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Quantitative Analysis and Upgrade Solutions for the Mud Crab Supply Chain in Mekong Delta VietNam

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Abstract. The supply chain of mud crabs in the Kien Giang, Bac Lieu, and Ca Mau provinces of the Mekong Delta in Vietnam was analyzed using surveys of 308 crab farmers and 551 additional supply chain actors. The study mapped six key distribution channels, with domestic channels accounting for 82% of consumption. An in-depth value chain analysis found that crab farmers contribute 70% of added value in the predominant channel. The average waiting time for crabs ranged from 45-107 hours, reducing meat quality and prices over time. A SWOT analysis identified strengths like farmer experience and weaknesses like high supply chain risks and low farming cost-effectiveness (31%). Solutions are proposed to upgrade quality management and enhance actor linkages to improve competitiveness.

Keywords: mud crab, supply chain, supply chain management, Mekong Delta

1. Introduction

In recent years, there have been many studies on the supply chain of the seafood industry in the world as well as in Vietnam. (Quagrainie et al., 2007; Shamsuddoha, 2007; Chojar, 2009; Mojammel et al., 2016; Patchanee et al., 2017; Jahan et al., 2016; Abduho et al., 2018; Coronado Mondragon et al., 2021; Love et al., 2021; Loc, 2006; Nga et al., 2020; Loc, 2009; Van, 2010; Vi et al., 2010; Belton et al., 2011; Xuan et al., 2012; Thai, 2013; Thu, 2015). Most of the studies have shown a number of solutions to enhance the efficiency of supply chain operations in the seafood industry, such as "saving operating costs, improving the quality of seafood products, enhancing vertical-liking, and cross-linking between actors in the supply chain". In addition, there are a few studies on "risk management in the supply chain, optimization in logistics, strengthening distribution channels". (Christopher, 2011; Panchal et al., 2012; Phong, 2014; Anggrahini et al., 2015; Lin et al., 2016; Love et al., 2021). However, most of the studies on the seafood industry have not focused on the transportation time of products from production to consumption. While the mud crab industry is a fresh industry, it means product quality will decrease with waiting time along with the risk of loss during large transportation. Meanwhile, there are currently no studies in Vietnam that analyze in-depth the process of risk management, waiting time management, and logistics optimization for the mud crab industry.

In these difficult conditions, mud crabs (Scylla paramamosain) have fast growth, high tolerance to changes in environmental factors, resistance to diseases, wide food spectrum, large size, proactive seed source, high economic value and easy storage after harvest. Consequently, mud crabs are considered an object favored by people for effective polyculture with shrimp. (Nghi et al., 2015; Long, 2019; Johnston et al., 1999). According to the Directorate of Fisheries in 2020, the total output of mud crabs in the Mekong Delta in 2020 is 67 thousand tons, an increase of 19% compared to that of 2015. Profits from converting the specialized shrimp farming model to combining shrimp-crab farming are initially highly economic. On average, each farmer earns 30 million VND/ha/crop. However, products of mud crab are mainly consumed domestically, they have not been exported to the international market (Nhung, 2013). Although the mud crab consumption market in the world is quite large, in 2019, the total production was 187 million tons, and countries such as the US, China, Indonesia, and Singapore have the leading consumption markets (FAO, 2020).

Besides, most mud crabs are consumed fresh whole on the domestic market as well as for export. Currently, the Mekong Delta does not have a large-scale crab export processing factory, but only raw, small, and retail processing facilities in the locality. Meanwhile, if the waiting time for mud crabs from the harvest of smallholdings to the consumer is quite high, it means the quality of the meat, as well as the cost of the product, will be reduced. Therefore, an quantitative Analysis and Upgrade Solutions for the Mud Crab Supply Chain in Mekong Delta Vietnam is really necessary. The research objective is to help actors in the supply chain operate effectively, and meet the right time, quantity, quality and consumers of mud crab products at competitive prices to help develop the mud crab industry in the Mekong Delta sustainably.

2. Literature Review

The overview of empirical research on the supply chain in the world and in Vietnam on the seafood industry, which developed in the early 1960s, but did not develop stronger until the 1980s. Research objects for the seafood industry also focus on objects of high economic value, such as shrimp, catfish and marine fish. The main research methods are descriptive statistics, synthesis methods and linear regression (Gorga et al., 1979; Lee, 1969; Olson, 1972; Penn et al., 1979). These studies have shown the characteristics of the seafood industry and the development direction of the industry, but they have not analyzed the causes of the existing problems of the commodity. Until the early 1980s, research mainly focused on analyzing market structure fluctuations, price relationships of seafood products, analyzing policy matrix studies (Meyers et al., 1980; Jones, 1968; Airth, 1976; Marion et al., 1979). Developing more and realizing the export standards of the seafood industry, researchers also use

analytical methods to manage the quality of the seafood supply chain to meet the strict requirements of the market (Vi et al., 2010; Loc et al., 2011; Lan et al., 2013; Quagrainie et al., 2007; Tobias et al., 2007; Christopher, 2011; Hieu, 2012; Panchal et al., 2012).

This method mainly focuses on enhancing the quality in the production and processing stages to ensure that the output products meet the requirements of the consuming market. It is called the market structure analysis method. This approach manages input products and processing and delivers them to consumers through distribution channels. The analysis of waiting time in the supply chain to shorten the shelf life of seafood products and enhance the quality of fresh seafood products (He et al., 2002; Kannan et al., 2005; Panchal et al., 2012; Ralahallo, 2021) and logistics analysis in the supply chain of the seafood industry to help optimize the time and method of transporting products from the production to the consumer (Martin, 2016; Tseng et al., 2020; Mangun et al., 2021; Trang et al., 2020; Dung, 2015; Trang, 2015).

