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## MATERIAL CONVERGENCE: AN IMPORTANT AND UNDERSTUDIED DISASTER PHENOMENON

JOSÉ HOLGUÍN-VERAS, RENSSELAER POLYTECHNIC INSTITUTE, JHV@RPI.EDU
MIGUEL JALLER, RENSSELAER POLYTECHNIC INSTITUTE, JALLEM@RPI.EDU
LUK N. VAN WASSENHOVE, INSEAD, VWL@INSEAD.EDU
NOEL PÉREZ, RENSSELAER POLYTECHNIC INSTITUTE, PEREZN@RPI.EDU
TRICIA WACHTENDORF, UNIVERSITY OF DELAWARE, TWACHTEN@UDEL.EDU

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# MATERIAL CONVERGENCE: AN IMPORTANT AND UNDERSTUDIED DISASTER PHENOMENON

*José Holguín-Veras, Rensselaer Polytechnic Institute, jhv@rpi.edu*

*Miguel Jaller, Rensselaer Polytechnic Institute, jallem@rpi.edu*

*Luk N. Van Wassenhove, INSEAD, vwl@insead.edu*

*Noel Pérez, Rensselaer Polytechnic Institute, perezn@rpi.edu*

*Tricia Wachtendorf, University of Delaware, twachten@udel.edu*

## ABSTRACT

The paper reports the research conducted by the authors on material convergence, which is one of the most important, and ironically one of the most understudied disaster phenomena. This spontaneous flow of supplies, equipment, and general donations to the impacted area brings much-needed relief as well as major complications to the operations. The paper reviews empirical evidence from disaster literature, and complements it with lessons learned from fieldwork conducted by the authors, to identify the problems created by the non-priority component of the material convergence. The paper develops a mathematical formulation to gain insight into optimal control procedures and policy making, ending with policy recommendations regarding the use of appropriate material convergence management and control strategies.

*Keywords: humanitarian logistics, material convergence, unsolicited donations.*

## INTRODUCTION

In 2011, 322 natural disasters impacted 244.7 million people worldwide, resulting in 30,000 deaths and a record $366 billion in economic damage (Guha-Sapir et al., 2012).These disasters range from localized events impacting local communities, such as the tornado in Joplin, Missouri, to large scale catastrophes like the Port-au-Prince earthquake in Haiti, and the Tohoku disasters in Japan. Such disastrous events exemplified the vulnerability of modern society, prompting large humanitarian responses that confirmed both the importance and intrinsic complexity of humanitarian logistics (HL) operations.

The complexity of HL operations it determined, among other factors, by the magnitude of the triggering event, particularly whether or not the event is catastrophic. A catastrophe is a disaster in which: 1) "most or all of the community-built structure is heavily impacted… [and] facilities and operational bases of most emergency organizations are themselves usually hit;" 2) "local officials are unable to undertake their usual work role;" 3) "help from nearby communities cannot be provided;" 4) "most, if not all, of the everyday community functions are sharply and concurrently interrupted;" 5) "the mass media system especially in recent times socially constructs catastrophes even more than they do disasters;" 6) there are "mass out-migrations for protracted periods of time;" and 7) "the political arena becomes even more important" (Quarantelli, 2006; Wachtendorf et al., 2010). In non-catastrophic disasters, local communities, private sectors, and governments are able to cope with the initial impacts by providing a first wave of resources to aid the survivors. However, catastrophes are likely to destroy a large proportion of local inventories of supplies at businesses and households, which otherwise would have served as that first wave of aid. In addition to the impacted population's spiked increase in demand for goods (disaster agent-generated demands), which may be worsened by precautionary or opportunistic buying in nearby areas, the response itself necessitates large quantities of goods and resources (disaster response-generated demands) (Dynes et al., 1972; Holguín-Veras et al., 2012b). Local procurement is almost impossible given that the severed or destroyed private sector supply chains cannot help. The local distribution effort required to cover a large geographic impacted area with limited manpower and resources adds to the complexity of the problem. The final complicating element is that the local socio-technical networks—the collective of individuals, their interconnections, together with the technical activities they perform—that typically take charge of the response operations in smaller disasters cannot do so after a catastrophe because of impacts to the networks themselves. The net effect is an almost complete reliance on outside help; most of the supplies and logistics must be brought in from other regions. This makes for a completely different environment from the one faced by commercial logistics (CL). Recent research has therefore highlighted the unique features of HL, and its differences from its commercial counterpart (Holguín-Veras et al., 2012b). A brief discussion of Holguín-Veras et al. (2012b) follows.

Holguín-Veras et al. (2012b) established that the term HL describes a broad spectrum of relief operations ranging from the regular distribution of critical supplies, such as distributing food to fight hunger, to the distribution of critical supplies after a disaster. The former is an example of what was termed "Regular Humanitarian Logistics" (R-HL), and the latter is referred to as "Post-Disaster Humanitarian Logistics" or PD-HL. Holguín-Veras et al. (2012b) analyzed and compared CL, R-HL, and PD-HL and concluded that understanding the differences between them requires consideration of the following characteristics: 1) objectives pursued; 2) knowledge of demand; 3) decision-making structure; 4) periodicity and volume of logistics activities; 5) the state of the social fabric and networks; 6) the type and status of supporting systems; and 7) the origination of the commodity flows. One of the authors' chief conclusions is that these three modalities of logistic systems are part of a continuum of cases, with commercial logistics at one end and PD-HL at the other, and R-HL somewhere in between.

There is a fundamental distinction between these modalities in terms of the objectives pursued. While commercial logistics aims at minimizing private (logistics) costs, HL's

objective is to minimize social costs (i.e., logistics costs plus the economic valuation of the human suffering). The quantification of the latter requires the use of the concept of deprivation cost, which is the economic valuation of the human suffering resulting from the lack of access to a good or service (Holguín-Veras et al., 2012c).

In commercial logistics, there are a small number of agents involved with defined roles and responsibilities, making routine decisions based on standard procedures. In PD-HL, there may be hundreds or even thousands of formal or informal/improvised supply chains that interact, overlap, cooperate, or even compete for scarce resources.

Material convergence—the flow of supplies, general donations (solicited or unsolicited), and equipment that travels to the site of the disaster (Fritz and Mathewson, 1957)—is one of the most unique, overlooked, and poorly understood disaster PD-HL phenomena. While in commercial logistics the cargoes that are transported are under the control of the relatively small number of companies involved, the situation in PD-HL could not be more different. After a major disaster or catastrophe, large quantities of supplies and equipment are sent to the disaster area by thousands or tens of thousands of donors (e.g., individuals, faith-based groups, non-profit organizations, companies, governments). The crux of the problem is that the materials and supplies converging at the disaster site include a large proportion of inappropriate or useless goods that create havoc in the disaster response. Multiple examples of this phenomenon are discussed later in the paper. Fundamentally, material convergence is a complex problem, with multifaceted logistical challenges: a huge quantity of items, an extremely heterogeneous flow, arriving within a short timespan to an area with limited space, resources, and personnel to process and distribute them to their intended recipients, people in great need. The intrinsic challenges involved are increased exponentially due to the sheer magnitude of useless supplies and materials within the overall mix. Vehicles transporting the supplies congest the entry points to the disaster area, impeding the flow of high-priority supplies, at a time when transportation networks are still crippled by the event. The main issue is that a significant portion of the material convergence brings no benefits to the disaster victims, and may even pose risks (e.g., expired medicines). Moreover, the arrival en masse of supplies that have a market value depresses local markets, negatively impacting local production at a time when reigniting economic activity is essential. A major handling effort is often required to inventory and sort the goods, as they tend to be poorly packed. These efforts require large amounts of resources that are scarce, and needed for other more essential tasks. Although this phenomenon has been identified in all major disasters (Fritz and Mathewson, 1957; Boileau et al., 1978; Wettenhall, 1979; Scanlon, 1991; Neal, 1994; Holguín-Veras et al., 2007; Jaller, 2011), it has not received commensurate attention in the HL literature.

