CLIMATE CHANGE IMPACTS ON PORTS AND PORT ADAPTATION

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The Background

According to the main outcomes and summary of discussions of the *Ad Hoc* Expert Meeting on Climate Change Impacts and Adaptation: A Challenge for Global Ports (organized by UNCTAD, 29-30 September 2011), there is a general lack of (and urgent need for the development of):

- Generally-accepted methodologies in assessing the impacts of climate change on port operation and activities

- Understandings on the experiences and approaches of ports adapting (and planning) to the (potential) risks and challenges posed by climate change, especially in developing countries

The Background

According to reports on climate change and adaptation undertaken by the USA's National Research Council (NRC), efforts so far have focused on mitigation and the technical details of engineering projects, e.g., dykes, elevation, levees, etc. Adaptation is still not well understood, especially in reducing uncertainty in decision-making, climate policy and institutional practice.

- NRC (2010): *Adapting to the Impacts of Climate Change*. National Academies Press, Washington, DC.

- NRC (2010): *Advancing the Science of Climate Change*, National Academies Press, Washington, DC.

Aims and Objectives

- To conduct case studies on climate change and port's adaptation planning, and generalize experiences from them, so as to identify and improve the 'international best practices'

- To develop a generally-accepted methodology to assess potential risks posed by climate changes on port operation and management

- To understand the relationship between institutional/political systems and the process of port adaptation planning to climate change impacts, so as to improve the decision-making process

Research Collaboration (2012-13)

- Department of Supply Chain Management, I.H. Asper School of Business, University of Manitoba, Canada

- National Centre for Ports and Shipping, Australian Maritime College, University of Tasmania, Australia

- Liverpool Logistics, Offshore and Marine Research Institute (LOOM), Liverpool John Moores University, UK

- Center for Integrated Facility Engineering, Stanford University, USA

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Scholarly Outputs (so far)

- Ng, A.K.Y., Becker, A. and Fischer, M. (2013): 'A theoretical discussion on climate change, port adaptation and institutions'. *Proceedings of Canadian Transportation Research Forum (CTRF) 2013*, Halifax, NS, Canada, 10-12 June.

- Ng, A.K.Y., Chen, S.L., Cahoon, S., Brooks, B. and Yang, Z. (in press): 'Climate change and the adaptation strategies of ports: the Australian experiences'. *Research in Transportation Business and Management* (available online, doi: 10.1016/j.rtbm.2013.05.005).

- Ng, A.K.Y., Yang, Z., Cahoon, S., Chen, S.L., Becker, A. and Fischer, M. (2013): 'Analyzing risk posed by climate change on ports using a fuzzy approach'. *Proceedings of the IAME 2013 Conference*, Marseille, France, 3-5 July.

- *(Another paper on "institutions and climate change adaptation planning", based on a case study in a North American port along the Pacific coastline, is currently under review in a scholarly journal)*

Scholarly Outputs (so far)

Presentation for:

Ng, A.K.Y., Yang, Z., Cahoon, S., Chen, S.L., Becker, A. and Fischer, M. (2013): 'Analyzing risk posed by climate change on ports using a fuzzy approach'. *Proceedings of the IAME 2013 Conference*, Marseille, France, 3-5 July.

Session:	3.B.2 - Green Management in Shipping and Ports
Date:	5 July 2013 (Fri)
Time:	11:00 a.m.
Venue:	Room Estaque

Using of Fuzzy set in risk analysis

- Identify risk parameters
  - Likelihood (L)
  - Severity of Consequent (S)
  - Time Frame (T)

- Define fuzzy set membership functions for the risk parameters

It is obviously possible to have some flexibility in the definition of linguistic variables and their membership functions to suit different situations.

Using of Fuzzy set in risk analysis

- Calculate fuzzy risk score S
  - $R=C^{\circ}(L\times T)$
  - $\mu_R = \mu_R = \mu_{C^{\circ}(L\times T)}$

where $\mu^{ij}_{LxT} = \min(\mu^i_L, \mu^j_T)$, both i and j = 1, 2, …, 7 and $\mu^j_R = \max(\min(\mu^1_C, \mu^{1j}_{L\times T}), \min(\mu^2_C, \mu^{2j}_{L\times T}), \ldots, \min(\mu^7_C, \mu^{7j}_{L\times T}))$, both i and j = 1, 2, ..., 7.

