Activity-Based Costing in Production and Logistics Process: Processed Rice Products of Ban-Nong-Oan Community Rice Mill Enterprise

Sanit Srichookiat* and Apinan Aue-aungkul

Major in Entrepreneurship and Management, Faculty of Economics and Business Administration, Thaksin University
No. 140 Moo 4, Khoa-Roob-Chang Sub-District, Muang, Songkhla 90000, Thailand
*Corresponding author. E-Mail address: sanit@scholar.tsu.ac.th
Received: 24 May 2020; Revised: 11 December 2020; Accepted: 4 January 2021

Abstract

The objectives of this study aim: 1) to investigate the cost structures of rice products in production and logistics activities at Ban-Nong-Oan Community Rice Mill Enterprise in Songkhla; and 2) to develop the program in Excel that helps the enterprise to simulate cost and profit according to the forthcoming change of the cost in some resources. The research findings show that there are eleven main activities involved in production and logistics processes. The cost associated with each process are as follows: 1) Transportation of paddy from fields to the drying area, 0.12 baht/kg; 2) Drying of the paddy for humidity reduction, 0.33 baht/kilogram; 3) Transportation of the dried paddy from the drying area to the mill's warehouse, 0.15 baht/kg; 4) Screening of dirt from the dried paddy, 0.40 baht/kg; 5) Milling of the dried paddy, 0.72 baht/kg; 6) Screening of the mixed milled rice, 0.99 baht/kg; 7) Milling of the broken milled rice, 0.58 baht/kg; 8) Sifting for the rice germ, 0.64 baht/kg; 9) Vacuum packaging of rice product, 5.19 baht/kg; 10) Packing for shipping, 0.15 baht/kg; and 11) Shipping the packs of products to the customer, 0.05 baht/kg. All activities' costs are allocated into five types of rice products. The cost of raw materials (Paddy) is then allocated and included in the total product cost. The unit cost for each product line is as follows: A pack of rice product, 33.43 baht/kg; the rice germ is 143.52 baht/kg; the mixed rice is 10.10 baht/kg, the broken rice is 8.29 baht/kg; and the fine broken rice is 7.61 baht/kg. When considering the proportion of the product cost structure, it is estimated that the approximate ratio of the raw material cost to the production and logistics cost is about 3:1. The development of the Excel cost simulation program enables the mill to increase its management efficiency. For example, the program allows the manager: 1) to adjust the purchase price of paddy as usually changed by seasons; 2) to recalculate the new unit cost of the rice products; and 3) to adjust the new selling price of the rice products to achieve the optimal profit.

Keywords: Costing, Activity-based Costing, Cost Estimating Program, Logistics, Rice Mill

Introduction

Rice is one of the world's most important economic crops. It is also the staple food of Thailand, which is considered as one of four requisites for people living. Rice is an agricultural commodity that is partly contributed to the economy and national security. The trade of rice can provide economic benefits for Thailand. It is evident that the country was the world's second-largest rice exporter in 2019 (Sowcharoensuk, 2019). In addition, rice is an important agricultural export product generating massive income for Thailand in 2019, with a value of 130,543.93 million baht (Office of the Permanent Secretary, Ministry of Commerce, n.d.). Rice cultivation can strengthen Thailand's food security. According to His Majesty King Rama IX saying, *"Rice must be planted because the Thai population will probably be 80 million people in the next 20 years. If Thai people dramatically decrease the rice farming efforts, rice products will not be enough. Consequently, we have to buy some rice from abroad. Thai people have to do rice farming even if the domestic grown is unable to compete with those international growns. We just have to continue farming"* (Office of the Royal Development Projects Board, 2013).

The need for the development of the Thai rice industry has therefore been realized by the Thai government from past to present. One of the strategies adopted by the government in developing the country for sustainable

development is to promote development from urban local areas following the royal initiative of His Majesty King Rama 9 on "Explosion from the Inside". This has been partly done through the establishment of community enterprise groups. Thailand has promoted the Act assisting the operation of community enterprise in 2015 (The Secretariat of the House of Representatives, 2018). These community enterprises are encouraged to nurture and take benefits from local knowledge and resources in order to produce products and services. This can bring about job creation and income generation for the local communities. Ultimately, the community can become self-reliant (The Secretariat of the House of Representatives, 2018).

