CHAPTER 4

Testing and Confirming of the New Performance Measurement Framework

The developing of new performance measurement model of the Thai's frozen shrimp supply chain is recommended to provide the effectiveness and efficiency in the area of study. The impact of the new model significantly improves the performance measurement indicators in terms of financial, quality, flexibility and other essential factors in the supply chain. Response to companies's need and suggestions from literature reviews of previous studies, the objectives of the comprehensive performance measurement model is not only to integrate the new model but also to prioritize the key performance indicators and combine the evaluation methods for improvement of the specific PM model of Thai frozen shrimp supply chain.

In this chapter, the results is provided to answer with the two research objectives including; 1) explaining the impact of the performance measurement aspects and the key performance measurement indicators on the frozen shrimp supply, and, 2) testing the validity and reliability of the new performance measurement model for evaluating the effectiveness of the frozen shrimp supply chain in Thailand. The principles and theory to enhance the developing of the new model, which was explained in chapter 2, were applied. The evaluation methods of PM for construction, confirming and testing of the new model were analyzed in chapter 3. The results are described in this chapter.

4.1 Integrating Conceptual Performance Measurement Model

Within this process, the research integrated the model based on a performance measurement approach. Then, the approach was translated into operation definition and the model. The definition is showed in chapter 2 and a Table 4.1. Next, the CFA method was developed based on an analysis method of a covariance structure model. The CFA is composed of the measurement model and the structure model. The measurement model shows the relationship between observe variables and latent variables therefore the researcher converted All KPIs into the Y model which were included the observed variables and linked to the latent variables: efficiency (E1-E5), flexibility (F1-F5), responsiveness (R1-R5), quality (Q1-Q10), innovativeness (I1-I2) that shows in Table 4.1 and Figure 4.1.

Table 4.1 The observed variables and the latent variables in the performance measurement model

Latent variable(η_{i*})	Observed variables (E_i, F_i, R_i Q_i, I_i)$i* = 1,2,3..,n$
Financial Efficiency(η_1)	1. Manufacturing costs (E1)
	2. Distribution costs (E2)
	3. Inventory costs (E3)
	4. Profit (E4)
	5. Return on investments (E5)
Flexibility(η_2)	6. Volume flexibility (F1)
	7. Delivery flexibility (F2)
	8. Customer satisfaction (F3)
	9. Backorders (F4)
	10. Lost sale (F5)
Responsiveness(η_3)	11. Full rate (R1)
	12. Product lateness (R2)
	13. Customer response time (R3)
	14. Lead time (R4)
	15. Customer complaints (R5)
Qualities(η_4)	16. Appearance (Q1)
	17. Product safety (Q2)
	18. Product reliability (Q3)
	19. Traceability (Q4)
	20. Storage and transport conditions (Q5)
	21. Working condition (Q6)
	22. Energy use (Q7)
	23. Carbon credit (Q8)
	24. Water use (Q9)
	25. Chemical use (Q10)
Innovativeness(η_5)	26. Launch of a new product (I1)
	27. New technology use (I2)

