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MAPPING OF SUPPLY CHAIN RISK IN INDUSTRIAL FISHERIES BASED ON HOUSE OF RISK FRAMEWORK (HOR)

Nhận diện, phân tích và đánh giá rủi ro chuỗi cung ứng thủy sản dựa trên việc thiết lập mô hình ngôi nhà rủi ro HOR

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Abstract. One of the sectors which contributes importantly to the development of Vietnam economy is fisheries industry. However, recent years have witnessed many difficulties on managing the performance of the fisheries supply chain operations as a whole. In this paper, a framework for supply chain risk management (SCRM) is proposed. Initially, all the activities were mapped by using Supply Chain Operations Reference (SCOR) model. Next, the risk ranking was analyzed in a House of Risk 1 (HOR-1). Furthermore, some mitigation actions were deployed, then being analyzed by using HOR-2. For an illustrate purpose, the model has been tested in several case studies with fisheries companies in Can Tho, Mekong Delta. According to the results, 22 risk events and 20 risk agents were identified. Also, there are 10 most critical risk agents which were derived from the highest Aggregate Risk Potential (ARP) and 22 proposed prevention actions were prioritized.

Keywords: *House of Risk; Fisheries supply chain; Supply chain risk management; Supply Chain Operations Reference (SCOR)*

Tóm tắt. Một trong những lĩnh vực đóng góp đáng kể cho sự phát triển nền kinh tế Việt Nam là ngành công nghiệp thủy sản. Tuy nhiên, vài năm trở lại đây, chuỗi cung ứng thủy sản ngày càng được mở rộng cùng với sự tham gia của nhiều thành phần, vì vậy, việc quản lý rủi ro trong chuỗi ngày càng khó khăn và phức tạp hơn.Nghiên cứu được thực hiện nhằm xây dựng một phương pháp chung để quản lý rủi ro cho các thành phần trong chuỗi. Trước tiên, nghiên cứu sử dụng mô hình SCOR để xác định các hoạt động cụ thể trong chuỗi cung ứng từ đó nhận diện các rủi ro có thể xảy ra từ các hoạt động. Tiếp đến, mô hình House Of Risk 1 (HOR-1) được xây dựng để xác định mối quan hệ giữa rủi ro với nguyên nhân gây ra rủi ro. Bên cạnh đó, tác giả tiếp tục phát triển mô hình House of Risk 2 (HOR-2) để xây dựng các giải pháp nhằm giảm thiểu, làm dịu nhẹ rủi ro và xem xét các yếu tố hiệu quả nhất. Mô hình khảo sát được thực hiện tại một số doanh nghiệp thủy sản trên địa bàn Cần Thơ, thuộc ĐBSCL. Kết quả chỉ ra rằng, 22 rủi ro và 20 tác nhân được nhận diện thông qua kết quả khảo sát. Hơn nữa, 10 rủi ro có chỉ số ảnh hưởng xếp hạng cao nhất được chọn để phân tích trong mô hình giải pháp HOR-2.

Từ khóa: *Chuỗi cung ứng thủy sản; Mô hình tham chiếu SCOR; Ngôi nhà rủi ro; Quản lý rủi ro chuỗi cung ứng*

1. INTRODUCTION

The Mekong Delta is one of the great regions contributing to Vietnam's economy. According to Can Tho University' estimates, this region takes account for 70 % of nation's aquaculture areas and 60 % of nation's fish. Nevertheless, the growth rate is low, variable and unsteady. In fact, the common factors affecting the fisheries industry are climate change, temperature, uncontrollable weather, flood-tide, disaster and disease. Also, the majority of fisheries households in Mekong Delta have small extent of culturing lands, do not aware of cooperating with others as well as how to accommodate with the changing of climate. Moreover, understanding of protecting environment and using modern technologies are restricted. Besides, some other factors such as quality requirements, production process, transportation, etc can affect the supply chain as well.

Supply chain risks management is the implementation of strategies to manage both daily and extra-ordinary among supply chain based on continuous risk assessment. Each partner of supply chain has its risks linking from backward or forward one in supply chain adversely affecting the effectiveness of a whole chain. With the objective of reducing vulnerability and ensuring continuity, SCRM is collaboratively with partners in a supply chain or on your own as well as applies risk management tools to deal with risks and uncertainties caused by, logistics related activities and resources in supply chain.