The objective of this paper is to contribute to the study of this important phenomenon and its impacts on PD-HL. The analyses are based on the fieldwork conducted by the authors at recent disasters (e.g., Hurricane Katrina, Port-au-Prince earthquake, Tohoku disasters, Joplin tornado, and Hurricane Irene), and historical accounts. Another objective is to raise awareness about this problem as experience shows that the impacts of material convergence are still an issue today as in the 1950s (Fritz and Mathewson, 1957).

The remainder of the paper is organized as follows: Section 2 discusses the evidence and nature of material convergence; Section 3 focuses on the analysis of the logistical impacts of material convergence; Section 4 provides a mathematical formulation to illustrate the impacts

on the PD-HL process; and the results from this section lead to a set of policy implications. The paper ends with a summary of key findings in the conclusions section.

# MATERIAL CONVERGENCE: EVIDENCE AND NATURE

Convergent behavior was identified in the first sociological study of a disaster: Prince's doctoral research on the Halifax ship explosion (Prince, 1920; Scanlon, 1991). Fritz and Mathewson (1957) developed the first taxonomy of the phenomenon, defining "convergence" as the movement toward the disaster area, and identifying variants including personnel convergence ("movements of individuals…"), informational convergence ("movement or transmission of symbols, imageries, and messages…") and material convergence ("the actual movement of supplies and equipment…") (Fritz and Mathewson, 1957).

Strictly speaking, material convergence includes the supplies and equipment sent by all of the entities that respond to a disaster, including governments, relief agencies, companies, churches, local community groups and individuals. A typically overlooked feature of this phenomenon is its heterogeneous nature—including everything from life-sustaining critical items to such useless items as wedding gowns, costumes, flags, and even dangerous supplies such as expired food and medication. According to the Saber Donar campaign (Learn How to Donate) (Saber Donar, 2011b)—sponsored by a coalition of international organizations including the World Food Program, the Pan-American Health Organization, Oxfam International, the International Federation of the Red Cross, and others—37% of the medicines sent to El Salvador after the January-February 2001 earthquakes were completely inappropriate (Saber Donar, 2011a). The heterogeneity and volume of the flow are what make material convergence such a challenging problem. The heterogeneity of items reflects the diverse nature of the donors (i.e., individuals, groups, companies, and even public sector agencies), their radically different perceptions of the needs on the ground, and their varied levels of access to supplies. The problem is that large numbers of donors send to the disaster area whatever they have on hand, under the assumption that anything and everything could be of use. Clearly, significant portions of the convergent flows are extremely important to the beneficiaries, and to the response itself. However, the problems produced by useless and inappropriate donations—which are typically referred to as "unsolicited donations"—are of such seriousness that most discussions of material convergence tend to focus on them. Although the term "unsolicited donations" has become synonymous with useless or inappropriate donations, the authors firmly believe that it is incorrect to equate the two, as meaningful portions of "unsolicited donations" are indeed useful. It is therefore more appropriate to focus on the intrinsic usefulness of the item donated, rather than whether or not it was "solicited" or "unsolicited" by the local authorities. To this effect, the classification of items developed by the Pan American Health Organization (PAHO) is useful.

PAHO classifies donated items as: urgent or high-priority (HP), those items that are required for immediate distribution and consumption; non-urgent or low-priority (LP), those not immediately needed that may be useful later on, requiring storage for later use; and finally, non-priority (NP), those items that should not have been sent to the disaster site (Pan American Health Organization, 2001; Holguín-Veras et al., 2012b). The bulk of the problems

produced by material convergence are the result of the large volumes of NP flows, and to a lesser extent the LP donations, that arrive at disaster sites.

The heart of the problem with NP donations is that they: "…often complicate unnecessarily the logistics of relief operations…;" "…frequently, [are] items that have not been asked for…;" "…do not respond to the needs of the affected population…;" "…their handling leads to a waste of time and resources…;" "…are useless or irrelevant…;" "…those…considered useless due to their condition (damaged, expired, totally inappropriate) should be discarded as soon as possible, particularly to make room for useful supplies…;" "…require their own logistics in terms of transport, temporary storage, and waste management…;" "…do not have adequate labeling to meet the necessary specifications for their identification per common international denomination, have brand names unknown in the country, lack expiration dates or are in languages unknown in the receiving country…;" "…donated amounts exceed needs, and cause problems of adequate storage…;" "…it is hard to reject them if they are useless…;" "…these materials may be incinerated, buried, or otherwise disposed of…" (Pan American Health Organization, 2001). There is remarkable agreement among almost all major relief organizations and the research conducted on the subject confirming the negative impacts of NP flows (Fritz and Mathewson, 1957; American Red Cross, 2010; Destro and Holguín-Veras, 2011; Jaller, 2011; Holguín-Veras et al., 2012a; Holguín-Veras et al., 2012d; Jaller and Holguín-Veras, 2012). Not surprisingly, some responders refer to the arrival of NP donations as "a second tier disaster" (Newsweek, 2002). In most cases, as suggested by PAHO, the best decision regarding NP donations is to simply destroy them, though most relief groups do not take that step for fear of alienating the donors that they depend on.

Low-priority (LP) supplies can also create enormous complications when they arrive in large quantities. The case of the blankets in Japan (Holguín-Veras et al., 2012b), and bottled water after the Port-au-Prince earthquake as reported in (Holguín-Veras et al., 2012a) are quite telling, because in both cases the items were needed at the start of the crises. However, a week after the tsunami in Japan, when the weather warmed up, the blankets were no longer needed. In Port-au-Prince, so much bottled water arrived that local relief groups had great difficulty finding adequate storage space for it; the same situation was reported in Japan (Holguín-Veras et al., 2012d) and Joplin, Missouri.

The complications produced by low or NP material convergence have been reported in all disasters, as illustrated by the sampling of eyewitness accounts, below:

**1953 Arkansas tornado**: "All this clothing and food and all this vast store of supplies started moving … There was no place to put it … No buildings to put it in ... That created a big problem ... We got a tuxedo, a nice one … One other big building…probably 100ft long and 60ft wide, with 14ft ceiling… was filled in 12 hours." "60% of it was not good; it shouldn't have come to the area at all." (National Opinion Research Center, 1954).

**1992 Hurricane Andrew**: "Excessive donated clothing created major problems… not appropriate for the tropical climate (e.g., winter coats). Excessive food donations created further emergency management problems." (Neal, 1994).

**2001 World Trade Center**: "Chris Ward is snaking through a tunnel of cardboard crates, past boxes … The problem is, very little of it was needed…. Little of the cargo reached the intended recipients, as they simply had no use for it…The propensity of Americans to ship stuff to national disasters has become such an overpowering reflex that rescue workers now

have to divert considerable resources to ensure the largess does not get in the way. Some even describe the torrent of sundries as a 'second tier disaster' " (Newsweek, 2002).

**2004 Hurricane Charley**: "One of the most outrageous things I have seen is a truck load of sex toys that arrived at one of the distribution centers in Florida..." (Holguín-Veras, 2011).

**2005 Gulf Coast**: "Donation management is the most difficult part of every disaster," he said of the unsorted mountains of clothes. "We have a little bit of everything." (Corpus-Christi Caller-Times, 2005). "Sometimes generosity can go awry."….. Collection sites along the Mississippi Gulf Coast became "nothing more than dump sites" (The Times-Picayune, 2005).

