UNIVERSITI PUTRA MALAYSIA

EFFICIENCY PERFORMANCE OF MALAYSIAN BRACKISH WATER WHITE SHRIMP PRODUCTION

LIM GHEE THEAN

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DOCTOR OF PHILOSOPHY
UNIVERSITI PUTRA MALAYSIA

2014

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By

LIM GHEE THEAN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

July 2014

DEDICATION

Specially dedicated to my beloved

Grandma,

Tang Siew Gan (1926 – 2008)

Wife,

Lee Huay Lin

Parents,

Lim Ah Seng & Ng Gook Hiang

Daughter,

Lim Shu-Na

Lim Xin-Er

Brothers,

Lim Ghee Sern & Lim Ghee Geen

Uncles, Aunties, Cousins

And

Friends

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

EFFICIENCY PERFORMANCE OF MALAYSIAN BRACKISH WATER WHITE SHRIMP PRODUCTION

By

LIM GHEE THEAN

July 2014

Chairman : Mohd Mansor Ismail, PhD
Institute : Institute of Agricultural and Food Policy Studies

Shrimp aquaculture industry is playing a vital role in Malaysia agricultural economy, especially its increasing contribution to balance of trade of agricultural products. Brackish water white shrimp production is the main contributor of Malaysian shrimp aquaculture industry. However, Malaysian brackish water white shrimp production is facing low productivity performance and issue of environmental degradation that caused by shrimp culturing. Hence, this study attempts to measure technical, allocative and cost efficiency, and production risk of Malaysian brackish water white shrimp production. Parametric (stochastic frontier analysis) and non parametric approaches (data envelopment analysis) are applied in this study. In this study, dependent variables are production of white shrimp and cost of production; while independent variables are quantity of inputs (labour, feed and seed) and price of inputs (labour, feed and seed). In addition, the factors such as full-time, farmer's age, education level, experience, seminar, land ownership, pond size, number of ponds, pond age, fertilization, size of fry and culturing days are applied in technical inefficiency and cost inefficiency analyses. Average scores of technical, allocative and cost efficiency that generated by parametric approach are 54.7%, 66.3% and 36.4%, respectively. While average scores of technical, allocative and cost efficiency that generated by non parametric approach are 43.3%, 59.9% and 26.1%, respectively. Besides, result of production risk analysis indicated that labour is considered as a risk decreasing input, but feed and seed are considered as risk increasing inputs. Results of parametric and non parametric approaches consistently showed that factor of seminar negatively and significantly affect technical inefficiency and cost inefficiency. Hence, government authority should organize more seminars that related to shrimp aquaculture, management, accounting and motivation for the shrimp farmers. Besides, government authority should implement mandatory attendance at seminar for the shrimp farmers. Efficiency performance of Malaysian brackish water white shrimp production needs to be improved in order to achieve higher productivity, at the same time minimize the environmental degradation.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

PRESTASI KECEKAPAN PENGELUARAN UDANG PUTIH AIR PAYAU DI MALAYSIA

Oleh

LIM GHEE THEAN

Julai 2014

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Industri akuakultur udang memainkan peranan penting dalam ekonomi pertanian Malaysia, terutamanya sumbangan yang semakin meningkat dalam imbangan perdagangan produk pertanian. Pengeluaran udang putih air payau merupakan penyumbang utama kepada industri akuakultur udang Malaysia. Walau bagaimanapun, pengeluaran udang putih air payau Malaysia telah menghadapi masalah-masalah seperti produktiviti yang rendah dan isu pencemaran alam sekitar yang disebabkan penternakan udang. Oleh sedemikian, kajian ini bertujuan untuk mengukur kecekapan teknikal, kecekapan peruntukan input, kecekapan kos, dan risiko pengeluaran dari pengeluaran udang putih air payau Malaysia. Pendekatan parametrik (stochastic frontier analysis) dan bukan parametrik (data envelopment analisis) telah digunakan dalam kajian ini. Dalam kajian ini, variabel dependen ialah pengeluaran udang putih dan kos pengeluaran; manakala variabel bebas merupakan kuantiti input (buruh, makanan dan benih) dan harga input (buruh, makanan dan benih). Tambahan pula, faktor-faktor seperti sepenuh masa, umur petani, taraf pendidikan, pengalaman, seminar, pemilikan tanah, saiz kolam, bilangan kolam, umur kolam, pembajaan, saiz benih dan hari pembelaan telah diaplikasikan dalam menganalisis ketidakcekapan teknikal dan ketidakcekapan kos. Skor purata kecekapan teknikal, kecekapan peruntukan input dan kecekapan kos yang dihasilkan oleh analisis pendekatan parametrik ialah 54.7%, 66.3% dan 36.4% masing-masing. Sebaliknya, skor purata kecekapan teknikal, kecekapan peruntukan input dan kecekapan kos yang dihasilkan oleh pendekatan bukan parametrik ialah 43.3%, 59.9% dan 26.1% masing-masing. Selain itu, keputusan analisis risiko pengeluaran menunjukkan bahawa buruh adalah dianggap sebagai input yang dapat mengurangkan risiko pengeluaran, tetapi makanan dan biji benih adalah dianggap sebagai input yang dapat meningkatkan risiko pengeluaran. Keputusan-keputusan pendekatan parametrik dan bukan parametric sama-sama menunjukkan bahawa seminar didapati mempengaruhi secara negatif terhadap ketidakcekapan teknikal dan ketidakcekapan kos dengan ketaranya. Oleh itu, pihak berkuasa kerajaan haruslah menganjurkan lebih banyak seminar yang berkaitan dengan akuakultur udang, pengurusan, perakaunan dan motivasi untuk penternak-penternak udang. Di samping itu, pihak berkuasa kerajaan juga haruslah mewajibkan penternak-penternak udang untuk menghadiri seminar yang dianjurkan. Prestasi kecekapan pengeluaran udang putih air payau di Malaysia perlu dipertingkatkan supaya dapat mencapai produktiviti yang lebih tinggi sambil mengurangkan pencemaran alam sekitar.

