

## Editorial

# Challenges of emergency logistics management

Emergency logistics management has emerged as a worldwide-noticeable theme as disasters, either artificial or natural, may occur anytime around the world with enormous consequences. This may hold particularly under conditions of large-scale calamities such as the Chichi earthquake in Taiwan (1999), the Bam earthquake in Iran (2003), the tsunami in the Indian Ocean (2004), as well as the Hurricane Katrina in the US (2005), which need quick-responsive emergency logistics systems for efficient disaster relief supply and recovery. For instance, the Indian Ocean tsunami of 2004 engendered by a major earthquake has reportedly caused more than 200,000 casualties, 100,000 missing, and more affected people who had their homes and livelihoods swept away (Yamada et al., 2006). Despite the fact that such a catastrophe had increasingly raised global humanitarian supports in relief supply and rehabilitation, emergency logistics remains as the key to efficient and effective alleviation of disaster impact in the immediate aftermath.

Although emergency logistics is vital, it has also raised numerous challenging issues, which may not be addressed as easily as in business logistics. Here, the challenges of emergency logistics management can be characterized in the following four main facets.

1. *The definition of emergency logistics remains ambiguous.* Unlike business logistics which has been clearly defined in the previous literature (Bowersox and Closs, 1996; Ballou, 1999; Johnson et al., 1999) as

*“Logistics is the process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services and related information from the point of origin to the point of consumption for the purpose of conforming to customers requirements at the lowest total cost.”*

the definition of emergency logistics has not yet been well clarified. Intuitively, the above definition may not fully apply to emergency logistics as the nature of problem, operational purposes, and demand features, e.g., the people served and the urgency of relief needs in emergency logistics, is distinctively different from that of business logistics. Accordingly, adapted from the above definition, we tend to clarify emergency logistics as

*“A process of planning, managing and controlling the efficient flows of relief, information, and services from the points of origin to the points of destination to meet the urgent needs of the affected people under emergency conditions.”*

Under such, the corresponding goals and purposes should also be amended to meet the essence and missions of emergency logistics. Furthermore, such a definition may also help to clarify the induced “reverse emergency logistics” which aims to deal with the resulting reverse flows of useless materials from the affected areas for rehabilitation.

2. *The timeliness of relief supply and distribution is hardly controllable in the emergency context.* This is true particularly in the crucial rescue period which refers to the critical 3-day period right after the occurrence of a disaster. This can be further explicated in two different facets: (1) inbound logistics to relief distribution centers (termed the phase of relief supply), and (2) outbound logistics from relief distribution centers to affected areas (termed the phase of relief distribution). The main mission of the relief-supply phase is to acquire relief supplies from multiple suppliers, either internal or external, to relief distribution centers,

and thus, the corresponding operational problems may stem from the difficulties in identifying the relief supply sources, as well as coordinating the supplied relief for quickly responding to the urgent needs of the affected people. As a consequence, the delay between when the relief demand is actuated and when the corresponding relief is assigned turns out to be rather uncertain. Note that such a delay is arguably similar to the lead time devoted to procurement and order processing as addressed in the operational cases of business logistics (Simchi-Levi et al., 2000). In contrast, the phase of relief distribution may aim to carry out relief delivery from relief distribution centers to the affected areas so as to satisfy the urgent needs of trapped people. Therein, the reliability of damaged infrastructure and its effects on the accessibility to affected areas may raise the uncertainties in the relief distribution context, thus amplifying the complexity and difficulty in time-based emergency logistics control.