**2010 Haiti**: "Nobody seemed to know exactly what was on the boat [that arrived in Port-au-Prince with no instructions about what to do on arrival], or who actually sent it. One rumor was that it was from Costa Rica…"; "The boat, it turned out, had mostly packs of water bottles, which is nice and everything, but water isn't really what Haiti needed right after the quake. There was plenty of water. Sanitation equipment or rice would have definitely been more useful. This is one example of aid that just might have been hurting more than it was helping." (National Public Radio, 2010). Interviews conducted by the authors revealed that ten containers of European refrigerators were of no use in Port-au-Prince because of the power outage and the use of a different voltage (Holguín-Veras, 2010). When participants in the response to the Haiti earthquake were asked to identify the major logistical problems they faced, unsolicited donations always came at the top, adding that "people send things that they do not know if are needed or not…"; "not suitable"; "expired"; "whatever could fit in a box, it is a dump policy"; "people don't follow proper protocols" (Holguín-Veras and Jaller, 2010d); "donations were hard to control"; "a lot of inappropriate donations"; "about 80% of clothing donations were useless" (Holguín-Veras and Jaller, 2010a); "..big bottleneck and create a big problem"; "shiploads of these from different organizations, even countries"; "those donations can slow down the distribution of priority goods, useful goods"; "they need storage, handling, resources" (Holguín-Veras and Jaller, 2010c); "donations need to be controlled and be subject to standards"; "donors need to provide transportation (to the impacted area)" (Holguín-Veras and Jaller, 2010b); "washcloths arrived before water, and Senators before surgeons" (Associated Press, 2010b).

**2010 Floods in Colombia**: Examples of NP items included a tiger (carnival) costume, used wedding and party gowns, and even three Spanish flags. "It seems like people were taking this opportunity to get rid of all their junk…"; "We have received some demeaning donations like a box full of used underwear…"; "It is offensive to send these type of things to the victims…" commented a Red Cross volunteer in Barranquilla, Colombia (Ovalle, 2011).

**2011 Tohoku Earthquake, Japan**: Interviews conducted during fieldwork in Japan indicated, yet again, the problems caused by NP donations. Individuals interviewed complained about: "too many blankets"; "too much clothing"; "a lot of broken bikes…"; "people got offended when we told them that we did not need these goods…we had to ask them to 'postpone' the donation to a better time.(Holguín-Veras et al., 2011a; Holguín-Veras et al., 2011b; Holguín-Veras et al., 2011c; Taniguchi et al., 2011). One of the distribution centers visited had in excess of 700 metric tons of bottled water, sufficient to satisfy the needs of 350,000 person/days, and 2 million face masks –almost enough to give one mask to each person living in the entire Tohoku region. Other distribution centers had similar volumes that so greatly exceeded needs as to become a problem. It is important to mention that the NP

donations came, in spite of the fact that they were discouraged as part of the local disaster response procedures (Holguín-Veras et al., 2012e).

**2011 Joplin tornado, Missouri**: A field trip to the impacted area revealed numerous cases of excessive material convergence: "We have been overwhelmed by disorganized generosity…"; "we have enough water to fill more than two swimming pools"; "about 70% of what we got was clothing" commented a volunteer from a faith-based organization active in the disaster response. When asked about clothing, the interviewees responded "We received about 9 semi-trailers with clothing…"; "How to stop the flow?"; "about 70% of the clothing we receive is unusable" (Jaller and Brom, 2011c). One of the directors of operations for a large organization put the number of items of usable clothing at 1 in 500 and that "only from 10-15% gets ever distributed", adding that people "need to know the implications of what they are doing" (Jaller and Brom, 2011b). At every warehouse and organization visited, the research team found an excess of donated water, "We have too much water, we don't know what to do with it… we need the space…" (Jaller, 2011; Jaller and Brom, 2011a; Jaller and Brom, 2011c; Jaller and Brom, 2011b; Jaller and Brom, 2011d).

Regrettably, though the phenomenon of material convergence has been documented for a long time, there have been few attempts to formally analyze its effects on HL operations. Scanlon (1991), Neal (1994), Holguín-Veras et al. (2007), Destro and Holguín-Veras (2011), Jaller (2011) and Jaller and Holguín-Veras (2012) are among the few who have studied the subject. While there are no data to quantify the volume of the NP flow, there are strong indications that it exceeds 50% of the cargo that arrives in the first weeks after the disaster. The interviews conducted with the logisticians involved in relief operations after the Tohoku earthquake indicated that "50% of the cargo was no good…" and that "70% was non-priority…" These estimates were ratified during a visit to a large distribution center in Iwate Prefecture, where visual inspection revealed 40-50% of the space occupied by clothing. Once other NP items are added, it seems reasonable to estimate that the NP flow is in excess of 50% of the total (Holguín-Veras et al., 2012e). These estimates are consistent with the literature (e.g., "...60% of it was not good...") (Fritz and Mathewson, 1957).

For a number of reasons, NP convergence remains a major problem for post-disaster humanitarian logistics. In a significant number of cases, NP goods are sent by spontaneous donors who are not aware of the actual needs at the disaster site, and who do not check with local authorities or experienced relief organizations about how best to help out. In other instances, the NP donations are made by private companies that perceive the disaster as a marketing opportunity, or as a practical outlet for dumping unwanted inventories of supplies, or receiving a charitable contribution tax deduction. Given the endless number of potential motives, there are also numerous ways to influence donor behaviors for the better. Many of these donors do not understand or believe that they are creating a problem. A large relief organization organized focus groups with donors of NP supplies which revealed that the donors believe that they were doing nothing wrong, and that it is the responsibility of the relief organization to make good use of whatever supplies are donated. This puts relief organizations in a very delicate situation. On the one hand, they rely on donors to support their operations, particularly after a large disaster. On the other hand, a significant percentage of these donors tend to donate LP and NP goods, which creates complications that these groups would like to avoid. Statements made to the authors revealed a fear that restricting or refusing donations would be criticized, which in turn would negatively affect the

willingness of the donors to support the organization. This places relief groups in a prisoner's dilemma. If all relief groups collectively educate the public on how to donate, all of them would be better off. However, if one group does not cooperate it could become the main beneficiary of the donations (both good and bad) coming from those donors who were turned off by the education campaign. This dilemma, in turn, leads all organizations to reject the cooperative strategy of publicly confronting the problem. There have been efforts to reduce the amount of NP supplies, including the International Federation of the Red Cross (IFRC)'s introduction of a Relief Mobilization Table (Gatignon et al., 2010). Although this strategy has improved things, interviews with logisticians and representatives of numerous relief organizations indicate that NP convergence is still a major issue to be resolved.

Like three lanes of traffic merging into a one-lane tunnel, the large volumes of LP and NP supplies that arrive at a disaster site impede the flow of HP goods. Without traffic control, huge delays can affect all lanes. However, with controls whereby NP flows are diverted and LP flows are delayed or sent to storage to warehouses outside the disaster area, the tunnel capacity could benefit the HP flows (Jaller and Holguín-Veras, 2012). The fundamental insight is that, to maximize the beneficial impacts of the relief effort, the available transportation capacity should be allocated primarily to the transport of HP supplies. This insight is consistent with the literature of optimal pricing of capacitated transportation facilities (Holguín-Veras and Jara-Díaz, 1998; Holguín-Veras and Jara-Díaz, 2008).

