Container Operational Risk management

Subjects: Management

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The risk associated with container shipping has been a major concern in recent decades. This study presents three major risk frameworks to systematically and inclusively explore and validate container operational risk scales based on risk factors derived from the extant literature. The three risk frameworks identified are risks related to information flow, risks related to physical flow, and risks related to payment flow. Each risk factor is grouped into sub-factors (dimensions), three factors for information flow, two factors for physical flow, and two factors for payment flow. The study uses Ethiopia as a case study and employed both qualitative and quantitative research methods. An interview survey was conducted to explore additional risk factors and validate the identified risk factors in container shipping, and a questionnaire survey was then accompanied to collect the relevant data. A pairwise comparison chart (PCC) was employed to rank the risk dimensions. The results showed that the container operational risk model is satisfactory by employing exploratory and confirmatory factor analysis. Furthermore, the PCC result indicates that risk of loss or damage of goods/assets, payment delay, and decrease in or total loss of payment were ranked first, second, and third, respectively, and consequently the most significant dimensions of the risk factors. This study provides a reliable and valid scale for measuring container operational risk in container shipping companies. It also unlocks future works for using the identified risk factors as guidelines for researchers and experts to design and develop container operational risk dimensions.

Keywords: container operational risk ; information risk ; physical risk ; payment risk ; container shipping

1. Introduction

In the global economy, container shipping has become the foundation of maritime conveyance and logistics systems [1][2]. As they gain prominence in diverse areas, container shipping companies have to deal with uncertainties and interruptions. As recognized in the literature, "risk" has continuously been debated as a major impelling factor in maritime transportation [3][4]. Risks associated with shipment management are classified as one of the leading possible accident risks in container docks, as stated by some port safety authorities such as Health and Safety Executive UK [5] and Hong Kong Marine Department [6]. In the case of Ethiopia, the Ethiopian Shipping and Logistics Service Enterprise (ESLSE) is an international shipping industry known for its volatility and high risks associated with its container shipping system [7]. Many studies in risk management have gained attention in logistics risk in general and container operational risk in particular [8][9][10][11][12][13][14]. However, they have not come to a common consensus on container operational risk dimensions [11]. The extant literature shows that the lack of management commitment of the shipping company to container handling is a typical dimension for container operational risk [15][16][17]. Drewry [18] indicated that the risk factors related to container logistics operations dimensions could be categorized into seven themes: booking and invoicing errors, documentation, errors in customs regulatory compliance and security compliance, theft and cargo loss or damage, strikes and transport congestions, piracy, and terrorist attack. In their study, Fu et al. [19] found that piracy has been a significant threat to container liners. It was also found by [20][21] that the risk related to container operational risk such as ‘‘delay in information transmission by parties involved’’ and ‘‘delay in the processing of document by government authorities (e.g., customs)’’ had a significant adverse effect on Taiwan’s shipping industry. This present study concentrates on risks in container shipping operations but endeavors to contribute to the research in this field by exploring additional risk factors. To further enrich the contribution, the paper validates and ranks the dimensions of the identified risk factors that could serve as a platform for researchers interested in this field.

To successfully achieve container safety risk management, the shipping companies are responsible for understanding how to explore the container operational risk dimensions for risk management purposes and for knowing the dimensions of container operational risks for port operation. To better understand how best to explore the container operational risk dimensions for risk management, the first step is to understand the experts’ and port employees’ perspectives and perceptions of the container operational risk dimensions. Additionally, to help container shipping companies to differentiate among the risk factors, the risk factors will be ranked to reveal which risks factors would have a more serious impact than the others and which ones would be the most significant among all other risks factors. Experts’ and employees’ perspectives and perceptions of container operational risk factors could provide the information needed for container shipping companies and maritime managers to make better decisions regarding the risk factors for successful container operational risk management.

2. Data Analysis and Results

2.1. Interview Results

In the interview exercise, all the identified risk factors from the extant literature presented in the research framework were confirmed. Two new risk factors were recommended and added to the existing ones, which sum up 37 risk factors.