Ban-Nong-Oan Community Rice Mill Enterprise is one of the community enterprises that adhere to the above concept. It was established in 2011 through fundraising by local people. The enterprise is located in Khuan Ru Subdistrict, Rattaphum District, Songkhla Province. The missions of community rice mills are: 1) to generate income for farmers in the surrounding area. The starting point for the enterprise establishment was an effort to tackle the low-price problems of rice prices, which is a common problem facing farmers across the country; 2) to encourage local farmers to grow organic rice for both consumptions in the community and sell rice products at the high in the market. It could be said that rice mills were established to support farmers to earn more income from rice farming. Furthermore, local people in the community and nearby areas will eventually have high-quality rice for consumption, which adheres to the principle of sufficiency economy. It can be seen that the enterpriser's mission is not making a profit as much as possible. The enterprise is, in fact, established to support local farmers and remedy social problems. The activities in transforming the rice products from farm to shops are the main focus of this research.

Ban-Nong-Oan Community Rice Mill Enterprise occupies an operating area of approximately 400 square meters. The machines used in processing the rice products provide a maximum capacity of 500 kilograms/hour. The enterprise purchases paddy from local farmers, who are members of the rice mills. After that, the processes of moisture reduction, rice milling, and vacuum packaging are followed to produce the rice product under the brand "Song Ley". Currently, the mill has received many agricultural and food standards such as Good Agricultural Practices (GAP), Food and Drug Administration (FDA) marks, Industrial Product Standards (TIS), and Halal. In 2018, the mill has offered 5 varieties of rice to the market including Sung-Yod, Riceberry, Lep-Nok, Hom-Baiteoy, and Hom Pathum. The total yield is approximately 93,171 kilograms. Currently, the enterprise starts farming new rice species, Kor Khor 43. In the milling process, there are some leftover materials such as mixed rice, broken rice, grits, and germ, which usually are considered as waste. However, the enterprise also put some effort to sells the remaining rice products.

In general, the turnover of the enterprise is growing continuously. The enterprise has been assisted and funded by government agencies (e.g., community development, bank for agriculture and agricultural co-operatives), universities (e.g., PSU and TSU), and civil society agencies (e.g., the Social Enterprise Initiative of Thailand). It is also the center for rice learning that allows people inside and outside the community to visit. From the researchers' viewpoints, the enterprise is independent and self-sufficient. It seems to be able to generate income for the local farmers and positively contribute to food security for the community people in the long run. The enterprise has the vision to enhance processing capacity to offer a complete range of organic rice products and to expand the market share to earn more income. It can be said that the development of the enterprise can be achieved in two different strategies. The initial strategy is to increase sales for enterprises, which may be through the

development of new innovations to meet the customers' expectations. The latter strategy is to reduce the cost of the business activities by increasing work efficiency.

Although there are many community enterprises currently being promoted and supported by both academia and government, these enterprises are currently facing management problems (The Secretariat of the House of Representatives, 2018). This is also the case of Ban-Nong-Oan Community Rice Mill Enterprise. According to the interview with the enterprise's committee, it has been found that effective price setting is one of the major problems. This problem is a consequence of a lack of cost and financial analysis. Specifically, the enterprise's manager does not know whether the selling price is appropriate or not. This is worsened in the case of the varying price of paddy in the market. Moreover, the manager has to decide what cost should be prioritized as the most important that deserves management attentions. Furthermore, the manager wants to make a good decision under changing circumstances such as an increase in some expenses. The root of the problem is the actual cost incurred in each activity for processing a rice product is still unknown. The researchers are confident that if the enterprise can fully understand the cost structure that occurred in the production and logistics processes, the enterprise can then efficiently manage and effectively make decisions, which eventually lead to strengthen the competitiveness of the enterprise in the long run.

A popular concept for an investigation of cost structure is Activity-Based Costing (ABC). The concept aims to scrutinize the cost structure of each value-creating activity in an organization. ABC has been widely accepted by researchers (Garrison, Noreen, & Brewer, 2018; Hansen, Mowen, & Guan, 2009) and practitioners (Brierley, Cowton, & Drury, 2008) in such a way that it provides more accuracy in cost estimation than the traditional methods. The application of this concept can be the basis for an increase in organizational efficiency (Hugos, 2011). ABC enables managers to identify value-adding and non-value-adding activities in the production process. Careful consideration of how these activities create value for the products is valuable tools because these activities are more properly adjusted and controlled, which will lead to an improvement in organizational efficiency. Literally, the improvement can consequently be a source of competitive advantage (Kingphadung & Woottichaiwat, 2017).