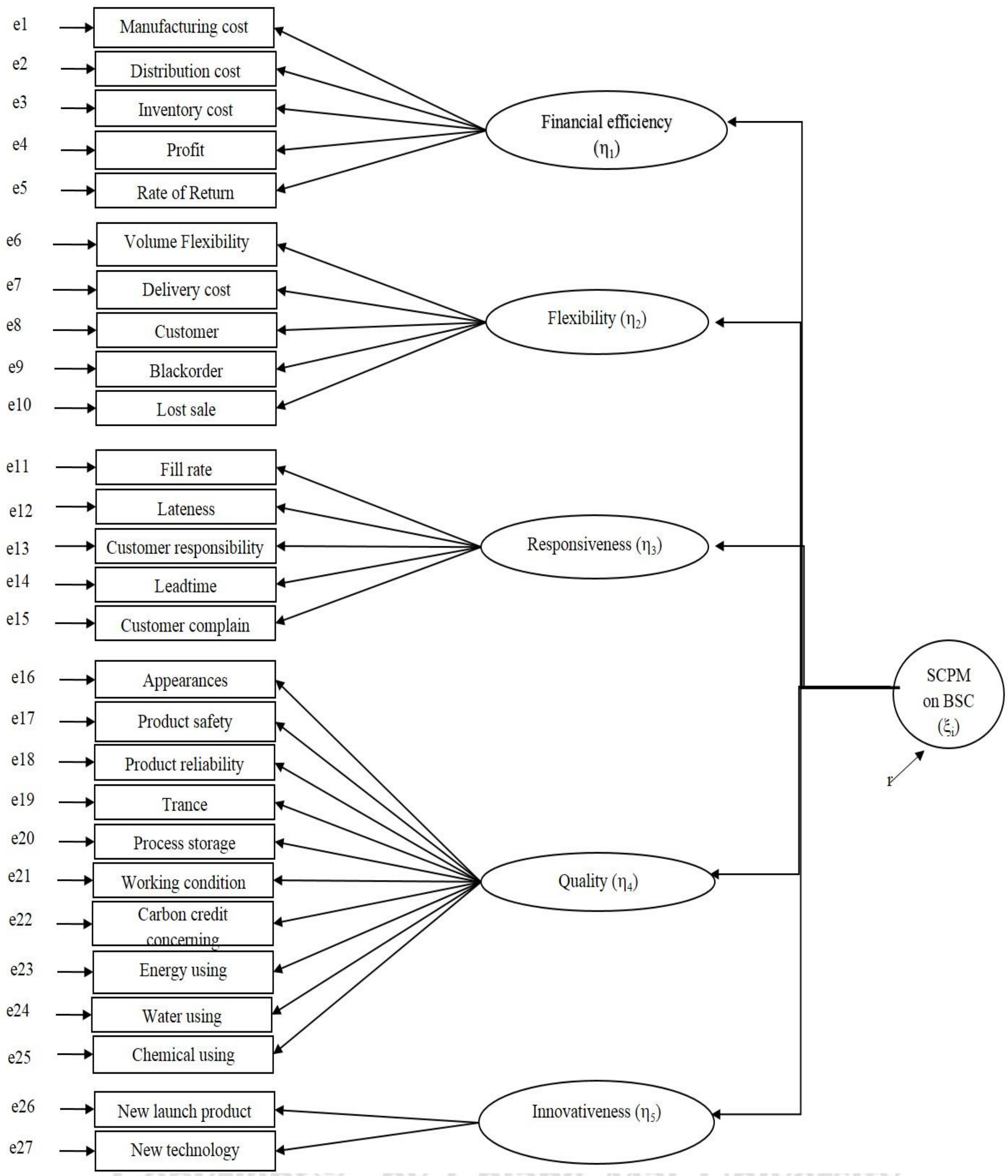

Figure 4.1 The first construction of CFA model

4.2 Analysis Results to Answer the Research Objectives

The researcher presented the results and analyzed data to answer two research objectives. Therefore, the results of this section are divided into three main sections. Section 1, the CFA assumption testing to check normality of data before applies CFA method. Section 2, the impact of KPIs on the Thai frozen shrimp chain was explicated. Section 3, the results showed the validity and reliability value of the performance measurement model. The model fitting degree of the performance measurement model, which is acceptably conceptualized, was provided in the section 3.

4.2.1 CFA assumption testing

Firstly, the researcher applied a factor analysis method to check more a CFA assumption that it is correlation matrix adequacy. A Bartlett test of Sphericity and Measure of Sampling Adequacy (MSA) were used to verify, and the result was showed in Table 4.2 as follows. From Table 4.2, The KMO value is 0.718, which is larger than 0.5, and the Bartlett's Test of Sphericity is rather high. Hence, it is suitable to analyze by factor analysis method.