One suggested risk factor during the interviews is "Exchange rate fluctuation during payment process". It was recommended as a risk factor as it results in an increase in cost, which has the tendency to delay the payment process. Similarly, "Unexpected rise in operational cost" was also recommended as a risk factor. **Table A1** in the Appendix A summarizes all the risk factors identified in this research, two of which were identified through interviews (i.e., DPL1 and DLP3, highlighted in bold). The code of each item is listed in the second column in **Table A1**. The interviewees further confirmed the validity of the scale being identified.

Eighteen interviewees participated in the content and the face validity analyses of the container shipping scale. As shown in **Table 1**, the majority of the university faculty members (66.67%) and ESLSE experts (58.33%) were male. The age pattern revealed that most respondents of the two groups of the participants were aged 50–59 years. Most of the ESLSE experts had more than 20 years of working experience, and most of the university faculty members (50%) had more than 20 years of working experience. The majority (61.11%) of the interviewees who participated in the reliability analysis were male. Most of these interviewees were aged 50–59 years, and 44.44% of them had >20 years of working experience.

Table 1. Demographics of the interviewees in the content validity and the reliability analyses.

Variables	Validity Analysis		
	University Faculty Members (n = 6)	ESLSE Experts (n = 12)	Reliability Analysis (n = 18)
Gender			
Male	4 (66.67)	7 (58.33)	11 (61.11)
Female	2 (33.33)	5 (41.67)	7 (38.89)
Age (y)	50.6 (8.3) *	50.7 (10.2) *	50.7 (9.3) *
<30	-	-	-
30–39	1 (16.67)	2 (16.67)	3 (16.67)
40–49	2 (33.33)	3 (25.00)	5 (27.78)
50–59	3 (50.00)	6 (50.00)	9 (50.00)
≥60	-	1 (8.33)	1 (5.56)
Working experience (y)	18.7 (9.4) *	19.3 (6.07) *	19.0 (7.52) *
<1	-	-	-
1–5	-	-	-
6–10	-	2 (16.67)	2 (11.11)
11–15	1 (16.67)	2 (16.67)	3 (16.67)
16–20	2 (33.33)	3 (25.00)	5 (27.78)
>20	3 (50.00)	5 (41.67)	8 (44.44)

* Mean and standard deviation in years provided for age and working experience of the participants.

The analysis of the content validity of the scales, which were rated by the university faculty members and ESLSE experts, showed that all the 37 items had an excellent content validity. The acceptable level of CVR for the 18 interviewees is >0.38 [22]. Consequently, the 37 items were retained.

2.2. Questionnaire Results

This paper conducted the questionnaire data analysis through descriptive analysis, reliability and validity analysis, and exploratory factor analysis (EFA) to explore and validate the risk factors based on experts' and employees' perceptions.

However, before the EFA, we established the demographic characteristics of the survey participants. As shown in **Table 1**, the largest category of the participants at ESLSE who participated in the questionnaire survey was those between 36 and 40 years of age (32.28%), followed by those in the 31 to 35 years of the age range (20.75%). There were only seven respondents who were 20 years or below in age. Regarding the genders of the participants, male participants were higher in frequency than female participants at percentages of 61.28 and 38.62, respectively. Most participants had 11–15 years of working experience (34.29%), followed by those with 6–10 years of working experience (32.85%). The demographic information of the survey respondents is summarized in **Table 2**.

Table 2. Demographic characteristics of the participant.