The market analysis method is also applied by researchers in the supply chain analysis of the seafood industry with the aim of identifying the determinants in the seafood supply chain (Airth, 1976; Hanekom et al., 2010; Thai, 2013; Thuan et al., 2014). In addition, recent research has focused on analyzing and upgrading supply chains to improve linkages between actors in the supply chain (Olson, 1972; Lambert et al., 1998; Loc, 2006; Nagarajan et al., 2008; Chojar, 2009; Freitas et al., 2009; Van, 2010; Vi et al., 2010; Hieu, 2012; Xuan et al., 2012; Trang, 2015; Patchanee et al., 2017; Loi et al., 2019; Anh et al., 2021). Analyzing the factors affecting the supply chain of the seafood industry to find out the factors affecting the performance of the supply chain (Kuei et al., 2001; Chu et al., 2006; Shamsuddoha, 2007; Tobias et al., 2007; Chojar, 2009; Lan et al., 2013; Phong, 2014; Haque et al., 2015; Mojammel et al., 2016; Thuy, 2018; Nga et al., 2020). Risk analysis in the supply chain aims to measure and predict potential adverse events affecting supply chain performance (Love et al., 2021; Anggrahini et al., 2015; Fitrianto et al., 2012; Karningsih et al., 2018; Fleming et al., 2014; Hien et al., 2022).

The research on the factors affecting the intention of consumption behavior for seafood products has been studied extensively at home and abroad, the studies show three groups of factors affecting the intention to consume. such as social influence, self-criticism, and self-perceived control (Annunziata et al., 2009; Binpeng et al., 2016; Blackwell et al., 2006; Higuchi et al., 2017; Xe et al., 2021). Besides, seafood products provide daily nutrition for meals, so the level of choice depends on factors such as brand awareness, health, food safety and hygiene (Zaeema et al., 2016; Manus et al., 2014; Lorenzo et al., 2021; Ngoc et al., 2013; Riniwati et al., 2017). In recent times, the study of mud crabs has been of great interest to researchers. However, because mud crab is a new research object, studies on the supply chain of mud crabs mostly analyze in the direction of completing the chain structure, analyzing simple financial indicators in the crab fishing industry, cost and benefit analysis of the mud crab farming industry (Hungria et al., 2017; Bain et al., 2017; Nascimento et al., 2017; Uddin, 2002; Mirera, 2011; Mangubhai et al., 2017; Zafar et al.,2006). Just like in Vietnam, the economic studies on the supply chain of the mud crab industry have not received much attention. Through the literature review, there are only a few studies on the economic efficiency of the model (Hien et al., 2015), and some studies on the factors affecting the technical efficiency of the extensive crab farming model (Nhung, 2013; Nghi et al., 2015). In general, there has been no research to analyze the supply chain of mud crabs from products produced with the lowest operating costs to the final consumer to meet the requirements in terms of quantity, quality, time, location, and the right consumers.

3. Research Methods

The objective of the article is to evaluate qualitative to accomplish the above objectives.

The process is outlined as follows:

Step One: Initial research applies qualitative techniques to identify and adjust From there, develop a suitable questionnaire for official research. This phase involves conducting in-depth, technical, one-on-one interviews and discussions with the individuals under consideration. These individuals including

supply chain actors and experts and experts in related fields. The main purpose is to explore the factors that influence the supply chain.

Step two: Official research and application after recalibration Qualitative research questionnaire with simple language, comprehensive and inclusive additional information. Variables are added or removed as needed. The questions are distributed to actors in the mud crab supply chain. The collected data is then processed using SPSS software version 20.

3.1. Research area

Criteria for selecting a survey site for mud crab farmers based on the area and production of mud crabs in 2018 in the Mekong Delta. Among the 6 provinces with a mud crab farming model in the Mekong Delta, three provinces Kien Giang, Bac Lieu and Ca Mau were selected to interview farmers in the model of mud crab farming because the area and production of mud crabs are the largest in the Mekong Delta (91% area and 76% of regional production).

The interview area in Kien Giang province includes three districts of An Minh, An Bien and Vinh Thuan, with the highest yield of mud crab (65% of the province's area). Correspondingly, the interview area in Ca Mau province includes three districts of Nam Can, Dam Doi and Ngoc Hien (60% of the province), and the interview area in Bac Lieu includes three districts of Gia Rai, Phuoc Long and Dong Hai (70% of the province's area).

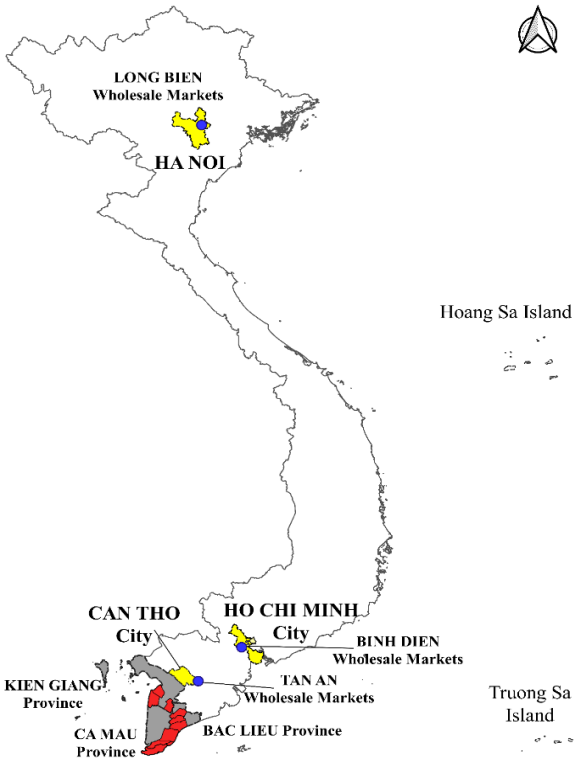

Fig.1: Study Areas

After interviewing the mud crab farmers, the input supply group, the mud crab consumer group, and the whole supply chain support group were gradually identified through the chain-linked sampling method (relational network sampling). Since this article mainly analyzes the current state of the mud crab supply chain of the domestic market, the group of actors and consumers interviewed mainly for the domestic market.

