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Country logistics performance and disaster impact

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ABSTRACT

The aim of this paper is to deepen the understanding of the relationship between country logistics performance and disaster impact. The relationship is analyzed through correlation analysis and regression models for 117 countries for the years 2007-2012 with disaster impact variables from The International Disaster Database- EM-DAT and logistics performance indicators from The World Bank. The results show a significant relationship between country logistics performance and disaster impact overall and for 5 out of 6 specific logistic performance indicators. These specific indicators were further used to explore the relationship between country logistic performance and disaster impact for three specific disaster types (epidemic, flood and storm). The findings enhance the understanding of the role of logistics in a humanitarian context with empirical evidence of the importance of country logistics performance in disaster response operations.

Key words: Logistics performance, Humanitarian logistics, Disaster impact and Disaster preparedness

Introduction

A rise in the number of natural disasters and people affected by these disasters has occurred in the last decade (EM-DAT, 2009; McEntire, 1999; Tatham *et al.*, 2012;). The current decade has also seen population growth, urbanization and climate change contribute to an increased vulnerability to natural disasters, especially in less developed countries (Abramovitz, 2001; Fink & Redaelli, 2011). The logistical challenges of humanitarian response are of interest to both academicians and practitioners and in recent years activities related to the humanitarian response supply chain have received much attention (Day *et al.*, 2012; Jahre *et al.*, 2009; Kovàcs & Spens, 2007; van Wassenhove, 2006). Results from research state that up to 70% (van Wassenhove, 2006) or even up to 80% (Trunick, 2005) of the costs in humanitarian response account for logistics cost. Furthermore, factors such as availability of supplies and country infrastructure are recognized to be critical success factors in humanitarian supply chains (Beresford & Pettit, 2009). Moreover when a country is hit by a disaster, humanitarian organizations strive to reach the affected area within 72 hours of the event depending on its location (Tatham *et al.*, 2012). A country´s capacity to handle an event during these first 72 hours can have an effect on the impact of the event (Beresford & Pettit, 2009; Haavisto, 2012). Therefore when humanitarian organizations do arrive on location; they rely heavily on the resources in-country (Tatham *et al.*, 2012) one of them being the logistics network. The importance of the timing window for the response means that planning and preparing for disasters is generally considered to be more cost-effective than post-disaster initiatives such as disaster relief and recovery (Altay et al., 2013; Christoplos et al., 2001; Skoufias, 2003). Logistics activities during the response often require planning and preparing for (Beresford & Pettit, 2009; Kovàcs & Spens, 2007; McEntire, 2002; Perry, 2007; van Wassenhove, 2006;) since activities such as supplier selection, procurement and customs clearance are time consuming processes. This study combines disaster impact literature and humanitarian logistics literature and strives to understand the role of country logistics performance in disasters response. In this study we are looking at country specific logistics performance (LPIs); these indicators for country logistics performance have been compiled by the the World Bank, through surveys in different countries over the years 2007 to 2012 and their purpose is to connect logistics performance and trade competitiveness (Arvis, et al., 2010; The World Bank, 2012). The metrics developed are then used to rank the logistics performance of countries and serve as a catalyst for domestic policy reform. The aim of this study is to analyze country logistics performance in relation to the number of people affected in a disaster. The study builds on Haavisto (2012) findings which indicate that a correlation between country logistics performance and disaster impact for the 2007-2010 periods can be found. The first part of the study covers different notions relating to disaster and logistics such as disaster preparedness, disaster response, and disaster impact as well as logistics performance. The second part includes the methodology, discussion of the data, an analysis of the correlations and regression models and a concluding discussion.

Literature on disasters and logistics performance

McEntire (1999) states that humanitarian organization organizations' planning and preparing for disasters have improved over time and logistical decision making is part of humanitarian organizations' strategies but that there is still a lack of sufficient capacity building and planning by countries to cope with disasters alone. Disaster response is characterized by numerous factors that create uncertainty and that cannot be found in the commercial sector (Kovàcs & Spens, 2009; Murray, 2005; van Wassenhove, 2006;). The commercial sector differs from the humanitarian sector since in most cases, the beneficiaries, their location and their needs are unknown at the start of the response activities (Kovàcs & Spens, 2009; van Wassenhove, 2006). A relief operation is therefore characterized by demand uncertainties in the form of location, type and volume of activities (Beamon & Balick, 2008), these demand uncertainties being hard to manage; Beamon and Balick (2008) further argue that the unpredictability of a disaster makes the planning and preparation even more important. The lack of preparedness in the humanitarian sector can be due to the fact that organizations do not have enough funds allocated for planning, countries not having capacity for disaster preparedness and/or the unpredictability of the event (Day *et al.*, 2012; Oloruntoba, 2005). Furthermore, donor countries might not donate international emergency aid as a function of the actual disaster impact, but rather following a different set of criteria such as the status of the affected countries (former colonies, oil exporting countries and other factors; (Fink & Redaelli, 2011)). Affected countries, especially developing countries with poor infrastructure and where emergencies often take place (Beresford & Pettit, 2009; Jennings *et al.*, 2000), might also not have the required resources for disaster prevention and preparedness. To understand this lack of resource, Kovács and Spens (2009) emphasize that it is crucial for a humanitarian operation to recognize what the preparedness level of the pre-disaster area is. The impact of a disaster can further be reduced by setting up warning systems (Beresford & Pettit, 2009) and by effective disaster management. To enhance disaster management and respond properly, authorities ought to have a disaster response plan, trained personnel, and the necessary physical resources (relief goods, means of transportation) (McEntire, 2004; Oloruntoba, 2005).

