PERFORMANCE ASSESSMENT SCHEME FOR DISASTER RELIEF OPERATIONS

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DEDICATION

Especially dedicated to my wife for her kindness and love.

To my father and mother for their support.

To the memory of my grandfather, Mohammad Rostami, who was my first teacher instilling in me the passion to learn.

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ABSTRACT

The significant growth of natural disasters, together with the declining financial support from governments, and the increasing competition for scarce donations have heightened the need for transparency and accountability in disaster relief operations. As important as it is, majority of humanitarian organizations merely report their performance achievement by annual financial reports which provide insufficient information about operational transparency and effectiveness. Performance assessment of disaster relief operations is challenging due to the complexity of field operations, operational constraints, unreliable and imprecise information. As a result, most humanitarian organizations have limited information, awareness, skill, and technological necessities to formulate and implement suitable performance assessment scheme. Existing performance measurement frameworks are largely theoretical and are ill-equipped in dealing with fuzzy and imprecise information. They also lack an overall integrated performance score that incorporates both financial and non-financial performance indicators. This necessitates a thorough investigation to formulate an improved performance assessment scheme based on relevant performance indicators. In this research, the objective is to formulate a performance assessment scheme for disaster relief operations. Data was gathered based on the case study method using questionnaire survey and direct interviews with the logistic practitioners from prominent Malaysian based humanitarian organizations. A conceptual model for disaster relief operations performance indicators and their causal interrelationships based on Balanced Scorecard (BSC) perspectives were developed to establish a foundation for the performance assessment. This causal model clustered performance indicators into the four BSC's perspectives, namely beneficiaries and donors, internal processes, financial, and learning and innovation. The model provides an overall view of the related performance indicators and their interdependencies. Then, the Analytical Hierarchy Process (AHP) was employed to establish the weight and priority of the performance indicators. The outcomes of AHP analysis serve as inputs to a multistage fuzzy inference system. This system addresses uncertain and imprecise input data for performance measurement. The proposed approach integrates multiple performance indicators and provides an overall performance score for individual BSC's perspectives as well as a global performance score. As a proof-of-concept, a prototype demonstrator was developed using MATLAB. The flexibility of the method allows decision-makers to address the complexity in the performance assessment for disaster relief operations. The fuzzy inference scheme provides better flexibility compared to the AHP scheme. The utility of the fuzzy inference scheme lies in its ability to support decision making in surmounting the challenges posed by the complexity of performance evaluation with respect to imprecise performance data. The proposed performance assessment schemes collectively guide decision-makers about important and relevant criteria for performance assessment in disaster relief operations, facilitates a more detailed and multi-dimensional performance assessment of relief operations, and suggests performance indicators that decision-makers should focus for operational performance improvement.