3.2. Sampling techniques

This study utilizes statistical data and existing information to create tables, graphs, and charts for

comparison and evaluation. The synthesis analysis method is applied to reason and explain the characteristics of the supply chain in the seafood industry in the researched area. Additionally, interviews with 12 farmers in An Minh district, Kien Giang province, using structured questionnaires, aim to gather insights on improving crab farming processes, reasons for changes since 2012, and shifts in choosing channels for crab consumption. Experts and support personnel, totaling 10 observations, are interviewed in provinces with crab farming models in the Mekong Delta to identify supply chain issues, propose strategies to enhance crab product quality, and suggest changes in product consumption channels. Individual interviews with two consumer groups (5 individuals each) in Can Tho City, using structured questionnaires, explore factors influencing crab type selection and differences in crab quality concerning extended storage times. Finally, three input suppliers, such as seafood breeding material in 2018, are interviewed using structured questionnaires to assess the development of the crab supply chain and the input market for seafood breeding materials and breeds.

3.3. Survey design

The study involves interviewing 9 individuals who are owners of seafood and crab breeding agency as input suppliers. For the production factor, 308 crab farmers are interviewed using a systematic sampling method. The distribution factor includes interviews with 27 wholesalers, 9 markets, 3 wholesalers, and 33 retailers using a network-based sampling method. Additionally, 159 local consumers are interviewed using a convenient sampling method. The research aims to conduct a comprehensive analysis of the structure, operation, and economic aspects of the supply chain in the crab industry in the Mekong Delta.

3.4. Data Sources and Sampling Method

The sample size of smallholdings was determined to satisfy the minimized sample size of the formula of (Slovin, 1960) $n=N/(1+N*\varepsilon 2)$ = 227 households. According to (Subong et al. 2005), ε=6% and according to the statistical yearbook of the three provinces of Kien Giang, Bac Lieu and Ca Mau, the total number of smallholdings raising mud crabs is N=225,167 smallholdings. Therefore, in order to be highly representative, the researchers chose to interview 308 crab-shrimp farming smallholdings in three provinces of Kien Giang, Bac Lieu and Ca Mau to ensure greater than 227 smallholdings calculated according to the formula, and interview from October to December 2019.

The research team interviewed 551 crab-shrimp smallholdings to observe the actors inside and outside the mud crab supply chain in the Mekong Delta. The group of actors in the chain includes the input supply group (seeds, feed, medicine to prevent crab diseases), mud crab farmers, and the consumer group (traders, storehouses, wholesalers in the Mekong Delta provinces and Ho Chi Minh City, retailers in traditional markets, supermarkets and seafood stores/sales agents and consumers in Can Tho City, HCMC and Hanoi. The group of actors outside the supply chain includes local ministries, banks, and experts on mud crabs. Farmers and consumers were interviewed directly and sampled by a systematic and multi-stage sampling method.

3.5. Sampling technique

Mud crab farming households: Multi-stage probability sampling according to yield criteria with 6 Mekong Delta provinces selecting three provinces (Kien Giang, Bac Lieu, Ca Mau), each province selecting three districts and each district three communes and each commune Choose 3 hamlets. At the hamlet, based on the list of mud crab farmers, probability sampling was conducted using a systematic sampling method. Direct interviews with mud crab farmers using a structured questionnaire

Mud crab consumers: First, the study analyzed the current situation of the research area in three large cities: Can Tho, Ho Chi Minh and Hanoi, next the study conducted qualitative research from synthesis. expert opinions and prepare a pilot survey questionnaire, and finally, from the results, edit the questionnaire and conduct an official investigation. Interview consumers by directly interviewing 150 people at households using non-probability sampling method (convenience sampling). Results after the interview: 134 votes met the quality and quantity requirements of Can Tho (38 observations), Hanoi

(48 observations) and Ho Chi Minh (48 observations) to be included in the analysis.

Table 1. Sample size and Sampling method

Area	Actors	Sample size	Sampling method
1. Ca Mau province, Bac Lieu province, Kien Giang province	1.1. Crab farmers	308	Multiple stages and the final stage are systematic sampling
	1.2. Traders (collectors)	27	Relation network
	1.3. Storehouses	9	Relation network
	1.4. Actors outside the supply chain	12	Relation network
2. Can Tho City, Ho Chi Minh City, Hanoi	3.1. Wholesaler (markets concentrate large quantities of goods from production or business sources for further distribution to markets and other circulation channels)	03	Relation network
	3.2. Traditional retailers (markets)	27	Relation network
	3.3. Modern retailer (supermarket)	6	Relation network
	3.4. Business consumers (restaurants, cafeterias)	09	Relation network
	3.5. Individual consumers	150	Convenience
Total		**551**	

3.6. Methods of data analysis

Supply chain economic analysis: it is an assessment of the capacity and economic performance of the chain. It includes the determination of added value at stages in the supply chain, production costs and operators' income. In other words, the goal of a chain economic performance analysis is to determine the benefits and costs of each actor in the entire chain. Therefore, propose solutions to increase the added value of each actor as well as of the entire supply chain.

Analysis of logistics costs in the supply chain: Logistics costs include: transportation costs (costs of circulation and distribution), capital opportunity costs (minimum return that the company earns when capital is not invested in inventory but in another activity); Cost of goods preservation (expenses for renting a warehouse, preserving goods, bringing goods to the warehouse, damaged goods, and insurance for goods).

Analysis of the supply chain risks: In a supply chain, the front actor supplies the product to the actor behind it, each of which contains risks, so if there is a problem at any stage, it will affect the entire chain. Therefore, we need to limit the risk because of its impact on cost, the efficiency of production, processing and marketing. Especially, risks that occur along the supply chain (Merrill, 2007; Dave et al., 2007; Concina, 2014).