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APPROVAL

I certify that a Thesis Examination Committee has met on **14th July 2014** to conduct the final examination of Lim Ghee Thean on his thesis entitled "**Efficiency Performance Of Malaysian Brackish Water White Shrimp Production**" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Fisheries in Malaysia

Malaysia, a country with around 28 million people in 2013, more than three ethnics and different religions, fish food is always the necessary source of animal protein in their community. Fisheries sector is responsible in providing food security to Malaysia growing population. With surrounded by South China Sea and the Strait of Malacca, coupled with development of aquaculture industry, Malaysia is rich in fish resource. Self-sufficiency level of food fish has shown an increase recently (Table 1.1). In addition, the self-sufficiency level of food fish has been estimated exceed 100 percent since 2009. Beside poultry meat and eggs, food fish is the third food commodity which has achieved self-sufficient in Malaysia. Additionally, per capita consumption of fish is in an increases trend since 2009, just like the other meat commodities (beef, mutton and poultry). In fact, fish food is still the most consume of animal meat protein by Malaysian compared to consumption on beef, mutton, pork and poultry meats (Table 1.2).

According to FAO fishery and aquaculture statistics, since 1976 Malaysia has always being the net importer of fishery commodities (in ton) and the index of gap between import and export is also climbing all the time. This issue is large contributed by Malaysia tends to export high valued fish from both capture and aquaculture fisheries, yet import cheaper fish from other countries (especially from Thailand, Indonesia and Philippine) to overcome the short fall in supply over demand. In fact, small amount of high valued exotic fish is also imported for domestic market demand.

Table 1.1: Self-sufficiency level of major food commodities

Food commodities	**2008**	**2009**	**2010**	**2011**	**2012p**	**2013e**
Crops						
Rice	70.2	70.4	71.4	72.0	71.7	71.7
Vegetables	39.6	39.2	41.2	58.4	58.6	57.0
Fruits	63.7	64.7	65.8	59.9	57.8	57.2
Livestock						
Beef	25.4	27.0	28.6	29.4	29.9	30.4
Mutton	10.1	10.3	10.6	11.4	12.5	13.8
Pork	96.6	96.9	101.7	98.2	96.0	96.4
Poultry	122.1	122.2	127.9	129.9	130.6	131.5
Poultry Eggs	114.2	114.7	115.4	130.2	130.8	131.2
Milk	4.8	4.9	4.9	5.1	5.2	5.4
Food Fish	95.6	100.1	101.7	123.3	127.2	128.0

Source: Agrofood Statistics, 2013
p = preliminary
e = estimated

Table 1.2: Per capita consumption of major food commodities

Food commodities	2008	2009	2010	2011	2012p	2013e
Crops						
Rice (kg/year)	77.9	79.6	79.6	79.3	79.1	78.8
Vegetables (kg/year)	54.1	54.4	54.7	55.3	56.2	57.3
Fruits (kg/year)	90.5	92.9	93.0	93.2	93.4	93.6
Livestock						
Beef (kg/year)	5.4	5.5	5.6	5.7	5.8	5.9
Mutton (kg/year)	0.7	0.7	0.8	0.8	0.9	0.9
Pork (kg/year)	18.2	18.8	19.9	20.2	20.6	20.0
Poultry (kg/year)	34.3	34.7	35.0	35.3	35.6	35.9
Poultry Eggs (nos./year)	274	285	295	298	304	307
Poultry Eggs (kg/year)	15.1	15.7	16.2	16.4	16.7	16.9
Milk (liter/year)	42.5	45.1	47.5	48.1	48.8	49.5
Food Fish (kg/year)	48.5	45.1	45.5	46.4	47.3	48.2

Source: Agrofood Statistics, 2013
p = preliminary
e = estimated

1.2 Aquaculture

There are thirteen states in Malaysia, every state are having aquaculture activities. Sabah, Perak, Selangor, Penang and Johor were the top five active states in aquaculture industry, accounted almost 90% of national aquaculture production in 2012 (Table 1.3). Since 2008, production of Malaysia aquaculture has showed an increasing trend. However, Perlis was the only state inactive in aquaculture compared to other states in Malaysia. It was estimated that 29,494 culturists were engaged in aquaculture industry in 2013 producing 660,000 ton or approximately RM2868.42 million of production (Table 1.4). Number of culturists has fluctuated around 28,000 since 2008.

Table 1.3: Estimated aquaculture production by state, 2008-2012

States	2008	2009	2010	2011	2012
Perlis	521.78	893.77	505.15	185.39	241.95
Kedah	3582.27	10600.03	8696.43	6435.24	6631.96
Pulau Pinang	25094.19	26313.71	38123.54	39504.68	39492.10
Perak	77070.13	98466.71	118510.85	89897.26	123288.64
Selangor	42055.52	58767.55	68046.45	52156.26	35756.58
Negeri Sembilan	6052.98	13246.62	10286.40	8604.92	7999.03
Melaka	8686.46	28816.53	14026.00	7389.35	8090.38
Johor	41069.11	43130.39	46474.59	28821.48	26801.34
Pahang	12268.46	18082.68	21620.77	13557.33	12585.47
Terengganu	6064.18	5716.65	5637.06	5266.25	8369.46
Kelantan	933.78	3240.93	2963.32	2105.72	2642.26
Sarawak	7492.37	8018.93	11553.19	11988.49	12487.66
Sabah	123536.32	157011.95	234604.66	260595.03	349983.57
Total (ton)	**354427.55**	**472306.44**	**581048.41**	**526504.40**	**634376.38**

Source: Annual Fisheries Statistics, 2008-2012

Table 1.4: Information of aquaculture

Year	Number of aquaculturist[1]	Production	
		Quantity ('000 ton)	Value (RM Million)[2]
2008	30634	354	1740.05
2009	23986	472	2322.93
2010	26291	581	2798.74
2011	28599	527	3056.10
2012[p]	29494	634	2758.10
2013[e]	29494	660	2868.42

Source: Agrofood statistics, 2013

Note: [1] Including Seaweeds culturist

[2] The sum of component figures may not tally with subtotal or total figure due to rounding

[p] Preliminary

Malaysian food fish aquaculture can basically be distinguished into fresh water aquaculture and brackish water sub-sectors. In 2012, fresh water aquaculture contributed 25.8% and 36% of total aquaculture output and value, respectively. On the other hand, brackish water aquaculture contributed 74.2% and 64% of total aquaculture output and value, respectively (Table 1.5). Obviously, brackish water aquaculture occupied larger farming area than fresh water aquaculture. Recently, farming area of brackish water aquaculture was found at least four times larger than fresh water aquaculture. Besides, farming area of brackish water aquaculture was showing an increasing trend since 2008 (Table 1.6). It seems that brackish water aquaculture is always the attention of Malaysian aquaculture contributing to the Malaysia economy.