Items	Options	Frequency	Percentage (%)
Employee at ESLSE	**Yes**	**347**	**100.00**
	No	**0**	**0.00**
Gender	**Male**	**213**	**61.38**
	Female	**134**	**38.62**
Age	**≤20**	**7**	**2.02**
	21–25	**38**	**10.95**
	26–30	**67**	**19.31**
	31–35	**72**	**20.75**
	36–40	**112**	**32.28**
	>40	**51**	**14.70**
Education	**Bachelor**	**158**	**45.53**
	Masters	**63**	**18.16**
	PhD	**13**	**3.75**
	Others	**113**	**32.56**
Experience	**1–5**	**73**	**21.04**
	6–10	**114**	**32.85**
	11–15	**119**	**34.29**
	>15	**41**	**11.82**

2.3. Descriptive Analysis

Descriptive statistics analysis was done for all items for their mean, standard deviation, skewness, and kurtosis to test the normality of the data. According to Hair et al. [23], normality refers to the "degree to which the distribution of the sample data corresponds to a normal distribution". The data can be assessed for normality statistically by obtaining skewness and kurtosis. Skewness is the measure of the symmetry of the data distribution [24], while kurtosis measures the peak or flatness of the distribution [23]. The distribution is normal when the values of skewness and kurtosis range between −1 and +1 [25]. The results show that the values of mean ranged from 4.04 to 4.11 on a five-point scale, which indicates that most of the respondents had an agreement with the items of risk factors associated with container shipping, as displayed in **Figure 1**

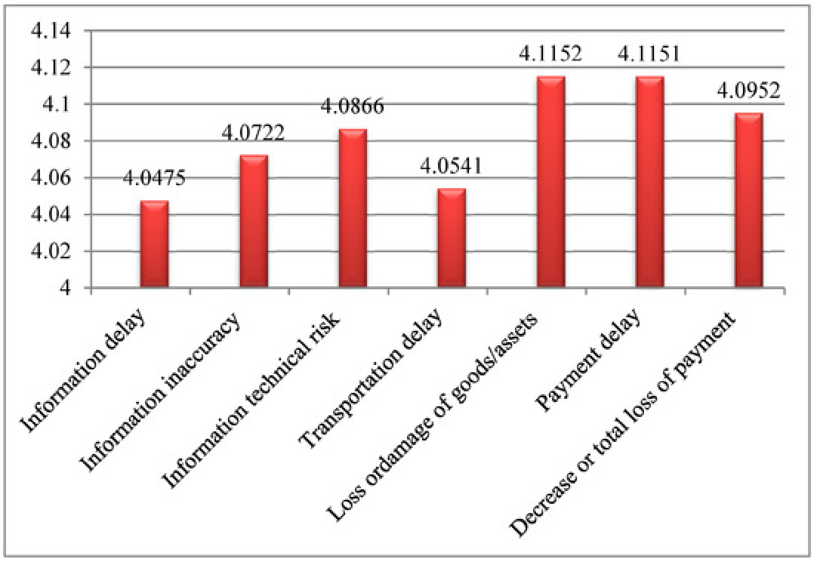

Figure 1. Mean values of risk factors.

Furthermore, we presented the results of the descriptive statistics in **Table 3** for each item. The results showed that the standard deviations range between 0.082 and 0.971, which implied that the values were acceptable. The normality distribution of the data was adequate because the values ranged between −1 and +1 according to the assumption of skewness and kurtosis.

Table 3. Descriptive Analysis.

Factors	Items	Mean	Std.	Skewness	Kurtosis
Information delay (ID)	ID1	4.11	0.898	−0.964	0.408
	ID2	4.08	0.706	−0.791	0.070
	ID3	3.93	0.536	−0.789	0.066
	ID4	4.05	0.871	−0.795	0.104
Information inaccuracy (II)	II1	3.97	0.868	−0.949	0.459
	II2	3.99	0.786	−0.925	0.462
	II3	4.07	0.849	−0.852	0.031
	II4	4.12	0.852	−0.912	0.387
	II5	4.20	0.815	−0.853	0.114
Information technical risk (ITR)	ITR1	3.94	0.803	−0.850	0.124
	ITR2	4.13	0.875	−0.853	0.125
	ITR3	4.19	0.897	−0.851	0.254
Transportation delay(TD)	TD1	3.90	0.786	−0.814	0.136
	TD2	3.94	0.849	−0.963	0.516
	TD3	4.15	0.773	−0.917	0.272
	TD4	4.08	0.780	−0.912	0.287
	TD5	4.25	0.693	−0.922	0.259
	TD6	4.03	0.572	−0.958	0.525
	TD7	4.18	0.705	−0.903	0.465
	TD8	3.95	0.692	−0.862	0.540
	TD9	4.01	0.669	−0.917	0.691