SWOT matrix analysis: According to a study by (Gordijn et al., 2018) of the research and innovation center of Wageningen University, Netherlands, which introduces a grading method of SWOT analysis that allows for more thought-provoking based rather than habitual or instinctive responses. The SWOT matrix analysis model includes the causes of good points, and bad points as well as rewrites good and bad points as opportunities and threats, including 7 steps.

4. Results and Discussion

4.1. The production and consumption of mud crabs in the Mekong Delta

In the Mekong Delta, mud crabs have been a new animal that people have chosen to raise since 2012, and until 2016, the planned area for stable mud crab farming in the three provinces in 2020 was 465 thousand hectares (Kien Giang 73 thousand hectares, Ca Mau province). Mau 277 thousand ha, Bac Lieu 72 thousand ha), an increase of 9.5% compared to 2016. Meanwhile, the output of mud crabs in the three provinces is 54 thousand tons/year (Kien Giang 20 thousand tons, Ca Mau 24 thousand tons and Bac Lieu 10 thousand tons), an increase of 11.9% compared to 2016. Although Ca Mau is the province with the highest crab farming area, the yield is not high because farmers here raise shrimp-crab-rice, and shrimp stocking density is very low. According to the results of interviews with local

government supporters at all levels and actors participating in the chain, the reason why the crab farming area has been stable in the last five years is that the government has implemented the planning, and the production level has increased. This is because farmers have a lot of experience accumulated after 10 years of converting and applying science and technology to production. The rapid increase in output will put pressure on commodity consumption, and the price of crabs will drop sharply at the time of harvest, affecting the income of crab farmers as well as the seafood consumption market.

In 2020, Vietnam's mud crab exports will reach 126 million USD, a decrease of 5.5% compared to 2019. In which, the Mekong Delta exported mud crabs through 3 main markets: Hong Kong, Asia, and the EU, accounting for 72% of the total export production (VASEP, 2020). In the Mekong Delta, mud crabs are mainly consumed domestically through traders and retailers at wholesale markets. Due to the characteristics of seasonal products, prices are not stable, often high prices in the opposite season and low prices in the main season. Most of the crab prices are set by traders and often lower prices for farmers. The market for mud crabs is divided into 5 types of crabs with different prices, but in reality, there are only 3 main types of crabs: meat crabs, brick crabs and defective crabs. The purpose of traders is to offer many different types to easily "press prices" on farmers (Binh Dien wholesale market 2020). According to the forecast of the Directorate of Fisheries and the planning of the Ministry of Agriculture and Rural Development, the output of mud crabs in the Mekong Delta by 2025 will reach 80,000 tons, up 9% compared to 2021. Production will cause many difficulties and challenges for the mud crab industry, such as environmental pollution, reduced quality of crabs, antibiotic residues, fake prices and unstable markets (Pho, 2015). In the coming years, Vietnam's seafood export industry will face many difficulties when major markets such as the US, EU, and Japan apply export barriers, traceability, food safety and hygiene, as well as the impact of export barriers. environmental action. According to VASEP's forecast, by 2025, if there is no specific industry development plan with rampant production in the traditional way, export turnover will continue to decrease by 36% compared to 2021.

4.2. Analysis of the mud crab supply chain in the Mekong Delta

Map of the mud crab supply chain in the Mekong Delta

The supply chain map of mud crab products in the Mekong Delta is formed from the participation of many actors: input suppliers (seedlings, aquatic materials), crab farmers, traders, retailers, wholesalers, retailers and consumers. In addition, the chain also receives support from external organizations to perform the main functions of the chain: input, production, trade and consumption. The chain's consumption product is fresh mud crab. The majority of brick crab and a small portion of y (meat) crab are exported, and lower quality crabs and defective crabs are consumed domestically. The supply chain integrates with the opposite direction from consumer demand to crab farmers.

(1) *The input function includes activities to provide raw materials for the crab farming process, including seed, fishery supplies, and labor.*

(2) *The production function includes activities of farming, tending, harvesting and selling crabs of farmers.*

(3) *The commercial function includes the activities of buying and selling crabs between actors: traders, storehouses, wholesalers in wholesale markets and retailers.*

(4) *The consumption function includes the activities of buying crabs for consumption or processing them into dishes to provide to the end consumer.*

