authors describe a quantitative case study of the effect on trade volume of the cholera epidemic in East Africa in 1998. Such quantitative investigations are central to informing policy-makers of the potential economic impacts of trade embargoes that are used to limit the incursion of infections into their populations.

The European Union (EU) embargo of exports of fresh fish from the Lake Victoria region in 1998 has been carefully described (2). The restrictions were implemented in two phases; the first phase followed the detection of salmonella at the end of 1996. After inspection visits by the EU, imports of fish became subject to salmonella testing at the port of entry. With the advent of cholera in 1997, requirements to test for cholera and *Vibrio parahaemolyticus* were introduced, and, given that these tests take five days to perform, these requirements effectively precluded trade. The EU issued notification through the Sanitary and Phytosanitary (SPS) Committee of the World Trade Organization in 1998 restricting the import of seafood products from East African countries (i.e. Kenya, Mozambique, Uganda and the United Republic of Tanzania) to protect EU citizens from cholera (6). Member economies of the WTO file SPS notifications when they change their import policies towards the goods of a trading partner. The notifications are recommended but not required if the restriction is in line with the existing trade and embargo laws of the importer. Notification is required if the restriction is not already codified in national trade law.

The case study by Henson *et al.* (2) suggests that the incomes of fishermen in Tanzania declined by 80% during the sanction period. This observation was quoted in subsequent SPS working committee proceedings (7). The WHO, attending as an observer at SPS working group meetings, brought this evidence into deliberations about the revision of the IHR. In fact, the WHO considered the restriction of seafood imports unnecessary; they published their opinion in the media (press release, 9 January 1998) and presented it to the SPS working group meeting in March 1998 (5). The discussions have highlighted the need for a more complete and systematic evidence base when considering the issues of trade disruption and epidemic control. The work presented here was undertaken, in part, to respond to this need for better evidence. While other econometrically based methods exist, such as vector autoregression modelling and equilibrium modelling, they generally have not been tailored for poor economies. The authors cannot locate other case studies that use empirical information about a specific commodity, as has been done here.

Methodology

The objective of this paper is to estimate the impacts of trade embargoes by some EU members, as a result of reported cholera outbreaks in the area of Lake Victoria, on the import of fishery products to the EU from four African countries. The authors attempt to estimate the impact on the volume of import from each African country to each of these European countries (Denmark, Germany, Greece, the Netherlands, Portugal, Spain, Sweden and the United Kingdom).

The volumes of fishery products imported by each of the European countries from each of these African countries were observed in the years before and after the imposition of the trade embargo. This work focuses on estimating the volumes of expected trade in the 'post embargo' years if there had been no trade embargo. These volumes of trade are not observable, and thus the estimation of the authors is cautious and conservative. To give a more reliable estimation, relevant economic theory and econometric techniques were used, which allow estimation of the relationships between certain endogenous variables and some explanatory variables. These relationships are then used in the estimation exercise.

Economic theory tells us that the volume of trade between two countries depends on the export supply function of the exporting country and the import demand conditions in the importing country. Since the equilibrium depends on both import demand and export supply, the economic conditions of the importing and exporting countries should be studied together to give a more complete model for estimation.

The historical equilibrium between each pair of (exporting and importing) countries would be most informative but is not known for these country pairs. Constructing equilibria would be prohibitive in terms of data requirements and computation. The authors therefore propose an alternative approach that is more manageable and less data demanding but appears to yield reasonably reliable results.

The approach is based on the following assumptions:

- a) the fishery industries are small fractions of the economies of the exporting and importing countries
- b) the cost structure, including the marginal cost of fish production, in each exporting African country remains fairly constant, independent of the export level
- c) the import demand of the importing countries can be described by well-behaved import demand functions
- d) domestic production of fishery products in each importing country, if it exists, is only a small fraction of the level of import.