Table 4.2 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.718
Bartlett's Test of Sphericity	Approximated Chi-Square	1486.087
	d_f	351
	Significant	0.000

Next, the CFA method bases on a maximum likelihood estimation (MLE) method in generally that means the result of CFA analysis will be correct when the assumption of data is a multivariate normality. In this section, skewness and kurtosis are parameter normality for AMOS software. Curran et al. (1997) and Schumacker and Lomax (2010) suggested if, the |skewness| has a value more than 3 and |kurtosis| also has a value more than 10, the parameter will be nonnormality distribution. Therefore, from the result in Table 4.3 showed |skewness| and |kurtosis| of some factor were violently from critical criteria, it is that means this research data is nonnormality data.

Table 4.3 Assessment of normality

Variable	min	max	skew	c.r.	kurtosis	c.r.
MANUCOST	1.000	5.000	-.356	-1.592	-.492	-1.100
DISTCOST	1.000	5.000	-.150	-.669	-.848	-1.895
INVENTCOST	1.000	5.000	-.359	-1.604	-.341	-.763
PROFIT	1.000	5.000	-.252	-1.125	-.198	-.443
ROI	1.000	5.000	-.583	-2.607	-.052	-.116
VOLFLEX	1.000	5.000	-.338	-1.511	-.162	-.362
DELIVCOST	1.000	5.000	-.258	-1.155	-.735	-1.643
CUSTOMERS	1.000	5.000	.045	.201	-.736	-1.646
BACKORDERS	1.000	5.000	1.312	5.869	.275	.616
LOSTSALES	1.000	5.000	1.218	5.447	.370	.827
FILLRATE	1.000	5.000	.878	3.925	-.427	-.954
LATENESS	1.000	5.000	.238	1.063	-.855	-1.911
RESPONSE	1.000	5.000	.034	.151	-.761	-1.702
LEADTIME	2.000	5.000	.560	2.502	-.919	-2.055
COMPLAIN	1.000	5.000	-.098	-.439	-.369	-.825
APP	1.000	5.000	-.204	-.911	-.618	-1.381
SAFETY	1.000	5.000	-.177	-.790	-.271	-.606
RELIA	1.000	5.000	-.278	-1.242	-.242	-.540
TRANCE	2.000	5.000	.279	1.249	-.791	-1.768
STORAGE	2.000	5.000	.152	.678	-.438	-.980
WORKING	1.000	5.000	-.059	-.265	-.346	-.774
CARBON	1.000	5.000	.502	2.245	-.423	-.946
ENERGY	1.000	5.000	-.127	-.568	-1.400	-3.130
WATER	1.000	5.000	-.154	-.687	-.397	-.888
CHEM	1.000	5.000	-.237	-1.062	-.262	-.587
NEWLP	1.000	5.000	.115	.516	-.270	-.604
NEWTECH	3.000	5.000	-.234	-1.048	-1.298	-2.903
Multivariate normality					61.875	8.564

The analyzed software likes AMOS and LISREL, in general, uses the MLE method for model estimating. Because the MLE method is a fundamental tool for all statistics software that it suits to normality distributional or slight nonnormality distributional of data (Schumacker & Lomax, 2010). The MLE way will be accurate if the │skewness│ has valued more than 3 and │kurtosis│ has a value also more than 10 (Schumacker & Lomax, 2010). Nevertheless, the model estimation should be changed into General Least Square (GLS) or the Asymptotic Distribution Free Function (ADF). For estimating parameters of an assessment measurement model validity such as

Goodness-of-fit, absolute fit model, and goodness-of-fit index. In this research, the researcher attempts to correct violations of distributional assumptions therefore GLS, which is an acceptable method to fix this nonnormality distribution problem (Newsom, 2015). Moreover, the analyzed results got an important fix indices that they are significantly within suggested criteria value from AMOS software. For example, Cri-square Probability Level (CMIN-p) is less than 0.05, Goodness of Fit Index (GFI) is more over 0.9, and so forth. Additionally, with less sample size, many methods of ADF such as Weighted Least Squares (WLS), Arbitrary General Least Square (AGLS) but all indices value did not converge to criteria standard value. For this reason, the GLS estimation method is the optimal method to verify the model estimation.

