Developing Measurement of Emergency Relief Logistics and Operations Performance: An Empirical Study of Thailand Floods in 2011

Pairach Piboonrungroj
Logistics Systems Dynamics Group,
Cardiff Business School, United Kingdom
and
Chiang Mai School of Economics,
Chiang Mai University, Thailand

Thanawut Limpanitgul
Faculty of Management Sciences,
Kasetsart University, Si Racha Campus, Thailand

Contact Address:
Logistics Systems Dynamics Group,
Logistics and Operations Management Section
Cardiff Business School,
Cardiff University
Aberconway Building, Room D46
Colum Drive,
Cardiff, United Kingdom
CF10 3EU

Email:
me@pairach.com

Track: Operations, Logistics and Supply Chain Management

Word count: 1,199 words (excluding tables and references)

Developing Measurement of Emergency Relief Logistics and Operations Performance: An Empirical Study of Thailand Floods in 2011

Summary

Albeit emergency relief logistics is an emerging field in operations, logistics and supply chain management, the development of performance measurement is still limited. Although one of the objectives of emergency relief logistics is to satisfy customers (victims in the disaster) the development of performance measurement based on victim's perspective is limited. Then this study propose a measurement of emergency relief logistics performance and tested with an empirical data from the Thailand floods in 2011. We fit the propose measurement model with the data of 382 respondents using Confirmatory Factor Analysis with Mplus version 6 and R version 2.14.1. The result shows that the model is fit with the data. It was found that response had the highest contribution to the total performance, followed by preparedness and recovery respectively. The result also shows that information, operations and evacuation have different contribution to the performance of each stage.

1. Introduction

Recently there are several natural disasters around the world. Hence needs for humanitarian relief is highly required (Chang et al., 2007). However knowledge on managing humanitarian logistics for natural disaster cannot keep pace with the numbers of disasters (Chandes and Paché, 2010). Hence there are calls for research on emergency relief and humanitarian logistics (Kovac and Spens, 2011).

Emergency relief logistics is relatively a new subject area. Therefore there is limited research and study on this subject. Table 1 summarises the literature on humanitarian logistics and emergency relief for the disaster. It shows that most of the study were conceptual papers or literature review. Thus there is a need for an empirical study in the field . Therefore, this paper aims to propose a measurement of emergency relief logistics performance and tested with an empirical data. A case of Thailand floods in 2011 was selected due to its significance and data access.

In 2011 Thailand faced the worst floods in their history. The World Bank (2011) reported that the 2011 Thailand floods were "The biggest damages and losses were in the manufacturing sector, with a total of THB 1,007 Bn (USD 32 Bn approximately)". The tourism and agricultural sector were also affected and losses approximately THB 95 Bn (USD 3 Bn) and THB 40 Bn (USD 1.3 Bn) respectively (The World bank, 2011).

Table 1: Summary of Literature in Humanitarian logistics and Emergency Relief

Author(s)(year)	Topic	Method	Focus
Perry and Lindell (2003)	Emergency Planning Process	Literature review	Proposing 10 guideline for Emergency Planning Process
Özdama et al. (2004)	Vehicle routing problem in emergency logistics planning	Mathematical model	Proposing two multi-commodity network flow problem
Petit and Beresford (2005)	An evaluation of military, non-military and composite response model	Conceptual paper	A refine model for logistics requirement in emergency conditions.
Altay and Green (2006)	OR research in disaster operations management	Literature review	Four typical activities of disaster operations management (Mitigation, Preparedness, Response and Recovery)
Sheu (2007)	Emergency logistics distribution for quick response	Mathematical model with numerical result	Two recursive mechanism in the proposed methodology. disaster-affect are grouping and relief co-distribution
Beamon and Balcik (2008)	Performance measurement	Conceptual paper	Comparison of performance measurement in the humanitarian relief chain.
Kovács and Tatham (2009)	Performance	Literature review	Gender issue in humanitarian logistics performance