Certain disaster prone areas have higher preparedness to face a disaster. Iceland, Japan and New Zealand are good examples of high mitigation capacity (Keefer *et al.*, 2011). Mitigation is required since these areas are prone to earthquakes, have a high probability of predicting an upcoming event and they further have a high level of local preparedness. Proper preparation and planning can partly be explained by good governance as well as the possibility to pay for the costs of such preparedness, which poorer country might not be able to afford (Keefer *et al.*, 2011). These costs for developing disaster prone areas such as for example West Africa (EM-DAT, 2009) which has a pattern of slow on-set disasters might be too high and results in a lack of preparedness.

Disaster impact, disaster phase and disaster type

All disasters, whatever their type, have a common aspect: the severe impact they have on people’s lives, properties and on the environment (Shaluf, 2007). These impacts are often quantified by researchers on a population and on a nation’s development (Albala-Bertrand, 1993; Loayza *et al.*, 2012; Skidmore & Toya, 2007). The damage caused by a disaster is seen to not only have an immediate impact on peoples’ lives but might also have a long term negative impact on a country’s economic development depending on the type of disaster (Loayza *et al.*, 2012). To be able to measure the impact of a disaster it is important to recognize the different characteristics and types of disasters. Different types of disasters: man-made, natural, sudden-onset, slow-onset (Kovàcs & Spens, 2009; van Wassenhove, 2006), can further be divided into disaster sub-groups such as: geophysical, meteorological, hydrological, climate-related and biological disasters (EM-DAT, 2009). Disasters have a predicted impact that can be measured in magnitude for example on the *Richter scale* for earthquakes, or the *Saffir-Simpson Hurricane Damage Intensity Scale* for hurricanes. For an industrial accident such as for example an oil spill, the environmental impact is often measured through economic costs. One way of measuring the impact of a disaster is to measure post-event variables (Fink & Redaelli, 2011; Skidmore & Toya, 2007; Strömberg, 2007). Disasters can occur suddenly or can be foreseen; Van Wassenhove (2006) finds 97% of disasters as man-made which mean that they should have been preventable. Preventability is not always possible, for example an earthquake cannot be prevented but its impact can be reduced through proper planning. To respond to a disaster, NGO’s and governments´ need different resources and approaches for each response phase. The phases of a disaster have been extensively researched (Beamon, 2004; Bedini *et al.*, 2009; Jahre & Heigh, 2008;

Schulz & Heigh, 2009; Thomas, 2002) and although different terminology is used, the phases can broadly be put in three categories: preparation, response and reconstruction. Each of these phases has its own implications and limitations for the purpose of humanitarian logistics. Supply availability can be limited and it can be time consuming to retrieve knowledge from a potential disaster area (Yi & Kumar, 2007). Activities in the first phase include planning for logistics deployments (Tatham *et al.*, 2012) and assessment of country logistics capability and is seen as the most crucial phase since a proper preparedness level will affect the performance in the two second phases (Jahre & Heigh, 2008).

The second phase of response is the point where logistic resources might be severely disrupted for a short period of time depending on the type of disasters, its geographical location and its impact (Day *et al.*, 2012; Safran, 2003). These disruptions to the country logistic performance might play a role in the impact of the disaster. A reduction of this impact could be obtained through the deployment of resources delivering aid and assistance in a timely manner which prevents victims from being displaced or evacuated and preventing injuries or other issues through mitigation of the disaster impact's and its aftermath. The third phase, involves development agency and sometimes long term aid (McEntire, 2004; Régnier *et al.*, 2008). Neither the third phase nor first phase are aimed at using resources to respond once a disaster has struck thus this research focuses more on the country logistic performance after a disaster strikes and the country is in the response phase.

Disasters can also have different timings, there are fast-onset disasters (for example: earthquake, landslide, flood, storm) and slow-onset disasters (for example: erosion, pests, insects, drought) (Kovàcs & Spens, 2009). The characteristic of a slow onset disaster is that it unfolds slowly with some predictable outcomes, while rapid onset disasters include hurricanes, earthquakes and tornados which are unpredictable (EM-DAT, 2009; van Wassenhove, 2006). The predictability of slow onset disasters means that theoretically there is more time for countries and organizations to plan and prepare for a slow onset disaster, but since these disasters often develop over a long period of time, resolving the issue is often not urgently discussed (Kivikuru, 2011). The lack of discussion can lead to less interest from donors resulting in less funding to organizations and affected countries to plan, prepare and respond (Lindberg & Bryant, 2001). Timing for occurring disasters can last from a few minutes to decades for extremely slow on-set disasters, water level rises for example, can allow for communities to adapt to their changing environment and not actually be affected by the disaster (Cutter *et al.*, 2008). Because of these differences in disaster timing the impact is not the same depending on the type of disaster; a review for South-East Asia points out that the majority of disasters related deaths are from fast on-set disasters (Heltberg, 2007). However, slow on-set disasters can be linked to severe disruptions as well. In the case of resource poor areas such as northern Kenya, the better preparation and a knowledge of lead times (Mude *et al.*, 2009) can help reduce performance needs of logistics to respond to a disaster. Disasters can also occur in different patterns with fast and slow on-set taking turns escalating each other, this can be the case of epidemics where a storm, flood or drought leads to malnutrition, poor sanitation and crowding in certain area which helps communicable diseases to spread.