Table 1.5: Production and value of fresh water and brackish water

Year	Fresh water		Brackish water	
	Quantity ('000 ton)	Value (RM Million)	Quantity ('000 ton)	Value (RM Million)
2008	96	471.79	259	1268.25
2009	153	704.28	320	1618.61
2010	155	760.34	426	2038.40
2011	122	684.15	404	2371.94
2012[p]	164	992.39	471	1765.71
2013[e]	170	1032.08	489	1836.34

Source: Agrofood statistics, 2013

Table 1.6: Area of fresh water and brackish water aquaculture system

Year	Fresh water (ha)	Brackish water (ha)	Total (ha)
2008	7502.22	24482.26	31984.48
2009	7250.00	25050.97	32300.97
2010	6479.42	26328.53	32807.95
2011	6985.51	27710.23	34695.74
2012[p]	7368.46	31466.77	38835.23
2013[e]	7368.46	31466.77	38835.23

Source: Agrofood statistics, 2013

1.3 Brackish water aquaculture

Malaysian brackish water aquaculture consists of several types of aquaculture culturing: ponds culturing, cages culturing, brackish water tanks culturing, cockles culturing, mussels culturing, oyster culturing and seaweeds culturing. Observably, culturing areas of all brackish water culturing has showed a fluctuated trend (Table 1.7). Besides, none of the states was found showing a sustainable growth in brackish water aquaculture production since 2008, except Sabah (Table 1.8 and Table 1.9). These incidents indirectly showed that Malaysia brackish water aquaculture has experienced an unsustainable development in the past. In 2013, production of Sabah aquaculture has recorded 35,9853 tons, accounted to 73.5% of national brackish water aquaculture production. However, value of Sabah brackish water aquaculture was only RM 453 million, accounted to 24.7% of total value of national brackish water aquaculture.

Table 1.7: Area for all types of brackish water aquaculture system

Year	Ponds (ha)	Cages (ha)	Water tanks (ha)	Cockles (ha)	Mussels (ha)	Oyster (ha)	Seaweeds (ha)
2008	7137.06	162.02	0.50	9400.79	24.61	27.21	7730.57
2009	7344.21	174.13	0.57	9941.76	18.09	33.75	7538.46
2010	7722.82	198.87	18.21	10383.09	28.55	36.49	7940.50
2011	7576.66	193.65	1.12	10688.51	29.29	12.77	9208.23
2012[p]	7525.43	237.48	1.42	10740.20	29.74	35.67	12896.83
2013[e]	7525.43	237.48	1.42	10740.20	29.74	35.67	12896.83

Source: Agrofood statistics, 2013

Table 1.8: Production of brackish water aquaculture by state, 2008 – 2010

State	2008		2009		2010	
	Quantity (tons)	Value (RM Million)	Quantity (tons)	Value (RM Million)	Quantity (tons)	Value (RM Million)
Johor	27028	303.27	30347	290.06	32278	302.88
Kedah	1468	17.15	4379	45.13	4896	43.63
Kelantan	229	3.28	1079	14.88	598	7.68
Malacca	184	2.61	212	2.39	216	2.06
Negeri Sembilan	447	5.38	1164	15.03	1405	17.17
Pahang	5917	123.24	10670	224.35	12260	260.63
Penang	22676	174.34	21497	230.05	31859	347.84
Perak	48884	213.76	46766	252.92	48191	270.13
Perlis	268	5.80	363	4.85	354	4.33
Selangor	26629	182.73	43517	211.42	53179	222.65
Terengganu	1953	24.58	2072	26.78	2076	26.12
Peninsular Malaysia	**135684**	**1056.14**	**162065**	**1317.86**	**187312**	**1505.12**
Sabah	118754	145.37	152153	234.45	229734	403.38
Sarawak	4143	66.74	5459	66.30	8604	129.90
Malaysia	**258581**	**1268.25**	**319676**	**1618.61**	**425650**	**2038.40**

Source: Agrofood statistics, 2013

Table 1.9: Production of brackish water aquaculture by state, 2011 - 2013

State	2011		2012^{e}		2013^{p}	
	Quantity (tons)	Value (RM Million)	Quantity (tons)	Value (RM Million)	Quantity (tons)	Value (RM Million)
Johor	18194	228.92	16290	217.90	16941	226.62
Kedah	3281	80.63	2659	33.47	2766	34.81
Kelantan	410	29.61	609	8.50	634	8.84
Malacca	141	1016	124	2.99	129	3.11
Negeri Sembilan	1418	20900	1016	12.44	1057	12.94
Pahang	4216	2.99	3807	67.68	3959	70.39
Penang	34168	1.24	34498	444.73	35878	462.52
Perak	36279	634	31025	165.35	32266	171.96
Perlis	118	32266	89	1.24	93	1.29
Selangor	37792	34.81	20900	173.76	21736	180.71
Terengganu	2165	462.52	4150	59.45	4316	61.83
Peninsular Malaysia	**138182**	**1278.49**	**115168**	**1597.35**	**119775**	**1235.02**
Sabah	256514	948.06	346013	435.59	359853	453.02
Sarawak	9592	145.39	9434	142.53	9811	148.23
W.P. Labuan	-	-	4.44	0.09	4.62	0.10
Malaysia	**404288**	**2371.94**	**470620**	**1765.71**	**489444**	**1836.37**

Source: Agrofood statistics, 2013

Currently, there are fifteen types of main species being cultured in Malaysian brackish water aquaculture (Table 1.10). Among the fifteen brackish water species, white shrimp, seaweeds, sea bass, grouper and tiger prawn ranked the top five most marketable and valuable aquaculture products, accounted to more 80% of total retail value of brackish water aquaculture production in 2012. Retail value of prawn category (white shrimp and tiger prawn) was RM 802,385,920, accounted 36.32% of total retail value of brackish water aquaculture production.