## Nature of Material Convergence

Understanding the nature of material convergence requires a look at the underlying factors that influence donation behavior, at both the individual and group/organizational level. An extensive body of research exists on philanthropy, and although an in-depth review is beyond the scope of this paper, a general discussion is provided. Philanthropy has been studied from such fields as: social sciences, social psychology, biological psychology, neurology and brain sciences, sociology, political science, anthropology, evolutionary psychology, marketing, economics, and, engineering (Bekkers and Wiepking, 2010). From the early 1970s, philanthropy has been associated with the wellbeing or utility derived by individuals from giving and consuming (Schwartz, 1970; Hood et al., 1977), and major efforts have been devoted to analyzing questions of: who gives? what? how much? why? how? and to whom? (Bird and Bucovetsky, 1975; Hood et al., 1977; Schervish et al., 2002; Bryant et al., 2003; Bekkers and Wiepking, 2010; Havens and Schervish, 2010). This has resulted in multiple theories, and, in some cases, contrasting conclusions.

However, only a handful of publications have analyzed the factors that affect the likelihood of donations in the aftermath of disasters. Destro and Holguín-Veras (2011) analyzed the donations reported in the media after Hurricane Katrina, and estimated econometric models of both monetary and in-kind donations. They found econometric evidence that indicates that monetary donation amounts are a direct relation with family income per capita, population density, individual and corporate donations, and an inverse one with the percentage of unemployed population with only high school education with respect to total population, and distance to the impacted area. In addition, they found that in-kind donation amounts increase with median rent and population density, and decrease with distance to impacted area, percentage of younger population than twenty years, unemployed population over sixteen

years, average family size This is consistent with the literature. Fong and Luttmer (2009) analyzed racial effects in charitable giving after Hurricane Katrina. The results show no clear relation between the likelihood of donation and race (objective race); however, subjective racial identification or ethnic proximity does relate. Steinberg and Rooney (2005) describe the results of a survey conducted after the events of September 11, 2001, and conduct multivariate analyses of the determinants of giving and volunteering. Results indicate that about 65% of all surveyed American households made financial contributions; 27.2 donated other goods such as food, clothing, or blood; and about 9% volunteered. Their findings are consistent with the literature. Schweitzer and Mach (2008) analyzed donations before and after the 2004 Asian Tsunami. Their results indicate that there were statistical similarities between donations made before and after the disaster. In addition, they found dynamics effects on individual donations triggered by the mass media portrayal of the disaster. In their analysis of corporate donations after the South Asian Tsunami, Hurricane Katrina and the Kashmiri earthquake, Muller and Whiteman (2008) suggest that corporate philanthropic disaster response varies systematically across regions. Furthermore, they analyzed the effects of corporate donations due to home regional effects and local presence effects, by which corporations give more importance to disasters closer to home, or in locations where they have local presence. The authors argue that this is the result of a possible sense of responsibility or a greater degree of tangibility. As a result, there are regional differences in the way corporations respond to specific disasters. In addition, results suggest that in the aftermath of a catastrophic disaster, corporate donations are expected to be larger than those provided by individuals/households.

The individuals who make donations of LP and NP supplies out of a genuine philanthropic interest, tend to make them through other organizations (Destro and Holguín-Veras, 2011). Thus, it is useful to analyze the nature of the organizations involved, and to think of donors as remote or virtual participants in the HL response. Deprived by distance of the opportunity to participate in the actual response, donors focus their energy instead on gathering the donations that they believe would help the survivors. (Obviously, this assumption does not apply to individuals and companies with other motives for donating.) Quarantelli and Dynes (Quarantelli, 1966; Quarantelli et al., 1966; Dynes, 1970) produced a taxonomy of the different types of social collectives, entities or organizations involved in disaster response operations. The taxonomy is a function of the nature of the tasks undertaken, and the post-disaster structure. See Table I.

Table I – Taxonomy of Organizational Structures

| | | Post-disaster tasks | |
|---|---|---|---|
| | | Regular | Non-regular |
| Post-disaster structure | Old (familiar) | Type I (Established) | Type III (Extending) |
| | New (unfamiliar) | Type II (Expanding) | Type IV (Emergent) |

Note: After (Quarantelli et al., 1966)

The tasks undertaken could be either regular or non-regular (Quarantelli, 1966; Quarantelli et al., 1966; Dynes, 1970). Regular tasks are those that would be routinely undertaken prior to the disaster, either old, routine, assigned, or everyday. Examples include: the fire department controlling fires, or hospitals treating injured people. In contrast, there are disaster-generated tasks, which may be new, novel, assumed or unusual for the groups undertaking them.

Examples of organizations engaged in non-regular tasks include the US Army providing water to the affected population, churches sheltering evacuees, or teachers' associations handling and distributing supplies at an aid center.

In terms of structure, organizations could have old/established structures, or new/emergent ones (Quarantelli, 1966; Quarantelli et al., 1966; Dynes, 1970). Organizations with old/established structures have members that share pre-disaster social and working relationships. These groups could have different levels of organizational formality, ranging from highly structured systems, e.g., the military, to less formal structures, e.g., a volunteer group. These groups existed as entities prior to the disaster, and the interactions between the different members continue during the disaster's regular and non-regular activities. Essentially, pre-disaster social bonds are maintained in post-disaster tasks. In contrast, new/emergent structures are those in which the structure is developed or comes into being during the disaster; either morphing from other pre-disaster structures or arising as a new entity (e.g., an informal search and rescue team formed by volunteers after the disaster). Although these emergent social entities may be partly planned, the actual group materializes during the disaster (Quarantelli et al., 1966).

As shown in Table I, four distinct types of organizations are defined. Type I (established) are old organizations carrying out their regular tasks, such as the police controlling traffic in the impacted area. Type II (expanding) are new organizations performing regular tasks, which are more often than not the result of community or organizational planning, such as volunteers running a shelter. Type III (extending) are old organizations that undertake non-regular tasks, such as a construction company utilizing their assets on rescue operations. Type IV (emergent) organizations are new structures that engage in non-regular tasks, such as an ad hoc group made up of the city mayor and a local church leader working together to coordinate the overall response efforts (Quarantelli, 1966; Dynes, 1970).

Although caution must be exercised when making general statements about expected donation behavior—particularly in relation to a complex and poorly understood subject like material convergence—it seems safe to establish a set of working hypotheses about the different types of groups identified in Table I and their contributions to material convergence. The first hypothesis is that organizations that regularly gather and distribute donations in response to a disaster are more likely to have a better sense of the actual needs than an organization for which these tasks are new (non-regular). Thus, it could be expected that established and expanding organizations would generate a flow of cargo (or solicit donations) with a relatively higher percentage of HP goods. Conversely, since for extending and emergent organizations PD-HL is a non-regular task, these groups are likely to generate flows of cargo less suited to the actual needs, with relatively large proportions of LP and NP supplies. Should this conjecture be confirmed, it would mean that the level of familiarity of the task could provide an indication of the relative amounts of HP, LP, and NP supplies that these groups are expected to generate. From this perspective, one could assume that the flows of established and expanding organizations are regular flows, while those from extending and emergent organizations are non-regular flows. Obviously, this does not mean that established and expanding organizations would not send inappropriate donations; or that emergent and extending organizations would not send high priority supplies. It simply says that they have different probabilities of doing so. Moreover, there is a great deal of nuance and complexity; while established and expanding organizations may be expected to donate

primarily HP supplies, the reality is that if they collectively send supplies in excess of the actual needs, the usefulness of those supplies will rapidly decline. This was the case with blanket donations after the Tohoku disasters, the bulk of which came from established organizations. In light of these considerations, the paper assumes that the material convergence generating behavior of these organizations could be characterized by a set of probabilities—to be determined empirically—that measure the fractions of HP, LP, and NP supplies generated.

# LOGISTICAL IMPACTS OF MATERIAL CONVERGENCE

To formulate appropriate corrective measures, it is essential to understand the logistical impacts of material convergence. Figure 1 shows a schematic of the flows converging to the disaster site through an specific logistics corridor as a series of lines emanating from the donor sites; the different flows are depicted by different dotted lines. The figure shows the entry points and end sites inside the disaster area, where the impacts of the material convergence are most acute.