3. *Resource management for emergency logistics remains challenging.* Unlike business logistics under which the corresponding operational resources, e.g., containers, modes, and servers, are known and readily controllable to logistics suppliers, the operational environments of emergency logistics are intricately uncertain as the corresponding resources are attributed from both public and private sectors. As argued in Lyles (2005), there is always a fierce need for coordinating the logistics resources of public and private sectors to avoid arbitrary resource allocation during disasters. In addition, the communication failure among relief suppliers, logistics servers, and demanders is another factor that leads the disaster resource coordination to be relatively thornier under emergency conditions.
4. *Accurate, real-time relief demand information is required but almost inaccessible.* This issue, in reality, may stem from the fact that the communication from the relief demander (i.e., affected people) and the corresponding information provider (e.g., on-the-spot reporters and rescuers) may be inconsistent. Unlike business logistics in which the demand information (e.g., product orders) is provided actively and directly by customers themselves, the sources of on-the-spot relief demand information can be limited and almost unidentifiable in the immediate aftermath. In most disaster cases, such on-the-spot affection information including relief demand may not be actively and timely provided by the affected people under emergency conditions. In addition, the relief demand information needed for emergency logistics is a kind of aggregate-demand information rather than disaggregate demand information which is conventionally treated in business logistics. To a certain extent, such relief demand information is rather fuzzy, and hardly predictable due to the lack of referable time-series historical data. Thus, it may further trigger such a challenging issue as real-time relief demand forecasting.

In addition, the induced issues rising in either the strategic plan domain (e.g., emergency logistics network configurations, relief distribution channels, relief supply chain management) or the operational domain (e.g., relief supply/distribution strategies, reverse emergency logistics for recovery and rehabilitation) also warrant more investigation. Particularly, when the operational scope is expanded from the domestic to international domain, the aforementioned issues may turn out to be more intricate.

Considering the uniqueness of emergency logistics and the urgent need for more research, we issued a call for papers for the special issue of Transportation Research Part E in May (2005), a couple of months right after the global-shocking calamity of the Indian Ocean tsunami. The submission deadline was set to December 2005. Frankly, my motivation of organizing the special issue originates from the shock of more than 200,000 fatalities (including missing people) and millions of people affected by the globally-known tsunami, followed by a series of self-criticisms as: “As logistics professionals, what can we do for these affected people?” “Does our research, e.g., business logistics models and results of experimental studies serve to such practical emergency conditions?” “What is the value added in emergency logistics?” “Do we need to do research that is really meaningful to those people who are struggling to survive?” Fortunately, my idea was fully supported and approved by our respectable Editor-in-Chief, Professor Wayne K. Talley, after my sending an email requesting to publish a special issue “urgently”. Furthermore, he further gave me some valuable suggestions to kick off this special issue.

In the meantime, I received a total of 18 articles, in which 12 of them were suitable for the special issue. Those 12 qualified submissions were then sent out to referees for the first-round peer review. Nevertheless, I am still grateful to all the authors for their effort and interest in the special issue.

Furthermore, I am grateful to all referees for their impartial and professional reviews, which significantly improved the quality of the special issue. Through my thorough search from related academic websites for the

last six months, 21 invited referees were finalized and accepted for refereeing. My basic policy of inviting referees is that all the referees should be professional in related areas, and conduct their reviews independently. In addition, the names of authors are excluded from my invited referee list to ensure fairness in the review process. Therefore, in every case, the authors appeared to greatly appreciate the corresponding referees for their thoughtful and constructive comments.

A total of six papers are collected in this special issue. Despite the existence of a variety of problems unsolved in emergency logistics, the papers collected in the special issue may concentrate on addressing the issue of relief distribution to affected areas, and in some studies, the issue of evacuating affected people is also considered. A brief introduction to the accepted papers is summarized in the following.

Yi et al. (this issue) propose an ant colony optimization (ACO) based heuristic for the multi-commodity and vehicle dispatching problem arising in disaster relief activities. The distinctive feature of their method is that the original emergency logistics problem is decomposed into two phases of decision making, i.e., the vehicle routes construction, and the multi-commodity dispatch, where vehicles, relief, and wounded people are treated as commodities, are formulated as a multi-commodity network flow problem in the second phase, and then solved using the proposed ACO meta-heuristic algorithm. The performance of the heuristic is compared with a CPLEX solution based on both the criteria of quality and computational time. As pointed out by one referee, such a complex problem has not yet been modeled and solved in the Operations Research literature.

Based on certain idealistic assumptions with respect to disaster information acquisition and communication to simplify the disaster contextual background, Tzeng et al. (this issue) formulate the corresponding relief distribution problem with a fuzzy multi-objective programming method. Distinctively, they conceptualize the satisfaction of fairness in formulating the multi-objective functions so as to avoid the possibility of a severely unfair relief distribution to certain affected areas in the relief distribution process. Furthermore, the technique of fuzzy programming is introduced to deal with the fuzzy nature of the weights associated with these objective functions, thus leading to their proposed method with considerable flexibility to incorporate the corresponding decision makers' perceptions of the relative significance of operational objectives toward an adaptive decision support system for relief distribution.