Table 1.10: Estimated retail value of brackish water aquaculture production

Species	**Retail value (RM '000)**	**Percentage (%)**
Mangrove snapper (Jenahak)	58317.17	2.64
Cockles (Kerang Dewasa)	104881.71	4.75
Grouper (Kerapu)	262274.05	11.87
Mud Crab (Ketam Nipah)	938.54	0.04
Red snapper (Merah)	100562.25	4.55
Seaweeds (Rumpai Laut)	198938.17	9.01
Mangrove Red Snapper (Siakap merah)	1070.07	0.05
Sea bass (Siakap)	365176.30	16.53
Mussels (Siput sudu)	3052.25	0.14
Red Tilapia (Tilapia Merah)	10251.98	0.46
Oyster (Tiram)	3710.55	0.17
Tiger prawn (Udang Harimau)	190214.52	8.61
White Shrimp (Udang Putih)	802385.92	36.32
Others	107145.40	4.85
TOTAL	2208918.90	100.00

Source: Annual Fisheries Statistics, 2012

1.4 Aquaculture fisheries policies

After describing briefly the background, structure of fisheries sector, current situation and recently achievements of Malaysian fisheries sector, this study would like to highlight aquaculture fisheries policies that implemented in Malaysia before narrow down and proceed to description of Malaysian brackish water white shrimp aquaculture which is the target of this study.

There are several aquaculture fisheries policies being implemented in Malaysia, but this study has only selected the two most important policies for the discussion. There two policies are High Impact Project - Aquaculture Industrial Zone (AIZ) and National Agrofood Policy.

1.4.1 High Impact Project - Aquaculture Industrial Zone (AIZ)

Under High Impact Project (HIP), an aquaculture industrial zone program has been established in 2007 with allocating a total of 28,099 hectares of land for aquaculture purposes. 19% of the allocated land (5465 hectares) has been reserved for shrimp culturing activities. Table 1.11 showed that AIZ land allocation for shrimp culturing. Runkup hilir in Perak has the largest area (2175 ha) for shrimp aquaculture. Terengganu has the second largest area (1720 ha) for shrimp aquaculture and the shrimp culture areas has been scattered in three locations. This implies that these two states (Perak and Terengganu) are given strong supports by the Malaysia government to develop the state shrimp aquaculture. There are seven objectives have been made for this project (HIP-AIZ) to develop Malaysian aquaculture (Table 1.12).

Table 1.11: Land allocation of AIZ (shrimp culturing)

State	Location	Hectarage (ha)
Kedah	Air Hangat, Langkawi, Kedah	60
Melaka	Taman Akuakultur Sebatu Melaka	100
Sarawak	Taman Akuakultur LKIM Telaga Air, Sarawak	165
Pahang	Kg. Merchong, Pekan, Pahang	404
Terengganu	Kg. Pengkalan Gelap, Setiu, Terengganu	520
Terengganu	Kg. Pasir Puteh, Marang, Terengganu	200
Terengganu	Penarik, Setiu, Terengganu	1000
Sarawak	Tanjung Manis, Sarawak	430
Perak	Rungkup Hilir, Perak	2175
Selangor	Sg. Nipah, Sabak Bernam, Selangor	28
Pahang	Tanjung Batu, Pekan, Pahang	283
TOTAL		**5365**

Source: Department of Fisheries, Malaysia

Table 1.12: Objectives on development of AIZ and High Impact Project

Item	Objective	Description
1	Contribution to GDP	Increase output of fish and raw materials used in processing of fish products.
2	Balance of Trade (BOT)	Increase export of fish and high value fish products. Reduce import of low value fish products for local consumption and raw materials used in fish products processing.
3	Private sector involvement	Increase investment from national and international companies.
4	Increasing of income of aquaculture farmers and entrepreneurs	Increase monthly incomes of aquaculture farmers and entrepreneurs to a minimum of RM3000. Create new business opportunities and employments.
5	Innovation and technology capability	Introduce new technologies for aquaculture sector.
6	Enhancing the value chain	Establish more hatchery, livestock field, farm, food factory, processing factory and develop an effective marketing system to support value chain of aquaculture sector.
7	Efficient aquaculture development	Certification of farm in accordance with SPLAM/SAAB.

Source: Ministry of Agriculture, Malaysia

1.4.2 National Agrofood Policy

National food fish demand was expected to increase from 1.3 million tons in 2010 to 1.9 million tons in 2020 with 3.8% annual growth. On other side, fish consumption per capita was expected to be raised from 46 kg to 55 kg with 1.9% annual growth. In general, the whole aquaculture industry was anticipated to be raised up to 790,000 tons or equivalent to 41% of national total food fish demand in 2020. Besides, export of aquaculture including fish product especially fish fillet was being look forward to be increased from RM1.4 billion in 2010 to RM3.2 billion in 2020. Development of aquaculture industry will be focused on improvement in production and strengthening in competitiveness through strategies as below,

- Increase production of high valued aquaculture products.
- Ensure consistency and quality of seed supplied.
- Increase feed production for aquaculture industry purposes.

1.5 Malaysian brackish water shrimp aquaculture

Today, global and domestic demand of shrimp product keeps increasing recently. This is due to the changes of taste and preferences of consumer. Nowadays, people are more likely to consume white meat (shrimp and fish product) rather than red meat (ruminant products). Outbreaks of mad cow disease and hand, foot and mouth disease (HFMD) is believed causing the switching (Amri and Kanna, 2011).