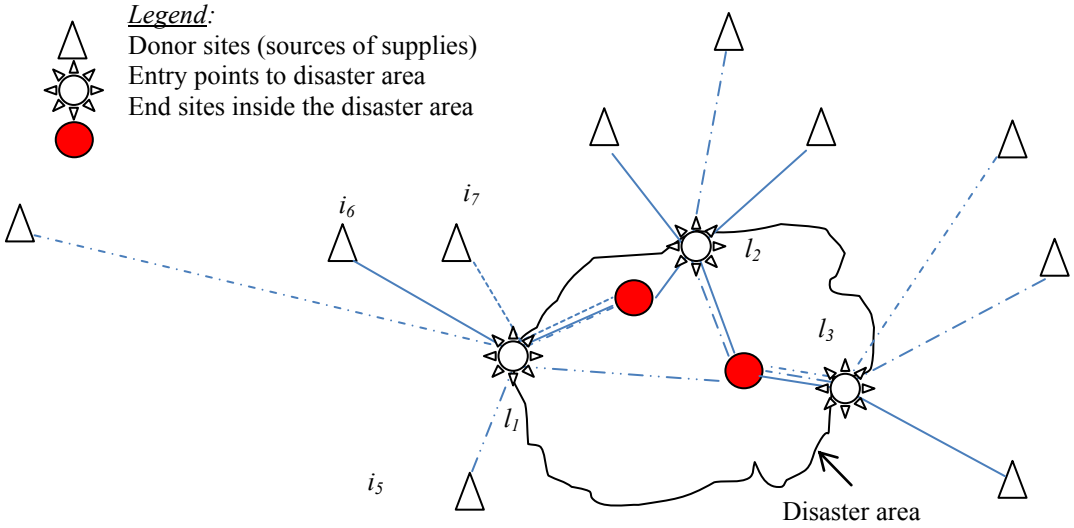


Figure 1: Schematic of Supplies Flowing to a Disaster Site

## Impacts at Entry Points

"Entry points" are the locations at which the disaster area can be accessed. These could be located in the region surrounding the disaster area (e.g., the highways leading to New Orleans after Hurricane Katrina, the Port-au-Prince airport after the Haiti earthquake), or hundreds of miles away (e.g. for Haiti, the Santo Domingo airport in the Dominican Republic). Some of the flows go through multiple entry points, such as cargo planes that arrived at Santo Domingo impacting both the airport and the border crossing at Jimaní. In localized disasters there could be numerous entry points as the impacted area could have multiple connections to the rest of the area, whereas in large disasters and catastrophic events the number of entry points is typically small as these tend to be the transportation links that connect the impacted area to the rest of the country. At entry points, convergent flows may be inspected by government officials who check the cargos, the manifest, bills of

lading, or any other shipping documentation available, deciding whether to grant access to the disaster area. In cases where access to the disaster area is not controlled—e.g. after the Port-au-Prince earthquake—NP items are allowed to travel unimpeded to the disaster area. This essentially shifts the problem from the entry point to the end site. Material convergence impacts entry points in different ways, including the congestion produced by vehicular traffic. Although there are no reliable estimates of the traffic associated with the material convergence, the Haiti disaster provided anecdotal evidence of the congestion problem. Two days after the disaster, the number of planes wanting to land at the Port-au-Prince airport skyrocketed from an average of about 25 flights per day (Shaughnessy, 2010) to more than 120 takeoffs and landings (Associated Press, 2010a). Due to landing capacity constraints, there were sometimes two dozen planes circling the airport for more than two hours; many had to be diverted to Santo Domingo or Florida (Associated Press, 2010a). In the words of some of the participants: "…when the quake hit, the global crush of compassion turned the Haitian capital's airport into a virtual baseball catcher, with pitchers throwing balls from all directions at the same time…" (Associated Press, 2010b); "…the airport is actually overwhelmed by aid…" (Sheridan and Branigin, 2010).

To ensure that critical supplies could land, the US Air Force air traffic controllers who took over the airport imposed a priority landing system, or run the risk of a complete airport shutdown (New York Times, 2010). Scores of planes that did not meet the criteria for priority landing were diverted 180 miles away to the Santo Domingo airport, where they also created major logistical problems. After lengthy international flights, cargo planes had to be allowed to land because they were running short of fuel. The Dominican authorities had no choice but to ensure that the planes were promptly unloaded so that they could leave as soon as possible, otherwise they would quickly clog taxi areas and warehouses, leading to the shutdown of a critical airport that normally receives thousands of tourists. Thus, the cargo had to be sorted, transported to Haiti, or discarded if unusable. The situation at the Jimaní border crossing (between Haiti and the Dominican Republic) was similar. Witnesses reported more than a hundred trucks on peak days, waiting for the border to open. The road leading to the border crossing, designed for a much smaller volume, had only one lane per direction with narrow shoulders, hence any inspection of the cargo of a truck delayed the entire queue waiting to enter Haiti. The port in Port-au-Prince—severely damaged by the earthquake—was spared the onslaught in the first days of the emergency. However, once a floating pier was anchored at the port, the convergent traffic dramatically increased.

In addition to the congestion produced by the vehicles, the NP flow of supplies typically requires longer inspection times, increasing processing delays significantly. Critically, a large portion of the NP flow lacks proper documentation frequently arriving without a consignee, and consisting of poorly labeled boxes with mixed contents that require considerable processing time and effort to extract whatever useful supplies they may contain. These goods are typically assembled at donation drives by volunteers with no training in shipping or logistics; then hastily packed in a truck or shipping container, and sent to the disaster area in the hope they may benefit the survivors.

NP material convergence is also generated by large and prominent private companies that—either out of ignorance or a misguided sense of public relations/marketing—donate inappropriate products. Less than 24 hours after the Haiti earthquake, a plane landed in Port-au-Prince loaded with children's toys donated by a Thai manufacturer, accompanied by a

television crew from that country. After pictures and videos were taken, the planes and the television crew left, leaving several tons of toys on the tarmac where they remained for months, obstructing traffic (Holguín-Veras and Jaller, 2010a). Another egregious example was a shipment of several tons of a highly caffeinated drink and potato chips that arrived at the Port-au-Prince airport to great fanfare. Due to the prominence of the donor, key staff members from the relief agencies were asked to participate in a 'thank you' ceremony. Indeed, prominent companies frequently use their political influence with governments to ensure their donations are "accepted" by the local responders. There were also reports of planes with solar-powered talking bibles (Reuters, 2010). Meanwhile, a French portable hospital and planeloads of doctors with medical supplies were diverted to the Dominican Republic (Associated Press, 2010b). After the tornado in Joplin, Missouri, several tons—thousands of bottles—of a beverage arrived that had apparently been pulled of the commercial market because it did not sell well. Months afterwards, untold amounts of the beverage remained in the warehouses of numerous relief groups as most who tried it deemed it "undrinkable" (Jaller and Brom, 2011c; Jaller and Brom, 2011d).

As a result, government officials manning the entry points are forced to choose among alternatives that are far from ideal. They can thoroughly inspect the vehicles, including those without proper documentation and/or consignee, to prevent the criminal element from taking advantage of the situation to smuggle contraband, drugs or weapons. This consumes significant resources and delays HP shipments. The second possibility is to simply deny passage to any vehicle without proper documentation or consignee. This requires the provision of space for detours, and potentially opens the door to accusations of impeding humanitarian aid. The third option entails cursory inspections of the vehicles, which avoids massive delays but fails to stop the criminal traffic. In cases where local officials bow to pressure and opt for the third alternative, which happens frequently, the problems caused by the flow of NP material convergence are simply transferred to the end sites.