In further examining these assumptions, four relationships can be described, which form the basis of the modelling:

a) using assumption (a), it is possible to focus on the fishery markets, neglecting the cross effects from other industries. This means that a partial equilibrium framework can be employed, focusing on the import demand and export supply of relevant countries

b) in each importing country, a constant marginal cost, as stated in assumption (b), will imply an infinitely elastic export supply curve (if there is a change in the import demand due to, say, a change in trade policy, then there will be a corresponding change in the volume of import). It follows that the volume of trade in fishery products will be demand driven

c) assumption (c) is needed in order to estimate the import demand function

d) assumption (d) implies that import demand, at least within the relevant range, is more affected by domestic demand than by domestic supply in an importing country. This means that the functional forms of the import demand function can be simplified.

Based on the above assumptions, it is postulated that the import demand of each importing country for fishery products can be written as a function of a series of explanatory economic factors. In order to allow reasonable econometric estimation, the function considered here involves only two explanatory factors: national income and price level. If M_t is the level of import at time t , it is postulated that, before the imposition of trade embargoes, M_t is a function of the importing country's national income, Y_t , and the price level, p_t , or

$$M_t = f(Y_t, p_t). \quad [1]$$

It is assumed that M_t depends positively on Y_t but negatively on p_t . Once the function in [1] is known, it can be used to estimate the volume of trade in those years after the cholera epidemic if no trade embargo had been imposed.

The next step is to estimate the import demand function described in [1]. The functional form assumed in the present paper is:

$$M_t = \alpha + \beta Y_t + \gamma p_t \quad [2]$$

where α , β and γ are constant coefficients. The log-linear model, which is linear in the log forms of the variables, was also examined, but the results are less satisfactory. Moreover, it should be noted that, while the estimated $\ln M_t$ in the log-linear model is unbiased, the estimated M_t is biased. The log-linear model gives some unreasonable predictions.

Data

Trade data were obtained from the United Nations Commodity Trade Statistics Database (UN Comtrade: <http://unstats.un.org/unsd/comtrade/>). Comtrade is very useful because it lists the volumes of export and import (in quantity and value) of commodities between any two member countries in the harmonised system (HS). Comtrade data for the import-export pairs is available only for recent years, and this restricted the accuracy with which the import demand function could be estimated.

Based on the notification form, the authors specified the embargoed products according to their HS tariff code (1992 edition, HS92). These putative codes were confirmed through SPS Secretariat focal points in the countries concerned whenever possible. The authors retrieved the import data (both the weight and the value of imports) for affected products from the four East African countries to the 15 EU member countries for the period 1988 to 2002. The price series is calculated from the import data (the price is equal to import value divided by import weight). The authors used real gross domestic product (GDP) (constant US\$ 1995) for each of the EU countries as a proxy for their national income. The values for GDP were obtained from the World Development Indicators published by the World Bank (<http://www.worldbank.org/data/wdi2005/>).

Comtrade data are not always complete, and the following strategies were used to maximise the data availability:

a) when import data are absent from the Comtrade data set, it is not clear whether the data are missing or there was no trade. The meaning of absent data was clarified by examining the export data for the same product from the exporting African country

b) if trade occurred and export data are available, the export data were used for regression or estimation

c) when complete price series were not available from EU importers for commodities under study, price series from neighbouring EU countries importing from the same exporter were substituted to obtain estimates.

Thirteen of the 15 EU member countries reported their trade using HS92 codes before 1997. Thus, a theoretical maximum of 52 (13×4) pairs of trading countries could be examined. Owing to the degrees of freedom in the estimation, data for at least three years is needed to estimate equation [2]. However, of the 52 pairs of countries, only 34 pairs of countries had adequate data on importation of specific fish products. After testing a variety of regression models for these 34 country pairs, the authors found that only 19 pairs could be reliably modelled. The reasons for not accepting other pairs

include coefficients of the wrong signs and insignificant coefficients.

The authors also estimated the 95% confidence interval for each expected volume (quantity) of import. The gaps between the estimated volumes of trade and the observed trade volumes are then interpreted as the impacts of the trade embargoes. The volumes of trade were multiplied by the price series to give the impacts in dollar terms.

Results

Equation [2], with an error term included, for each African country and each EU country was estimated using ordinary least squares regression and the data prior to 1997, the year of the cholera outbreak. The import demand is defined as the weight of fishery products imported. To allow for the possibility that one of the estimated coefficients is not significant or is of the wrong sign, the authors also estimated variants of the models with only one of the coefficients included, i.e. they estimated the following models:

$$M_t = \alpha + \beta Y_t \quad [3a]$$

$$M_t = \alpha + \gamma p_t \quad [3b]$$

The best equation out of the three possible equations was chosen based on the signs and the significances of the coefficients and the values of the adjusted R-squared.