Country logistics performance

In humanitarian logistics research, logistics performance is most often referred to as the logistics performance of an organization, a supply chain or a supply chain network (Beamon & Balick, 2008; Blecken *et al.*, 2009; de Brito *et al.*, 2007; Schulz & Heigh, 2009). However, this study analyzes logistics performance from a country perspective. Country logistics performance in this study is ascertained with the World Banks country logistics performance indicators (LPI´s). The LPI's investigates the connectivity of the main trading gateways (Dollar *et al*., 2004; The World Bank, 2012); this makes it a relevant indicator in relation to humanitarian logistics. Indeed, a number of actors in humanitarian logistics are international (Kovacs & Spens, 2007) and will thus have international supply chains that make use of the main trade gateways. Being situated near economic centers of countries, these gateways will play a role for pre-positioning and response. Indeed, since the procurement process is important for lead times (Maon *et al*., 2009), organizations will often have warehouses in areas close to the main port of entries either for pre-positioned goods procured locally (Coulter, 2007) or procured globally and can also set up temporary warehouses for arriving materials during emergencies (Bukhari *et al*., 2010). The type of items required in the emergency might also influence the use of the trading gateways with high value items or high quality items such as medical goods or pre-assembled kits being procured globally (Berger & Garyfalakis, 2013) while lower quality goods such as food aid might be procured locally or even might be substituted for direct cash payments (Lentz *et al*., 2013). The length and intensity of the disaster might also deplete local stocks and force the importation through main trading (air)ports of different type of goods. By measuring the performance of trade gateways, the LPI's offer an indicator of country logistics performance that will affect the most important humanitarian organizations that operate with global supply chains at different steps of a disaster response.

There is a limited amount of research conducted on country specific logistics performance in the humanitarian setting. One of the few studies conducted (Haavisto,2012) identified a negative correlation between country logsitics performance and average number of people affected in disasters for countries that have an average overall LPI ranking. However, there are multiple other indicators (*the port infrastructure index, the port efficiency index, the transport cost index* (Clark *et al*., 2004)) developed to measure the logistics performance of a country. The logistics performance might be related to the timeliness and cost in a humanitarian response operation, in a similar manner that it is linked to trade competitiveness (Hausman *et al.*, 2005; Navikcas *et al.*, 2011). The logistics performance of a country might even have a larger significance for the humanitarian sector than for the commercial one, since a disaster is determined by time and place uncertainty and the outcome of the operations is measured in lives (Kovàcs & Spens, 2007), number of people injured, number of people affected and economic damage (EM-DAT, 2009).

Empirical approach and analysis

To better understand logistics performance, we utilize specific logistics performance indicators as well as the overall measure of logistics performance. First, a simple Pearson´s ranked correlation analysis is conducted between the different LPIs and the measures of disaster impact from EM-DAT. Second, the correlation analysis is followed by an ordinary least square regression model that strives to portray how country logistics performance influences disasters impact, as measured by amount of people affected. To better understand the impact of the different aspects of country logistics performance, a regression model is developed for each specific LPI indicator (”LPI: Overall”, “LPI: Efficiency of customs clearance process”, “LPI: Quality of trade and transport-related infrastructure”, “LPI: Ability to track and trace consignments”, “ LPI: Ease of arranging competitively priced shipments”, “LPI: Competence and quality of logistics services” and “LPI: Frequency with which shipment reach consignee within schedule or expected time”). Finally, regression models are developed for disaster types, with the logistics indicators shown to have high significance in the overall regression models. The significance levels in this study are: * significant at $\rho < 0.1$, ** significant at $\rho < 0.05$ and *** significant at $\rho < 0.01$.

Data

The data measuring disaster impact in this study is extracted from the EM-DAT database. For disasters to be entered into the database, one out of four disaster criteria must be met: ten or more people killed, a state of emergency, a call for international assistance or one hundred or more people reported affected (EM-DAT, 2009). A person who is categorized as affected by the disaster in the EM-DAT data base is one who needs immediate assistance; he or she can be a displaced or evacuated person (EM-DAT, 2009). In this study the EM-DAT database data is utilized since this database has a broad coverage of disasters and is fully available to the public (Haavisto, 2012) and is often referred to in studies in disaster impact models (Fink & Redaelli, 2011; Keefer, et al., 2011; Loayza, et al., 2012; Skidmore & Toya, 2007).

EM-DAT classifies disasters into the following 15 disaster types: *complex*, *drought, earthquake, epidemic*, *extreme temperature, flood, industrial accident, insect infestation, mass movement dry, mass movement wet, miscellaneous accident, storm, transport accident, volcano* and *wildfire* (EM-DAT, 2009). All natural disaster types are included in the correlation analysis and in the initial multivariate regression. The subsequent disaster specific regressions are for: storm, flood, and epidemic. The extraction from EM-DAT provided the dates/type of the disaster, the country, location, type of disasters, name of the disaster, number of people killed, number of people affected, the estimated damages (US$ Millions) . The start date helps to determine the specific year and the years 2007-2012 were kept in the data as discussed below. The total number of people killed, people affected and the average economic cost was then tallied per country per year, which is then followed by a similar tally for three specific disasters: flood, disaster and epidemic.

It is important to note that EM-DAT has some limits when it comes to representing disaster data. The data is from multiple sources and international organizations that can have different data collection and assessment policies (EM-DAT, 2009), in certain cases the limited number of parties reporting the data might also reduce the accuracy of the data and make it harder to verify. Furthermore, EM-DAT data does not consider armed conflict as a disaster and thus does not record any information on this subject; such conflicts and the effects they have on natural disasters are therefore not accounted for in the data. Furthermore, the majority of data gathered in the EM-DAT database is generated by fast on-set disasters. Indeed, storm, flood and earthquake represent the majority of killed and affected victims (see table 1) in the 2007-2012 time-frame. The difficulty in assessing slow on-set and complex disasters over multiple years makes it harder to represent their impact accurately in the EM-DAT database. The EM-DAT has further been criticized since the data is gathered only on the direct effects of a disaster (Sharma, 2010) and, since the data is reported by the affected countries themselves, this can limit possibilities to conduct data verification. This study also focuses on the direct disaster impact as defined by the EM-DAT, but following Shaluf (2007) who argues that direct effects of a disaster do not take in consideration the full scale of the disaster impact, such as longer term economic impact, social and behavioral considerations, and the impact on political and institutional factors.