## Impacts at Entry Points

The term "end site" refers to the place where the material convergent flows terminate their journeys, where the flows interface with the impacted region. The potential end sites are endless: a formal warehouse operated by an established organization, an improvised staging area in the parking lot of a commercial center, an informal processing point at a local church, or a site where drivers dump their cargo when they cannot find anyone to take it. In most cases, since the end sites are either in the disaster area or close to it, they may have been impacted, and transportation and communication networks may not be fully functional.

With roads blocked by damage or debris, trucks carrying NP supplies increase congestion, aggravating citizens already traumatized by their experience, and disaster respondents who are working to help get things back to normal. The absence of a consignee magnifies the problem. Dominican Government officials indicated that during the days after the earthquake "about 60 to 70% of the planes came with no consignee…" The cargo was succinctly described as "Aid for Haiti." In the absence of a contact at the disaster site, drivers are simply instructed to give the cargo to any group that can make good use of it. If left unchecked, these wandering trucks seeking a willing recipient create congestion in the disaster area. Often failing to find anyone that accept the supplies they dump their cargoes in any open

area, preventing a more beneficial use of the space and putting the local population at risk. Rotting piles of unwanted supplies become a magnet for insects, rats, and other disease carriers. For example, days after the Joplin tornado a truck driver who arrived with a "…truckload of cat food…" called radio station KZRG to find out where to take the shipment. The startled radio announcer is heard saying "A truckload of cat food? Well…I don't actually know…" (National Public Radio, 2011). Obviously, several tons of cat food may not be a first priority need for a city where 8,000 houses have recently been destroyed (National Weather Service, 2011). After Hurricane Andrew: "Truck drivers with loads of clothes drove straight to severely damaged areas… they often did not know where to deliver the donated clothes, so they unloaded them on the side of the road. The heat and usual afternoon summer rains quickly turned the piles into heaps of stinking, rotting cloth." (Neal, 1994).

Disaster response agencies have taken some remedial steps to minimize the negative impacts of NP material convergence. For instance, the Federal Emergency Management Agency (FEMA) advises city governments to establish donation management procedures that are typically coordinated with the Volunteer Organizations Actives in Disaster (VOAD) network. FEMA, in collaboration with private companies and foundations, funded a national disaster relief coordination program called the National Donations Management Network Program (Federal Emergency Management Agency, 2011). This system is designed to help manage unsolicited donations and volunteers, connecting state and local governments with donors; VOAD at state and national levels, and FEMA. This Internet based system allows for the logging, tracking, sharing and matching of in-kind donations and volunteers with needs, and provides a portal for the referral of financial donations. It offers a promise to reduce the NP donations to the impacted area. However, interviews with relief organizations after the Joplin tornado and after Hurricane Irene indicated that the software is rarely used, though some large donors use it.

The resources required to handle NP flows are considerable. For instance, one-third of the 60 workers at a visited large warehouse in Iwate Prefecture (Japan) were assigned to sorting the clothes that had been donated. Similarly, a visit to an organization active in the Joplin Missouri tornado response showed that about 50% of the personnel were assigned to handling the flow of used clothing. Interviews with emergency responders at other organizations revealed that many of them, from lack of experience, initially accepted the non- and LP supplies. Obviously, using such manpower for the processing of useless NP supplies is a waste of human resources.

# CONCLUSIONS AND POLICY SUGGESTIONS

The research reported in this paper focuses on the important and overlooked phenomenon of material convergence, which is the spontaneous flow of supplies and equipment that is sent to the disaster area by donors of all kinds (e.g., individuals, community groups, companies, government agencies). Material convergence is comprised of a highly heterogeneous mix of supplies, which could be classified into high-priority (HP), the supplies that are needed in immediately; low-priority (LP), which are those that must be stored for later use; and non-priority (NP), that are the supplies that should not have been sent to the disaster site. Obviously, the HP and LP supplies benefit the survivors, or the response itself.

Unfortunately, large portions of the material convergence (the data available suggests between 50% and 70%) are NP supplies that create major complications for the response effort, particularly at the disaster area entry points and end sites because they arrive when the responders are struggling to restore things to normal, and when the transportation and logistical capacity to handle the massive flows of supplies are at their lowest point. Moreover, the NP supplies are problematic in other respects (Pan American Health Organization, 2001) as they: are not needed; are useless or irrelevant; arrive in excess of actual needs; are culturally inappropriate or offensive; have surpassed expiry dates, are perishable, or are in poor condition; arrive without a known or appropriate site for efficient distribution; require significant handling; require their own logistics; do not have adequate labeling or arrive in a condition impossible to efficiently inventory/identify; cause problems of adequate storage; cannot be rejected as they can lead to diplomatic or public relations difficulties; may need to be incinerated, buried or disposed of.

The donors and their motivations to send these supplies are as varied as the supplies themselves. Although for reasons of space, it is not possible to enumerate all possible motives, it is important to mention a few. There is the case of individuals, community groups, churches, and private companies that share a genuine interest in helping, and lack awareness about what is actually needed at the site and the negative impacts that their donations could produce. These donors tend to send whatever supplies they have at hand under the mistaken belief that anything and everything is useful. Less altruistic motives can be seen with private companies that see the disaster as a marketing opportunity, either donating unwanted items for a charitable contribution tax deduction, or, more egregiously, using the disaster as a way to get rid of unwanted inventories of products that either did not sell well or are expired or are about to expire. Changing donor behavior is essential to mitigate the negative impacts of material convergence. Research on how to influence donor behavior must be a high priority, given both the delicacy and importance of the issue. Awareness campaigns needed to induce donor behavior changes could, indeed, offend some donors, but not confronting the issue will lead to the perpetuation of the problem. Examples of these types of strategies include the guidelines provided by the Center for International Disaster Information (CIDI) in partnership with the United States Agency for International Development's Office of Foreign Disaster Assistance (OFDA) on the best ways to support disaster relief (Center for International Disaster Information, 2012), or the "Saber Donar" campaign (Saber Donar, 2011b; Saber Donar, 2011a).

As this paper makes clear, the problems and issues associated with material convergence are as clear today as when they were first discussed by Fritz and Mathewson (1957), decades ago. The humanitarian community must work together to mitigate the "second-tier disaster" that can so dramatically complicate their relief efforts.

Based on the important finding, the paper puts forward a set of policy suggestions—ideally to be incorporated as part of disaster response plans—to maximize the benefits of the material convergence, while minimizing its negative impacts. The most salient findings, together with the corresponding policy suggestions, are summarized in Table II.

Table II – Chief Findings and Policy Suggestions

| Chief conclusions | Policy Suggestions |
|---|---|
| (1) Material convergence increases with donors' wealth, and decreases with the distance between donor | (1) The resources allocated to physical control of the material convergence must be commensurate with the amounts expected, which may depend on proximity to |