In this approach, we analyzed the activities of partners in supply chain as well as identify essential risks and prevention actions. Some of risks can be solved, diminished, transferred whereas others are unavoidable. First, SCOR model (Supply Chain Operation Reference) was applied for the purpose of analyzing the activities according to five main stages including plan, resource, make, deliver, and return, of all partners among the fisheries supply chain. Second, using HOR-1 (House of Risk) to assess risks and their roots as well as analyzing the relationship between risks and causes. Next, the prevention actions were defined and analyzed by HOR-2 to obtain the priority actions that the company should do in order to maximize the effectiveness with subject to their acceptable resource and financial status.

2. LITERATURE REVIEW

2.1 The supply chain operations reference model (SCOR model)

The supply chain operations reference model (SCOR model) was developed in 1996 by the management consulting firm PRTM, now part of PricewaterhouseCoopers

LLP (PwC) and AMR Research, and endorsed by the Supply-Chain Council (SCC). SCOR is a process reference model describes the business activities associated with satisfying a customer's demand, which include plan, source, make, deliver, and return[3], [9]. Use of the model includes analyzing the current state of a company's processes and goals, quantifying operational performance, and comparing company performance to benchmark data. This reference model enables users to address, improve, and communicate supply chain management practices within and between all interested parties in the extended enterprise.

2.2 House of risk 1 (HOR-1)

House of risk is developed upon foundation of well-known model House of Quality (HOQ) but in sense of determining which risk actions to be tackled first and selecting a set of proactive actions deemed cost-effective to be prioritized. It is divided into two phases, House of risk 1 (HOR1) is used to determine which risk agents are to be given priority for preventive actions [1, 4-5] whereas House of risk 2 (HOR-2) is to give priority to those actions considered effective but with reasonable money and resource commitments [4].

HOR first stage as the stage for the data input work has 8 steps as follows:

Step 1 Identifying the activities in the supply chain based on the SCOR model, with a view to facilitate the detection process in which the risk of potentially emerge (where are the risk).

Step 2 Identifying the entire incident risks that may appear on any activity in the supply chain.

Step 3 Identifying severity level or degree of impact of each risk event using a scale of 1-10.

Step 4 Identification result (potential causes) an occurrence of the activity of the supply chain process, as a result will help to describe what disorders arising from any risk.

Step 5 Identifying the agency risk (risk agent), which detects any factors which may cause the occurrence risks identified in step.

Step 6 Identification of correlation between events to trigger agent risk. If an agency risk of causing a risk, it can be said there is a correlation. If a strong correlation is weighted 9; correlations are given weights 3 and a weight of 1 to the value of the correlation is weak.

Step 7 Identifying opportunities emergence (occurance) of each agent risks, to determine the risk of chance occurrence of an agent using a scale of 1-10.

Step 8 Determination of the risk priority index value, priority will be used benchmark index for recommendation selecting agent which risks need to design a risk mitigation strategy.

2.3 House of risk 2 (HOR-2)

HOR2 is used to determine which actions are to be done first, considering their differing effectiveness as well as resources involved and the degree of difficulties in performing. Company should ideally select set of actions that are not so difficult to perform but could effectively reduce the probability of risk agents occurring [4].

The steps are as follows:

(1) Selecting a number of risk agents with high-priority rank, possibly using Pareto analysis of the ARP_j, to be dealt with in the second HOR. Those selected will be placed in the left side (what) ofHOR-2. Put the corresponding ARP_j values in the right column.

(2) Identifying actions considered relevant for preventing the risk agents. Note that one risk agent could be tackled with more than one actions and one action could simultaneously reduce the likelihood of occurrence of more than one risk agent. The actions are put on the top row as the "How" for this HOR.

(3) Determining the relationship between each preventive action and each risk agent, E_{jk}. The values could be (0, 1, 3, 9) which represents, respectively, no, low, moderate, and high relationships between action k and agent j. This relationship (E_{jk}) could be considered as the degree of effectiveness of action k in reducing the likelihood of occurrence of risk agent j.

(4) Calculating the total effectiveness of each action as follows:

$$TE_k = \sum ARP_j . E_{jk} \quad (1)$$

(5) Assessing the degree of difficulties in performing each action, D_k, and put those values in a row below the total effectiveness. The degree of difficulties, which can be represented by a scale (such as Likert or other scale), should reflect the fund and other resources needed in doing the action.

(6) Calculating the total effectiveness to difficulty ratio

$$ETD_k = \frac{TE_k}{D_k} \quad (2)$$

Assigning rank of priority to each action (R_k) where Rank 1 is given to the action with the highest ETD_k.