4.2.2 Reliability Testing

The measurement properties of SCPM construct was firstly tested by using reliability and correlation analysis. Then, CFA was followed. The Cronbach α coefficient has been used to evaluate reliability. A scale was found to be reliable if α is 0.70 or higher (Li et al., 2005). However, Mueller (1996) observed that the traditional definitions of the reliability did not allow for the correlating measurement error of items or scales. Within CFA, the reliability cloud be tested. Bollen (1989) proposed the proportion of variance (R^2) which was an observed variable to test the CFA. It accounts all latent constructs. The coefficient will be readily and easily determined using by LISREL software and LISREL analysis. The primary data analysis, reliability and validity test of the tool were necessary.

Formerly collect data, a questionnaire was tested by pilot test groups. The groups approached from 5 shrimp farmers, three shrimp specialists from private companies and two shrimp supply chain specialists from academics for test reliability by using the SPSS v.20. The Cronbach α coefficient was applied and calculated to indicate reliability. The Cronbach's Alpha result in table 4.4 as below was indicated a good reliability with all value of factors were more than 0.8. Therefore, the questionnaire had had enough reliability to collect real data.

Table 4.4 Reliability testing in a pilot

Observe variable	Mean	Std. Deviation	N	Cronbach's Alpha
Manufacturing costs (E1)	4.5436	.46615	10	.820
Distribution costs (E2)	3.5538	1.11846	10	.821
Inventory costs (E3)	3.7231	1.17935	10	.816
Profit (E4)	4.5692	.66071	10	.823
Return on investments (E5)	4.6308	.54684	10	.822
Volume flexibility (F1)	4.4000	.58095	10	.823
Delivery flexibility (F2)	4.5731	.45226	10	.821
Customer satisfaction (F3)	4.4308	.78996	10	.818
Backorders (F4)	1.2000	.40311	10	.831
Lost sale (F5)	1.3538	.57093	10	.830
Full rate (R1)	1.2769	.35389	10	.829
Product lateness (R2)	1.2769	.35389	10	.829
Customer response time (R3)	4.3692	.97739	10	.813
Lead time (R4)	2.8500	.48372	10	.819
Customer complaints (R5)	4.0462	.79904	10	.822
Appearance (Q1)	3.1356	.48268	10	.817
Product safety (Q2)	3.1356	.48268	10	.817
Product reliability (Q3)	3.2918	.49863	10	.817
Traceability (Q4)	3.1877	.48535	10	.817
Storage and transport conditions (Q5)	4.6923	.46513	10	.825
Working condition (Q6)	3.8000	1.10680	10	.814
Energy use (Q7)	4.0923	1.12809	10	.814
Carbon credit (Q8)	3.1385	1.51943	10	.829
Water use (Q9)	3.7231	1.17935	10	.826
Chemical use (Q10)	1.0000	.00000	10	.827
Launch of a new product (I1)	3.5538	1.11846	10	.813
New technology use (I2)	3.7231	1.17935	10	.816

4.2.3 Validity testing

From the LISREL program, the researcher evaluated an Average Variance Extracted (AVE), a Construct Reliability (CR) by using standardized factor loadings and error indicators (ε_j). The results represented reliability where the Squared Multiple Correlation values were calculated by LISREL program (see Table 4.5).