From the above, the investigation of the unit cost structure of the enterprise's products is, therefore, required attention from management and policymakers. The finding can enhance the competitiveness of the enterprises. The results of the research will provide basic information for the control and development of the group's operations. This can be possibly achieved through the development of understanding and knowledge in cost structure analysis as well as the application of the Excel cost simulators to facilitate decision-making and cost management for the enterprise. The results of the study can also serve as an academic cost analysis practice for other rice mills, which have similar contexts and environments, in different parts of Thailand.

Study Objectives

1. To analyze the cost structure of rice products per unit according to the activities occurring in the production and logistics processes of Ban-Nong-Oan Community Rice Mill Enterprise.
2. To create the Excel cost simulation program for Ban-Nong-Oan Community Rice Mill Enterprise.

Research Methodology

This research employs the qualitative approach to investigate the in-depth information to achieve the research objectives. The cost estimation in this study follows the Bottom-Up approach, where the actual costs of resources used in every single activity are investigated and linked to establishing the unit cost. Although the data collection in this approach is detailed and takes considerable time in data analysis due to the complexity of activities, the bottom-up approach provides relatively high-cost estimation accuracy (Chapko, Liu, Perkins, Li, Fortney, & Maciejewski, 2009).

Data Collection and Analysis

Due to the complexity of cost data incurred in the rice processing activities, data collection cannot be completed at once. The process of collecting data is therefore carried out cyclically. This can be summarized into 4 steps as follows:

1. Primary Data Collection

A manager of the community enterprise was chosen as a key informant in this study. The reason is that the manager is one of the founders of the enterprise, who has been initially developing the enterprise and involved in many activities such as purchasing raw material, transportation of rice paddy, rice millings, vacuum packaging, and delivering rice products to customers. According to Hansen et al. (2009), the key informant who participated in the in-depth interview is usually in the position of manager. The main objective of the interview is to investigate the operational and logistics activities in detail.

2. Pre-analysis of Primary Data

After the in-depth interview, the data will be transcribed. Content analysis is applied to filter the relevant information related to the cost of rice products. At this stage, the researchers can identify cost information necessary for the analysis. If additional data are required, the researchers contact the enterprise's manager for arranging direct observation.

3. Observation of Actual Activities

In addition to information obtained from the in-depth interviews, the actual data observed from the onsite operation during the production process is used to cross-check and verify with the interviewed data. The researchers performed timing and measuring the actual output in many processes including drying, screening contaminated rice, rice milling, packaging, etc. Moreover, the financial reports, electricity bills, and Maintenance, Repair, and Operating supplies (MRO) bills were scrutinized.

4. Unit Cost Analysis in Each Activity

The relevant data is analyzed in the following order:

4.1 Analysis of the Main Activities and Resources Used in Each Activity.

4.2 Determination of Activity Driver and Activity Rate.

4.3 Calculation of Activity Unit Cost.

4.4 Calculation of Activity Unit Cost for Each Product.

4.5 Calculation of Raw Material Unit Cost for Each Product.

4.6 Calculation of Total Unit Cost for Each Product.

Due to the nature of the complexity in cost data, data collection and analysis is therefore continuously followed step 1-4 until the total cost per unit can be completely analyzed. Besides, important data is linked by formulas in Excel in order to construct the cost simulation program.

Scope of this Study

The research scopes for the cost estimation are discussed in the following section:

1. The main objective of this research is to analyze the unit cost of rice products (baht/kg). The reason is that the enterprise's top-selling rice product available in the market is the package of 1 kg.

2. The activities in the production and logistics processes are defined as the processes that start from the paddy transportation, the value-added processes, and the product shipment to customers.

3. There are five types of rice products, consisting of 1) vacuum-packed rice products; 2) net mixed rice; 3) net broken rice; 4) net grits; and 5) net germ. In this study, the vacuum-packed rice products are considered the main product, and the rest are the by-products.

4. Rice species in this study were selected from the species currently grown and sold. There are six rice species, including Sung-Yod, Riceberry, Lep-Nok, Hom-Baiteoy, Hom Pathum, and Kor Khor 43.