Schulz and Heigh (2009)	Performance management	Descriptive approach,	Conceptual development of logistics using process perspective. Four main development indicators; Customer service, Financial Control, Process adherence, and Innovation and Learning.
Tomasini and Van Wassenhove (2009)	Evolution of supply chain management in disaster relief	Literature review	Identified three research areas in humanitarian logistics (Preparedness, Response and Collaboration)
Banomyong and Sopadang (2010)	Emergency logistics response model	Monte Carlo simulation	Testing an proposed emergency logistics response for the case of Tsunami in Thailand with simulation
Chandes and Paché (2010)	Strategic action in humanitarian logistics	Literature review	Impact of collective approach in humanitarian logistics
Sheu (2010)	Relief-demand management	Mathematical model with numerical result	Dynamic relief-demand forecasting and allocation, emergency logistics operations.
Tatham and Petit (2010)	Supply Network Management in humanitarian logistics	Literature review, conceptual discussion	Challenge in humanitarian logistics research
Kovács and Spens (2011)	Trend and development in humanitarian logistics	Literature review using a gap analysis	Gaps within/between humanitarian logistics research, practice and eduction
Tatham and Houghton (2011)	Problem in humanitarian logistics and disaster relief aid	Literature review	How to manage wicked problem in humanitarian and disaster relief aid

2. Measurement model

Humanitarian relief logistics can be divided into three main elements of emergency relief logistics; (1) preparedness, (2) response, (3) recovery (Petit and Beresford, 2005). Hence we propose in the measure that there are three main aspect of the performance of the emergency relief logistics and operations for these three element. In each element, according to the interview with the flood victims, there are three aspects which are (i) information/communication, (ii) operations on mitigation, response and recovery, and (iii) evacuation. In each aspect we measure effectiveness , accuracy of information provided, reliability and availability (Beamon and Balcik, 2008). The conceptual framework of the three dimension of emergency relief logistics performance is shown in Figure1.
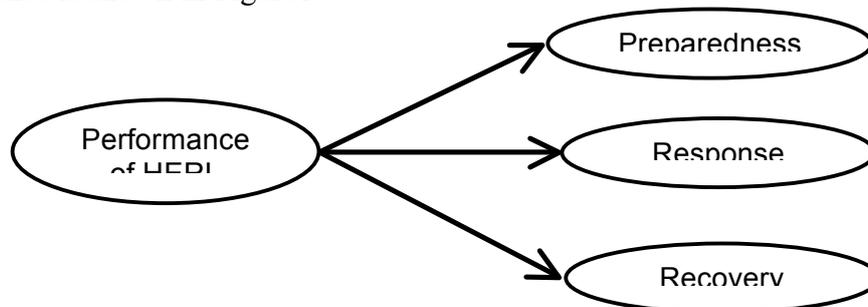
Figure 1: The conceptual framework of performance in Humanitarian Emergency Relief Logistics

3. Research Methodology

3.1. Measurement development

We developed the measure using the approach suggested by Churchill (1979). First we reviewed literature in disaster management and humanitarian logistics and supply chain management in order to cover all aspect of performance measurement of emergency relief logistics. Then, we asked 11 victims in 2011 Thailand floods and four academics to validate the measurement items.

3.2. Data collection

Data were from an online survey using self-administrated questionnaires. We randomly distribute the questionnaire to 382 potential flood victims. In the questionnaire we included a question to filter respondents so that the respondents were only those directly affected by the floods.

3.3. Analysis method

We tested the reliability of the data using Cronbach's alpha. We test the measurement using Confirmatory Factor Analysis (CFA). The goodness of fit of the model was assessed by a set of indicators i.e., Chi-square, CFI, TLI, RMSEA and SRMR (Hair et. al, 2010). We also addressed the issues of content validity, discriminant validity, convergent validity and common method bias. We used Mplus (Muthén and Muthén, 1998-2011) and R (R Development Core Team, 2012) to test the measurement model.

4. Results

4.1 Descriptive analysis

We randomly distribute the questionnaire to 382 potential flood victims. There were 57 respondents who were not affected by the floods. Finally we obtained 256 usable responses (response rate = 67.02%) from were subsequently analysed. Most of the respondents lived in Bangkok, the capital city of Thailand, (40%). The rest lived in Nonthaburi (18%) and Pathumthani (16%). Respondents lived in different types of house such as a detached house (46%, 37% in multiple floor and 9% in a single floor house) and townhouse (24%, 22% in a multiple floor and 2% in a single floor house). There are 41% of respondents who owned the house, 36% were residents and 6% rented the house. Considering the effects of floods, the majority of the respondents' house were flooded with the flood water level greater than one metre (73%). All respondents were directly affected by the 2011 floods. Table 2 present the summary of a profile of respondents in this study.