Factors	Items	Mean	Std.	Skewness	Kurtosis
Loss ordamage of goods/assets (LDG)	LDG1	3.93	0.735	−0.843	0.462
	LDG2	3.97	0.199	−0.954	0.481
	LDG3	4.17	0.082	−0.936	0.411
	LDG4	3.87	0.168	−0.921	0.397
	LDG5	4.41	0.694	−0.951	0.439
	LDG6	4.34	0.548	−0.972	0.480
Payment delay (PD)	PD1	4.14	0.920	−0.962	0.634
	PD2	4.16	0.837	−0.989	0.674
	PD3	4.09	0.749	−0.983	0.578
	PD4	4.07	0.538	−0.921	0.401
Decrease or total loss of payment (DLP)	DPL1	4.25	0.357	−0.993	0.600
	DLP2	3.97	0.648	−0.795	0.104
	DLP3	4.01	0.488	−0.798	0.114
	DLP4	4.09	0.849	−0.912	0.287
	DLP5	4.11	0.748	−0.983	0.578
	DLP6	4.14	0.392	−0.843	0.462

2.4. Exploratory Factor Analysis

To evaluate the dimensions of the three models, an EFA was employed to ascertain an initial set of dimensions through varimax rotation. Seven dimensions were achieved, explaining 71.26% of the variance. The values of the Cronbach alpha for all dimensions were greater than 0.80, satisfying the threshold value of 0.70 recommended by [26], thus establishing internal consistency reliability of the scales. The computed Kaiser–Meyer–Olkin value of 0.937 established that the sample for the analysis was adequate. Moreover, Bartlett's test for sphericity with a significance level (χ^2 = 4157.178, p < 0.01) verified the homogeneity of the variances [23]. **Table 4** provides the results of the rotated component matrix of the EFA for the seven dimensions of the container shipping risk factors, along with their corresponding coefficient alpha scores.

Table 4. Exploratory Factor Analysis Rotated Component Matrix.

Measurement Items	Information Delay (α = 0.935)	Information Inaccuracy (α = 0.921)	Information Technical Risk (α = 0.910)	Transportation Delay (α = 0.879)	Loss or Damage of Goods/Assets (α = 0.854)	Payment Delay (α = 0.916)	Decrease or Total Loss of Payment (α = 0.930)
ID3	0.857						
ID1	0.849						
ID4	0.826						
ID2	0.803						
II2		0.831					
II1		0.821					
II4		0.818					
II3		0.809					
II5		0.794					
ITR3			0.854				
ITR1			0.847				

Measurement Items	Information Delay (α = 0.935)	Information Inaccuracy (α = 0.921)	Information Technical Risk (α = 0.910)	Transportation Delay (α = 0.879)	Loss or Damage of Goods/Assets (α = 0.854)	Payment Delay (α = 0.916)	Decrease or Total Loss of Payment (α = 0.930)
ITR2			0.839				
TD7				0.842			
TD3				0.835			
TD2				0.819			
TD9				0.724			
TD5				0.717			
TD6				0.701			
TD1				0.699			
TD8				0.696			
TD4				0.692			
LDG3					0.844		
LDG2					0.826		
LDG5					0.794		
LDG6					0.716		
LDG1					0.708		
LDG4					0.698		
PD3						0.796	
PD2						0.789	
PD3						0.766	
PD4						0.765	
DPL1							0.837
DLP2							0.826
DLP6							0.804
DLP4							0.781
DLP5							0.738
DLP3							0.667

2.5. Measurement Model

As illustrated in **Figure 2**, the risk factor measurements were considered as latent constructs in confirmatory factor analysis (CFA). The result of CFA confirmed that the model that EFA initially established is acceptable. The chi-square minimum discrepancy (CMIN) divided by its degrees of freedom (*df*) or CMIN/df is less than the suggested 3.0 value, and the overall chi-square statistic for the measurement model was significant ($\chi^2 = 315.070$, $df = 176$, CMIN/df = 1.790, $p < 0.001$).