5. Cost structure for each unit can be divided into two parts. The first part account for costs that occurred in processing and logistics activities. The second part incorporates costs from purchasing raw materials. The cost estimation is based on the assumption that all rice species have a similar structure of the activity cost while the cost of raw material is varied by market prices of different rice species.

6. The allocation for the activity costs is based on the physical weight of outputs. This is because, during the manufacturing process, the weight of the outputs in each activity can be measure exactly. In contrast, it is difficult to determine the actual sales value of the outputs during each activity. For the cost allocation of the raw material, three criteria are attempted such as physical weight, selling price, and sales value.

Results

1. The Activities and Outcomes in the Production and Logistics Processes of the Rice Mill Enterprise

Figure 1 illustrates the activities and outcomes in the production and logistics process of the processed rice products at Ban-Nong-Oan Community Rice Mill Enterprise that includes 11 activities as follows.

1.1 Transportation of Fresh Paddy from Fields to the Drying Area

The fresh paddy reaped from paddy fields will be transported to the drying area. The outcome of this activity is the fresh paddy.

1.2 Drying of the Paddy for Humidity Reduction

A large quantity of the fresh paddy was dried with the Sun's heat for humidity reduction. The asset of the drying area belongs to the Kuanru Subdistrict Administrative Organization where it is free of charge. The outcome of this activity is the dried paddy.

1.3 Transportation of the Dried Paddy from the Drying Area to the Mill's Warehouse

The dried paddy was transported and kept in the mill's warehouse before the milling process. The outcome of this activity is still the dried paddy.

1.4 Screening of Dirt from the Dried Paddy

The dried paddy is firstly screened for any dirt that is contaminated during the previous harvesting. The main outcome of this activity is the clean paddy. The by-product is the remaining part of the fine broken rice and the rice germ, which will be further proceeded to the sifting process for the rice germ.

1.5 Milling of the Dried Paddy

The clean paddy is then cracked to separate the husk from the brown grain. The main outcome of this activity is the mixed milled rice, the brown rice which may contain a small number of other rice species. The by-product is the broken milled rice split by the milling machine.

1.6 Screening of the Mixed Milled Rice

The mixed milled rice was screened by the sorting machine to obtain the main rice from other kinds of rice. Thus, the main outcome is the pure brown rice related to the desired species. Meanwhile, the by-product is the mixed brown rice of other species.

1.7 Milling of the Broken Milled Rice

The broken milled rice in the 5th process was returned to the milling process again. The main outcome is the net broken rice. The by-product is the fine broken rice and the rice germ.

1.8 Sifting for the Rice Germ

The fine broken rice and the rice germ in the 4th and 7th processes were combined and sifted the rice germ from the broken rice. Thus, the main outcomes are the fine broken rice and the rice germ.

1.9 Vacuum Packaging of Rice Product

The pure brown rice produced from the 6th process was vacuumed in a plastic bag with the logo attachment. The main outcome is a vacuum pack of a rice product.

1.10 Packing for Shipping

The number of rice products, which had been ready for selling, was placed within carton boxes with secure sealing.

1.11 Shipping to Customers

The number of carton boxes was transferred to customers within Songkla province.

In conclusion, all activities provide five categories of product lines including: 1) a pack of rice product, brown rice in the vacuum package; 2) the mixed brown rice, the minority of other rice species; 3) the broken rice, rice which is broken during the milling process; 4) the fine broken rice, rice which is finely broken during the milling process; and 5) the rice germ, a small part of rice with rich nutrition which can be as a raw material of other rice germ product.

There are some challenges that make the unit cost analysis difficult. First, there are a variety of outcomes during the milling process. Second, the outcome weight is gradually lost during the milling process. Based on the field observation, the lost rate of outcome weight by each activity is illustrated in Figure 1.