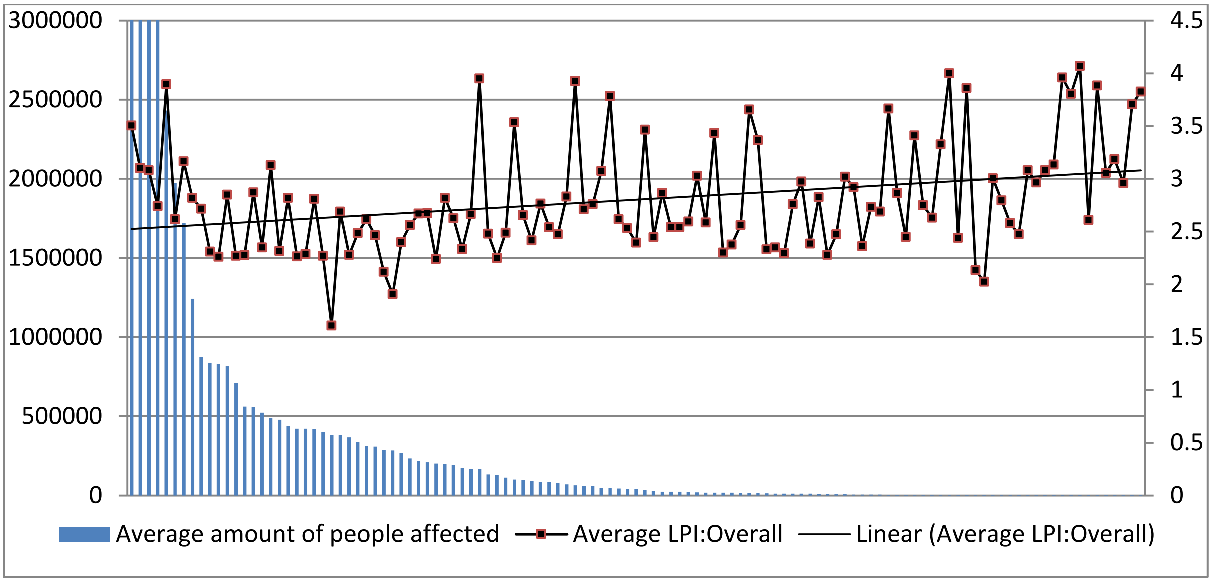
Table 1 Types of disasters and key aspects, 117 countries, 2007 - 2012

Type of disasters	Number of disasters	Total number of people killed	Total number of people affected	Total estimated damage (US$ Million)
Complex Disasters	3		2 838 400	
Drought	59	4	147 755 292	17 392,40
Earthquake	129	338 596	63 399 949	383 627,74
Epidemic	157	21 189	2 976 605	
Extreme temperature	116	62 505	85 719 802	23 915,72
Flood	755	24 499	589 881 895	113 100,06
Insect Infestation	1		500 000	
Mass Movement Dry	5	168	3 725	
Mass Movement Wet	94	4 992	2 490 685	1 413,08
Miscellaneous accident	151	4 825	130 345	250,70
Storm	398	153 203	134 249 677	200 580,10
Volcano	24	348	353 523	
Wildfire	39	439	1 891 724	11 569,45
Total	1 931	610 768	1 032 191 622	751 849

Source: (EM-DAT, 2009)

The other main variable in the analysis is the country logistics performance indicator. The logistics indicators used in this study are the logistics performance indicators published in 2007, 2010 and 2012 by the World Bank (The World Bank, 2013). The World Bank first started producing the biannual Logistics Performance Indicators ranking and compiling the data in 2005. They rely on detailed level data on time and cost to move a typical 20-foot container from the port of entry to a populous or commercially active city in the country. Measured activities are number of approvals needed for import and export transactions and time for trade document processing, customs clearance, technical clearance, inland transport, terminal handling and container security measures (Hausman *et al.*, 2005). The data is collected through a detailed questionnaire distributed to experienced logistics practitioners, mostly freight forwarders. The ranking of the LPI is based on a value from 1 (=worst) to 5 (=best) (The World Bank, 2013). The value of the rank offers a relative snapshot of the logistics performance in 117 countries. A summary analysis of the overall LPI per country and the number of people affected per disaster shows that as the LPI increases there is a reduction in the number of people affected (figure 1).

Figure 1 Trend line (117 countries) for average number of people affected and LPI per country 2007-2012 (Sorted according to average number of people affected.)



Source: (EM-DAT, 2009; The World Bank, 2013).