Considering the dynamics and uncertainties of relief demands in the crucial rescue period of a large-scale, Sheu (this issue) proposes a novel emergency logistics co-distribution approach for dynamically responding to the urgent relief demands in the crucial rescue period. Based on a proposed 3-layer relief supply chain, a dynamic emergency logistics co-distribution system which embeds five sequential operational phases is built using fuzzy clustering and composite weighted multi-objective optimization approaches. Aiming at the case of Chichi earthquake of Taiwan, a numerical study is conducted, and the corresponding results indicate the applicability of the proposed method and its potential advantages in saving cost, time, and lives for quick-responsive emergency logistics distribution. The uniqueness of Sheu's methodology is that a proposed dynamic relief demand forecast model is embedded to address the issue of forecasting time-varying urgent relief demand associated with each affected area. Such a treatment is rarely found in the previous literature.

Relative to both the studies of Tzeng et al., (this issue) and Sheu (this issue) aiming at inbound relief distribution toward the affected areas of a disaster, the intention of Chiu et al., (this issue) appears to address the issue of dynamically assigning multiple emergency response and evacuation traffic flows outbound from the affected areas, thus forming such a unique SMDTS-MPG (simultaneous mobilization destination, traffic assignment, and departure schedule for multi-priority groups) problem. To address the aforementioned challenging emergency evacuation issue, they propose a cell transmission model (CTM)-based linear program model. Although the simplicity of the present test network merely embeds 8 nodes and 14 directed links, the authors claim that the proposed SMDTS-MPG model formulated in a matrix form appears to permit the rapid deployment of the model to realistic networks, e.g., the city of El Paso, Texas, according to their preliminary results of tests on-going.

In Chang et al. (this issue), a decision support system proposed for flood emergency logistics network planning is investigated. In this article, the flood emergency logistics problem with uncertainty is formulated with two stochastic programming models that permit determining the locations of rescue resource storehouses, as well as the plans for rescue resource allocation and distribution. Therein, with the aid of the data processing and network analysis functions of geographic information system, the flooding potential maps are generated,

and utilized to identify the potential locations of rescue demand points and estimate the aggregate amount of rescue equipment. Then, the proposed models coupled with the technique of a sample average approximation (SAA) scheme are employed to approximate the optimal solutions of the aforementioned problem in their numerical study.

In contrast with large-scale disaster conditions addressed in the other papers of the special issue, the paper by Iannoni et al. (this issue) aims to analyze small-scale emergency medical systems (EMS) on highways using two extended hypercube models built upon earlier extensions of Larson's hypercube model by [Chelst and Barlach \(1981\)](#) and [Mendonça and Morabito \(2001\)](#), respectively. The first model serves to analyze EMS on highways with different types of calls and servers, and a particular operations policy involving partial backup, zero-line capacity, and single and multiple dispatching of either identical or distinct servers (e.g., rescue ambulances, medical vehicles) depending on the type of call. This model is then extended to incorporate a third status of servers (besides the usual two: idle or busy), to specify when they provide medical services to emergency requests at their home bases. After applying these two models to the case study of an EMS operating on Brazilian highways, they validate the models by comparing the produced performance measures with the actual data, and show that the second model represents the real EMS system much more accurately.

Overall, this special issue has covered six pioneering papers in emergency logistics management, and most of them serve to tackle the related problems in the domestic operations level. Nevertheless, it is expected that this issue can stimulate more future research expanded either to address the issues of international emergency logistics or to cover more subjects such as real-time relief demand forecasting, emergency logistics network planning and design, and the corresponding logistics resource allocation to enrich the area of emergency logistics management. Furthermore, the problems of reverse logistics management for recovery from disasters also warrant more investigation. Finally, I do hope that this special issue will draw the attention of more researchers to bridge the gap between the academic and humanistic perspectives toward the ultimate goal of maximizing the "value added" in emergency logistics and related areas.

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