ABSTRAK

Peningkatan signifikan bilangan bencana alam, dicampur dengan penurunan sokongan kewangan dari kerajaan, dan peningkatan persaingan untuk memperoleh sumbangan yang terhad telah meningkatkan keperluan bagi ketelusan dan akauntabiliti dalam operasi bantuan bencana. Walaupun penting, kebanyakan organisasi kemanusiaan hanya melaporkan pencapaian prestasi mereka dengan laporan kewangan tahunan yang tidak menyediakan maklumat yang cukup mengenai ketelusan dan keberkesanan operasi. Penilaian prestasi operasi bantuan bencana adalah mencabar kerana kerumitan operasi lapangan, kekangan operasi, maklumat yang tidak boleh dipercayai dan tidak tepat. Akibatnya, kebanyakan organisasi kemanusiaan mempunyai maklumat, kesedaran, kemahiran dan keperluan teknologi yang terhad untuk merumuskan dan melaksanakan skim penilaian prestasi yang sesuai. Rangka kerja pengukuran prestasi sedia ada adalah kebanyakannya teoretikal dan tidak lengkap untuk menangani maklumat kabur dan tidak tepat. Mereka juga tidak menyediakan skor prestasi bersepadu yang menyatukan penunjuk prestasi kewangan dan bukan kewangan. Ini memerlukan kajian menyeluruh untuk merumuskan suatu skim penilaian prestasi yang lebih baik berdasarkan petunjuk prestasi yang relevan. Dalam penyelidikan ini, objektifnya adalah untuk merangka skim penilaian prestasi yang lebih baik bagi operasi bantuan bencana. Maklumat telah dikumpul berdasarkan kaedah kajian kes menggunakan kajian soal selidik dan wawancara langsung dengan pengamal logistik dari organisasi kemanusiaan terkemuka yang berpangkalan di Malaysia. Suatu model konsep penunjuk prestasi operasi bantuan bencana dan hubungan antara penyebab berdasarkan perspektif Kad Skor Seimbang (BSC) telah dibangunkan untuk menubuhkan asas bagi penilaian prestasi. Model penyebab ini mengumpulkan penunjuk prestasi ke dalam empat perspektif BSC, iaitu penerima dan penderma, proses dalaman, kewangan, dan pembelajaran dan inovasi. Model ini menyediakan suatu pandangan menyeluruh tentang penunjuk prestasi yang berkaitan dan kebergantungan mereka. Kemudian, Analytic Hierarchy Process (AHP) digunakan untuk membangunkan pemberat dan keutamaan penunjuk prestasi. Hasil analisis AHP berfungsi sebagai input kepada sistem kesimpulan kabur pelbagai tahap. Sistem ini menangani data input yang tidak pasti dan tidak tepat untuk pengukuran prestasi. Pendekatan yang dicadangkan menggabungkan pelbagai penunjuk prestasi dan memberikan skor prestasi bagi setiap perspektif BSC serta skor prestasi keseluruhan. Sebagai bukti-konsep, prototaip penunjuk ajar telah dibangunkan dengan menggunakan MATLAB. Fleksibiliti kaedah ini membolehkan pembuat keputusan menangani kerumitan dalam penilaian prestasi untuk operasi bantuan bencana. Skim kesimpulan kabur ini memberikan fleksibiliti yang lebih baik berbanding dengan skim AHP. Kegunaan skim kesimpulan kabur terletak pada keupayaannya untuk menyokong proses membuat keputusan dan mengatasi cabaran dalam kerumitan penilaian prestasi yang melibatkan data prestasi yang tidak tepat. Skim penilaian prestasi yang dicadangkan secara kolektif membimbing pembuat keputusan tentang kriteria penting dan relevan untuk penilaian prestasi dalam operasi bantuan bencana, memudahkan penilaian prestasi operasi bantuan yang lebih terperinci dan pelbagai dimensi, dan mencadangkan petunjuk prestasi yang harus difokus oleh pembuat keputusan bagi penambahbaikan prestasi operasi.

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LIST OF ABBREVIATIONS

AHP	-	Analytic Hierarchy Process
ANP	-	Analytic Network Process
BSC	-	Balanced Scorecard
BRC	-	Building Resilient Communities
CSF	-	Critical Success Factor
CSR	-	Corporate Social Responsibility
CBDRM		Community-Based Disaster Risk Management
DEMATEL	-	Decision-Making Trial and Evaluation Laboratory
FL	-	Fuzzy Logic
FIS	-	Fuzzy Inference System
GUI	-	Graphical User Interface
HROs	-	Humanitarian Relief Organizations
IFRC	-	International Federation of Red Cross and Red Crescent Societies
IPA	-	Importance-Performance Analysis
IATI	-	International Aid Transparency Initiative
KPI	-	Key Performance Indicator
SCOR	-	Supply Chain Operations Reference
MCDM		Multiple Criteria Decision-Making
NGO	-	Non-Governmental Organization
NSC	-	National Security Council
PMS	-	Performance Measurement System
PROMETHEE	-	Preference Ranking Organisation METHod for Enrichment Evaluations
TOPSIS	-	Technique for order of preference by similarity to ideal Solution
UNHRD	-	United Nations Humanitarian Response Depot

LIST OF SYMBOLS

a_{ij}	-	Relative importance of two compared elements (i and j)
W	-	Eigen vector
W_i	-	Eigenvalue of the given matrix
$\lambda_{\max}$	-	The largest *eigenvalue* of a pair-wise comparison matrix
CR	-	Consistency Ratio
CI	-	Consistency Index
RI	-	Random Index
GPS_{ij}	-	Global priority score of the alternative
$\mathrm{CW}_{\mathrm{ij}}$	-	Local weight of the alternative with respect to criteria
GW_{ij}^{c}	-	Global weight of the criteria
b_1	-	Crisp performance score for beneficiaries and donors perspective
f_1	-	Crisp performance score for financial perspective
i_1	-	Crisp performance score for internal processes perspective
l_1	-	Crisp performance score for learning and innovation perspective
$\mu_{\tilde{A}}(x)$	-	Membership of x in fuzzy set $\tilde{A}$