The regression analysis also contains four other variables that are included in this study as control variables. One of these variables is *population*: it is expected to have a positive impact on the total number of people affected by a disaster. A second variable is *population density*; it can have both a positive or negative impact on the number of people affected: positive as more people are at risk in a given site and negative as they are more easily reached post disaster being close together. Total population is commonly used in country models as well as population density in certain models investigating disasters (Fink & Redaelli, 2011; Keefer *et al.*, 2011). The population data (number, density) are extracted from the World Bank indicators (2013) for the time period of 2007-2011, (2012 was not available at the time of the study). A third variable, government effectiveness was included since countries with higher government effectiveness suffer a smaller disaster impact as measured per number of people killed (Strömberg, 2007). Furthermore, in different models in the literature there is a discussion of the role of government and its influence on outcomes. Corruption is identified as being significant in the number of deaths in the case of earthquakes (Ambraseys & Bilham, 2011; Keefer *et al.*, 2011) while trade policies (Loayza *et al.*, 2012; Noy, 2009) and government size (Skidmore & Toya, 2007) are also used . For this model government effectiveness was chosen as it measures both quality of government services and quality of policies (Kaufmann *et al*., 2010). In this study, he variable for government effectiveness is extracted from the World Bank (2012) indicators (as measured by the World Bank Worldwide Governance Indicators) as the average government effectiveness for the 2007-2011 period. The variable governement effectivness is based on a scale of -2.5 to 2.5 and is in this study scaled from 0 to 5 to allow for calculations with the log function. Finally the Human Development Index is also presented as a control variable. This variable takes into account the level of development in the different countries aggregating information for each country on life expectancy at birth, mean years of schooling, the expected years of schooling and the gross national income per capita (United Nations Development Program, 2011). This variable accounts for multiple factors that might influence how many people are affected by a disaster that reflect the economic development level, it is important to note that the formula for calculating the rank has changed in 2010. Indeed, in previous models, economic indicators have been included to explain disaster impact (Keefer *et al.*, 2011; Loayza *et al.*, 2012; Skidmore & Toya, 2007). Skidmore & Toya (2007) and Loayza *et al., (*2012) furthermore include non-economic control variables such as years of schooling and life expectancy. The HDI variable further accounts for vulnerability since life expectancy allow controlling for other health related factors such as quality of health care system. The average HDI per country for the 2007-2011 periods is used with the exception of the year 2010 which is missing from the UNDP data (United Nations Development Program, 2011).

Results analysis

To have a better understanding of the relation between disaster impact and LPIs, a simple Spearman ranked correlation was calculated for 117 countries. As seen in table 2 a positive correlation between economic damage and LPIs is found also with the data in this study, as was in Haavisto's (2012) previous study. The finding indicates that a country with a higher logistics performance will incur more economic damage in a disaster. This result can be explained by findings from Arvis (2012) stating there is a positive relationship between country logistics performance and country economic development when calculated using GDP.

The Spearman rank correlation shows that the number of people killed in disasters is not correlated with logistics performance. None of the specific LPIs are significantly correlated to the average number of people killed which might be explained with the fact that impact of disasters differ depending on the type of disaster (Cutter *et al.*, 2008; Heltberg, 2007). Where certain types of disasters such as earthquakes tend to have a significant number of people killed as an impact, while other types, such as floods tend to have people affected (not killed) by the disaster. In the data in this study (see table 1) the number of people killed are in majority the result of earthquakes (55%), more particularly the Haitian earthquake in 2010 (this disaster alone accounts for 35% of people killed with 222 750). The fast-onset characteristics of an earthquake are such that the deaths are often immediate, thus occur during the disaster itself. Immediately occurring deaths can therefore explain why country logistics performance in the response phase does not play a significant role (see table 2) in decreasing the impact of a disaster when measured in number of people killed. Since there are no significant correlations between any logistics performance indicators and the total deaths (table 2), the number of people killed is not taken into account as an indicator of disaster impact in the regression models.

Table 2 Spearman ranked correlation between LPIs (World Bank) and measures of disaster impact (EM-DAT, 2012), 2007-2012:

		“LPI : Overall “	“LPI : Efficiency of customs clearance process “	“LPI: Quality of trade and transport-related infrastructure”	“LPI: Ability to track and trace consignments”	“LPI: Ease of arranging competitively priced shipments”	“LPI: Competence and quality of logistics services”	“LPI: Frequency with which shipment reach consignee within schedule or expected time”

Average number of people killed	Corr. Coeff.	-0.059	-0.086	-0.121	-0.053	-0.034	-0.047	0.025
Average number of people affected	Corr. Coeff.	-0.317***	-0.296***	-0,345***	-0,334***	-0,262***	-0,104	-0.269***
Average number of economic damage	Corr. Coeff.	0.504***	0.451***	0.490***	0.495***	0.472***	0.114	0.483***

* Significant at $\rho < 0.1$; ** Significant at $\rho < 0.05$; *** Significant at $\rho < 0.01$

Source: author calculations

There is a significant correlation (-0.317***) found between the overall country logistics performance and the number of people affected (see table 2). Although, the “LPI: Competence and quality of logistics services” has no significant link to any of the disaster impact measures. The non-existent correlation might indicate that, in disaster logistics, the competence and quality of logistics service providers such as transport providers and custom brokers do not have any influence on the outcome of deaths or the number of people affected. A significant correlation between the other specific LPIs and number of people affected could however be detected (table 2). The relationship is explored in greater detail in the following regression.

To build on the findings from the correlation analysis, a regression model was estimated drawing on a model by Toya and Skidmore (2007). They examined for 44 years the relationship between five independent variables (ln GDP; Total schooling; Size of Government; Openness of economy; M3/GDP), with 151 countries as their unit of observation and two dependent variables (ln number killed; ln Damage/GDP). In this study instead of using the number of killed or the variable economic damage per disaster as our dependent variable, we take the number of people affected. Logistics performance might not directly reduce the number of deaths in a disaster, as discussed for the example of earthquakes, but logistics performance might play a role for the success of delivering relief goods to people in the preparation and in the response phase thus decreasing the disaster impact.