Table 2: Respondents' profile

Characteristics	Percentage
City	
• *Bangkok*	**40%**
• *Nonthaburi*	**18%**
• *Pathumthani*	**16%**
• *Other cities*	**26%**
Type of house	
• *Single-floor detached house*	**9%**
• *Multiple-floor detached house*	**37%**
• *Single-floor townhouse*	**2%**
• *Multiple-floor townhouse*	**22%**
• *Others*	**30%**
Status in the house	
• *Owner*	**41%**
• *Tenant*	**6%**
• *Resident*	**36%**
• *Others*	**17%**
Level of flood water	
• *< 10 cm. but Not affect the house*	**11%**
• *> 1 m. but Not affect the house*	**7%**
• *<10 cm. with flooded house*	**7%**
• *> 1 m. with flooded house*	**73%**
• *Others*	**2%**

4.2 Validity and Reliability

To address the potential problem of content validity, we asked independent experts in humanitarian logistics and emergency relief to validate the measurement (Hansfield, 2011). We also assess reliability of the data using Cronbach's alpha which refer to the contribution of the variation of items to their construct (latent variable). The result shows that Cronbach's alphas of every construct were greater than 0.9 which is greater the cut-off level of 0.7 (Hair et al., 2010). Thus the data used in the study are highly reliable.

4.3 Common method bias

As data were collected from a single respondent in the same survey, common methods variance amy be a problem. Hence we applied Harman's one-factor test to examine the possibility of the common method bias (Podsakoff and Organ, 1986). We ran a principal component factor analysis with all items in the model. The factor analysis result shows that 15 factors with 6.7% of the variance of the variables explained by the first extracted factor. This result means that there was neither evidence that a single factor emerged nor any factor explaining most of the variance. Therefore the common methods bias should not be a critical problem with the data in this study.

4.4 Measurement model

To test the measurement we develop in this paper, we used a Confirmatory Factor Analysis or CFA (Jöreskog, 1969) with survey data. The result from CFA yielded factor loadings (Jöreskog and Lawley, 1968) of each item that were greater than 0.9 (the cut-off level is 0.7) (see Table 3). Fit Indices of the model are acceptable , Chi Square / d.f. = 2.324, CFI = 0.921 ,TLI = 0.915, RMSEA = 0.072, SRMR = 0.063.

Table 3: Construct measures (α = Cronbach's alpha)

Dimension	Survey items	Factor Loading
A. Preparedness	Published information was …	(α = 0.96)
A1. Information and Communication	(1) Accurate.	0.814
	(2) On time.	0.830
	(3) Up to date.	0.833
	(4) Helpful to mitigate the risk of life.	0.941
	(5) Helpful to mitigate the risk of assets.	0.948
	(6) Useful to make a decision to evacuate.	0.912
A2. Mitigating operations	The prepared operations were …	(α = 0.96)
	(1) In time.	0.818
	(2) Sufficient.	0.874
	(3) Effective.	0.956
	(4) Cover all areas.	0.925
	(5) Consistent all the time.	0.890
A3. Evacuation	The evacuation was …	(α = 0.94)
	(1) In time.	0.933
	(2) Complete.	0.918
	(3) Effective.	0.841
	(4) Safe.	0.836
B. Response	Published information was ...	(α = 0.97)
B1. Information and Communication	(1) Accurate.	0.862
	(2) On time.	0.907
	(3) Up to date.	0.877
	(4) Helpful to mitigate the risk of life.	0.942
	(5) Helpful to mitigate the risk of assets.	0.942
	(6) Useful to make a decision to evacuate.	0.925
B2. Response operations	The prepared operations were …	(α = 0.97)
	(1) In time.	0.901
	(2) Sufficient.	0.885
	(3) Effective.	0.901
	(4) Cover all areas.	0.905
	(5) Consistent all the time.	0.869
	(6) Able to make me safe and healthy.	0.926
	(7) Able to secure my assets.	0.933
B3. Evacuation	The evacuation was …	(α = 0.93)
	(1) In time.	0.904
	(2) Complete.	0.910
	(3) Effective.	0.880
	(4) Safe.	0.829
C. Recovery	Published information was ...	(α = 0.96)
C1. Information and Communication	(1) Accurate.	0.876
	(2) On time.	0.898
	(3) Up to date.	0.901
	(4) Helpful to mitigate the risk of life.	0.886
	(5) Helpful to mitigate the risk of assets.	0.922
	(6) Useful to make a decision to evacuate.	0.895
	(7) Helpful to claim for subsidies & help.	0.785
C2. Mitigating operations	The prepared operations were …	(α = 0.96)
	(1) In time.	0.876
	(2) Sufficient.	0.904
	(3) Effective.	0.869
	(4) Cover all areas.	0.921
	(5) Consistent all the time.	0.909
	(6) Quick.	0.780
	(7) Complete.	0.770