Table 4.5 Standardized Factor Loadings, Average Variance Extracted and Reliability Estimates of standardized total effect of ETA on Y

Indicator	Factor loading value				
	Efficiency	**Flexibility**	**Responsiveness**	**Quality**	**Innovativeness**
Manufacturing costs (E1)	0.683				
Distribution costs (E2)	0.639				
Inventory costs (E3)	0.793				
Profit (E4)	0.488				
Return on investments (E5)	0.731				
Volume flexibility (F1)		-0.337			
Delivery flexibility (F2)		-0.379			
Customer satisfaction (F3)		0.043			
Backorders (F4)		0.824			
Lost sale (F5)		0.971			
Full rate (R1)			-0.280		
Product lateness (R2)			0.759		
Customer response time (R3)			0.666		
Lead time (R4)			0.644		
Customer complaints (R5)			0.610		
Appearance (Q1)				0.691	
Product safety (Q2)				0.769	
Product reliability (Q3)				0.716	
Traceability (Q4)				0.581	
Storage and transport Conditions (Q5)				0.652	
Working condition (Q6)				0.540	
Energy use (Q7)				-0.224	
Carbon credit (Q8)				-0.395	
Water use (Q9)				0.513	
Chemical use (Q10)				0.704	
Launch of a new product (I1)					0.604
New technology use (I2)					0.704
Average Variance Extracted	0.455 (45.5%)	0.376 (37.6%)	0.377 (37.7%)	0.360 (36.0%)	0.525 (52.5%)
Construct reliability	0.844	0.276	0.689	0.4375	0.682

To assess the construct reliability and average variance extracted, the researcher applied equation 4.1 and 4.2 respectively and also explained how to calculate as below;

$$\text{Construct reliability} = \frac{(\sum \text{standardized loading})^2}{(\sum \text{standardized loading})^2 + \sum \varepsilon_j} \quad (4.1)$$

$$\sum \varepsilon_j = 0.127+0.137+0.121+0.126+0.052 = 2.17$$

$(\sum \text{standardized loading})^2$

= (0.666+0.707+0.699+0.480+0.850)2

= 11.574

$$\text{Construct reliability} = \frac{11.574}{11.574+2.17}$$

$$\text{Average Variance Extracted} = \frac{(\sum(standardized\ loading)^2}{n} \quad (4.2)$$

$$= \frac{(0.666)^2+(0.707)^2+(0.699)^2+(0.480)^2+(0.850)^2}{5}$$

= 0.477 (47.7%)

The results in Table 4.3 represented the AVE estimate range from 31% to 52.6%. However, the AVE should be 0.5 or higher for getting the right outcome. If, the AVE is less than 0.5, it means the error remains in the items and the variance could not fully explain the latent factor structure imposed on the measure. Next, the reliability is the indicator of the convergent validity and the construct reliability (CR) value when was used in conjunction with SEM model. For this research, the CR range from 0.4 to 0.86 that means the flexibility of the indicator and the quality indicator does not fully explain the internal consistency existing.

4.2.3 Model Fitting Degree Analysis

The completed CFA performance model shown in Figure 4.1. It represents the path between sub-indicator and the first order main indicator. Parameter estimation used GLS estimation method with the model fitting to evaluate the degree, and data is analyzed by AMOS software version 21 and LISREL software version 21. As perform CFA results as from two software, was represented in Table 4.6

Table 4.6 CFA Goodness-fit-statistics indices

Evaluating the Data –Model -Fit	Hypothesis	Criteria	Results
1. Chi-square (χ^2) or (CMIN-p)	H_0: Between expected and observed covariance matrices are differently.	p>0.05	p=0.993
2. Chi-square (χ^2) *df* (CMIN/d_f)		<3	0.774
3. Goodness-of-fit index (GFI)	H_0: GFI≥0.90	≥0.90	0.901
4. Root mean square error of approximation (RMSEA)	H_0: RMSEA≤0.08	<0.08	0.000
5. Increment fit index (IFI)	H_0: IFI>0.90	>0.90	≈ 1.00 (1.351)
6. Comparative fit index (CFI)	H_0: CFI>0.90	>0.90	1.00