The regression equation is the following:

Log (Number of affected people) = Log (Total population) + Log (Population Density) + Log (Human development index) + Log (Government effectiveness) + Log (Logistics Indicator (6 different ones)) + Constant

With an adjusted R Square of 0.427 for the “LPI: Overall” regression and adjusted R-Squares above 0.38 for the individual LPIs (table 3), the regression model accounts for a good portion of the variance. When looking at all disasters for the 2007-2012 period the “LPI: Overall” is significant (-0.457***) (table 3); all the specific logistics indicators found to be correlated to the number of people affected in the Spearman Rank are significant as well. As expected from the Spearman Rank correlation, the specific LPI “Competence and quality of logistics services” is not significant (beta of -0.59 with significance of 0.457; not reported in the table).

The first LPI, “LPI: Efficiency of customs clearance process “(-0.388***) (table 3) is probably as important as infrastructure for disaster responders since good quality infrastructure is not useful if relief goods are stuck at the border. The LPI for the efficiency of customs clearance process looks at border procedures and processing times (The World Bank, 2012) and it includes accounts for the law in place, the role of corruption, which can reduce the number of resources available in emergencies (Schultz & Soreide, 2008) as well as information on the predictability and simplicity of formalities (Arvis *et al.*, 2010). Potential delays in customs procedures can be due to high tariffs that have been imposed on the goods (Fisher, 2007) or the result of overburdening requirements by customs official including bribery or problems due to the amount of goods coming through customs; this sometimes require special government intervention to clear goods (Amin & Goldstein, 2008). Custom clearance related issues are included in the Logistics clusters main activities and therefore identified as important by the World Food Programme (WFP, 2000), who is in charge of the

Logistics Cluster (Whiting & Ayala-Ostrom, 2009). For logisticians, efficient customs clearance can help reduce the time to access people in need with relief goods and services and it can further help prevent waste through processing perishable goods such as food and medicine faster. This study thus confirms the importance of customs efficiency and its impact on reducing the number of people affected by disasters. Hence there is an important place for development of new regulation that standardize custom procedure in case of emergencies (Fisher, 2007) as well as for responders to work with customs official during disaster and before it strikes in the preparedness phase.

The second LPI "LPI: Quality of trade and transport-related infrastructure" has the biggest coefficient (-0.515***)(table 3) of the specific LPIs and is most likely one of the most important factors in the logistics response to disasters, it includes physical infrastructure such as ports, rail and roads as well as information technology infrastructure (Arvis *et al.*, 2010). Infrastructure, as Kovàcs and Spens (2007) point out, is one of the concerns of the United Nations Joint Logistics Center (now included in the Global Logistics Cluster). Furthermore, the Logistics Cluster agenda includes matters related to evaluating infrastructure and its deterioration (Jahre & Jensen, 2010). The importance of infrastructure in disaster response is understandable since it plays a significant role in the performance of transportation activities in the commercial sector (Chandes & Paché, 2010). In the humanitarian sector, the importance of infrastructure has further been shown in findings by Perry (2007) where early involvement of logisticians was hindered by the destruction of transport infrastructure in the aftermath of the 2004 Asian tsunami. Finally hurricane models have shown that access to aid resources is affected by the state of the distribution infrastructure (Horner & Downs, 2010). Our results indicate that in recent disasters (2007-2012), better transport infrastructure has a significant role in reducing the number of affected people.

The "LPI: Ability to track and trace consignments" is also significant (table 3) in the regression analysis (-0.399***). The LPI explains the predictability of consignment throughput which helps define the performance (Arvis *et al.*, 2010) and gives the logistic network better visibility of goods flowing through the network. Tracking and tracing has in previous studies been identified (Whiting & Ayala-Ostrom, 2009) as an important factor for successful disaster response, since it not only allows for better planning but further helps increase resilience when it comes to finding goods or shipments after a major disruption. To thwart these disruptions, tracking and tracing technologies such as radio frequency identification currently in practice in the private sector to remediate problems of disruptions in the supply chain, could be applied to the tracking needs of humanitarian logistics (Baldini *et al.*, 2012). However, the tools available for a commercial logistician might not be adapted for tracking and tracing the goods in a humanitarian setting. In the humanitarian setting electricity can be scare; yet it is estimated that of the logisticians working in the relief operations of the 2004 Asian tsunami, only 26% had access to specific software that could handle tracking and tracing (Hanaoka & Qadir, 2005). Further most tracking systems are applicable for larger shipments, for example on boats (Wallerstein, 1980) and are not suitable for tracking smaller batches of goods that are common in the humanitarian context.

The LPI for the "LPI: Ease of arranging competitively priced shipments" (table 3) (-0.28**) and "LPI: Frequency with which shipment reach consignee within schedule or expected time" (table 3) (-0.196*) were both found to be significant while having smaller coefficients than the previously discussed LPIs. The LPI "LPI: Ease of arranging competitively priced shipments" looks at how the market for transportation services can help create competitive prices. Issues that can come up can be related to availability of suppliers, the quality of suppliers and the distortion in the market linked to greater demand by humanitarian organizations.

The LPI “LPI: Frequency with which shipment reach consignee within schedule or expected time” refers according to the World Bank (2012) to the timeliness that consignments reach their destination. The timeliness is further stated (The World Bank, 2012) to be affected by level of corruption and the legal requirement of compulsory warehousing and maritime transshipments. The link between this specific LPI and number of people affected can be explained by the fact that having shipments reach consignee on times allows responding in a timely manner to the needs of a disaster and might prevent people from becoming affected. The shipments can also be priced improperly due to the lack of transparency in the business environment (Arvis *et al.*, 2010) leading to uncertainty and fluctuating transport prices and thus poor performance. It is this poor performance that will have an impact on the number of people affected; the pricing might also reduce the amount of resources available to purchase relief goods.