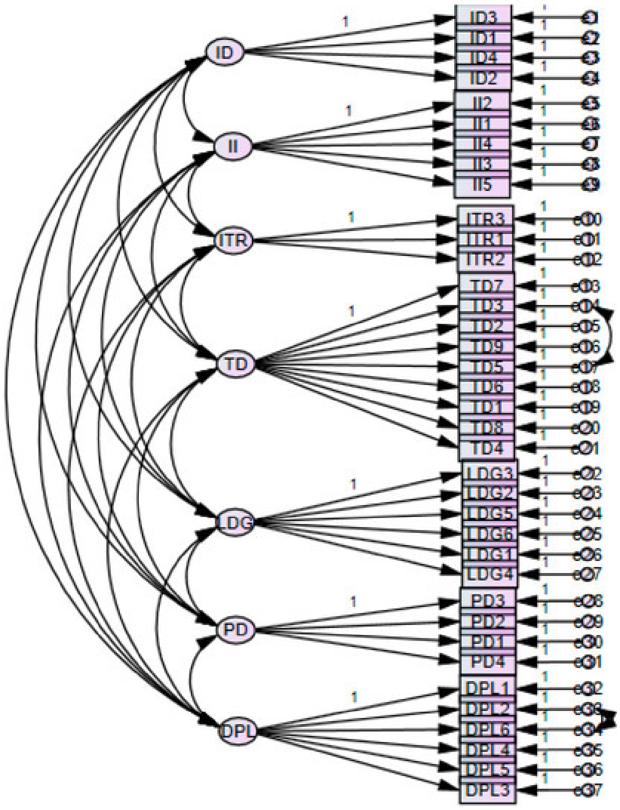

Figure 2. Confirmatory factor analysis of container shipping risk factor scale.

We followed the process outlined by [27] to complete the factor analysis, all individual items in each construct load at a statistically significant level ($p < 0.001$), with the standardized loadings for all items spanning from 0.794 to 0.923, as presented in **Table 5**. The standardized loadings met both the minimum (0.50) and preferred (0.70) guideline suggested by [28] for all 37 items. The AVE value was 0.745, and each construct's AVE exceeded 0.703, reaching the benchmark of 0.50 for convergent validity recommended by [29].**Table 5** shows the standardized factor loadings of the measurement model. **Table 6** shows the results for discriminant validity, where construct values for MSV, ASV, and AVE were compared to confirm MSV < AVE and ASV < AVE for all constructs. The discriminant validity of the constructs was also established by comparing the square root of the AVE with their paired correlations as shown in the diagonal of the matrix in **Table 7**.

Table 5. Standardized Factor Loadings of Measurement Model.

Factors	Items	Standardized Loadings (>0.7)	*p*-Value	Items Removed
Information delay (ID)	**ID3**	**0.874**	**0.001**	**No item**
	ID1	**0.855**	**0.001**	
	ID4	**0.865**	**0.001**	
	ID2	**0.872**	**0.001**	
Information inaccuracy (II)	**II2**	**0.879**	**0.001**	**No item**
	II1	**0.841**	**0.001**	
	II4	**0.818**	**0.001**	
	II3	**0.859**	**0.001**	
	II5	**0.794**	**0.001**	
Information technical risk (ITR)	**ITR3**	**0.870**	**0.001**	**No item**
	ITR1	**0.865**	**0.001**	
	ITR2	**0.862**	**0.001**	