3. METHODS

The data was collected from the companies through questionnaires, which formed based on the result of SCOR model and House of risk framework. The sample size consist of 8 small and medium fishery companies, in the total of 45 companies, (17.7%), which are located in Can Tho, Mekong Delta. The risk analysis was constructed by risk mapping and risk classifying based on SCOR and HOR. It helps us to select which risks and prevention actions should be tackled first in the constraint of budget and resource [4], [6].

4. RESULTS

4.1 The SCOR model and HOR-1 framework for fisheries companies

Risks and causes are found from activities in the planning, source, making, delivery and return stages are listed in the SCOR in Table 1.

According to survey, we obtain the aggregated of severity of risks, the probabilities of causes and the correlations among them are shown in Table 2.

For examples, we compute ARP_1 as follow:

$$ARP_1 = O_1 * (R_{11} * S_1 + R_{51} * S_5 + R_{61} * S_6 + R_{14;1} * S_{14} + R_{19;1} * S_{19})$$
$$= 5*(3*8 + 9*7 + 3*5 + 1*1 + 1*7) = 550$$

Based on this calculation, the aggregate risk potentials (ARPj) are obtained in Table 2.

Table 1. *SCOR model with risks and causes of risks at five stages through fisheries supply chain*

SCOR model	Activities in supply chain	Risks in supply chain (E_i)	Causes of risks (A_j)
Planing	- Planning product development -Planning for seafood processing and product quality -Understanding the contract or requirement of customers - Build a supplier selection strategy - Forecast the seafood market in the coming time	- Cancel the contract (E1) - Depend on a supplier (E2)	- Do not have long- term plan (A1) - Manage the finance ineffectively (A2) - Weakness in suppliers selection (A3) - Natural disaster (drought, flood,…) (A4) - Environmental pollution (A5) - Economic crisis (A6)
Source	- Predict the cycle of entering new material sources - The process of sharing information on fishery quality requirements and production lead time for suppliers - Consolidate invoices, pay for the cost of orders - Maintain the relationship with suppliers and sub-contract company	- The price of input materials fluctuate high (E3) - The quality of input materials does not match standardization (E4) - Lack of high skilled workers (E5) - Lack of capital (E6)	- Quantity limit (materials, products) from suppliers or sub-contract company (A7) - Difficult to compare the suppliers (A8) - Suppliers or sub-contractors went bankrupt (A9) - Production techniques are limited (A10)
Making	- Prepare for production schedule - Planning the amount of workers - Maintaining human resources attached to the company - Assign human resources among parts of company - Check the quality of products and production process - Controlling unexpected interruption in production system (devices, human…)	- Production process is delayed (E7) - Devices are out of order in production process (E8) - Regularly increasing production time (overtime) (E9) - Strike (E10) - Lack of materials (E11) - Errors in marking components which are used in production process (E12) - Products are contaminated, exceeded of proportion of heavy metal (E13) - Closed the company (E14)	- Changing production plan (A11) - Weakness in controlling system (quality of material, product, check hygienic of workers before production…) (A12) - Strict requirements for product (A13) - Low workers salary (A14)
Delivery	- Managing orders (amount, delivery date, received date) - Build shipping and distribution schedules - Managing the co-operative relationship with distributors	- Means of transportation are out of order regularly (E15) - Error in delivery (date, amount, type of product, address) (E16) - Delivery time of suppliers change many times (E17) - Reserved products/ materials are spoiled, increasing inventory cost (E18) - The risks of trade or negotiation with international ports (E19) - Exchange rate risks (E20)	- Less maintenance of machinery (A15) - Regularly late delivery (A16) - Long-term shortage of products in stock (A17) - Lack of collaboration with outside organizations (A18)
Return	- Adapting to the changes of customers' needs, time, age… - Managing the co-operative relationship with customers	- Do not meet the expectation of customers (E21) - Products are refunded (E22)	- Do not note the orders in detail (wrong date, amount, type of product) (A19) - Quality of products does not match requirements (A20)

Table 2 shows that the calculated values range from 30 to 550. There is only one risk agent with an ARP value of more than 500; two risk agents with an ARP value between 300 and 500; six risk agents with an ARP value between 100 and 300; and the rests (11) have an ARP value below 100. In addition, Pareto analysis shows that the first five risk agents contribute to about 60 % of the total ARP values and ten risk agents contribute to 80 % of the total ARP.