C3. Evacuation	The evacuation was …	(α = 0.96)
	(1) In time.	0.921
	(2) Complete.	0.941
	(3) Effective.	0.969
	(4) Safe.	0.874

5. Conclusion

Albeit emergency relief logistics is an emerging field in operations, logistics and supply chain management, the development of performance measurement is still limited. Although one of the objectives of emergency relief logistics is to satisfy customers (victims in the disaster) the development of performance measurement based on victim's perspective is limited. Then this study propose a measurement of emergency relief logistics performance and tested with an empirical data from the Thailand floods in 2011. The result shows that the model is fit with the data. It was found that response had the highest contribution to the total performance, followed by preparedness and recovery respectively. The result also shows that information, operations and evacuation have different contribution to the performance of each stage.

Figure 2: Results of Third-order Confirmatory Factor Analysis
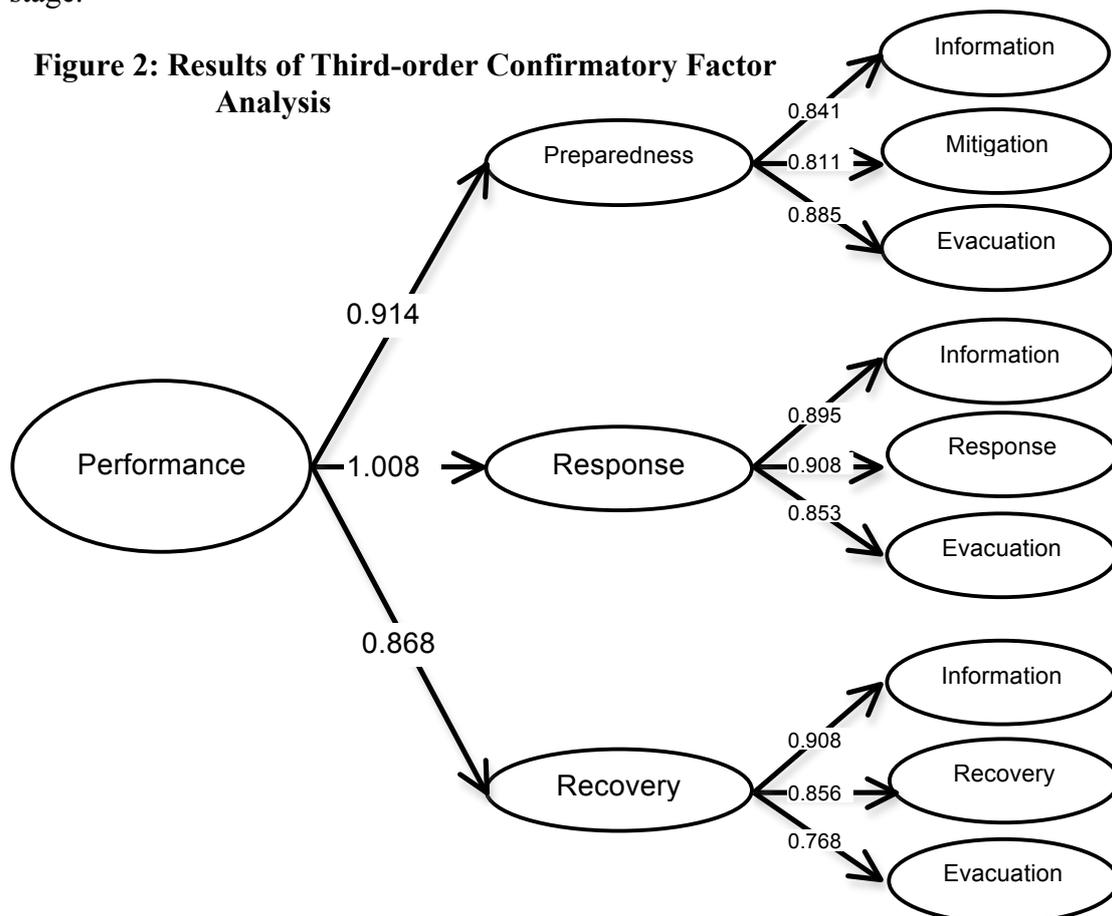
6. Plan to develop the paper

Based on the results of this study, we plan to examine the factors affecting performance in emergency relief logistics. This could contribute to the development of the general theory on performance measurement in humanitarian emergency relief logistics. To do so we will utilise the data we collected from the survey to test for significance of potential factors. Then we will conduct a national survey to test the structural relationships between those factors and performance of the humanitarian emergency relief logistics. Hence we can propose the hypotheses on the relationships. We will test the hypotheses with a Structural Equation Model (SEM).