After undergoing research, *Litopenaeus vannamei* is known as the superior variety of shrimp for pond culture. Several advantages or out-standing characteristics have drawn attention from the world, like disease resistance, higher growth rate, withstands changes of environmental temperature, requires shorter culture period (90-100 days per cycle), high survival rate and consume less feed. (Amri and Kanna, 2011).

Commercial shrimp aquaculture in many countries, including Malaysia has been prompted by increasing demand of international market and decreasing volume of shrimp catch. Therefore, brackish water shrimp culture industry is playing increasingly important role in Malaysian aquaculture. It is because this industry is believed that it can able to generate more foreign exchange earnings. In the Third National Agricultural Policy (NAP3), Malaysia government has shown the interest to promote brackish water shrimp culture by taking a number of initiatives. Targeted shrimp production in 2010 was set at the level of 180,000 tons or RM 4.3 billion (Islam *et.al*., 2011). However, the targeted volume has not materialized.

The government has allocated a huge amount of capital to the aquaculture sector. One of the reasons doing so is the Malaysia government can benefit from the replacement of declining landings of marine capture. In June 2007, a total of 28,099 hectares have been offered by the Malaysia government as a permanent zone for aquaculture development through the launching of High Impact Project (HIP) program on aquaculture sector. Shrimp aquaculture is recognized by the government as a potential industry for Malaysia to further develop. Therefore, in this project around 18.9% of the total land allocation (5,300 hectares) has been allocated through Aquaculture Industrial Zone program with exclusively for shrimp aquaculture activities (Khai *et.al*., 2011a). The areas are defined as shrimp aquaculture zone and are distributed all over Malaysia. One of the examples is the establishment of Integrated Shrimp Aquaculture Park (I-sharp) project in Setiu, Terengganu. The Setiu project was initiated in 2009 with 1,000 hectares of land, recognizing as an innovative approach to shrimp aquaculture and playing the role as a one-stop centre for shrimp culturists under a controlled and bio-secure environment. (Khai *et.al*., 2011c).

In Malaysia, shrimp commodity is recognized as one of the most important fishery commodities. It is because the high value of this commodity has created a trade surplus in recent years (Khai *et.al*., 2011a). Malaysian shrimp culturists are using pond culturing system for their shrimp farms. This pond culturing system is implemented in both fresh water and brackish water environment. Most of the Malaysian shrimp farmers tend to culture brackish water shrimp. The major brackish water shrimp species that cultured in Malaysia are white shrimp (*Panaeus vanamei* or *Litopenaeus vannamei*) and tiger shrimp (*Panaeus monodon*) (Khai *et.al*., 2011a). Malaysian shrimp farms are established along coastal mangrove areas. According to Clough (1992), this is because mangrove area that contains clay soil with acceptable higher salinity level is suitable for aquaculture practice. Besides, FAO (1987) stated that clay soil can stabilize the bed of pond and absorbs a lot of nutrients. These soil nutrients will be released slowly to the overlying pond water over a long time. Besides, the clay soil can hold greater amount of soil organic matter compared to other light textured soils, thereby, increasing the productivity of pond (Khai *et.al*., 2011a).

In 1994-2004, Malaysia experienced a positive growth in shrimp production; however it turned to negative in 2004-2007. The spreading of white spot disease globally has caused the decreasing of production of cultured black tiger shrimp (*Panaeus monodon*). The recovery was achieved by replacing black tiger shrimp with white shrimp through implementation of Aquaculture Industrial Zone (AIZ) in 2007. In 2008, the shrimp industry experienced great improvement, 15% of growth rate in shrimp production and 61% of growth rate in value of shrimp production were recorded. This achievement has proven to the Malaysia government that shrimp aquaculture has become a potential sector in reducing the food trade deficit (Ismail *et.al.*, 2011).

This study focuses on Malaysian brackish water white shrimp aquaculture. There is some basic information on white shrimp. Malaysian white shrimp is known with scientific name of *Litopenaeus vannamei* or *Penaeus vannamei*. It is widely known as white leg shrimp or western white shrimp or Pacific white leg shrimp in international commercial trading. America white shrimp is also another name for *Litopenaeus vannamei* due to it is a shrimp of America origin. *Penaeus vannamei* is an alternative shrimp variety that can be cultured in Malaysia besides *Penaeus monodon* (black tiger prawn). *Penaeus vannamei* is originated from coastal and surrounding sea of Latin America like Mexico, Nicaragua and Puerto Rico. After that, *Penaeus vannamei* was imported by Asia shrimp culturists from China, India, Thailand, Bangladesh and Malaysia (Amri and Kanna, 2011). Hatchery farms of *Penaeus vannamei* were soon set up all around Asia. According to Amri and Kanna (2011), the size of shrimp that usually being harvested is around 14.29 gram (70 pieces per kilogram) taking around 100 days for the growth. 80 post larvae per meter square is the standard that used to determine the volume of seed to put into pond. Survival rate of shrimp seed usually around 80% and the feed conversion rate is 1.2. Salinity range of water for shrimp aquaculture has to be maintained is 5-35 parts per thousand (ppt).

1.5.1 Production

Penang, Perak, Johor, Sarawak and Sabah are the states active in white shrimp aquaculture (Table 1.13). Penang and Sarawak showed a sustainable growth during the period 2008 to 2012. Sabah and Penang was top and second seat, producing 47% (22,988 tons) of Malaysian white shrimp production in 2012. However, Perlis, Kedah, Perak, Selangor, Negeri Sembilan, Melaka, Johor, Kelantan, Pahang and Terengganu showed a fluctuated trend from 2008 to 2012. In 2012, Penang, Perak, Johor, Sarawak and Sabah contributed almost 83.4% of total white shrimp production. On the other hand, tiger prawn aquaculture was less popular in Malaysia. Production of tiger prawn was recorded only (6577.25 tons) 11.84% of production of brackish water shrimp aquaculture in 2012. Pahang, Selangor and Sabah were the states active on tiger prawn aquaculture (Table 1.14). Selangor was the top seat, producing 36.3% of Malaysian tiger prawn production in 2012. However, Melaka and Kelantan have no tiger prawn aquaculture activity. From the table 1.13 and 1.14, Pahang, Johor and Selangor can be easily noted that active in both Malaysian white shrimp and tiger prawn aquaculture.