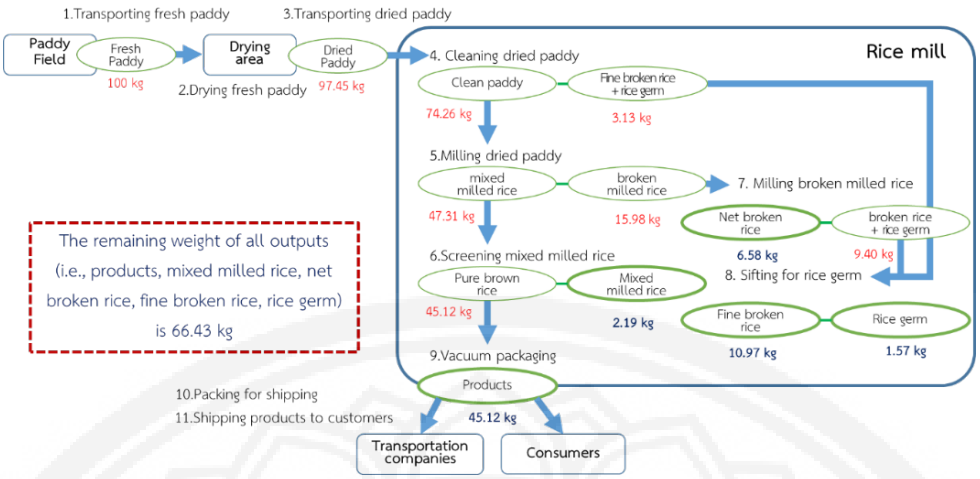

Figure 1 Activities, Outcomes, and Lost Weight of Outcomes in the Production and Logistics Process.

2. Unit Costs Demonstrated by Activities and Outcomes

Due to the complicated analysis of the unit cost classified by the structure of activities and outcomes, the explanation is aligned as seen in Figure 2. First, the analysis begins with the exploration of all activities and resources consumed by each activity that finalize the activity unit cost. Second, the activity unit cost of each activity is then allocated to different outcomes, which occur during the process. Third, the raw material cost is allocated to each outcome. Last, the activity and raw material unit cost are combined to the total unit cost for each outcome.

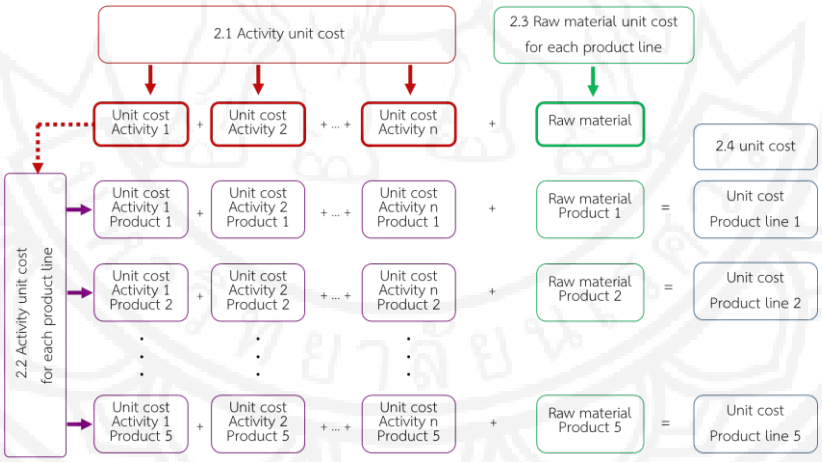

Figure 2 The Sequence of Unit Cost Analysis Structurized by Activities and Product Lines.

2.1 Activity Unit Cost

The analysis begins with the determination of the activity drivers for each activity. The activity drivers are supposedly agreed with the characteristic of the activity's outcome. The resource cost per activity driver for each activity is then calculated and divided by the outcome weight that finally generates the activity unit cost (see Table 1).

The bottom-up estimation for the first activity, the paddy transportation from the fields to the drying area, is here given as an example for the demonstration. The activity driver for this activity is "a sack of paddy"

which leads to the unit of the activity rate as "baht/sack". The resources consumed by this activity are explained as the following.

1) Staff wages for the paddy transportation from the fields to the drying area.

- The wage for two staffs was 200 baht/day.

- The average paddy weight per trip was 2,500 kgs/trip. The average paddy weight per sack was 30.69 kgs/sack. Then, the average number of sacks was 81.45 sacks/trip.

- The average trip per day was 3 trips/day. Then, the average sack per day was 244.34 sacks/day.

The above information can lead to the average wage per sack as the following.

$$200 \ \frac{\text{baht}}{\text{day}} \times \frac{1}{244.34} \ \frac{\text{day}}{\text{sack}} = 0.82 \ \frac{\text{baht}}{\text{sack}}$$

2) Transportation cost for the paddy from the fields to the drying area.