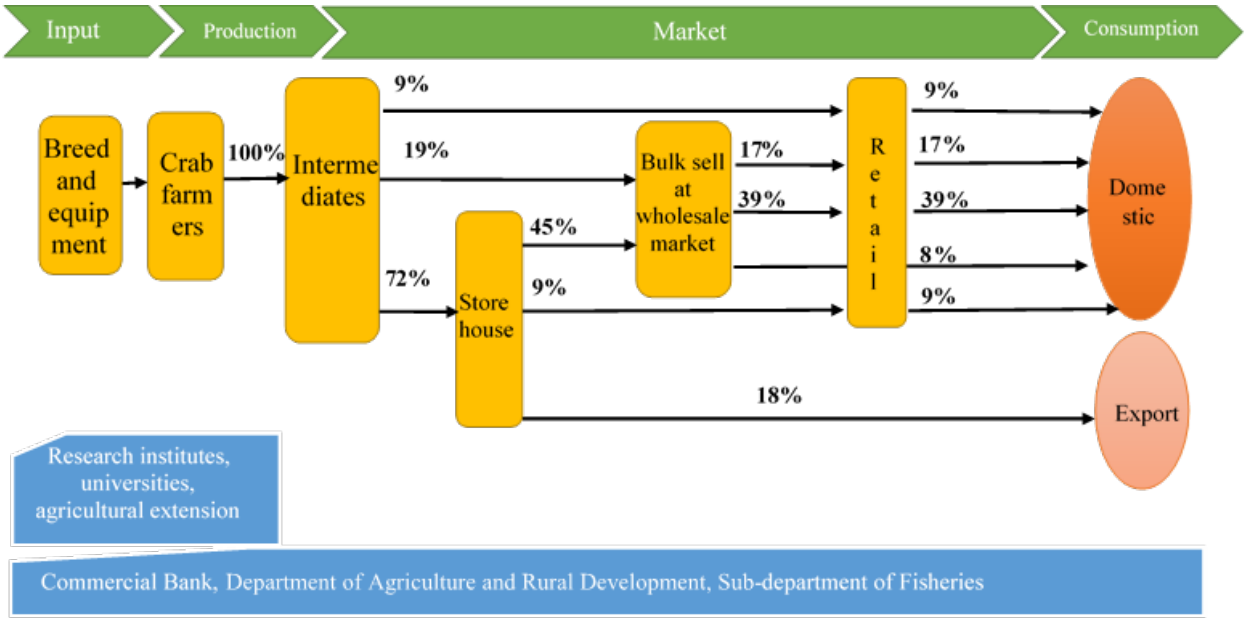

Fig.2: Map of the supply chain of mud crabs in the Mekong Delta

Source: Survey data, 219

The supply chain diagram of mud crab includes 6 distribution channels, including 5 domestic distribution channels and 1 export distribution channel. The domestic distribution channels include all 4 types of crabs, while the export distribution channels mainly distribute mainly brick crabs and a part of Y crabs.

Channel 1: Smallholdings -> Traders -> Storehouses -> Wholesale -> Retail -> Domestic consumption

This is the channel that accounts for the largest proportion of the distribution channels of inland mud crabs. Crab smallholdings sell 100% of their crab output to traders and are transported and distributed by traders to the storehouse. The storehouse distributes 45% of the output to wholesalers in the wholesale markets, and then the wholesalers in the wholesale markets will resell 56% of the output to retailers located throughout the traditional markets.

Channel 2: Smallholdings -> Traders -> Wholesale -> Retail -> Domestic consumption

In this consumption channel, crab smallholdings sell 100% of their crab output to traders and are transported and distributed by **traders** 19% of their output to wholesalers, wholesalers in wholesale markets continue to distribute output to retailers across the traditional markets.

Channel 3: Smallholdings -> Traders -> Retail -> Domestic consumption

According to this distribution channel, crab smallholdings sell 100% to traders and are transported and distributed by traders 9% of crab output to retailers, and all crabs are sorted by retailers for consumers.

Channel 4: Smallholdings -> Traders -> Storehouse -> Retail -> Domestic consumption

Similar to channel 1, smallholdings sell 100% of crabs to traders. Traders continue to transport and distribute to the storehouse. From there, the storehouse owners will distribute 9% to retailers in traditional markets across the markets in the provinces.

Channel 5: Smallholdings -> Traders -> Wholesale -> Domestic consumption

In this channel, which is shorter than channel 2 and channe l 4, crab smallholdings sell the mud crabs to traders who then transport and distribute 19% of crab output to wholesalers and then wholesalers will sort crabs and sell them directly to consumers.

Channel 6*: Smallholdings -> Traders -> Storehouses -> Export Company -> Export Consumption

This is the only distribution channel for export crabs in the whole chain. In this distribution channel, farmers with 100% of the original crab output will sell to traders. The crab is then transported to the

storehouse for export, accounting for 18% of crab production.

In addition to the main actors involved in the mud crab supply chain, there are the following chain supporters:

Farmers' Association, Provincial Center for Agriculture and Fisheries Extension: Organize training courses on farming techniques for crab farmers, training on preliminary processing techniques for collection - preliminary processing. Organize visits to typical crab farms and sample models, and disseminate information related to the crab-shrimp model. In addition, this association also focuses on transferring seed production techniques supported by the program/project for farmers. Moreover, they also support output for farmers by establishing cooperatives to find the output in the market.

Can Tho University: Study the process of producing mud crabs and farming mud crabs; train agricultural extension workers and farmers on mud crab farming techniques.

Departments, Boards, Sectors, and Local authorities: coordinate with programs and projects to propose policies to support the sustainable development of mud crabs, and support output prices for farmers.

Policy bank: financial support to farmers for seed production or crab farming. Commercial banks support intermediaries to lend capital to set up businesses.

Analysis of net added value and distribution of net added value by channel 1

Table 2. Value added of channel 1 in the supply chain of mud crabs in the Mekong Delta

Items	Smallholdings	Traders	Storehouse	Wholesale	Retail
a) Crab full of fat					
The price (1)	324.000	367.037	398.889	416.667	456.087
Input Cost (2)	63.210	324.000	367.037	398.889	416.667
Cost increased (3)	37.090	12.628	11.544	14.139	25.570
VAT (4=1-2)	260.790	43.037	31.852	17.778	39.420
Net VAT (5=4-3)	223.700	30.409	20.308	3.639	13.850
VAT /cost (6=5/(2+3)	2,23	0,4	0,27	0,05	0,16
b) (Y1 Crab)					
The price (1)	203.924	231.852	277.222	296.667	331.538
Input Cost (2)	63.210	203.924	231.852	277.222	296.667
CP increased (3)	37.090	12.628	11.544	14.139	25.570
VAT (4=1-2)	140.714	27.928	45.370	19.444	34.872
Net VAT (5=4-3)	103.624	15.300	33.827	5.305	9.302
VAT/Cost (6=5/(2+3) (times)	1,03	0,2	0,45	0,07	0,1
c) (Y4 Crab)					
The price (1)	146.836	177.000	217.778	238.333	271.111
Input CP (2)	63.210	146.836	177.000	217.778	238.333
Cost increased (3)	37.090	12.628	11.544	14.139	25.570
VAT (4=1-2)	83.626	30.164	40.778	20.556	32.778
Net VAT (5=4-3)	46.536	17.536	29.234	6.416	7.208
VAT/Cost (6=5/(2+3) (times)	0,46	0,23	0,39	0,08	0,08
d) Defective Crab					
The price (1)	88.830	90.370	91.875	110.000	141.852
Input Cost (2)	63.210	88.830	90.370	91.875	110.000
Cost increased (3)	37.090	12.628	11.544	14.139	25.570
VAT (4=1-2)	25.620	1.540	1.505	18.125	31.852
Net VAT (5=4-3)	-11.470	-11.088	-10.039	3.986	6.282
VAT/Cost (6=5/(2+3) (times)	-0,11	-0,15	-0,13	0,05	0,07

