Table Captions

Table 1

Risk Type	Cause	
Operational Risk Factors	Port equipment/machinery failures	Cranes, straddle carriers, RTGs, forklifts, terminal tractors and trailers.
	Vessel accident/grounding	General cargo, containerships, bulk carriers, short-sea/RoRo vessels and oil supply vessels.
	Cargo spillage	General cargoes, bulk cargoes, hazardous cargoes and petroleum products.
	Human errors	Seafarers, stevedores, pilotage and port/terminal operators.
Security Risk Factors	Sabotage	IT systems, port control systems and equipment.
	Terrorism attacks	Attack on port facilities and sinking of a large vessel in port channel.
	Surveillance system failures	
	Arson	
Technical Risk Factors	Lack of equipment maintenance	
	Lack of navigational aid maintenance	
	Lack of IT system maintenance	
	Lack of dredging maintenance	
Organisational Risk Factors	Labour unrest	
	Dispute with regulatory bodies	
	Berth congestion	
	Gate congestion	
	Storage area congestion	
Natural Risk Factors	Geologic/Seismic	Earthquake and tsunami
	Hydrologic	Heavy rainfall, flooding and snow
	Atmospheric	Hurricane and cyclone

Table 2

Level of importance in qualitative descriptors	Description	Triangular fuzzy numbers (TFNs)
Equal importance	Two attributes contribute equally to the risk of disruption	(1, 1, 2)
Between equal and weak importance	When compromise is needed	(1, 2, 3)
Weak importance	The subjective judgement and experience of experts slightly favour one attribute group over another	(2, 3, 4)
Between weak and strong importance	When compromise is needed	(3, 4, 5)
Strong importance	The subjective judgement and experience of experts strongly favour one attribute group over another	(4, 5, 6)
Between strong and very strong importance	When compromise is needed	(5, 6, 7)
Very strong importance	A given attribute is favoured very strongly over another	(6, 7, 8)
Between very strong and absolute importance	When compromise is needed	(7, 8, 9)
Absolute importance	The evidence favouring one attribute group over another is of the highest possible order	(8, 9, 9)

Table 3

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Table 4

Step 1: Map the calculated FTN_{LS} over FTN_P (i.e. 5 grades defined over the universe of discourse of risk (VL, L, M, H and VH))

Step 2: Determine the point where the newly mapped FTN_{LS} intersects each linguistic term of the FTN_P

Step 3: Use a maximum figure if FTN_{LS} and a linguistic term of FTN_P intersect at more than one point.

Step 4: Establish a set of intersecting points (Z_P) that defines a non-normalised 5 grades in the form of fuzzy sets.

Step 5: Normalise the Z_P (5 non-normalised grades) to obtain Z (5 normalised grades) which is known as the belief structure.

Table 5

FTN_{LS}	$0.125, 0.375, 0.75$				
Grade	VL	L	M	H	VH
Z_P	0.25	0.75	0.80	0.40	0
Z	0.10	0.34	0.36	0.20	0

Table 6

Grade	Occurrence Likelihood (L)	Consequence Severity (S)	Membership Functions
1	Very Low	Negligible	(0.0,0.0,0.25)
2	Low	Moderate	(0.0,0.25,0.5)
3	Medium	Serious	(0.25,0.5,0.75)
4	High	Very Serious	(0.5,0.75,1.0)
5	Very High	Disastrous	(0.75,1.0,1.0)

Table 7

Qualitative Scale for Risk Level (grade of *P*)	**Description of Risk Evaluation Variables**	**Membership Functions**	**Centroid Values (Risk Levels) *K***
Very Low: Risk is acceptable	If likelihood is very low and severity is negligible	(0.0,0.0,0.0625)	0.020
Low: Risk is tolerable but should be reduced if it is cost effective	If likelihood is low and severity is moderate	(0.0,0.0625,0.25)	0.104
Significant: Risk must be reduced if it is practicable	If likelihood is medium and severity is serious	(0.0625,0.25,0.5625)	0.292
High: Risk must be reduced	If likelihood is high and severity is very serious	(0.25,0.5625,1.0)	0.604
Very High: Risk must be reduced and controlled	If likelihood is very high and severity is disastrous	(0.5625,1.0,1.0)	0.854

Table 8

Parameters	**Abbreviations**	**Weights**
Geologic	R51	0.35
Hydrologic	R52	0.325
Atmospheric	R53	0.325