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|---|---|
| and disaster. | large donor areas. |
| (2) How the media portrays the needs has a large influence on the material convergence that is generated. | (2) Disaster response agencies and groups must try to educate the media before a disaster so that they are aware of the impacts that their reports could have on the response itself. |
| (3) The flow of material convergence is comprised of a highly heterogeneous mix of HP, LN and NP supplies. | (3) Efforts must be made to minimize the flows of LP and NP supplies, ideally at the source of the donations. This will require proactive education and awareness campaigns aimed at small donors that produce large amounts of LP and NP supplies.<br>(4) Information systems that advise on actual needs could be useful, particularly for and to large established organizations. However, since these advisory systems do not take into account the amount of supplies already in transit, they could lead to excessive donations of HP and LP supplies.<br>(5) As major relief agencies have started doing, cash donations must be encouraged.<br>(6) In cases where donors have access to physical donations with market value, they should be encouraged to sell them and donate the proceeds to reputable relief organizations. This will make good use of the supplies at hand, will avoid the cost of transporting the supplies to the site, and eliminate the numerous problems produced by LP and NP flows. |
| (4) NP supplies could exceed 50% of the cargo reaching the site, overwhelming responders when they have other more urgent tasks.<br>(5) LP and NP supplies hamper the flow of HP supplies.<br>(6) The negative impacts of LP and NP supplies at end sites are larger than at entry points. | (7) Access control must: prevent NP supplies from entering the disaster area, delay LP flows, and expedite HP supplies.<br>(8) Multi-stage access control systems play a key role. Pre-screening locations before entry points could be used to stop NP flows, allowing only LP and HP donations to proceed (Jaller, 2011; Jaller and Holguín-Veras, 2012). At entry points, LP supplies could be stored or rerouted to other storage locations; while HP supplies are allowed to continue their journey.<br>(9) To expedite the process, the supplies transported by established and expanding organizations—for whom post-disaster response is a regular task and are likely to have a solid idea about actual needs—could be waived inspections at access control locations. |

Suggestion (1) in Table II implies that response plans should account for the fact that the amount of material convergence depends on the proximity to potential donors. The closer the disaster to a large and wealthy urban area, for instance, the larger the convergence that is likely to take place. The table also highlights, in suggestion (2), the imperative necessity to proactively engage the media so that the way in which they portray the actual needs helps, and not hinders, the response process. It should be said that while some researchers (Wachtendorf et al., 2006; Schweitzer and Mach, 2008; Wachtendorf, 2010) have tried to understand the impact of the media on material convergence, how to use the media to influence donation behavior is still an open question. The rest of the suggestions are reactive in the sense that they are the kind of activities that take place once the disaster happened. Of great importance are suggestions (3) to (6) as they could dampen NP material convergence at the source thus saving the donors the expense of transporting supplies that are not likely to be used. However, for these measures to be successful, local authorities must be ready to both engage the media, and put forward clear and succinct press releases

that the media could disseminate. This is particularly important when dealing with the international media. Suggestions (7) to (9) are the last line of defense against the negative impacts of NP convergence. Because of the speed at which the convergence arrives, local authorities must start preparing for it as soon as practically possible. As suggested in the table, multi-stage control procedures must be set in place. The main goal of such control process is to use the resources available to expedite the HP flows, by preventing the NP flows to enter the disaster area, and slowing down or sending to storage the LP supplies (Jaller, 2011; Holguín-Veras et al., 2012e; Jaller and Holguín-Veras, 2012). This necessitates making decisions concerning location of access control sites, identification of manpower and access rules that specify what slows are allowed to enter the disaster are.

The paper's chief conclusion is that a multi-disciplinary management and control approach is needed to maximize material convergence's potential benefits while minimizing its negative impacts on the response, and ultimately, on the welfare of the disaster victims. Towards this end, it is imperative that further research efforts are spent on understanding material convergence, its origins and dynamics, and the role of the media in influencing donor behavior.

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## REFERENCES

American Red Cross. (2010). "Help Now."

Associated Press. (2010a). "Aid trickles through Haiti's cramped airport " MSNBC.

Associated Press. (2010b). "Haiti flight logs detail early chaos after quake." MSNBC.

Bekkers, R. and P. Wiepking (2010). "A Literature Review of Empirical Studies of Philanthropy: Eight Mechanisms That Drive Charitable Giving." Nonprofit and Voluntary Sector Quarterly. Sage Publications: 1-50. 10.1177/0899764010380927. XX(X)

Bird, R. and M. Bucovetsky (1975). Canadian Tax Reform and Private Philanthropy. Canadian Tax Foundation.

Boileau, A., B. Cattarinussi, G. D. Zotti, C. Pelanda, R. Strassoldo and B. Tellia (1978). Friuli: La Prova del Terremoto. Milan, Italy.

Bryant, W. K., H. Jeon-Slaughter, H. Kang and A. Tax (2003). "Participation in Philanthropic Activities: Donating Money and Time." Journal of Consumer Policy **26**: 43-73.

Center for International Disaster Information. (2012). "Guidelines for Effective International Disaster Donations."

Corpus-Christi Caller-Times (2005). Officials sort out leftover Katrina donations. Corpus-Christi Caller-Times. Corpus-Christi, Texas.

Destro, L. and J. Holguín-Veras (2011). "Material Convergence and its Determinants: The Case of Hurricane Katrina." Transportation Research Record **2234**: 14-21.

Dynes, R., E. Quarantelli and G. Kreps (1972). A Perspective on Disaster Planning. Report Series #11. Columbus, Columbus: Disaster Research Center, The Ohio State University.

Dynes, R. R. (1970). Organized Behavior in Disaster. Lexington, MA: D.C. , Heath.

Federal Emergency Management Agency. (2011). "National Donations Management Network (NDMN)."

Fong, C. and E. Luttmer (2009). "What Determines Giving to Hurricane Katrina Victims? Experimental Evidence on Racial Group Loyalty." American Economic Journal: Applied Economics **1**(2): 64-87.

Fritz, C. E. and J. H. Mathewson (1957). Convergent Behavior: A Disaster Control Problem. Special Report for the Committee on Disaster Studies. Disaster Study. Washington D.C., National Academy of Sciences. **9**.

Gatignon, A., L. Van Wassenhove and A. Charles (2010). "The Yogyakarta Earthquake:Humanitarian Relief through IFRC's Decentralized Supply Chain." International Journal of Production Economics **126**(1): 102-110.

Guha-Sapir, D., F. Vos, R. Below and S. Ponserre (2012). Annual Disaster Statistical Review 2011: The Numbers and Trends. C. f. R. o. t. E. o. D. (CRED). Brussels, Belgium, Université Catholique de Louvain, Brussels, Belgium.

Havens, J. and P. Schervish (2010). Individual Giving Model: Forecast for 2009, Advancing Philanthropy. Center on Wealth and Philanthropy.

Holguín-Veras, J. (2010). Interview with official of Operación Mano Amiga. Santo Domingo, Dominican Republic.

Holguín-Veras, J. (2011). Interview with Florida Official Involved with Response to Hurricane Charley. Kansas City.

Holguín-Veras, J. and M. Jaller (2010a). Interview with a Logistician of a Large International Health Organization. Interview on April 26 2010. Santo Domingo, Dominican Republic.

Holguín-Veras, J. and M. Jaller (2010b). Interview with a Logistician of a Large International Organization. Interview on April 28 2010. Port au Prince, Haiti.

Holguín-Veras, J. and M. Jaller (2010c). Interview with Logistician of a Large International Health Organization. Interview on April 28 2010. Port au Prince, Haiti.

Holguín-Veras, J. and M. Jaller (2010d). Interview with the Director of Operations of a Large International Health Organization Interview on April 28 2010. Port au Prince, Haiti.

Holguín-Veras, J., M. Jaller and T. Wachtendorf (2012a). "Comparative Performance of Alternative Humanitarian Logistic Structures after the Port-au-Prince Earthquake: ACEs, PIEs, and CANs." Transportation Research Part A: Policy and Practice **46**(10): 1623-1640.

Holguín-Veras, J., M. Jaller, L. N. V. Wassenhove, N. Pérez and T. Wachtendorf (2012b). "On the Unique Features of Post-Disaster Humanitarian Logistics." Journal of Operations Management **30**(7-8): 494-506.

Holguín-Veras, J. and S. Jara-Díaz (1998). "Optimal pricing for priority service and space allocation in container ports." Transportation Research Part B: Methodological **33**(2): 81-106.