Table I shows the regression results for the 19 pairs of countries based on equation [2]. The table shows the explanatory variables included in the best equation for each pair of countries. Of these 19 pairs of countries, 13 pairs have their trade in fishery products best described

Table I
Choice of models and their adjusted R-squared

European Union Member States	East African countries			
	Kenya	Uganda	Tanzania	Mozambique
Denmark	—	—	GP (0.968)	—
Germany	G (0.642)	G (0.646)	G (0.869)	—
Greece	GP (0.513)	G (0.339)	G (0.798)	—
Netherlands	GP (0.709)	G (0.990)	G (0.865)	—
Portugal	G (0.876)	—	G (0.889)	G (0.692)
Spain	—	G (0.517)	GP (0.582)	G (0.404)
Sweden	G (0.757)	—	P (0.991)	—
United Kingdom	—	—	GP (0.995)	—

G: only gross domestic product (GDP) is included as an explanatory variable

P: only price is included as an explanatory variable

GP: both GDP and price are included as explanatory variables

—: no model is reported, either because data are not available or because the coefficients are insignificant or of the wrong sign

The numbers in parentheses are the adjusted R-squared

by model [3a], with explanatory variable Y_t only included, one pair is best described by model [3b], with explanatory variable p_t only included, and five pairs are best described by model [2], with both Y_t and p_t included as explanatory variables. Table I also shows the corresponding adjusted R-squared. The estimated coefficients are not reported in the table because there are so many equations. The coefficients are available from the authors upon request.

Using the estimated coefficients and the assumed model, the estimated volumes of import for each pair of countries were calculated for the years after 1996, and the impacts of the trade embargoes were given by the differences between the estimated trade volumes and the observed trade volumes. The values of the impacts on trade were obtained by multiplying the differences by the price levels. The 95% confidence intervals for each estimate were computed. The estimated impacts for the 19 pairs of countries were summed.

Table II shows the total impacts of the trade embargoes for these 19 pairs of countries (column 2) and the lower and upper confidence intervals (columns 3 and 4) in the years after 1996. The results are also shown graphically in Figure 1. The impact was relatively small in 1997: a drop in the value of trade for these 19 pairs of countries by about US\$ 63.6 million. The impact rose rapidly in later years to more than US\$ 292 million in 2002.

In order to get an idea of the significance of these impacts on the economies of the African exporting countries, the authors compared the impacts with the GDPs and with the total volumes of exports of these countries. Table III summarises the results. Column 2 gives the total GDPs of these four African countries in the various years; these totals are then compared with the loss in trade (LIT). The LIT as a percentage of GDP rose rapidly from 0.26% in 1997 to 0.96% in 2002. The percentage grew more slowly in the last four years but still reached a figure close to 1%, suggesting large impacts of the trade embargoes on these small economies. Column 4 of Table III gives the total

Table II
Total impact of the cholera epidemic on trade between 19 pairs of countries (in US\$)

Year	Total impact	95% confidence interval	
		Lower	Upper
1997	63,605,933	5,300,715	122,005,575
1998	121,559,272	32,432,931	210,599,571
1999	192,462,774	82,559,611	302,530,750
2000	203,991,760	37,556,484	370,963,529
2001	251,213,357	78,863,546	423,506,582
2002	292,311,119	100,804,844	483,869,667

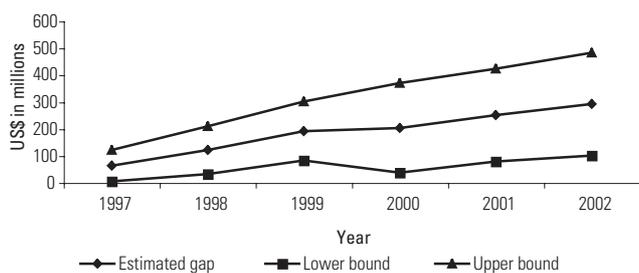


Fig. 1
Total impact of the cholera epidemic on trade between 19 pairs of countries (upper and lower 95% confidence limits are also shown)

values of exports from these African countries (excluding Mozambique because its export data are not available). The LIT as a percentage of total exports also rose rapidly after the embargo and reached more than 10% in 2002. It is interesting to note that the total export dropped substantially in 2001, boosting the LIT as a percentage of total export in that year. The overall picture illustrates that the trade embargoes lowered both the GDP and the total export of these African countries.