Factors	Items	Standardized Loadings (>0.7)	*p*-Value	Items Removed
Transportation delay (TD)	TD7	0.884	0.001	No item
	TD3	0.795	0.001	
	TD2	0.867	0.001	
	TD9	0.857	0.001	
	TD5	0.855	0.001	
	TD6	0.856	0.001	
	TD1	0.878	0.001	
	TD8	0.903	0.001	
	TD4	0.865	0.001	
Loss or damage of goods/assets (LDG)	LDG3	0.899	0.001	No item
	LDG2	0.897	0.001	
	LDG5	0.879	0.001	
	LDG6	0.874	0.001	
	LDG1	0.871	0.001	
	LDG4	0.846	0.001	
Payment delay (PD)	PD3	0.861	0.001	No item
	PD2	0.857	0.001	
	PD3	0.851	0.001	
	PD4	0.853	0.001	
Decrease or total loss of payment (DLP)	DPL1	0.920	0.001	No item
	DLP2	0.799	0.001	
	DLP6	0.823	0.001	
	DLP4	0.922	0.001	
	DLP5	0.914	0.001	
	DLP3	0.851	0.001	

Table 6. Scale Reliability and Validity Statistics for Measurement Model.

Construct	α	AVE	MSV	ASV
Information delay	0.935	0.751	0.454	0.279
Information inaccuracy	0.921	0.703	0.524	0.315
Information technical risk	0.910	0.749	0.351	0.208
Transportation delay	0.879	0.744	0.417	0.251
Loss or damage of goods/assets	0.854	0.771	0.531	0.382
Payment delay	0.916	0.732	0.419	0.266
Decrease or total loss of payment	0.930	0.762	0.282	0.249

Note. χ^2 = 315.070; df = 176; GFI = 0.953; AGFI = 0.937; IFI = 0.951 CFI = 0.986; NFI = 0.968; RMSEA = 0.047. AVE = average variance extracted; MSV = maximum shared variance; ASV = average shared variance.

Table 7. Factor correlation matrix with square root of the AVE on the diagonal.

	ID	II	ITR	TD	LDG	PD	DLP
ID	0.867						
II	0.284 **	0.839					
ITR	0.453 **	0.503 **	0.866				
TD	0.590 **	0.563 **	0.417 **	0.863			
LDG	0.248 **	0.194 *	0.299 **	0.476 **	0.878		
PD	0.378 **	0.138 *	0.539 **	0.526 **	0.425 **	0.856	
DLP	0.415 **	0.189 *	0.485 **	0.576 **	0.521 **	0.468 **	0.873

Note. ** $p < 0.01$; * $p < 0.05$.

Moreover, other goodness of fit measures show that the model is satisfactory and hence acceptable. The GFI (0.953), AGFI (0.937), IFI (0.951), CFI (0.986), and NFI (0.968) were all greater than the 0.90 threshold value recommended by [30]. Furthermore, the RMSEA (0.047) computed value is far below the 0.08 threshold value recommended by [23]. Lastly, the calculated CFI value of 0.985 is above the recommended threshold value of 0.95 by [31]. (See bottom of **Table 6**.)

In order to rank the risks, pair-wise ranking was performed using the pairwise comparison chart (PCC) to help rank the risk dimensions as experienced by the experts based on their impact on container shipment (**Table 8**). In this way, the study also reveals which risks have a more serious impact than others and consequently which ones are the most significant among all other risks.

Table 8. Pairwise comparison chart (PCC).