Source: Survey data, 2019

Channel 1 is the channel with the highest proportion of the 6 channels of the supply chain of mud crabs in the Mekong Delta, and this is also the longest channel with the most intermediaries. In this channel, the selling price of brick crab is the highest, then Y crab, and the lowest price is defective crab. If calculated on 1kg of crab, the input cost of farmers is the lowest at 63 thousand VND, the cost of farmers is mainly seed and aquatic materials (Table 4.51). As for the intermediate actors, the input cost is mainly the purchase price of crabs from the front actor and depends on the type of crab. Of the four types of crabs, brick crabs bring the highest profit to intermediaries, but besides that, they also bear many risks, because brick crabs are crabs that are carrying eggs, the more bricks, the higher the loss rate during transportation. move higher. Therefore, when trading in brick crab, the intermediary

actors require a lot of experience in the process of classification and transportation. For crabs Y1 and Y4, the least loss is from 0.5-1%. Therefore, when doing business with Y, the safety will be higher than that of the brick crab, but the profit is lower than that of the brick crab. Finally, this crab is a defective crab, usually, intermediaries are very limited in buying this crab because of the high risk of dying during transportation with a loss rate (4-6%) %. Meanwhile, the profit from this crab business is the lowest among all crabs. Therefore, when intermediaries have a lot of experience and a wide market, they often choose to do business with crabs. As for intermediaries with little experience, they usually choose Y's business to ensure the lowest risk

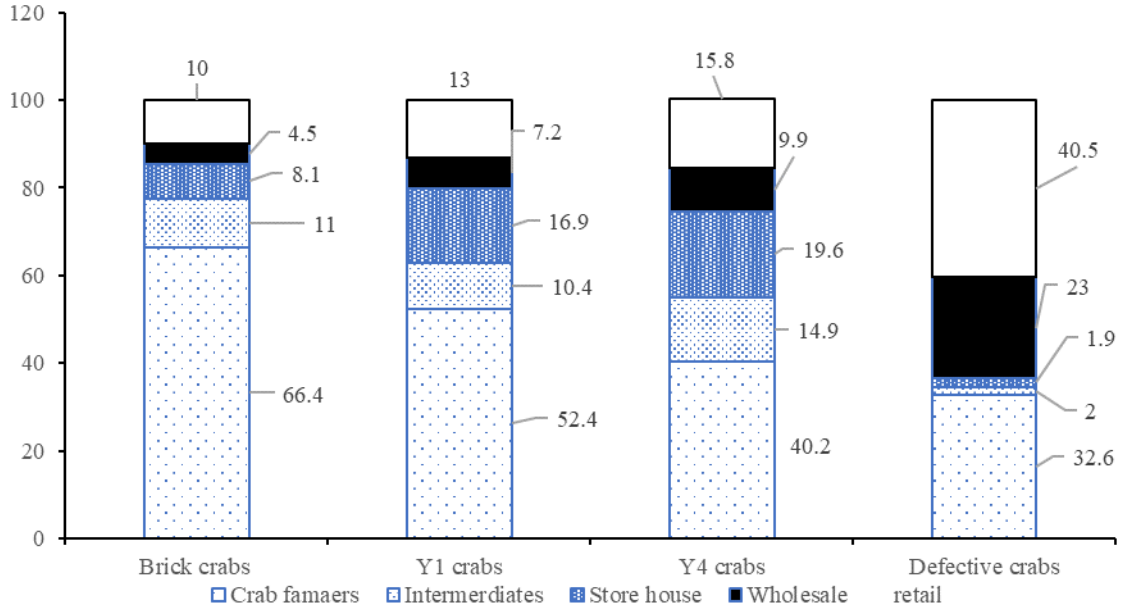

Fig.3: Value-added distribution channel 1 of the supply chain in the Mekong Delta

For channel 1 for Brick crabs and Y crabs, the smallholding actor receives the highest VAT distribution. But for defective crab, which brings VAT, the high retailer is distributed the highest, this shows that local retailers when having defective crab can sell at a higher profit than selling the other two types of crabs. In general, in order to increase VAT through actors in the chain, when producing or trading, individuals in the supply chain of mud crabs in the Mekong Delta should increase the output of brick crab. For 1 kg of mud crab, the distribution of VAT among smallholdings is the highest, accounting for more than 60%, and the lowest for wholesalers is 3.1%. This shows that there is a big difference in the distribution of VAT among actors in the supply chain of mud crabs in the Mekong Delta. The distribution of VAT in this mud crab supply chain is similar to that of the shrimp supply chain in Quang Nam province of Thu & Xuan (2012) or the seafood supply chain in the Mekong Delta of Loc (2006).

4.3. Waiting time management in the Mekong Delta mud crab supply chain

Waiting time management in the supply chain will ensure the right time to meet the orders of mud crab consumers. The characteristics of the supply chain of mud crabs in the Mekong Delta are presented through the supply chain diagram and the characteristics of the actors of the mud crab supply chain. Up to 82% of mud crabs are consumed in the domestic market (about 200-1000 km from the pond), including the neighboring provinces of Can Tho, Ho Chi Minh City and Hanoi. About 60% - 80% of mud crabs raised in the three provinces of Kien Giang, Ca Mau, and Bac Lieu are transported to Ho Chi Minh City, Can Tho and Hanoi to sell to the final consumers of mud crabs, which are smallholdings. individual families, and institutional buyers. Consumers buy mud crabs mainly at traditional markets or seafood stores. Less than 7% of mud crabs are consumed through large supermarkets in Vietnam. About 80-90% of mud crabs are consumed by individual smallholdings, and the remaining 10-20% are consumed by institutional buyers such as seafood eateries and restaurants. Crab consumers organize their purchases of crabs either from wholesalers or at wholesale markets.