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Over the last decade, efficiency of supply chain operations in disasters relief have become increasingly important due to significant growth of the scale and complexity of natural disasters coupled with declining financial support from authorities and rising competition for scarce donations (Santarelli *et al.*, 2015; Ergun *et al.*, 2010; Van Wassenhove, 2006; Kovács and Spens, 2007). Humanitarian Relief Organizations (HROs) are increasingly being scrutinized to increase their transparency and accountability of their operations (Haavisto and Goentzel, 2015; Development Initiatives, 2017). There is a growing concern about the utilization of funds in HROs. Donors ask HROs to deliver aid in efficient and cost-effective ways in order to ensure that their money makes the best possible impact in disaster relief and assisting beneficiaries.

Researchers have acknowledged that to improve the efficiency and transparency of disaster relief operations, performance of operational activities such as logistics and supply chain operations should be evaluated (D'Haene *et al.*, 2015; Beamon and Balcik, 2008; Abidi *et al.*, 2014). Measuring performance of humanitarian relief chains is central to the enhancing transparency, accountability, and operational improvement schemes (Santarelli *et al.*, 2015; Haavisto and Goentzel, 2015; Abidi *et al.*, 2014).

As important as it is, unfortunately HROs are facing considerable challenges and complexities in performance assessment and development of suitable Performance Measurement System (PMS). In practice, most HROs do not evaluate their supply chain performance and some have limited information, awareness, human resources, and technological necessities to develop and implement suitable performance

measurement scheme (Blecken, 2010; Abidi *et al.*, 2014). Common reasons for this limited practice of performance evaluation are: complexity of field operations (Van Wassenhove, 2006), imprecise and incomplete information (Abidi *et al.*, 2014; Tofighi *et al.*, 2016), and limited information technology capacity and infrastructure (Davidson, 2006; Van der Laan *et al.*, 2009b). In general, besides endogenous factors which relate to the way operations are managed, exogenous situational and operational factors (i.e. government, socio-economic, and infrastructure) impede the performance of disaster relief operations (Kunz and Reiner, 2012; Dube *et al.*, 2016).

As a result, many HROs have merely focused on traditional accounting-based performance assessment schemes by reporting performance indicators that are mainly related to the financial inputs and outcomes such as donations, expenditures, operating expense in their annual report (D'Haene *et al.*, 2015). While financial performance indicators are essential for making strategic decisions and external reporting to constituencies and donors, performance indicators related to efficiency of the utilization of funds on warehouse and logistics operations, and employees development provide a more transparent and accurate performance assessment in humanitarian operations (D'Haene *et al.*, 2015; Santarelli *et al.*, 2015).

Nonetheless, HROs have gradually started recognizing a need for theoretical and empirical research that could provide insights into suitable performance assessment schemes that incorporate financial and non-financial performance criteria (Haavisto and Goentzel, 2015). There is a need for performance assessment approaches in order to support decisions in the complex and uncertain humanitarian relief environment. This is evident as an increasing number of studies have recently pointed out the necessity of development of multi-dimensional performance evaluation approaches in humanitarian relief operations (Abidi and Scholten, 2015; D'Haene *et al.*, 2015; Santarelli *et al.*, 2015; De Leeuw, 2010; Haavisto and Goentzel, 2015). As a result, researchers have been trying to adapt established performance measurement frameworks and models from the industrial and supply chain domain to the disaster relief sector (Lu *et al.*, 2016; Schiffling and Piecyk, 2014). For example, an increasing number of studies have adopted Balanced Scorecard (BSC), a well-established PMS in the commercial and supply chain domain, to the humanitarian relief operations

performance assessment (Moe *et al.*, 2007; Schulz and Heigh, 2009; Widera and Hellingrath, 2016; Schiffling and Piecyk, 2014; De Leeuw, 2010).