- Risk score transformation to safety expressions

  Define safety expressions using the risk parameters, for example,

  $R_{Poor} = C_{Catastrophic}{}^{\circ}(L_{Very\ high}\times T_{Very\ short})$

Safety expressions

Linguistic terms	0	1/6	1/3	Probability 1/2	2/3	5/6	1
Poor	**0**	**0**	**0**	**0**	**0**	**0.75**	**1**
Fair	**0**	**0**	**0**	**0**	**0.75**	**0.25**	**0**
Average	**0**	**0**	**0.25**	**1**	**0.25**	**0**	**0**
Good	**0**	**0.25**	**0.75**	**0**	**0**	**0**	**0**
Excellent	**1**	**0.75**	**0**	**0**	**0**	**0**	**0**

Using of Fuzzy set in risk analysis

- Match the risk score obtained with the safety expressions using a Best-fit method

$$d_i(R_i, Poor) = \left[\sum_{k=1}^{7}(\mu_{R_i}^k - \mu_{Poor}^k)^2\right]^{1/2}$$

$$\alpha_{ij} = \frac{1/d_{ij}}{\sum_{j=1}^{5} 1/d_{ij}}$$

$S(R_i)$= {(α_{i1}, "*Poor*"), (α_{i2}, "*Fair*"), (α_{i3}, "*Average*"), (α_{i4}, "*Good*"), (α_{i5}, "*Excellent*")}

- Rank the safety evaluation

  Use the categories and membership values to obtain the relative weights of different safety expressions.

$[w_p, w_f, w_a, w_g, w_g]$= [0.079,0.315, 0.539, 0.764, 1

- Calculate numerical risk degrees

$P_{S(Ri)} = \alpha_{i1}\times 0.079 + \alpha_{i2}\times 0.315 + \alpha_{i3}\times 0.539 + \alpha_{i4}\times 0.746 + \alpha_{i5}\times 1$

The higher $P_{S(Ri)}$ *is*, the better the safety level of the threat

Model Calibration

"Timeframe, severity of consequence and likelihood of the potential threats of environmental drivers due to climate change on the studied port WITH adaptive measures despite having imposed the adaptation measures as indicated in the table below"

Environmental driver (ED) due to climate change	Potential threat of ED on the studied port	Adaptation measure to address the potential threat of ED on the studied port	Timeframe (Q3a)					Severity of consequence (Q3b)					Likelihood (Q3c)					Cost of adaptation (Q4)				
			VS	S	M	L	VL	CA	CR	MA	MI	NE	VH	H	A	L	VL	VH	H	A	L	VL
Sea level rise	High waves that can damage the studied port's facilities	Move facilities																				
		Build new breakwaters																				
		Increase breakwater dimensions																				

The Next Step (2013-)

- More case studies on climate change risks and the adaptation planning efforts undertaken by ports around the world

- Further study on the assessment of environmental risks (using the model established by the IAME 2013 paper) based on questionnaire surveys

- Global experiences; with the aim to identify and develop 'international best practices', and reduce the uncertainty in the decision-making process, so as to help ports in adapting to climate change impacts

The Next Step (2013-)

- Undertake a number of surveys for local/nearby ports (3-5 ports; 6-8 survey respondents) (Oct-Nov 2013)

- Participate in the preparation of the manuscript

- Scholarly Publications (pioneer results for IAME 2014; and finally journal publications ~ perhaps in environmental studies)

- A proposal which aims to obtain research grants (the Partnership Development Grant from Canada's Social Science and Humanities Research Council (SSHRC)?)

The Next Step (2013-)

- University of Manitoba, Canada
- Stanford University, USA
- University of Rhode Island, USA
- Australian Maritime College, University of Tasmania, Australia
- University of Sydney, Australia
- University of Antwerp, Belgium
- Liverpool John Moores University, UK
- University of Oxford, UK
- University of Southampton, UK
- Kühne Logistics University, Germany
- MedCruise/University of the Aegean, Greece
- Wuhan University of Technology, China
- Inha University, South Korea
- Tokyo University, Japan

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The Next Step (2013-)

- Other components of transportation and the supply chain?

- A PhD opportunity being offered by the Australian Maritime College on climate change and seaport adaptation (Peggy will provide the details during the discussion).

Thank you very much

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