It should be noted that trade embargoes usually hurt both the exporting and the importing countries. This article has shown that, in the present case, the drops in the trade volume caused by the trade embargoes were significant for the exporting countries because they are poor and fishery products are important commodities for export. A drop in the GDP by 1% and a drop in the total export by 10% can be regarded as significant.

These findings do have a very important policy implication. For African exporters, the prospect of economically important embargoes, as described herein, may allow governments to argue for additional resources to prevent or curtail epidemic threats in a timely way. When there are insufficient resources to counter every epidemic threat, analyses such as that presented here may allow donor and recipient governments to prioritise resources based on evidence.

Further discussion and conclusions

The present paper examines the quantitative impact of an infectious disease and the subsequent trade embargoes on the flow of the affected products from four African countries affected by cholera to their trading partners

Table III
Loss in trade (LIT) as a percentage of the total gross domestic product (GDP) or the total export of the four African countries studied

Year	Total GDP (billion US\$)	LIT/GDP	Total export (in US\$)	LIT/total export
1997	24.7	0.26%	2,959,996,288	2.15%
1998	25.7	0.47%	3,056,564,000	3.98%
1999	26.8	0.72%	2,798,671,552	6.88%
2000	27.6	0.74%	2,628,410,784	7.76%
2001	28.9	0.87%	1,213,393,824	20.70%
2002	30.3	0.96%	2,769,109,024	10.56%

* Excluding Mozambique (export data are not available)

within the EU. By using economic theories and econometric techniques, the effect of the trade embargoes imposed by the EU on the volume of trade between these two groups of countries has been estimated. The methodology and results presented here should be useful to health officials, government planners and economists who are interested in knowing the economic costs of trade embargoes resulting from the occurrence of epidemic diseases. In particular, this study suggests that the economic costs to the countries that are affected by the diseases could be very high. This could impel countries, especially developing countries looking to foreign trade as a development strategy (1), to invest in health and sanitary infrastructure as an important element in such a strategy.

Increasingly, the economic impact of infectious diseases, in addition to their direct morbidity and mortality, is seen as an important measure of the priority they should be accorded in global policy discussions (1). However, the IHR pertain only to the flow of persons and commerce between nations. As the recommended revisions are adopted, countries will be working through an algorithm to determine the best course of action in the face of an epidemic threat in a partner economy. Thus, a method that allows the direct impact on trade to be measured is needed to inform this decision-making. It might be that, in a given situation, the risk of spreading infection to the importing country justifies an embargo. If that were the case, policy-makers should have the evidence base to determine as accurately as possible what the cost of an embargo will be.

Did the WHO statements of January 1998 make a difference in the course of the events described here? The impact of the trade restrictions clearly extends long after the six month period in which they were formally in place. While it is entirely conceivable that the impact could have been greater in the absence of WHO expert advice, this theoretical impact is unmeasurable.

Determining the economic impact of global infectious diseases has been an area of active research since the onset of the human immunodeficiency virus/acquired immune deficiency syndrome pandemic. Economic models have been used to quantify the overall direct and indirect 'costs' of such catastrophic events as the plague in Surat, India, the cholera outbreak in Peru and the outbreak of severe acute respiratory syndrome in 2004 (4). A review of this work (3) shows that the methods and assumptions behind such efforts vary broadly among studies. The method presented here is designed with a focus on trade flows per se, and the results are therefore only relevant to this particular aspect of such events. In addition, the method presented here is objective and relatively simple to implement.