While existing works provided insights into possible examples of performance measurement frameworks and systems in humanitarian relief operations, they are largely theoretical and are ill-equipped in dealing with inherently uncertain and imprecise performance evaluation situations. In humanitarian relief operations, assessment models and systems require inputs based on decision-makers and practitioners experience and knowledge towards performance indicators which are generally qualitative, imprecise and fuzzy. The information required for a decision often might not be precise and accurate in humanitarian relief chains (Van Wassenhove and Pedraza Martinez, 2012; Van Wassenhove, 2006). Uncertainty in decision parameters is one of the most challenging and important problems in disaster relief operations (Öztaysi *et al.*, 2013; Liberatore *et al.*, 2013).

Performance assessment in humanitarian relief operations adheres to uncertain and imprecise information (Van Wassenhove, 2006; Van Wassenhove and Pedraza Martinez, 2012; Abidi *et al.*, 2014). Much of the information related to performance indicators in humanitarian relief operations is not precise (Tofighi *et al.*, 2016; Ganguly *et al.*, 2017; Lu *et al.*, 2016; Abidi *et al.*, 2013, 2014). Existing PMSs and models are based on techniques which are not able to address uncertainty and imprecision in input data. In practice, with few exceptions, existing PMSs and models in humanitarian relief operations are theoretical and not adequately flexible to be applied in a practical and managerially useful manner.

There is a need for a performance assessment scheme that considers imprecision in input data and aggregates different dimensions of performance into a multi-dimensional scheme. A performance assessment scheme focuses on structured procedures for performance evaluation of disaster relief operations relying on financial and non-financial performance indicators. In developing a performance assessment scheme, decision-makers are exposed to uncertainty regarding the determination of relevance and importance of performance indicators and integrating these indicators into an overall score. This thesis aims to address a practical approach to the

performance evaluation of humanitarian relief operations by recognizing a need for multi-dimensional performance assessment and dealing with imprecision and uncertainty in performance evaluation processes.

1.2 Problem Statement

This research is motivated by the need for a systematic and practical performance measurement approach to aid decision-making regarding performance evaluation of humanitarian relief operations. Performance measurement in humanitarian relief operations is a complex multi-criteria decision-making problem. Reviewed literature indicates that existing performance measurement approaches are limited to structural frameworks and provide limited information on how to evaluate the performance of humanitarian relief operations (Schiffling and Piecyk, 2014; Lu *et al.*, 2016; Santarelli *et al.*, 2015). Existing studies focused on proposing relevant performance indicators and answered questions that often relate to what to measure in humanitarian relief operations (Abidi *et al.*, 2014; De Leeuw, 2010). These studies have not adequately investigated issues related to how to evaluate disaster relief operational performance.

Previous works did not address the complexities associated with multi-dimensional performance evaluation with respect to uncertain and imprecise performance measures data. The lack of performance assessment scheme addressing the uncertainty of the performance evaluation data is a deficiency in the extant literature which is to be addressed by this study. The major challenges are to determine the prominent performance criteria and to evaluate humanitarian relief operations performance with respect to multiple indicators that are usually incommensurable and imprecise.

1.3 Research Questions

This research aims at answering the following research questions:

i) What is the current state of research trends in the humanitarian relief operations performance evaluation?
ii) How to determine a relevant set of performance indicators in humanitarian relief operations and establish a classification for these indicators?
iii) How to develop a performance assessment scheme that incorporates multi-dimensional performance indicators?
iv) How to develop a performance assessment scheme that considers uncertainties and impreciseness of performance measurement parameters?

1.4 Research Objectives

The purpose of this thesis is to develop a performance assessment scheme that addresses uncertainty in performance evaluation of humanitarian relief operations. To achieve the aim of this study the following objectives were addressed:

i) To determine a relevant set of performance indicators in disaster relief operations and establish classifications and causal relationships for these indicators.

ii) To formulate a performance assessment scheme that incorporates multi-dimensional performance indicators.

iii) To develop a fuzzy inference performance assessment scheme to address uncertainty and imprecision in decision-making.

1.5 Research Scope

i) This research scope and its findings are limited to the international disaster relief organizations in Malaysia. Thus, performance indicators and their importance were studied in the context of the prominent international disaster relief organizations in Malaysia.
ii) The focus of the study is on the performance assessment of disaster relief operations.
iii) The performance assessment data are limited to qualitative and descriptive information.