As for the control variables, total population is highly significant in all six regression (0.01 in table 3). High population countries (China, India the Philippines) generally have higher number of people affected by a given disaster. The number of individuals affected by disasters is negatively linked to the level of human development (HDI) in all six regressions model (significance ranging from 0.05 to 0.001 in table 3). The findings indicate that human development can decrease the number of people affected when there is a disaster. Population density is not significant in any regression (table 3); while government effectiveness was found to be significant in the case of the model for “LPI: Quality of trade and transport-related infrastructure” but in a positive relation (0.261**) (table 3).

Table 3 Logarithmic regression results for all natural disasters 6 LPIs with the number of people affected as dependent variable, 2007-2012 average

For all disasters	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.365	0.171	0.079	0.201	0.223	0.282
Population density	-0.091	-0.103	-0.092	-0.102	-0.108	-0.131
Population total	0.576***	0.524***	0.578***	0.559***	0.534***	0.505***

HDI	-0.259**	-0.344**	-0.272**	-0.267**	-0.322***	-0.329***
Government effectiveness	1.562	0.214	0.261**	0.152	0.09	0.032
“LPI : Overall “	-0.457***					
“LPI : Efficiency of customs clearance process “		-0.388***				
“LPI: Quality of trade and transport-related infrastructure”			-0.515***			
“LPI: Ability to track and trace consignments”				-0.399***		
“LPI: Ease of arranging competitively priced shipments”					-0.28**	
“LPI: Frequency with which shipment reach consignee within schedule or expected time”						-0.196*
N	117	117	117	117	117	117
R-Square	0.451	0.446	0.466	0.442	0.424	0.413
Adjusted R-Square	0.427	0.421	0.442	0.417	0.398	0.386
Max VIF	3,924	3.476	3.891	2.991	3.615	2.792

* Significant at $\rho < 0.1$; ** Significant at $\rho < 0.05$; *** Significant at $\rho < 0.01$

Source: Author calculations

Since disasters have different characteristics, the impact of disasters can as well differ depending on the disaster type. Even though the type used in this study is natural disasters, these types of disasters can be brought on in part by human activity or negligence (Kovàcs & Spens, 2009). In order to try and understand the differences between type of disaster with respect to the relationship between the number of people affected and logistics performance indicators, a second set of regressions were estimated (table 4). To sharpen the model for the specific disasters, only the four LPIs “LPI: Overall”, “LPI: Efficiency of customs clearance process”, “LPI: Quality of trade and transport-related infrastructure” and the “LPI: Ability to track and trace consignments” were utilized since they were found to be significant at the 0.01 level in the previous model. Furthermore, for these models, the disaster types of epidemic (54 cases), flood (101 cases) and storm (65 cases) were chosen for further calculation as other disaster types lacked the minimum number of cases for a relevant regression. For the group of epidemic disasters there is not a significance relationship between logistics performance and disaster impact to be found, only total population is significant (table 4). Epidemic can be fast or slow onset disasters depending on their vector of transmissions such as pests and insects (Kovàcs & Spens, 2009). These variations as well as the small number of people affected make any conclusion on epidemics in relation to logistics hard to make.

Table 4 Logarithmic regression results for epidemic for multiple LPIs with the number of people affected as dependent variable, 2007-2012 average

Epidemic	Model 1	Model 2	Model 3	Model 4
Constant	0.274	0.22	0.212	0.251
Population density	-0.023	-0.026	-0.022	-0.026
Population total	0.614***	0.596***	0.605***	0.608***
HDI	-0.123	-0.142	-0.134	-0.127
Government effectiveness	-0.161	0.147	0.164	0.155
“LPI : Overall “	-0.054			
“LPI : Efficiency of customs clearance process “		-0.006		
“LPI: Quality of trade and transport-related infrastructure”			-0.039	
“LPI: Ability to track and trace consignments”				-0.039
N	54	54	54	54
R-Square	0.394	0.393	0.393	0.393
Adjusted R-Square	0.331	0.329	0.330	0.33
Max VIF	2.069	1.788	2.191	1.963

* Significant at $\rho < 0.1$; ** Significant at $\rho < 0.05$; *** Significant at $\rho < 0.01$

Source: Author calculations

In the case of storm (table 5) and flood (table 6) and for all LPIs, total population is a significant variable (0.001 significance). The specific “LPI: Quality of trade and transport-related infrastructure” is significant for both storm (-0.604***) and flood (-0.431***) while the “LPI: Efficiency of customs clearance process” is also significant for storm (-0.363**) and flood (-0.351**). These disasters account for 70% of the total affected (table 1) population in disasters, the significance of “LPI: Quality of trade and transport-related infrastructure” and “LPI: Efficiency of customs clearance process” might be explained by the large population affected that require an important amount of logistical resources to help cope with this type of fast on-set disaster. As in all disasters discussed above, customs and infrastructure play a key role in the logistic response to a disaster. The “LPI: Ability to track and trace consignments" is also significant for storms (-0.401*) and floods (-0.366**). The HDI is also significant for all models for both flood and storms, with a higher HDI reducing the number of people affected, while population density and government effectiveness are not significant.