The present study is based on some simple economic theories and assumptions. In particular, a partial equilibrium approach is adopted, and only a limited number of factors affecting import demand were considered. As a result, this approach ignores important factors such as technological progress, intersectoral impacts, resource allocation, changes in the costs of production and substitution effects across commodities and countries. Unfortunately, to take these factors into consideration would require a much more complicated framework and more resources and would go beyond the available data. The authors do believe, however, that the

results presented here yield credible estimates of the economic impacts of infectious diseases.

The method presented here, however, is limited by the available data. The time lag in reporting to Comtrade can be considerable, especially for resource-poor economies. In addition, the accuracy of the data may vary across reporting countries. In fact, the current study relied largely on EU import data. Furthermore, no record is entered in the Comtrade database if no trade occurs, a situation that should ideally be reported as zero. Lastly, since the statistical model estimates the value of expected trade as a function of national income and the price of each product, and since the price is obtained from the value and quantity of trade, when no trade occurs, the price value cannot be obtained and thus the value of expected trade cannot be estimated. It is hoped that when more data and resources are available more in-depth studies can be carried out.

Acknowledgement

This work was financially supported by the Puget Sound Partners in Global Health and the WHO.



Une réglementation sanitaire internationale fondée sur des données probantes : analyse quantitative de l'impact d'une épidémie sur le commerce international

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Résumé

Lors de l'épidémie de choléra qui a frappé le Mozambique, le Kenya, la Tanzanie et l'Ouganda en 1997, l'Union européenne, invoquant la nécessité de protéger la santé humaine, déposa auprès du Comité sanitaire et phytosanitaire de l'Organisation mondiale du commerce une requête urgente visant à limiter les importations de produits de la pêche provenant de ces pays. Les auteurs analysent l'évolution des importations des produits spécifiés, afin d'évaluer l'impact dans le temps de cette mesure sur les échanges. À partir des tendances constatées antérieurement dans les échanges de marchandises spécifiques, les auteurs élaborent un modèle des flux commerciaux hypothétiques permettant de calculer le manque à gagner potentiel. Il ressort de cette analyse que les restrictions imposées par l'Europe sur l'exportation de poisson de Mozambique, du Kenya, de Tanzanie et d'Ouganda ont coûté, entre 1998 et 2002, au minimum

332 217 415 US\$ aux économies de ces pays africains. Les informations fournies par de telles études quantitatives seront d'une grande utilité pour choisir les politiques à mener dans le cadre de la nouvelle réglementation sanitaire internationale de l'Organisation mondiale de la santé et devraient, partant, nourrir les débats préalables à l'adoption de cette réglementation.

Mots-clés

Épidémie – Impact sur les échanges commerciaux – Organisation mondiale de la santé – Restrictions au commerce international – Santé internationale.



Fundamento científico de las normas sanitarias internacionales: cuantificación del impacto de enfermedades epidémicas sobre el comercio internacional

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Resumen

Cuando en 1997 se declaró el cólera en Mozambique, Kenia, Tanzania y Uganda, la Unión Europea, invocando la protección de la salud humana, presentó ante el Comité de Medidas Sanitarias y Fitosanitarias de la Organización Mundial del Comercio una solicitud urgente de restricciones a la importación de productos piscícolas. Los autores exponen un análisis de las importaciones de esos productos a lo largo del tiempo, con la idea de cuantificar los efectos de semejante medida sobre el comercio. Partiendo de las tendencias observadas hasta entonces, los autores elaboraron un modelo de los intercambios comerciales que cabía prever en ausencia de restricciones y compararon las importaciones previstas con las reales para calcular el costo de las eventuales pérdidas. Ese análisis llevó a la conclusión de que las restricciones europeas a las exportaciones de pescado de Mozambique, Kenia, Tanzania y Uganda entrañaron, para la economía de esos países africanos, un volumen de pérdidas de al menos 332.217.415 dólares entre 1998 y 2002. Los resultados de este tipo de estudios cuantitativos serán importantes a la hora de tomar decisiones normativas en el marco del Reglamento Sanitario Internacional revisado de la Organización Mundial de la Salud, y deben ser tenidos muy en cuenta al debatir la aprobación de ese Reglamento.

Palabras clave

Efecto sobre el comercio – Embargo comercial – Enfermedad epidémica – Organización Mundial de la Salud – Salud internacional.



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