Table 1.13: Estimated white shrimp production (tons) from brackish water pond by state, 2008-2012

State/Year	2008	2009	2010	2011	2012
Perlis	0.00	119.50	192.96	87.48	19.00
Kedah	814.44	2659.54	2733.30	2140.68	1471.53
Penang	2492.29	4906.38	7463.66	10975.76	11299.46
Perak	12454.64	16134.43	17601.35	10038.04	4726.76
Selangor	5058.77	4819.55	4951.63	4451.81	3507.18
Negeri Sembilan	413.74	1081.10	1367.52	1377.12	971.76
Melaka	13.05	138.30	155.63	64.92	69.00
Johor	8426.89	8715.08	13326.29	7276.27	4274.64
Pahang	177.29	307.19	257.10	998.81	1433.02
Terengganu	46.60	443.02	349.75	273.80	564.21
Kelantan	17.34	46.52	131.76	136.00	119.00
Sarawak	2487.66	4701.13	7499.00	8473.38	8848.00
Sabah	5141.60	8854.68	13054.15	14027.94	11688.25
Total	**37544.31**	**52926.42**	**69084.10**	**60322.01**	**48991.81**

Source: Annual Fisheries Statistics, 2008 - 2012

Table 1.14: Estimated tiger prawn production (tons) from brackish water pond by state, 2008-2012

State/Year	2008	2009	2010	2011	2012
Perlis	203.33	64.96	90.75	0.00	14.50
Kedah	45.20	363.64	93.97	17.50	26.45
Penang	171.56	268.85	520.18	298.91	41.70
Perak	587.33	227.00	457.00	283.00	366.50
Selangor	3557.90	3585.50	3594.50	2413.00	2388.38
Negeri Sembilan	0.00	20.00	31.00	38.00	30.00
Melaka	82.05	23.62	0.00	0.00	0.00
Johor	1780.48	801.32	521.53	200.09	1047.84
Pahang	5635.17	9947.49	11687.12	2999.50	2126.73
Terengganu	50.90	43.71	31.54	18.80	69.00
Kelantan	55.65	0.00	0.00	0.00	0.00
Sarawak	871.06	0.00	0.00	118.01	84.00
Sabah	462.68	1005.33	1090.92	763.98	382.15
Total	**13503.31**	**16351.42**	**18118.51**	**7150.79**	**6577.25**

Source: Annual Fisheries Statistics, 2008 - 2012

1.6 Culture of white shrimp (*Penaeus vannamei*)

According to FAO (2014), there are four main categories of white shrimp aquaculture practices: extensive, semi intensive, intensive and super intensive. These four categories can be defined as low, medium, high and extremely high stocking densities of post larvae, respectively.

Extensive white shrimp culture system can be easily found in Latin American countries. Tidal area where minimal or no water pumping or aeration is provided, is the place where extensive white shrimp culture system is conducted. The pond size is usually around 5 to 10 ha (some ponds size even up to 30 ha) with the pond depth is around 0.7 to 1.2 meters. In the beginning, the shrimp farmers had their post larvae from wild seeds that go into the pond tidally, or they applied the seeds that bought from collectors. Since the 1980s the post larvae that cultured in hatchery are stocked at 4 to10 per meter square in this culture system. Although the stocking density is low, small shrimps of 11 to 12gram are harvested in 4 to 5 months. This system has 1 to 2 crops per annum. The productivity of extensive white shrimp culture system is only around 150 to 500 kg/ ha/ crop.

Semi intensive white shrimp culture system can also be easily found in Latin America countries. Shrimp pond of this system is equipped with aeration and water pumps that exchange pond water regularly. The pond size is usually around 1 to 5 ha and the pond depth is around 1 to 1.2 meters. Post larvae that cultured in hatchery are stocked at 10 to 30 per meter square. This system usually has 2 crops per annum. Besides, the productivity of semi intensive white shrimp culture system is around 500 to 2000 kg/ha/crop.

Intensive white shrimp culture system can be easily found in Latin America and Asia. Low salinity and non tidal areas are the places that intensive white shrimp culture system is conducted. These areas are the shrimp ponds that can be fully drained, dried and prepared before stocking. The pond size is usually around 0.1 to 1 ha and the pond depth is usually more than 1.5 meters. Post larvae that cultured in hatchery are stocked at 60 to 300 per meter square. This system usually has 2 to 3 crops per annum. Besides, the productivity of intensive white shrimp culture system is around 7 to 20 tons/ha/crop and the productivity of this system can up to a maximum of 30 to 35 tons/ha/crop.

Super intensive white shrimp culture system is found in a research that conducted in United States of America recently. This culture system is enclosed in greenhouses where water exchange is unneeded. Super intensive raceway system is applied in this culture system and the size of raceway is 282 meter square. Juveniles that cultured in hatchery with the weight of 0.5 to 2 gram are used and stocked at 300 to 450 per meter square. Besides, the productivity of super intensive white shrimp culture system is around 28 to 68 tons/ ha/ crop.

The productivities of white shrimp cultures have a great different among the four culture systems mentioned above. Observably, super intensive white shrimp culture system which has the highest productivity compared to others.