4.2 Building the HOR-2

For HOR-2, ten risk agents which contribute to about 80 percent of the total ARP should be used to further analysis. The result can be used to identify and prioritize actions that the company should do in order to maximize the effectiveness of effort with acceptable resource and financial commitments. The difficulty of performing each action is classified into three categories: low with a score of 3, medium with a score of 4, and high with a score of 5 (Likert scale). As pointed out above, the degree of difficulty should also reflect the money and other resources needed to perform the corresponding action. Hence, the ratio would indicate the cost effectiveness of each action.

Based on Table 4, we compute TE1, for example:

$$TE_1 = \sum_{j=1}^{10} \mathrm{ARP}_1 * E_{10;1} = 288*9 = 2592$$

After that we compute ETDk. Calculating ETD1, for example: $ETD_1 = \frac{TE_1}{D_1} = \frac{2592}{3} = 864$

Table2. *HOR-1 Analysis*

Risks	Causes of risk																				S_i
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	
E1	3			9			3						3			9					6
E2			3					9													4
E3						3															6
E4			9		1							9									5
E5	9	3																			7
E6	3	9																			5
E7		1		9	3						3	3									3
E8															9						5
E9							3				3										4
E10														9							1
E11			9				3		3												6
E12										9		3									8
E13										9		9									9
E14	1	9																			1
E15												1			9						6
E16												3							9		4
E17			1																		5
E18												3					9				4
E19	1																	3			7
E20				3		9															3
E21													9								4
E22																3				9	5
O_j	5	2	1	1	2	2	3	1	3	2	4	2	4	4	1	2	3	2	1	1	
ARP_j	550	160	116	90	40	90	162	36	54	306	108	378	144	36	99	30	108	42	36	45	
P_j	1	5	7	11	16	12	4	17	13	3	8	2	6	17	10	20	8	15	17	14	

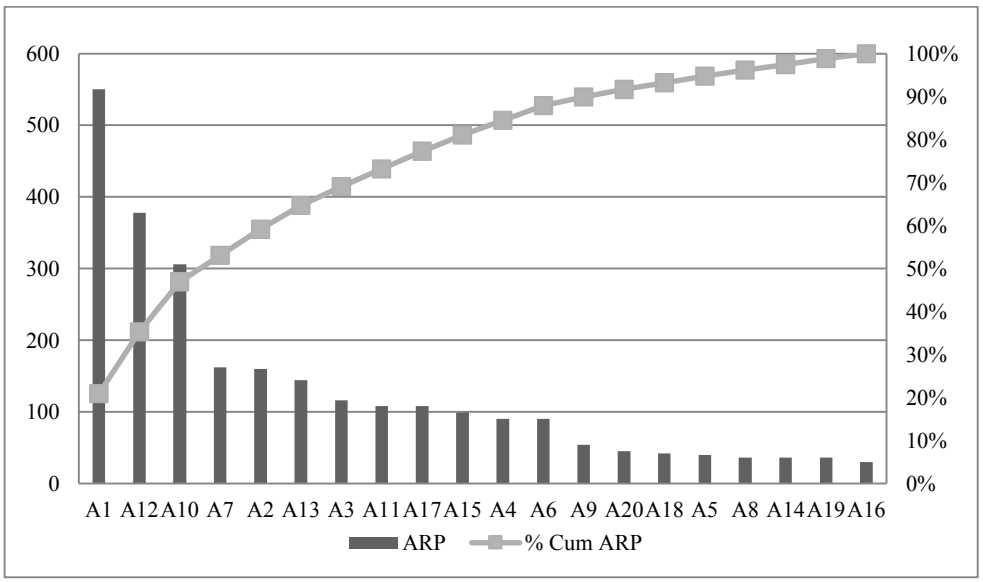

Figure 1. *Pareto diagram of aggregate risk potentials of all risk agents*

Based on Table 4, we compute TE_1, for example:

$$TE_1 = \sum_{j=1}^{10} \mathrm{ARP}_1 * E_{10;1}$$

$$= 288*9 = 2592$$

After that we compute ETD_k. Calculating ETD_1, for example:

$$ETD_1 = \frac{TE_1}{D_1} = \frac{2592}{3} = 864$$

With the degree of difficulty D_k obtained from the survey, we take similar calculation for the rest ETD_k. Finally, we have the ranking of PA_k according to ETD_k.