References

Altay, N. and Green III, W.G. (2006) OR/MS research in disaster operations management. *European Journal of Operational Research*, 175(1), pp. 475-493.

Banomyong, R. and Sopadang. 2010. Using Monte Carlo simulation to refine emergency logistics response models: a case study. *International Journal of Physical Distribution & Logistics Management*, 40(8/9), pp. 709-721.

Chandes, J. and Paché. 2010. Investigating humanitarian logistics issues: from operations management to strategic action. *Journal of Manufacturing Technology and Management*, 21(3), pp. 320-340.

Chang, M.S., Tseng, Y.L., Chen, J.W. 2007. A scenario planning approach for the flood emergency logistics preparation problem under uncertainty. *Transportation Research Part E*, 43 (6), pp. 737–754.

Churchill, G.A. 1979. A paradigm for developing better measures of marketing constructs. *Journal of Marketing Research,* 16(1), pp. 64-73.

Hair, J.F., Black, W.C., Babin, B.J. and Anderson, R.E. 2010, *Multivariate Data Analysis: A Global Perspectives*. 7th ed., London: Pearson.

Handfield, R. 2011. The reviewers hated it! What to do when your result won't added up", *Journal of Supply Chain Management*, 47(4), pp. 11-16.

Jöreskog, K.G. 1969. A general approach to confirmatory maximum likelihood factor analysis. *Psychometrika*, 34(2), pp. 183–202.

Jöreskog, K.G., and Lawley, D.N. 1968. New methods in maximum likelihood factor analysis. *British Journal of Mathematical and Statistical Psychology*, 21(1), pp. 85-96.

Kovács, G. and Spens, K.M. 2011. Trends and developments in humanitarian logistics - a gap analysis. *International Journal of Physical Distribution & Logistics Management*, 41(1), pp. 32-45.

Kovács, G. and Peter Tatham, P. 2009. Humanitarian logistics performance in the light of gender, *International Journal of Productivity and Performance Management*, 58(2), pp.174 – 187.

Muthén, L. K., & Muthén, B. O. (1998-2011). *Mplus User's Guide*. Sixth Edition. Los Angeles, CA: Muthén & Muthén.

Özdama, L., Ekinci, E. and Küçükyazici, B. 2004. Emergency Logistics Planning in Natural Disasters. *Annals of Operations Research*, 129(1-4), pp. 217–245,

Perry, R.W. and Lindell, M.K. 2003. Preparedness for Emergency Response: Guidelines for Emergency Planning Process. *Disaster*, 23(7), pp. 336-350.

Petit, S. and Beresford, A. 2005. Emergency relief logistics: an evaluation of military, non-military and composite response models. *International Journal of Logistics Research and Applications*, 8(4), pp. 313-331.

Podsakoff, P.M. and Organ, D.W. 1986. Self-reports in organizational research: problems and prospects. *Journal of Management*, 12(4), pp. 531-44.

R Development Core Team. 2012. *R: A Language and Environment for Statistical Computing'. R Foundation for Statistical Computing*, [Online]. Available at: <http://R-roject.org> [assessed on 11 November 2011].

Schulz, S.F. and Heigh, I. 2009. Logistics performance management in action within a humanitarian organization. *Management Research News*, 32(11), pp. 1038-1049.

Sheu, J-B. 2007. An emergency logistics distribution approach for quick response to urgent relief demand in disasters. *Transportation Research Part E*, 43(6), pp. 687-709.

Sheu, J-B. 2010. Dynamic relief-demand management for emergency logistics operations under large-scale disasters. *Transportation Research Part E*, 46(1), pp.1-17.

Tatham, P. and Houghton, L. 2011. The wicked problem of humanitarian logistics and disaster relief aid. *Journal of Humanitarian Logistics and Supply Chain Management*, 1(1), pp. 15-31.

Tatham, P.H. and Petit, S.J. 2010. Transforming humanitarian logistics: the journey to supply network management. *International Journal of Physical Distribution & Logistics Management*, 40(8/9), pp. 609-622.

The World Bank. 2011. *The World Bank Supports Thailand's Post-Floods Recovery Effort*. [Online]. Available at: <http://go.worldbank.org/TCFEHXJML0> [assessed on 14 February 2012].

Tomasini, R.M. and Van Wassenhove, L.N. 2009. From preparedness to partnerships: case study research on humanitarian logistics. *International Transactions in Operational Research*, 16(5), pp. 549-559.