There are four important indices: 1) CMIN-p, 2) CIMN/d_f, 3) GFI, and 4) RMSEA. Four indices can indicate a good fit and reach the acceptable level of the model estimation. More particulars, the data were looked at the several fit indices from the table 4.5. The criteria standard value suggested the result can be at least relied on the one absolute fit index and one incremental fit index. The first index is a goodness of fit index (GFI), which is 0.901. The GFI value represents the overall goodness of fit of the model GFI, which is more than 0.90. Next, the root means square error of approximation (RMSEA) is 0.000 less than 0.080. The RMSEA fitted to the research model with 27 measured factors that analyzed from the sample size is 120 subjects. The third Increment fit index (IFI) which suitable for the small size of sample data. The IFI also exceed conservative standard that suggested cutoff values. Therefore, it supported the research that will be acceptable. Moving forward to the final index, the incremental fit indices (CFI) which is the most widely to indicate a good fit and reach as the acceptable level. With the comparative fit index (CFI) of 0.90, the CFI value exceeds the CFI guidelines by greater than 0.90 for the complexity model of the study sample size. In conclusion, the CFA results are suggested the performance model can be accepted and provided the reasonably good fit. Therefore, the new model is conceptualized as the 2nd multidimensional construction, which it is consisted of Efficiency, Flexibility, Responsiveness, Quality, and innovativeness.