	ID	II	ITR	TD	LDG	PD	DLP	Score	Rank
ID	....	7	5	10	4	7	6	39	7th
II	11	....	8	11	5	5	7	47	5th
ITR	13	10	....	7	6	6	7	49	4th
TD	8	7	11	....	6	7	6	45	6th
LDG	14	13	12	12	....	10	11	72	1st
PD	11	13	12	11	8	....	9	64	2nd
DLP	12	11	11	12	7	9	....	62	3rd

We rank the risk dimensions based on the perceptions and perspectives of the interviewees using the five-step procedure of the pairwise comparison chart (PCC) as follows: In the first step, we listed down the risk dimensions along the top row of the table and along the left hand side of the table. In the second step, we put dashes diagonally downwards in the chart. In the third step, we moved to the whole chart comparing two risk dimensions at a time to determine which one is more or less important based on the experts' perspectives and perceptions. We recorded 1 in the row for the risk dimension that was more important and 0 in the row for the risk dimension that was less important. In the fourth step, we added across each row to determine the total. Finally, in the fifth step, we ranked the risk dimensions and reflect on the results.

From the results in **Table 8**, the ranking shows that risk of loss or damage of goods/assets ranks number one among the seven dimensions of the risk factors with a total score of 72. The second-ranked risk is the risk of payment delay with a score of 64 followed by a decrease in or total loss of payment with a score of 62 that ranks third. The fourth, fifth sixth, and seventh are information technical risk, information inaccuracy, transportation delay, and information delay with scores of 49, 47, 45, and 39 respectively.

3. Discussions and Conclusions

The main objectives of this study were the exploration, validation, and ranking of the container shipping risk factor scale. Inclusive literature was reviewed in identifying the risk factors, and an exploratory factor analysis was employed to validate the identified risk factors. After assembling all the container operational risk factor scales, a qualitative evaluation exercise was first done by a group of experts and university faculty members to evaluate the content validity of the scales as suggested by Seo et al. [32]. After that, we applied EFA and CFA to assess the construct validity of the scales. Moreover, the internal consistency reliability of the scales via the Cronbach alpha was also adequate as the results showed values above 0.80, meeting the threshold of 0.70 [26]. Hence, the scales were discovered to be a valid and reliable instrument to measure the container operational risk dimensions.

The EFA was done to explore the dimensions of the container operational risk factors in the three frameworks. The risk factor dimensions were categorized as information delay, information inaccuracy, information technical risk, transportation delay, loss or damage of goods/assets, payment delay, and decrease or total loss of payment. These results are consistent with the findings of the previous studies that stated the information delay, information inaccuracy, information technical risk [9][33][34], transportation delay, loss or damage of goods/assets [10][18][33][35], payment delay [13][33], and decrease or total loss of payment [13][33][35] as container operational risk dimensions. Furthermore, CFA's findings support the application of the seven-dimension model of the three frameworks for measuring the container operational risk factors. The assessment of the major fit indices revealed that the dimensional structure of the container operational risk scale was satisfactory. The outcome of the Chi-square test for the examination of the CFA model showed a statistically significant result. The Chi-square test is one indicator of good model fit; however, it is more sensitive to minor misspecifications in the structure of the model [36]. Previous studies used other indices to verify the model fit when the Chi-square result was significant [36][37][38]. Tharaldsen et al. [39] also employed other fit indices, but they did not report the Chi-square result. We therefore used GFI, AGFI, CFI, NFI, goodness of fit, and RMSEA to evaluate the CFA model fit. Furthermore, the risk dimensions were also ranked via the PCC approach; the PCC result indicates that risk of loss or damage of goods/assets, payment delay, and decrease in or total loss of payment were ranked first, second, and third respectively, and consequently the most significant dimensions of the risk factors.

The qualitative evaluation of the container operational risk scales by a group of experts is a common approach to assess the content validity of the scales [32]. The application of a quantitative method for conducting such analysis facilitates the decision-making process regarding retention or rejection of the items of the scale. The authors employed experts and a Likert-type scale for rating the items (risk factors) in the validation process. These were conducted to consider the recommendations given by Wynd et al. [40] for overcoming the limitations of only relying on qualitative validation.

In summary, the results of this study showed that the validity and the reliability of the explored scale were satisfactory. The scale was developed in response to a need for a container operational risk dimension scale in the shipping industry in Ethiopia. It can be used to investigate the perception of experts and container shipping employees about risk factors associated with container shipping operations.

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