1.7 Problem statement

Malaysian brackish water white shrimp aquaculture industry performed a sustainable growth of production from 2002 to 2010 (although slightly decline 4.84% in 2003) (Table 1.15 and Figure 1.1). However, productions of Malaysian brackish water white shrimp aquaculture declined 12.68% and 18.78% in 2011 and 2012, respectively. Additionally, productivity of Malaysian brackish water white shrimp aquaculture has also showed in a declining trend after 2010 (Table 1.15). Productivity of shrimp aquaculture is measured in total yield (tons) per total size of shrimp ponds (hectare). According to Amri and Kanna (2011), the stock density of Malaysian brackish water white shrimp aquaculture is 80 post larvae per meter square, and the shrimp pond is equipped with water pumps for exchange water purpose and aeration. This implies that Malaysian brackish water white shrimp aquaculture is applying intensive white shrimp culture system. According to FAO (Food and Agriculture Organization of United Nations) (2014), productivity of intensive white shrimp culture system is around 7 to 20 tons/ ha/ crop and the productivity can up to a maximum of 30 to 35 tons/ha/crop. Productivity of Malaysian brackish water white shrimp aquaculture is around 1.71 to 6.73 tons/ha/crop (or 3.42 to 13.459 tons/ ha/ year). It seems that productivity of Malaysian brackish water white shrimp aquaculture not even achieved the minimum productivity of intensive white shrimp culture system that stated by FAO. Furthermore, productivity of Malaysian brackish water white shrimp aquaculture is found unable to compete with productivities of other ASEAN countries. According to Taw (as cited in Nur, 2007), Hung and Quy (2013) and Wyban (2007), productivities of Indonesia, Vietnam and Thailand brackish water white shrimp aquaculture are around 10 to 15tons/ha/year, 10 to 20 tons/ha/crop and 24 tons/ha/crop, respectively. Additionally, Hashim (2008) showed that productivity of Malaysian brackish water white shrimp aquaculture can reach 8 to 12 tons/ha/crop. The relationship of productivity and technical efficiency is positive. Hence, the low productivity of Malaysian brackish water white shrimp aquaculture implies that this industry is facing inefficiency of white shrimp production. This study is playing a role in discovering the impacts of inefficiency, the factors affecting inefficiency and the production risk of input applied in Malaysian brackish water white shrimp aquaculture.

Besides, Malaysian brackish water white shrimp aquaculture has showed an increasing trend in expansion of total size of shrimp ponds from 2002 to 2012 (Table 1.16). Expansion of total size of shrimp ponds (or expansion of shrimp farms) can lead to disease outbreak and environmental degradation (both are interrelated) that intimidate sustainability of shrimp production (Begum *et.al*., 2013; Hossain and Lin, 2001; Islam, 1999; Rahman *et.al*., 1994). Outbreak of shrimp disease like early mortality syndrome (EMS) in white shrimp is one of the great challenges that faced by white shrimp farmer (Remany *et.al*., 2012; Lighter, 2012).

According to Haws *et.al*. (2001), Americas and Asia brackish water shrimp aquaculture usually increase their productions by using strategies of expansion and intensification. As a result, social, economical and environmental impacts are directly and indirectly created by these two strategies. Coastal habitats like wetlands and mangrove are the areas that used for construction of brackish water shrimp farms. Development of brackish water shrimp aquaculture not only creates loss of habitat, but also creates acid sulphate soil due to deforestation of mangrove. Formation of acid sulphate soil can affected the production of shrimp aquaculture in long term with water quality leading to poor production. Besides, struggle for scarce resources has created intensified production, use and abuse of chemicals and the simultaneous decline of proper water quality that due to absence of proper water management (Begum *et.al*., 2013). Losses that created by environmental degradation in long period of time can be irreversible and irrecoverable (Begum *et.al*., 2013). Hence, development of Malaysian brackish water white shrimp aquaculture in economically feasible and environmentally sustainable practice, has become an issue to be focused on. In this respect, improving efficiency of resource applied in Malaysian brackish water white shrimp aquaculture is an important task to be done. This task focuses on generating a sustainable growth in production of Malaysian brackish water white shrimp aquaculture, without increasing negative environmental externalities (mangrove deforestation) and undesirable output (wastes and pollutants) to the environment (Begum, 2013; Martinez-Cordero and Leung, 2004; Sharma, 1999). Therefore, investigation on factors affecting inefficiency of Malaysian brackish water white shrimp aquaculture and production risk of input applied in this industry is the necessity of avoiding environmental degradation in Malaysia.

Inefficiency is the core idea of this study. Inefficiency cause low productivity performance of Malaysian brackish water white shrimp aquaculture and severe environmental degradation. On the other hand, productivity and the technological efficiency improvement, couple with intensive use of inputs, can boost the production of Malaysian brackish water white shrimp aquaculture (Islam *et.al*., 2011). Hence, Malaysian brackish water white shrimp aquaculture needs to rectify the two issues that mentioned above get in the way of development of Malaysian brackish water white shrimp aquaculture. Research questions that related to the two issues will be answered in this study. Research questions are "What are the impacts of inefficiency on low productivity of this industry?", "What are the factors affecting inefficiency of the industry?" and "What is the production risk of inputs applied in this industry?"

Table 1.15: Annual Malaysian white shrimp production

Year	White shrimp (tons)	Pond size (ha)	Productivity (tons/ha/year)	Productivity (tons/ha/crop)
2002	844.46	246.89	3.420	1.710
2003	803.59	192.21	4.181	2.091
2004	5117.49	1201.59	4.259	2.130
2005	11497.80	2391.37	4.808	2.404
2006	18600.59	2733.71	6.804	3.402
2007	23737.40	4808.63	4.936	2.468
2008	37544.31	4691.23	8.003	4.002
2009	52926.42	4823.63	10.972	5.486
2010	69084.10	5132.85	13.459	6.730
2011	60322.01	5828.71	10.349	5.175
2012	48991.81	5349.17	9.159	4.580