For channel 1: Farmers -> Traders -> Storehouses -> Wholesale -> Retail -> Domestic consumption.

This is the main channel in the supply chain of mud crabs in the Mekong Delta. From farmers, it takes 20 hours for mud crabs to sell to traders, this time is mainly about farmers catching crabs and collecting enough quantity in 1 day. Due to the rudimentary fishing method, farmers cannot take the initiative in the output of crabs caught in one day, so the waiting time in this stage is high. From the Trader, collect and then sell to the storehouse owner with a waiting time of 5 hours in this stage. Traders mainly collect crabs in the early morning until noon, then bring them back to the storehouse owner, depending on the means of transport and the area of operation, the waiting time for mud crabs from collection to weighing for the storehouse. shorten or lengthen. The average time for wholesale sales at the wholesale market is 10 hours, this time is mainly from sorting, packing and transporting to the wholesale market. If the crab storehouse can take the initiative in the transportation process, the waiting time in the chain will be shortened, ensuring a better quality of mud crab meat and meeting the needs of consumers more promptly. From wholesalers of wholesale markets to traditional retailers, it takes an average of 3 hours, wholesale markets mainly hold the function of gathering and redistributing to retailers, so the waiting time in this stage is relatively short. The waiting time is low when operations are mainly active at night. Finally, the waiting time from retail to consumer is the longest, on average 48 hours, this time depends a lot on the consumer market, time of consumption as well as the sales policy of the retailer. If the retailer well manages the storage time of mud crabs and has a reasonable sales policy, the waiting time for mud crabs will be shortened, thereby improving the quality of mud crabs when reaching consumers. In addition, if consumers know the application of marketing in retail, they will meet the right quality, right time and right consumers. In the main channel, the time from harvesting crabs to reaching consumers is 45-107 hours, so the average idle time is too long compared to the time required to keep the quality for consumers. If the meat quality is good and the percentage of meat is not reduced, the maximum time for crabs to operate in the stages is (<48 hours)

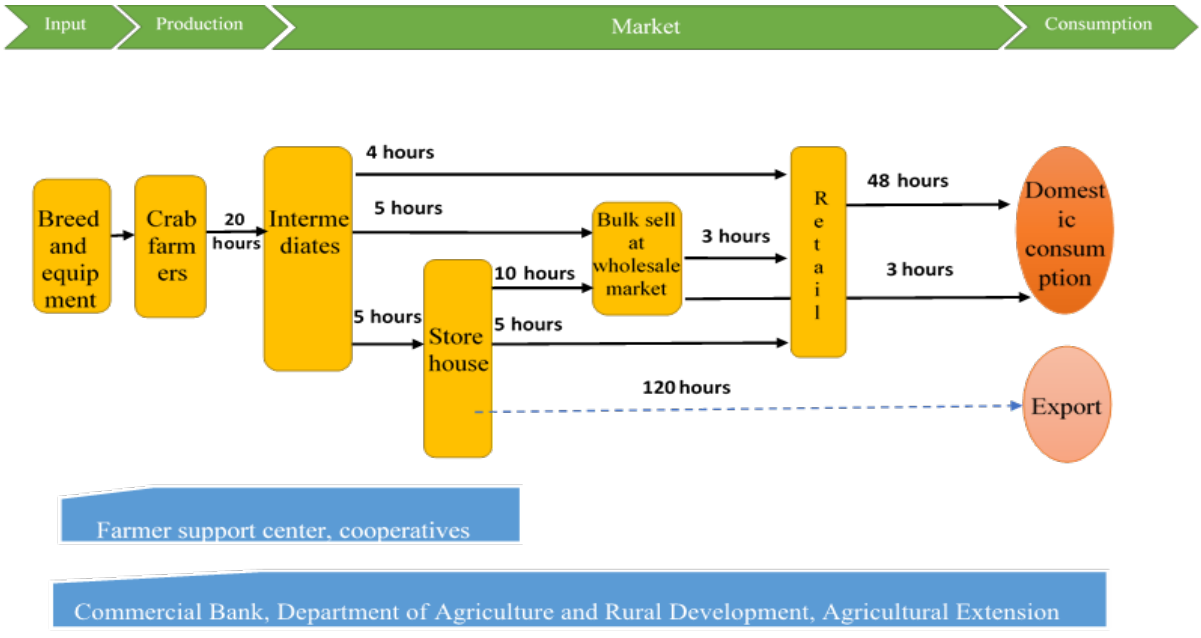

Fig.4: Supply chain operating time for mud crabs in the Mekong Delta

Source: Survey data, 2019

4.4. SWOT matrix

Through the combined results from the survey of the supply chain of the mud crab industry in the Mekong Delta and the opinion of the expert group, there are 11 good points and 11 bad points from the advantages and disadvantages. Based on the good and bad points of the supply chain is to choose 7 good points and 7 bad points to determine the cause for each good point and bad point. Based on the

analysis criteria, which is the supply chain of mud crabs in the Mekong Delta region to determine what are the strengths, weaknesses, opportunities, and threats are presented in the form of a matrix to see the relevance of the factors. After analyzing the factors into a matrix of analysis and accumulation of opportunities and threats. Through the results, the SWOT matrix is presented according to the scale.