Table 5 Logarithmic regression results for storm for multiple LPIs with the number of people affected as dependent variable, 2007-2012 average

Storm	Model 1	Model 2	Model 3	Model 4
Constant	0.329	1.66	0.123	0.226
Population density	-0.013	-0.019	-0.017	-0.02
Population total	0.616***	0.551***	0.653***	0.599***
HDI	-0.332**	-0.416***	-0.295*	-0.329*
Government effectiveness	0.212	0.195	0.3	0.16
"LPI : Overall "	-0.464**			
"LPI : Efficiency of customs clearance process "		-0.363**		
"LPI: Quality of trade and transport-related infrastructure"			-0.604***	
"LPI: Ability to track and trace consignments"				-0.401*
N	65	65	65	65
R-Square	0.481	0.477	0.513	0.467
Adjusted R-Square	0.437	0.433	0.472	0.422
Max VIF	4.727	3.719	4.707	5.116

* Significant at $\rho < 0.1$; ** Significant at $\rho < 0.05$; *** Significant at $\rho < 0.01$

Source: Author calculations

Table 6 Logarithmic regression results for flood for multiple LPIs with the number of people affected as dependent variable, 2007-2012 average

Flood	Model 1	Model 2	Model 3	Model 4
Constant	0.537	0.334	0.184	0.38
Population density	-0.084	-0.087	-0.084	-0.097
Population total	0.587***	0.542***	0.581***	0.578***
HDI	-0.237*	-0.313**	-0.273**	-0.236**
Government effectiveness	0.097	0.122	0.157	0.06
"LPI : Overall "	-0.408***			
"LPI : Efficiency of customs clearance process "		-0.351**		
"LPI: Quality of trade and transport-related infrastructure"			-0.431***	
"LPI: Ability to track and trace consignments"				-0.366**

N	101	101	101	101
R-Square	0.409	0.404	0.412	0.403
Adjusted R-Square	0.378	0.373	0.381	0.372
Max VIF	3.747	3.326	3.922	3.490

* Significant at $\rho < 0.1$; ** Significant at $\rho < 0.05$; *** Significant at $\rho < 0.01$

Source: Author calculations

Conclusion

Disaster impact measured as the number of people affected and the amount of people killed has been on the rise **(**EM-DAT, 2009; McEntire, 1999; Tatham *et al.*, 2012). The capacity of the country, in the form of country logistics performance measured as the World Bank logistics indicators can affect the impact of a disaster (Haavisto, 2012). The study set out to examine a possible quantitative link between a country's logistics performance and disaster impact through correlation analysis and multivariate regression for 117 (observations) countries over a period of 6 years, and furthermore, investigated specific types of disasters. The findings suggest that country logistics performance, when defined as the World Banks logistics performance index, has a significant ($p< 0.01$) relationship with disaster impact, when measured as number of people affected.

When breaking down the overall country logistics performance into specific performance indicators, the findings further show a significant relationship for the "LPI: Efficiency of customs clearance process" (-0.388***), "LPI: Quality of trade and transport-related infrastructure"(-0.515***), "LPI: Ability to track and trace consignments" (-0.399***), "LPI: Ease of arranging competitively priced shipments" (-0.28**), "LPI: Frequency with which shipment reach consignee within schedule or expected time" (-0.196*) and disaster impact. The specific country logistics performance indicator "LPI: Competence and quality of logistics services" does not have a significant relationship with people affected in a disaster. This indicates that such capabilities as level of quality of infrastructural network, both in terms of geographical network (e.g. locations of hubs and terminals) and the quality of road and information network can play a role in the amount of people who are affected by a possible disaster in a country. Further the quality and availability of suppliers for logistics services and the quality and timeliness of customs clearance processes can influence the outcome of a disaster. The importance of these specific performance indicators can differ depending in which phase of the disaster the response is in. In the preparation and the recovery phase time-related performance indicators are not as important as in the response phase where delays in customs or limited amount of available suppliers can severely affect response operations increasing the number of people are affected by the disaster. An example can be found in response to some recent disasters such as the Pakistan earthquake (2005) and the Myanmar tsunami (2008) where accessibility was limited. In the case of Pakistan, some beneficiaries could not be reached with crucial supplies (Bedini *et al.*, 2009; Halvarson & Hamilton, 2009; Tatham *et al.*, 2012), such as medicine, water or shelter due to non-existent road network and limited amount of available suppliers. In order to further understand the implications that a specific type of disaster can have on the relationship between country logistics performance and disaster impact, regression models were developed for the most numerous types of disasters: epidemic, flood and storm. A significant relationship for flood and storm could be detected but for epidemic, a significant relationship was not found. Country logistics performance could consequently impact the response to certain types of disasters such as storm and flood and thus country logistics performance should be taken into account when mitigating for disaster risks such as climate change, since it is expected there will be an increase in intensity of flooding events (Flew, 2003).

The findings enhance our understanding of the role of logistics in the humanitarian context with empirical evidence of the importance of country logistics performance in disaster response operations. Practical implications of the study suggest that governments and other disasters responders could address the role of country logistics performance more specifically the customs clearance process, the infrastructure, the ability to track and trace consignments, the complexity of the logistics service supplier network and the possibilities for timeliness of shipments and transportation when preparing for disasters.

Limits and future research:

One of the limitations of this study is that the EM-DAT data simplifies the complexity of disasters as mentioned above either through the method of gathering data or through the omission of the effects of conflicts. In the light of the critic of the EM-DAT database, further research could build on more long term measures of disasters impact. The World Bank indicators also have their own limits; one of them is that some indicators are based on the opinion of logisticians about the performance of their country (The World Bank, 2012) and might be biased by other factors not indicative of logistics. Further research is suggested to continue the development of a disaster impact model, where for the purpose of disaster mitigation, the actual variables that affect disaster impact would be identified. Furthermore, since the infrastructure LPI is significant and has the highest coefficients in most models, analyzing the role of investment in transport infrastructure in disaster prone countries might offer additional insights on the role of infrastructure.

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