Table 9

Risk Parameters	**Abbreviation**	**Weights**
Port Equipment/Machinery Failures	R11	0.510
Vessels Collision/Grounding	R12	0.083
Cargoes Spillage	R13	0.258
Human Related Error	R14	0.149
Sabotage	R21	0.481
Terrorism Attacks	R22	0.306
Surveillance System Failure	R23	0.124
Arson	R24	0.089
Lack of Equipment Maintenance	R31	0.490
Lack of Navigational Maintenance	R32	0.076
Lack of IT System Maintenance	R33	0.283
Lack of Dredging Maintenance	R34	0.150
Labour Unrest	R41	0.475
Dispute with Regulatory Bodies	R42	0.054
Berth Congestion	R43	0.081
Gate Congestion	R44	0.114
Storage Area Congestion	R45	0.275
Operational Risk Factors	R1	0.246
Security Risk Factors	R2	0.291
Technical Risk Factors	R3	0.188
Organisational Risk Factors	R4	0.153
Natural Risk Factors	R5	0.122

Table 10

Risks Factors	**Experts' L**	**Ratings S**	FTN_L	FTN_S	FTN_{LS}
R11	2	4	(0.00,0.25,0.50)	(0.50,0.75,1.00)	(0.00,0.19,0.50)
R12	3	2	(0.25,0.50,0.75)	(0.00,0.25,0.50)	(0.00,0.13,0.38)
R13	2	3	(0.00,0.25,0.50)	(0.25,0.50,0.75)	(0.00,0.13,0.38)
R14	3	4	(0.25,0.50,0.75)	(0.50,0.75,1.00)	(0.13,0.38,0.75)
R21	3	5	(0.25,0.50,0.75)	(0.75,1.00,1.00)	(0.19,0.50,0.75)
R22	4	5	(0.50,0.75,1.00)	(0.75,1.00,1.00)	(0.38,0.75,1.00)
R23	3	4	(0.25,0.50,0.75)	(0.50,0.75,1.00)	(0.13,.375,0.75)
R24	3	3	(0.25,0.50,0.75)	(0.25,0.50,0.75)	(0.06,0.25,0.56)
R31	2	3	(0.00,0.25,0.50)	(0.25,0.50,0.75)	(0.00,0.13,0.38)
R32	3	4	(0.25,0.50,0.75)	(0.50,0.75,1.00)	(0.13,0.38,0.76)
R33	2	4	(0.00,0.25,0.50)	(0.50,0.75,1.00)	(0.00,0.19,0.50)
R34	3	3	(0.25,0.50,0.75)	(0.25,0.50,0.75)	(0.06,0.25,0.56)
R41	2	2	(0.00,0.25,0.50)	(0.00,0.25,0.50)	(0.00,0.06,0.25)
R42	2	3	(0.00,0.25,0.50)	(0.25,0.50,0.75)	(0.00,0.13,0.38)
R43	3	2	(0.25,0.50,0.75)	(0.00,0.25,0.50)	(0.00,0.13,0.38)
R44	3	2	(0.25,0.50,0.75)	(0.00,0.25,0.50)	(0.00,0.13,0.38)
R51	2	5	(0.00,0.25,0.50)	(0.75,1.00,1.00)	(0.00,0.25,0.50)
R53	2	5	(0.00,0.25,0.50)	(0.75,1.00,1.00)	(0.00,0.25,0.50)
R53	2	3	(0.00,0.25,0.50)	(0.25,0.50,0.75)	(0.00,0.13,0.38)

Table 11

Risks Factors	FTN_{LS}	(Z_P) **VL**	**L**	**M**	**H**	**VH**
R11	(0.00,0.19,0.50)	0.56	0.89	0.45	0	0
R12	(0.00,0.13,0.38)	0.65	0.75	0.24	0	0
R13	(0.00,0.13,0.38)	0.65	0.75	0.24	0	0
R14	(0.13,0.38,0.75)	0.35	0.80	0.78	0.38	0
R21	(0.19,0.50,0.75)	0.11	0.56	0.50	0	0
R22	(0.38,0.75,1.00)	0.00	0.23	0.62	0.5	0
R23	(0.13,0.38,0.75)	0.35	0.80	0.78	0.38	0
R24	(0.06,0.25,0.56)	0.48	0.95	0.55	0.10	0
R31	(0.00,0.13,0.38)	0.65	0.75	0.24	0	0
R32	(0.13,0.38,0.75)	0.35	0.80	0.78	0.38	0
R33	(0.00,0.19,0.50)	0.56	0.89	0.45	0	0
R34	(0.06,0.25,0.56)	0.48	0.95	0.55	0.10	0
R41	(0.00,0.06,0.25)	0.80	0.57	0.00	0.00	0
R42	(0.00,0.13,0.38)	0.65	0.75	0.24	0	0
R43	(0.00,0.13,0.38)	0.65	0.75	0.24	0	0
R44	(0.00,0.13,0.38)	0.65	0.75	0.24	0	0
R51	(0.00,0.25,0.50)	0.50	0.93	0.50	0	0
R53	(0.00,0.25,0.50)	0.50	0.93	0.50	0	0
R53	(0.00,0.13,0.38)	0.65	0.75	0.24	0	0