1.6 Significance of the Research

The rising concern regarding the transparency and accountability in humanitarian relief have heightened the need for performance assessment of relief operations. There is an increasing pressure on HROs to be accountable toward donors and regarding the utilization of funds. Performance assessment is central to addressing transparency and accountability in humanitarian relief operations. Nonetheless, in practice performance assessment of humanitarian relief operations is complex and HROs often face a considerable amount of technical and economic challenges to demonstrate the efficiency and effectiveness of their programs.

This study proposes three complementary contributions to the performance evaluation of humanitarian relief operations. The general forms of these contributions are (i) a BSC that entails detailed categories of the performance indicators and their interdependencies in humanitarian relief operations, (ii) an AHP-based performance assessment scheme focusing on importance weights of performance indicators, and (iii) a fuzzy inference performance assessment scheme that addresses uncertainty and imprecision in performance evaluation of humanitarian relief operations. These approaches complement each other and are integrative. Scant studies have been carried out in the above areas in disaster relief operations. From a theoretical aspect, this

research proposes a performance assessment approach based on multiple financial and non-financial performance criteria and proposes a multi-criteria performance assessment scheme. It enables evaluation based on imprecise performance ratings, which is a challenge in disaster relief performance assessment.

1.7 Definition of Terms

This thesis uses a number of important terms consistently throughout the chapters. Below is a list of the frequently used terms and their definition adopted in this thesis:

- Performance Assessment

  Performance assessment can be defined as the process of quantifying the efficiency and effectiveness of action (Neely *et al.*, 1995).

- Performance Assessment System

  A performance assessment system can be defined as the set of metrics used to quantify both the efficiency and effectiveness of actions (Neely *et al.*, 1995).

- Balanced Scorecard

  The balanced scorecard is a multi-dimensional performance assessment system that includes four constructs, namely; (i) Customers, (ii) Internal business processes, (iii) Financial, and (iv) Learning and innovation.

- Fuzzy Logic

  Fuzzy logic is a reasoning system in which the objects of reasoning and computation are classes with unsharp boundaries (Zadeh, 2015).

- Fuzzy Inference System

A Fuzzy Inference System (FIS) is a rule-based system where fuzzy logic theory is used for representing knowledge about the problem and for modeling the relationships between variables (Kacprzyk and Pedrycz, 2015).

- Uncertainty

  Uncertainty is the condition in which the possibility of an error exists, because we have less than complete information about our environment (Klír *et al.*, 1997).

- Scheme

  Scheme refers to a structured procedure for performance evaluation of disaster relief operations based on multiple financial and non-financial performance indicators.

- Disaster Relief Operations

  Disaster relief operations refer to a wide array of activities that contribute to the cost-effective mobilization of relief assistance and provision of life-saving services to victims of disasters.

1.8 Structure of the Thesis

This thesis includes nine chapters. Figure 1.1 shows the outline of this thesis. Chapter 1 introduces the background of the study. Chapter 2 provides a review of the complexity of performance assessment in the humanitarian relief operation, research trends in supply chains performance evaluation, trends and issues in performance measurement in disaster relief operations that this study aims to address. Chapter 3 explains the methodology of this research. Chapter 4 provides a detailed discussion of related performance indicators and their interdependencies. This chapter provides an overall perspective of disaster relief operations performance indicators based on BSC and sets a basis for the remaining chapters. Chapter 5 discusses the development of an AHP-based performance assessment scheme. Chapter 6 elaborates on the development

of a fuzzy inference performance assessment scheme that addresses uncertainty in the performance evaluation of disaster relief operations. Chapter 7 focuses on the evaluation of the developed fuzzy inference performance assessment using the developed prototype. Chapter 8 focuses on the discussion of the results in light of current approaches for performance evaluation of humanitarian relief operations. This chapter outlines the managerial implications of this research. Chapter 9 concludes this thesis with a summary of the entire research and suggests future works.