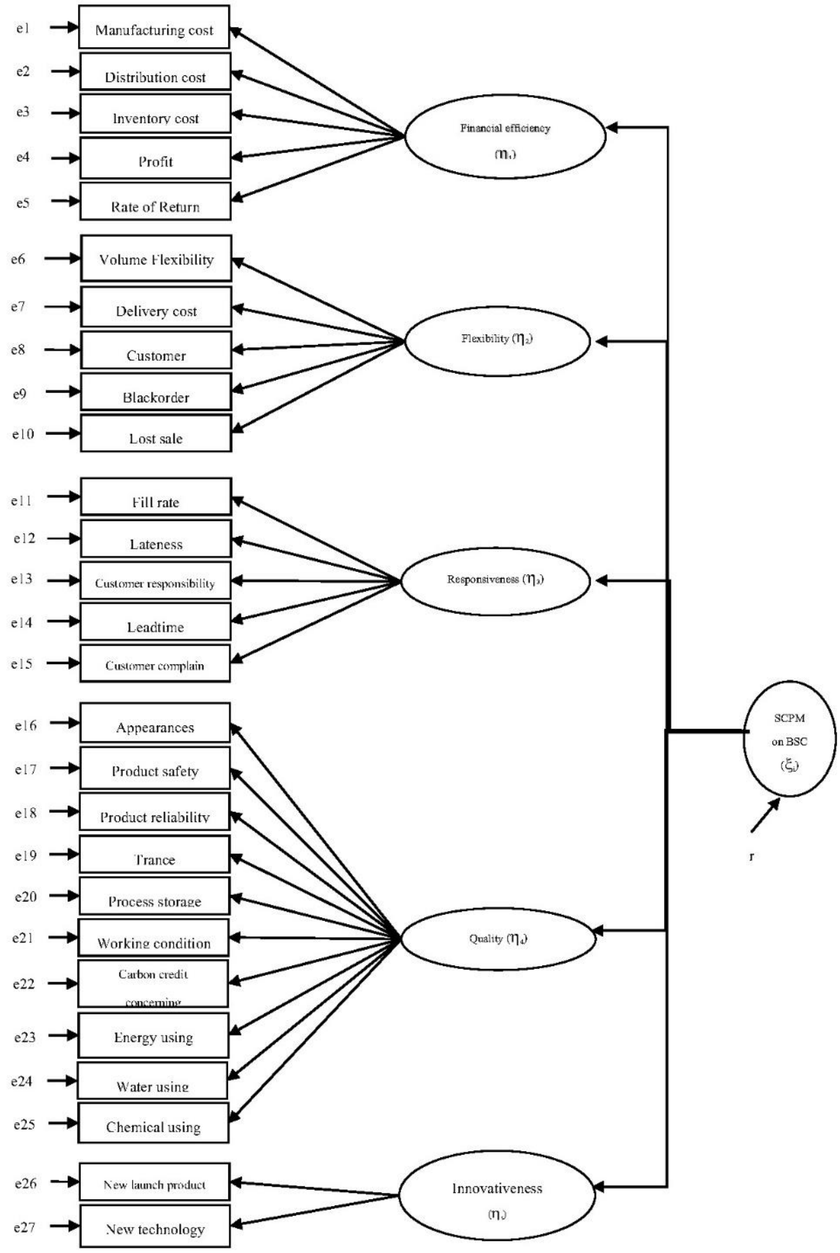

Figure 4.2 The 2nd order CFA of the performance measurement model

According to factor loading in Figure 4.2, the first group of financial efficiency is composed of five variables: 1) Manufacturing costs 2) Distribution costs 3) Inventory costs 4) Profit and 5) Return on investments. From CFA analysis, the result showed the highest of factor loading value is 0.793 on inventory costs. Follow by return on investments is with 0.731, and 0.683 of manufacturing costs, distribution costs is 0.639, and a factor loading value of profit is 0.488 respectfully. High factor loading score more than 0.3 implied observe variables in this group have influence or has a direct effect on financial efficiency. Furthermore, the inventory costs are the most indirect effect to BSC with the factor loading value is 0.447.

Next in the second group, lost sales and Backorders variables are paramount to flexibility criteria that are the second main factors with the factor loading value 0.971 and 0.824 by following. The result represented shrimp products and shrimped raw materials concerned with two observe variables. Because backorders and lost sales point out some problems occurs in farms or hatcheries like a significant problem in diseases, seasoning to cultivation, and shrimp price. In contrast factor, loading values is minus values in volume and delivery flexibility that point out reverse meaning to flexibility criteria. We can explain if delivery time and fast volume changing increase, the flexibility performance will decrease.

The third group addressed to key responsiveness factor. This group concerned to three significant variables in a term of product lateness, time and customer. For example in a real situation, shrimp raw materials such as shrimp larva must arrive at farms on a scheduled time to guarantee a shrimp survival rate. Therefore time and customer variables are important to responsiveness.

The fourth group of the quality criteria represent Q1 to Q6; Q9 and Q10 are important to measurement performance because these variables are in Thai GAP standard. Conversely, energy use (Q7) and carbon credit (Q8) are not only significant but also reverse to measure performance. From interviews, results pointed out all interviewers who are shrimp farmers did not attend to energy use because they used natural gas as the fuel that is cheap. Moreover, many shrimp farmer did not understand about carbon credit in term of meaning, how is it important to their shrimp farms?

The last group is a concern to innovation, factor loading value of launch of a new product and new technology use that are very significant to performance. Because of the new product that are include of developed shrimp genetics that can resist to shrimp diseases can grow in fresh water or sea water. Moreover, shrimp farmers need new technologies to cultivate, to harvest and to distribute.

4.3 Conclusion

This chapter aimed to explain the results on the impact of the integrated performance measurement aspects of general supply chain performance measurement, quality with including environmental aspects on the Thai frozen shrimp supply chain. Moreover, showed the impact of and the key performance measurement indicators and tested the validity and reliability of the new performance measurement framework for evaluating the effectiveness of the frozen shrimp supply chain in Thailand.

The chapter began with an exploration by divided the results into three sections including; section 1: the impact of KPIs on the Thai frozen shrimp chain was explicated related to KPIs used in the study, section 2: the results showed the validity and reliability value of the new performance measurement model is shown in the acceptable level and section 3: the model fitting degree of the performance measurement model is proved that it can apply to use the Thai frozen shrimp supply chain. The researcher will then provide the discussions and conclusion related to those results in Chapter 6.

Next step, the results on analyzing the importance and integrate the key performance measurement indicators for evaluating the effectiveness of the frozen shrimp supply chain in Thailand, indicating the adequacy and feasibility of the performance measurement model for assessing the effectiveness of the frozen shrimp supply chain in Thailand by comparing the results of this study with the outcome of the pilot companies, developing a new performance measurement model for evaluating the effectiveness of the frozen shrimp supply chain in Thailand will explained in Chapter 5.