Table 12

Risks Factors	Z_P					Z				
R11	0.56	0.89	0.45	0	0	0.29	0.47	0.24	0	0
R12	0.65	0.75	0.24	0	0	0.40	0.45	0.15	0	0
R13	0.65	0.75	0.24	0	0	0.40	0.45	0.15	0	0
R14	0.35	0.80	0.78	0.38	0	0.15	0.35	0.34	0.16	0
R21	0.11	0.56	0.50	0	0	0.10	0.48	0.42	0	0
R22	0.00	0.23	0.62	0.5	0	0	0.17	0.46	0.37	0
R23	0.35	0.80	0.78	0.38	0	0.15	0.35	0.34	0.16	0
R24	0.48	0.95	0.55	0.10	0	0.23	0.46	0.26	0.05	0
R31	0.65	0.75	0.24	0	0	0.40	0.45	0.15	0	0
R32	0.35	0.80	0.78	0.38	0	0.15	0.35	0.34	0.16	0
R33	0.56	0.89	0.45	0	0	0.29	0.47	0.24	0	0
R34	0.48	0.95	0.55	0.10	0	0.23	0.46	0.26	0.05	0
R41	0.80	0.57	0.00	0.00	0	0.58	0.42	0	0	0
R42	0.65	0.75	0.24	0	0	0.40	0.45	0.15	0	0
R43	0.65	0.75	0.24	0	0	0.40	0.45	0.15	0	0
R44	0.65	0.75	0.24	0	0	0.40	0.45	0.15	0	0
R45	0.65	0.75	0.24	0	0	0.40	0.45	0.15	0	0
R51	0.50	0.93	0.50	0	0	0.26	0.48	0.26	0	0
R53	0.50	0.93	0.50	0	0	0.26	0.48	0.26	0	0
R53	0.65	0.75	0.24	0	0	0.40	0.45	0.15	0	0

Table 13

Main Criteria	Very Low	Low	Medium	High	Very High
Operational risk	0.3074	0.4566	0.2223	0.0137	0.0000
Security risk	0.0754	0.3884	0.4195	0.1167	0.0000
Technical risk	0.3310	0.4652	0.1866	0.0172	0.0000
Organisational risk	0.5210	0.4253	0.0537	0.0000	0.0000
Natural risk	0.2561	0.5164	0.2275	0.0000	0.0000
Disruption Risks' Result	0.2349	0.4610	0.2348	0.0693	0.0000

Table 14

H_n	Very Low	Low	Medium	High	Very High
V_n	1	2	3	4	5
$u(H_n)$	$\frac{1-1}{5-1}=0$	$\frac{2-1}{5-1}=0.25$	$\frac{3-1}{5-1}=0.5$	$\frac{4-1}{5-1}=0.75$	$\frac{5-1}{5-1}=1$
β_n	0.2349	0.4610	0.2348	0.0693	0.0000
$\sum_{n=1}^{N}\beta_n = 0.2349+0.4610+0.2348+0.0693+0.0000=1 \rightarrow \beta_H = 0$					
$\beta_n \times u(H_n)$	0.0000	0.1153	0.1174	0.05198	0.0000
$D_{DR}=\sum_{n=1}^{N}\beta_n \times u(H_n) = 0.2846 \approx 0.285$					

Table 15

Decrement of input data associated with the highest preference linguistic term and simultaneously increasing the input data associated with the lowest preference linguistic term			
Sub-criteria	**10%**	**20%**	**30%**
Port Equipment/Machinery Failures	0.2874	0.2842	0.2794
Vessel Collision/Grounding	0.2887	0.2848	0.2806
Cargoes Spillage	0.2888	0.2851	0.2811
Human Related Error	0.2885	0.2819	0.277
Sabotage	0.2890	0.2824	0.2765
Terrorism Attacks	0.2837	0.2703	0.2532
Surveillance System Failures	0.2887	0.2831	0.2771
Arson	0.2881	0.2845	0.2399
Lack of Equipment Maintenance	0.2884	0.2814	0.2749
Lack of Navigational Aid Maintenance	0.2881	0.2833	0.2778
Lack of IT System Failures	0.2889	0.2839	0.2789
Lack of Dredging Maintenance	0.2888	0.2836	0.2783
Labour Unrest	0.2888	0.2855	0.2821
Dispute with Regulatory Bodies	0.2889	0.2870	0.2856
Berth Congestion	0.2884	0.2861	0.2835
Gate Congestion	0.2883	0.2857	0.2828
Storage Area congestion	0.2887	0.2859	0.2831
Geologic Factors	0.2872	0.2791	0.2678
Hydrologic Factors	0.2885	0.2853	0.2816
Atmospheric Factors	0.2884	0.2808	0.2738