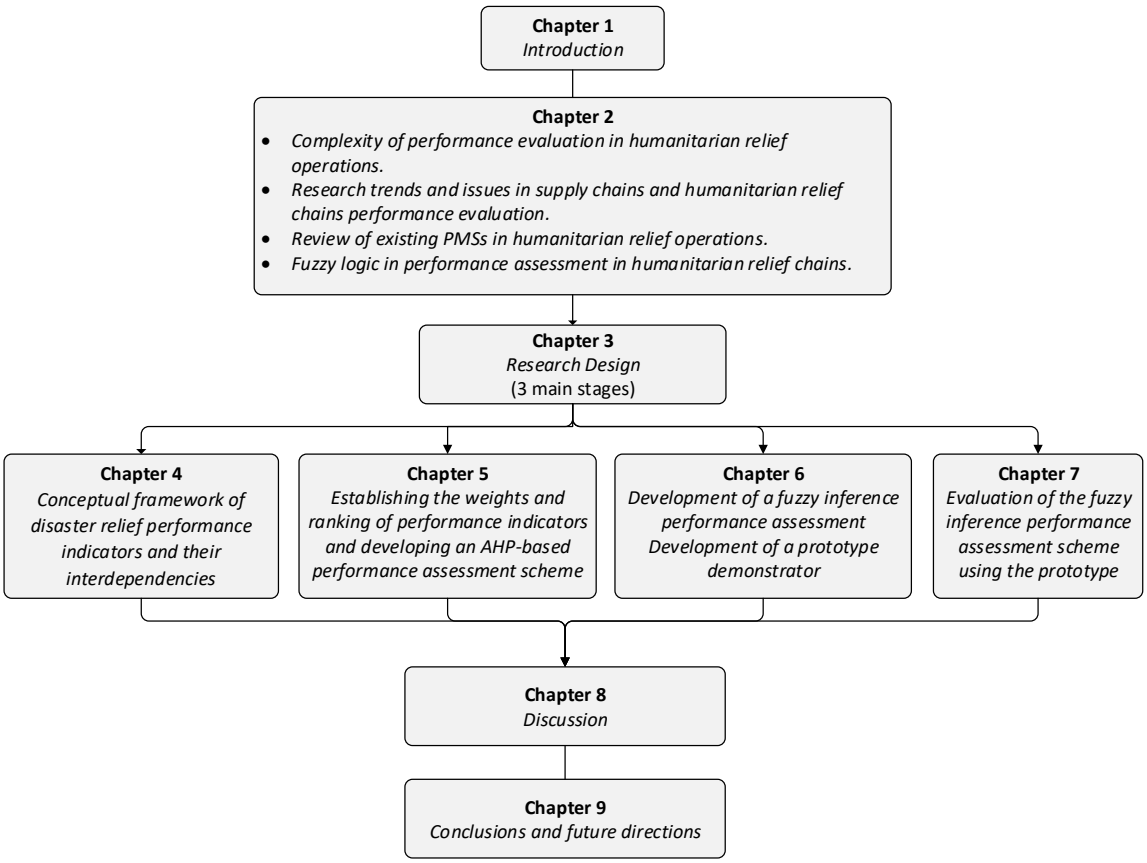

Figure 1.1 Outline of the thesis

1.9 Summary

This chapter highlighted important research issues and questions related to the performance evaluation of humanitarian relief operations. The chapter outlined key

objectives within the scope of this research. It has been emphasized that there is a need for further studies that provide useful insights for classification, prioritization, and addressing uncertainty in performance evaluation of humanitarian relief operations. The chapter highlighted important terms that were used frequently in the thesis and concluded with an outline of the entire structure of this thesis.

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Appendix J. Publications and Award

(a) **Published Scopus Indexed Journal**

1. Anjomshoae, A., Hassan, A., Kunz, N., Wong, K.Y. and Leeuw, S. de (2017), "Toward a dynamic balanced scorecard model for humanitarian relief organizations' performance management", *Journal of Humanitarian Logistics and Supply Chain Management*, Vol. 7 No. 2, pp. 194–218.

2. Ali Anjomshoae, Adnan Hassan, Kuan Yew Wong, (2019) "An integrated AHP-based scheme for performance measurement in humanitarian supply chains", International Journal of Productivity and Performance Management, Vol. 68 Issue: 5, pp.938-957, https://doi.org/10.1108/IJPPM-04-2018-0132.

(b) **Drafted Journal Papers (to be submitted)**

1. Anjomshoae, A., Hassan, and Wong, K.Y. (2019), "An integrated fuzzy inference performance assessment scheme in humanitarian relief operations".

2. Anjomshoae, A., Hassan, A., Kunz, N., and Wong, K.Y. (2019), "A system dynamics model for interdependencies of strategic operations in the humanitarian relief".

(c) **Awards**

1. Emerald Literati Award (Emerald, 2018).