Holguín-Veras, J. and S. Jara-Díaz (2008). "Optimal Two-Part Pricing and Capacity Allocation with Multiple User Classes and Elastic Arrivals at Constrained Transportation Facilities." Networks and Spatial Economics. <http://dx.doi.org/10.1007/s11067-008-9075-6>

Holguín-Veras, J., N. Pérez, M. Jaller, L. N. V. Wassenhove and F. Aros-Vera (2012c). "On the Appropriate Objective Function for Post-Disaster Humanitarian Logistics Models." Journal of Operations Management **(in review)**.

Holguín-Veras, J., N. Pérez, S. Ukkusuri, T. Wachtendorf and B. Brown (2007). "Emergency Logistics Issues Affecting the Response to Katrina: A Synthesis and Preliminary Suggestions for Improvement." Transportation Research Record: Journal of the Transportation Research Board **2022**: 76-82.

Holguín-Veras, J., E. Taniguchi, F. Ferreira, M. Jaller, F. Aros-Vera and R. Thompson (2012d). "The Tohoku Disasters: Chief Findings Concerning the Post Disaster Humanitarian Logistic Response." Journal of Transportation Research Part E: Logistics and Transportation Review **(in review)**.

Holguín-Veras, J., E. Taniguchi, F. Ferreira, M. Jaller and R. Thompson (2012e). The Tohoku Disasters: Preliminary Findings Concerning The Post Disaster Humanitarian Logistics Response. Annual Meeting of the Transportation Research Board, Washington DC.

Holguín-Veras, J., E. Taniguchi, K. Oi, R. Thompson, F. Pedroso, K. Yamashita and Y. Yamao (2011a). Interview with executives of trucking companies that participated in the distribution of aid after the Tohoku earthquake. Miyagi Prefecture, Japan.

Holguín-Veras, J., E. Taniguchi, K. Oi, R. Thompson, F. Pedroso, K. Yamashita and Y. Yamao (2011b). Interview with staff of Kesennuma City. Kesennuma City, Japan.

Holguín-Veras, J., E. Taniguchi, K. Oi, R. Thompson, F. Pedroso, K. Yamashita and Y. Yamao (2011c). Interview with staff of staff of a large retail company. Morioka, Japan.

Hood, R. D., S. A. Martin and L. S. Osberg (1977). "Economic Determinants of Individual Charitable Donations in Canada." The Canadian Journal of Economics **10**(4): 653-669.

Jaller, M. (2011). Resource Allocation Problems During Disasters: The Cases of Points of Distribution Planning and Material Convergence Handling. Ph.D., Rensselaer Polytechnic Institute.

Jaller, M. and M. Brom (2011a). Interview with Co-Director of Disaster Response Team for a Faith-Based Organization. Interview on Jun 2011. Joplin, MO.

Jaller, M. and M. Brom (2011b). Interview with the Director of Operations at Joplin of a Large International Aid Organization Joplin, MO.

Jaller, M. and M. Brom (2011c). Interview with Volunteer of a Faith-Based Organization. Joplin, MO.

Jaller, M. and M. Brom (2011d). Interview with Volunteer of an Organization Active in Disasters. Joplin, Missouri.

Jaller, M. and J. Holguín-Veras (2012). "Resource Allocation Model for Dynamic Control of Material Convergence after Disasters." Transportation Science **(in review)**.

Muller, A. and G. Whiteman (2008). "Exploring the Geography of Corporate Philanthropic Disaster Response: A Study of Fortune Global 500 Firms." Journal of Business Ethics **84**(4): 589-603.

National Opinion Research Center (1954). Vol. I: Human Reactions in Disaster Situations. Washington D.C., National Academy of Sciences.

National Public Radio. (2010). "Foreign Aid that Hurts Rather than Helps." Retrieved March 4, 2010.

National Public Radio. (2011). "Joplin Radio Station Aids Tornado Survivors."

National Weather Service. (2011). "Public Information Statement."

Neal, D. M. (1994). "The consequences of excessive unrequested donations- the case of hurricane Andrew." Disaster Management **6**(1): 23-28.

New York Times (2010). Rescues Beat Dimming Odds in Haiti New York Times. New York, New York Times.

Newsweek (2002). $75 Million of Stuff**:** 62-63.

Ovalle, V. (2011). "Cruz Roja, 'inundada' de donaciones absurdas." El Heraldo.

Pan American Health Organization (2001). Humanitarian Supply Management and Logistics in the Health Sector. C. d. V. d. Goyet. Washington, D.C.

Prince, S. H. (1920). Catastrophy and Social Change, Based Upon a Sociological Study of the Halifax Disaster. Ph.D., Columbia University.

Quarantelli, E. L. (1966). Organization under Stress. Symposium on Emergency Operations, Santa Monica, CA.

Quarantelli, E. L. (2006, November 15, 2010). "Catastrophes are Different from Disasters: Implications for Crisis Planning and Managing drawn from Katrina." Understanding Katrina: Perspectives from the Social Sciences.

Quarantelli, E. L., R. R. Dynes and J. E. Haas (1966). Organizational Functioning in Disaster: A Preliminary Report. Working Paper # 7, University of Delaware. Disaster Research Center.

Reuters. (2010, January 18th, 2010). "U.S. group sends solar-powered Bibles to Haiti."

Saber Donar. (2011a). "Afiche #5." from http://www.saberdonar.info/materiales/Afiche05.pdf.

Saber Donar. (2011b). "Una Iniciativa Interagencial para Promover la Calidad y Eficiencia en las Donaciones Humanitarias en América Latina." from http://www.saberdonar.info.

Scanlon, J. (1991). Convergence Revisited: A New Perspective on a Little Studied Topic. Ottawa, Canada, Carleton University.

Schervish, P., M. O'Herlihy and J. Havens (2002). Charitable Giving: How Much, By Whom, To What, and How? . The Non Profit Sector: A Research Handbook. W. P. a. R. Steinberg, Boston College, Center on Wealth and Philanthropy. Yale Pres.

Schwartz, R. A. (1970). "Personal Philanthropic Contributions." Journal of Political Economy **78**: 1264-1291.

Schweitzer, F. and R. Mach (2008). "The Epidemics of Donations: Logistic Growth and Power-Laws." PLoS ONE **3**(1).

Shaughnessy, L. (2010). "Chaos at Haiti airport calmed by Air Force." CNN.

Sheridan, M. B. and W. Branigin. (2010, January 15, 2010). "Chaos at Port-au-Prince airport slows Haiti emergency aid efforts." The Washington Post.

Steinberg, K. and P. Rooney (2005). "America Gives: A Survey of Americans' Generosity After September 11." Nonprofit and Voluntary Sector Quarterly **34**(1): 110-135. 10.1177/0899764004269738

Taniguchi, E., J. Holguín-Veras, K. Oi, R. Thompson, F. Pedroso, K. Yamashita and Y. Yamao (2011). Interview with staff of Ishinomaki City. Ishinomaki City, Japan.

The Times-Picayune (2005). Overloaded. The Times-Picayune. New Orleans, LA, The Times-Picayune Publishing company.

Wachtendorf, T. (2010). When Push Comes to Shove: The Framing of Need in Disaster Relief Efforts. International Research Committee on Disasters meeting, XVII World Congress of Sociology, International Sociological Association, Goteborg, Sweden.

Wachtendorf, T., B. Brown and J. Holguin-Veras (2010). "Catastrophe Characteristics and Their Impact on Critical Supply Chains: Problematizing Material Convergence and Management Following Hurricane Katrina." (in review).

Wachtendorf, T., J. M. Kendra, H. Rodriguez and J. Trainor (2006). "The Social Impacts and Consequences of the December, 2004 Indian Ocean Tsunami: Observations from India and Sri Lanka." Earthquake Spectra **22**(3): 693-714.

Wettenhall, R. L. (1979). "Disaster and Social Science in Australia." Disasters **2**(4): 241-245.