The priority for each action is obtained based on the values of the effectiveness to difficulty ratio of action k (ETD_k). The higher the ratio, the more cost effective is the proposed action. Based on the result from Table 4, we see that the most cost effective action would be to planning the entire production process and long term development orientation. In fact, this action is effective in both ways of budget and resource. For other actions, companies can choose to act base on their experience and real condition.

Table 3. *Prevention actions for ten risk agents which have highest ARP*

Code	Risk agent	Prevention action
A1	Do not have long term plan	Planning the entire production process and long term development orientation (PA1)
A2	Manage the finance ineffectively	Make a list of revenue and expenditure by item/rule (PA2)
		Forecast of revenue and expenditure during production process and long term production plan (PA3)
		Have a plan of capital when necessary (borrow, reserve funds…) (PA4)
A3	Weakness in suppliers selection	Build a relationship with different suppliers(PA5)
		Work with many suppliers (compare quality, price, prestige) (PA6)
A7	Quantity limit (materials, products) from suppliers or sub-contract company	Co-operate with companies in the same field (PA7)
		Build a relationship with different suppliers (PA5)
A10	Production techniques are limited	Learn about production experience from colleagues (PA8)
		Invest in advanced technology line (PA9)
		Sending staffs to developed country for training (PA10)
A11	Changing production plan	Forecast the quantity need to be produced daily, weekly… (PA11)
		Make detailed production plan before implementation (PA12)
		Carefully consider customer requirements before production (PA13)
A12	Weakness in controlling system (quality of materials, product, check hygienic of workers before production…)	Set up teams to inspect from input materials to output products (PA14)
		List the appropriate additives for each specific product (PA15)
		Tightly check workers from beginning to ending (PA16)
		Check warehouse periodically to avoid wasting, damaging materials/ products (PA17)
		Manage specific orders of suppliers and customers (quantity, date, type of product) (PA18)
A13	Strict requirements about product	Invest in advanced technology line (PA9)
		Open training courses to improve the skills of workers (PA19)
		Tightly check packages before shipment (PA20)
A15	Less maintenance of machinery	Make periodic maintenance plans (PA21)
A17	Long-term shortage of products in stock	Check warehouse periodically to avoid wasting, damaging materials/ products (PA17)
		Use JIT (Just In Time) in production to reduce cost (PA22)

5. DISCUSSIONS AND CONCLUSIONS

Results showed that 22 risk events and 20 risk agents are identified, and the two most important risks are A1 "Do not have long term plan" and A13 "Strict product requirement". Moreover, 10 risks which have highest priority are used effectively for House of Risk 2 with prevention actions. In HOR-2, it is showed that Planning the entire production process and long term development orientation (PA1), List the appropriate additives for each specific product (PA15), Tightly check workers from beginning to ending (PA16) are the three top actions which have higher values of the effectiveness to difficulty ratio of action.

In conclusion, the paper proposes a model for the risks mapping and actions priority calculation using SCOR-HOR for the applications in fisheries supply chain. The findings would help managers to analyze and to take actions for managing the risk factors to improve the performance of their organizations effectively. However, the sample size of experts is small and to remove the biasness of opinion, the model can be further validated using Structural Equation Modeling (SEM) in the future.In this paper, we also ignored the dependence between risk events. Therefore, such dependencies should be taken into account in future studies. In fact, there are some tools could be considered as a way to determine the relative severity of risk events such as Analytical Network Process (ANP) and Interpretive Structural Modeling(ISM) [2, 7-8].

Table 4. *HOR-2 Analysis*

	PA_1	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA	PA_{15}	PA	PA	PA	PA	PA	PA	PA	**ARP**
A1	9																						550
A12														3	9	9	3	3					378
A10								1	9	3													306
A7					9		3																162
A2		3	3	3																			160
A13									9										3	1			144
A3					3	3																	116
A11											3	9	3										108
A17																	9					9	108
A15																					9		99
TE_k	4950	480	480	480	1806	348	486	306	4050	918	324	972	324	1134	3402	3402	2106	1134	432	144	891	972	
D_K	3	3	3	5	4	4	4	5	5	5	3	3	3	5	3	4	3	3	4	3	4	5	
ETD	1650	160	160	96	452	87	122	62	810	184	108	324	108	227	1134	851	702	378	108	38	223	195	
R_K	1	13	13	10	6	20	15	21	4	12	16	8	16	9	2	3	5	7	16	22	10	11	

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BIOGRAPHY

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