Source: Annual Fisheries Statistics, 2002 – 2012

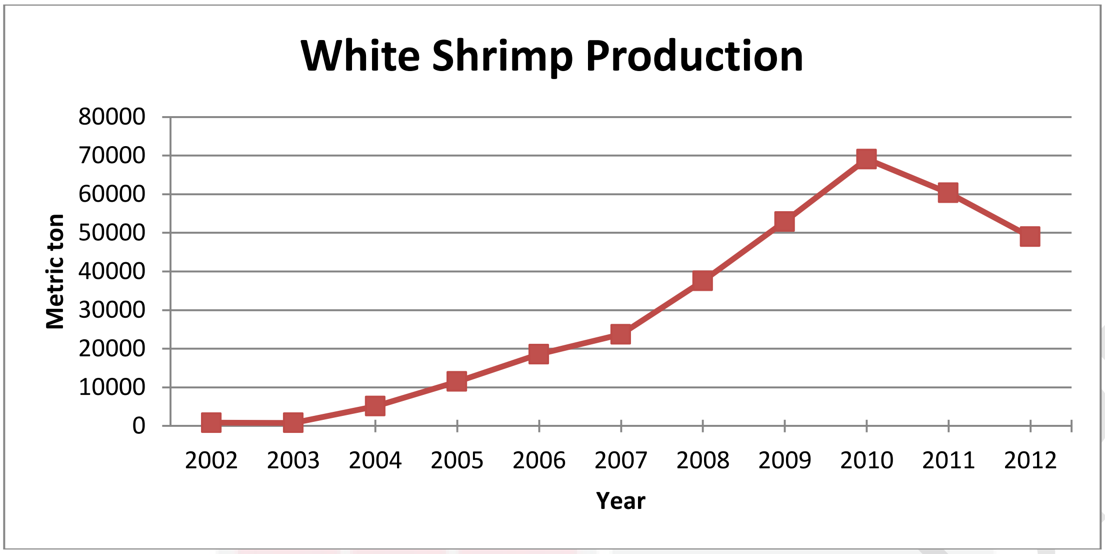

Figure 1.1: Malaysian white shrimp production, 2002-2012
Source: Annual Fisheries Statistics, 2002 - 2012

Table 1.16: Annual total number of ponds and total size of ponds of white shrimp

Year	Number of ponds	Change (%)	Total size of ponds (ha)	Change (%)
2002	308		246.89	
2003	253	-17.89	192.21	-22.15
2004	1761	596.10	1201.59	525.13
2005	3789	115.15	2391.37	99.02
2006	5242	38.36	2733.71	14.32
2007	7279	38.86	4808.63	75.90
2008	8572	17.76	4691.23	-2.44
2009	7694	-10.25	4823.63	2.82
2010	8971	16.60	5132.85	6.41
2011	10142	13.05	5828.71	13.56
2012	9070	-10.57	5349.17	-8.43

Source: Annual Fisheries Statistics, 2002 – 2012

1.8 Research theory

Theories behind this study are the theories of production function and cost function. Coelli *et.al*. (1998) defined a production function as a technical relationship between inputs and outputs. Besides, Coelli *et.al*. (2005) defined a cost function of shrimp farms depends on the decisions of shrimp farmers on the mix of inputs to be applied in operation of shrimp farms in order to minimize cost. In addition, cost function is also known as input demand function. This study focuses on the investigation on technical, allocative and cost efficiency of Malaysian brackish water white shrimp aquaculture. This study applied input oriented technical efficiency. Input oriented technical efficiency can be defined as the ability of a shrimp farm to minimize the inputs used, given the output constant. Allocative efficiency can be defined as the ability of a shrimp farm to use the inputs in optimal proportions to produce the fixed quantity of outputs, given the respective prices of inputs and the production technology constant. Cost efficiency can be defined the ability of a shrimp farm to use the minimum cost to produce the fixed quantity of outputs, given the respective prices of inputs and the production technology constant.

1.9 Objective of the study

The general objective of this study is to investigate the factors affecting technical and cost inefficiency of Malaysian brackish water white shrimp aquaculture.

The specific objectives are,

i. to investigate technical, allocative and cost efficiency of Malaysian brackish water white shrimp aquaculture.
ii. to investigate factors affecting technical and cost inefficiency of Malaysian brackish water white shrimp aquaculture.
iii. to investigate production risk of Malaysian brackish water white shrimp aquaculture.
iv. to describe characteristics of Malaysian brackish water white shrimp aqua culturist and farms.

1.10 Significance of the study

Malaysian brackish water white shrimp aquaculture plays a vital role in Malaysian fisheries industry. This study investigates the scores of technical efficiency, allocative efficiency and cost efficiency of Malaysian brackish water white shrimp aquaculture. Besides, the factors affecting technical and cost inefficiency, and production risk are also highlighted in this study. This study goes beyond classical technical efficiency analysis that using one approach and, conducts technical and cost efficiency analyses by using parametric and non parametric approaches.

There are not many previous studies on Malaysia fisheries sector, focussed on investigating technical efficiency analysis. This study extends the scope of the previous studies to include investigations on cost efficiency and production risk analyses. This is the first study that investigates technical efficiency, allocative efficiency, cost efficiency and production risk on Malaysian brackish water white shrimp aquaculture by using parametric and non parametric approaches. Results of this study are important information for policy makers in conducting a development planning of Malaysian brackish water white shrimp aquaculture. In addition, results of study contribute to the literatures that apply parametric and non parametric analyses to measure efficiency performance in Malaysia fisheries sector. This study can be applied as a teaching material in sharing knowledge of efficiency analysis and providing empirical evidence. Obviously, this study is significant in filling the knowledge gap that existed in Malaysian brackish water white shrimp aquaculture.

1.11 Organization of thesis

There are six chapters in the study. Chapter one provides overviews of Malaysia fisheries sector, aquaculture, brackish water aquaculture, aquaculture fisheries policies and Malaysian brackish water shrimp aquaculture. Problem statement of study and objectives of study are also illustrated in this chapter. Chapter two discusses literature reviews that have been gone through. All the previous studies have been highlighted and discussed according to criterions. Chapter three shares the information of approaches and methodologies that being applied in analysis throughout this study. Chapter four shows the findings of descriptive analysis and results of efficiency analyses of different approaches. Chapter five underlines significant findings and concludes the study as well as provides policy recommendations and suggestions for future research.

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