SWOT analysis	**Strengths (S):** S1. Crab farmers are well-trained in farming techniques S2. Traders are knowledgeable about the market and purchasing areas S3. Transportation infrastructure in the Mekong Delta region has been paid attention to and completed by the State	**Weaknesses (W):** W1: The cost-effective model is low W2: Risks in the supply chain of mud crabs are high W3: Long waiting time in the mud crab supply chain
Opportunity (O): O1. The mud crab farming model is simple and easy to implement O2. The State has a policy of developing and diversifying aquaculture species with high economic value (mud crabs). O3. The demand for processed mud crabs in the international market is high. O4. The demand for fresh mud crabs in the domestic market is increasing.	**S-O strategy:** Take advantage of the high demand for mud crabs to expand production scale and ensure the quality of mud crab products to meet market demand.	**O-W strategy:** Enhance the quality of mud crab products through production and intermediate stages to meet the increasing requirements of domestic consumers.
Threats (T): T1: Mud crabs have many other substitute products T2. Consumption market is unstable and changes by day and month T3. The quality of mud crab meat will decrease over time T4. Consumers are setting higher and higher quality standards for crab products	**S-T strategy:** Take advantage of infrastructure development to help reduce the waiting time of mud crabs in the supply chain of mud crabs in the Mekong Delta.	**W-T strategy:** Effectively control the supply of inputs as well as output products to compete on price with other seafood of the same type.

Based on the results of the SWOT analysis, the following solutions are proposed:

Solution No. 1: Take advantage of the high demand for mud crabs, expand production scale and ensure product quality to meet market demand in terms of quantity, quality, timeliness and convenience for consumers.

Short-term goal: By 2030, the domestic mud crab market share will reach 30%. The export of mud crabs accounts for 50% of the total output of mud crabs in the Mekong Delta.

Through the process of surveying and researching consumer demand, it was found that consumers prefer mud crab products, but the selling price of mud crabs is higher than other products of the same type, such as sentinel crabs, shrimps, and of the sort. In addition, through survey data, only 18% of mud crabs in the Mekong Delta are exported through China. Therefore, with the above goal, it is necessary to focus on a number of activities as follows:

Activity 1: Develop the consumption channel of mud crabs in the domestic market (forming chains of fresh seafood stores in neighboring provinces that do not have seacoasts, such as An Giang, Dong Thap, and Vinh Long).

Activity 2: Develop local OCOP products with large crab farming areas and identify farming areas for product traceability, along with developing products into modern sales channels in big cities.

Activity 3: Develop a process for processing mud crabs to promote the export market of processed mud crab products to Southeast Asian countries and the European market.

Solution No. 2: Improve the linkage between actors to boost the efficiency and quality of mud crabs by reducing the waiting time of mud crabs through the actors in the supply chain.

Short-term goal: By 2030, reduce waiting time in the chain to 48 hours on average.

Through the survey process, it was found that currently, the transport time of mud crabs from farmers to consumers ranges from 45-107 hours depending on the consuming market and channels in the supply chain. As a result, the quality of meat in mud crabs also decreases over time. Therefore, in order to achieve the above goal, it is necessary to perform a number of activities as follows:

Activity 1: Connect consumption channels from collection to modern retail systems (seafood stores, supermarkets) to shorten the operating time through many intermediaries.

Activity 2: Design application software for local traders to optimize in the logistics industry to reduce the waiting time of mud crabs during transportation.

Activity 3: The Department of Agriculture and Rural Development collaborates with institutes and schools to develop a training program on post-harvest preservation procedures and crab transportation techniques for intermediaries in the supply chain.

Activity 4: Support the cooperative to build a local mud crab processing factory.

Solution No. 3: Strengthen the quality management of mud crab products from farmers as well as the preservation process of intermediaries in the supply chain of mud crabs in the Mekong Delta.

Long-term goal: By 2035, the cost-effectiveness of mud crab farming will increase by 50%. Since then, 100% of fresh mud crabs have met food safety standards when the product is sold on the market.

Through the survey process, the study found that the model's cost-effectiveness was only 31% due to the waste of a lot of inputs such as seeds and aquatic chemicals, which greatly affected the quality of mud crab products when introduced to the market.

Activity 1: Train farmers on smart crab farming techniques to improve the cost-effectiveness of the model and reduce chemical residues in mud crab products.

Activity 2: Re-planning farming areas, rebuilding poor quality mud crab rearing areas and concentrated raw material areas to ensure stability in quality and quantity of mud crabs to meet market demand.

Activity 3: Apply blockchain technology in mud crab production to ensure traceability meets the standards of importing countries.

Solution No. 4: Improve the level of environmental control and input materials to reduce risks and reduce production costs to help create products with competitive prices with other similar aquatic products.

Long-term goal: By 2035, 70% of agricultural extension stations will set up environmental forecasting centers for water environment indicators such as rainfall, tidal regime, salinity, pH level, Alkalinity, and concentrations of phytoplankton and pathogenic microorganisms.

Through the survey process, it was found that, at present, most of the agricultural extension stations in the districts do not have data on forecasting indicators of water environment, tides as well as local climate. Therefore, farmers mainly rely on long-term farming experience when farming mud crabs. Therefore, in order to achieve the above goal, it is necessary to perform a number of activities as follows:

Activity 1: Build forecasting stations at agricultural extension centers in districts, and help agricultural extension ministries to have enough data to recommend the season for stocking, water pumping, water treatment and crab care for local farmers.

Activity 2: Build local weather forecasting software integrated into smartphones to help farmers catch timely bad changes to the farming process.

Activity 3: Establish operating regulations for associations, groups, and cooperatives to support and exchange experiences for all communes with mud crab farming smallholdings.

5. Conclusion

Surveys of over 550 mud crab farmers and supply chains actors in Vietnam’s Mekong Delta mapped

six distribution channels and provided data to quantify economic and logistics performance. Key findings show the prominence of domestic consumption (82% of supply) and the substantial value added by farmers (70% in main channel). Long waiting times from harvest to sale (45-107 hours) were identified as reducing quality and prices. Proposed solutions target improved quality management, strengthened farmer-buyer linkages, optimized logistics, and enhanced farming productivity to increase competitiveness. This study addressed a gap in quantitative supply chain analysis for the important mud crab industry within Vietnam's Mekong Delta.

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