- The hire for transportation was 500 baht for 13 trips that provided the average cost at 38.46 baht/trip.

- The average weight for a trip was 2,500 kgs/trips. The average weight for a sack was 30.69 kgs/sack. Therefore, the average number of sacks for a trip was 81.45 sacks/trip.

The average cost per trip can then be calculated as

$$38.46 \ \frac{\text{baht}}{\text{trip}} \times \frac{1}{81.45} \ \frac{\text{trip}}{\text{sack}} = 0.47 \ \frac{\text{baht}}{\text{sack}}$$

3) The cost of a plastic sack for the paddy transportation.

- The cost of a plastic sack was 5 baht/sack which could be used for 2 trips of transportation.

The average cost per sack can then be calculated as

$$5 \ \frac{\text{baht}}{\text{sack}} \div 2 = 2.5 \ \frac{\text{baht}}{\text{sack}}$$

Activity Rate = 0.82 + 0.47 + 2.5 = 3.79 baht/sack.

Output Rate = 30.69 kgs/sack.

Activity Unit Cost = 3.79/30.69 = 0.12 baht/kg. (see Table 1)

Table 1 Activity Unit Cost

	1. Transporting Fresh Paddy	2. Drying Fresh Paddy	3. Transporting Dried Paddy	4. Cleaning Dried Paddy	5. Milling Dried Paddy	6. Screening Mixed Milled Rice	7. Milling Broken Milled Rice	8. Sifting for Rice Germ	9. Vacuum Packaging	10. Packing for Shipping	11. Shipping Products
Activity Driver	**Sack**	**Sack**	**Sack**	**Hour**	**Hour**	**Hour**	**Hour**	**Hour**	**Pack**	**Carton**	**Trip**
Cost Categories (Baht/Activity Driver)											
(1) Wage	0.82	10.00	2.39	18.02	21.98	40.00	40.00	40.00	1.00	-	-
(2) Transportation	0.47	-	0.46	-	-	-	-	-	-	-	100.00
(3) Electricity	-	-	-	9.06	5.97	4.84	5.97	9.06	0.00867	0.00003	-
(4) Machinery Depreciation	-	-	-	1.38	4.23	182.82	4.23	1.38	0.17	0.27	-
(5) Plant Depreciation	-	-	1.64	0.53	0.53	29.14	0.53	0.53	0.14	-	-
(6) Material	2.50	-	-	-	2.02	-	-	-	3.87	3.10	-
(7) Total Cost/Driver (Baht/Activity Driver) (1-6)	3.79	10.00	4.49	28.99	34.73	256.80	50.73	50.97	5.19	3.37	100
(8) Output Weight (Kg/Activity Driver)	30.69	29.92	29.92	72.29	48.48	258.86	87.43	80.00	1.00	23.00	2,000
Activity Unit Cost (Baht/Kg) (7/8)	0.12	0.33	0.15	0.40	0.72	0.99	0.58	0.64	5.19	0.15	0.05

2.2 Activity Unit Cost for Each Product Line

This session exhibits how the activity unit cost for each product line is obtained. To ease the simulation, the 100 kgs of the fresh paddy is set at the 1st activity. Since the paddy had been processed through each activity, the product line (by-products) has subsequently come out that caused the initial weight of the main product to gradually decline. For the overall view of the allocation process, it first has to calculate the total activity cost for each activity by multiplying its total output weight with its activity unit cost (see Table 2). Then, the total activity cost regarding each activity is then allocated according to its different weights of outputs. This will finally explore the activity cost for each product line.

The key concept of cost allocation is to follow the rule that the total sum of each allocated cost must equate to the same total. To comply with such a concept, the cost allocating multiplier is designed to ease the cost allocation process. To discover the cost allocating multiplier for each activity, the weight proportion by each product line is firstly determined in every activity. Next, the weight proportion of each product line is subsequently multiplied over from the current to the final activity. Figure 3 demonstrates how the cost allocating multiplier in the 1st and 5th activity is calculated. It is seen that the total of the cost allocating multiplier is equal to 1, which implies that the total sum of each allocated cost is equal to the same total. For example, the total sum of each product line is equal to "A", the total of the 1st activity cost.

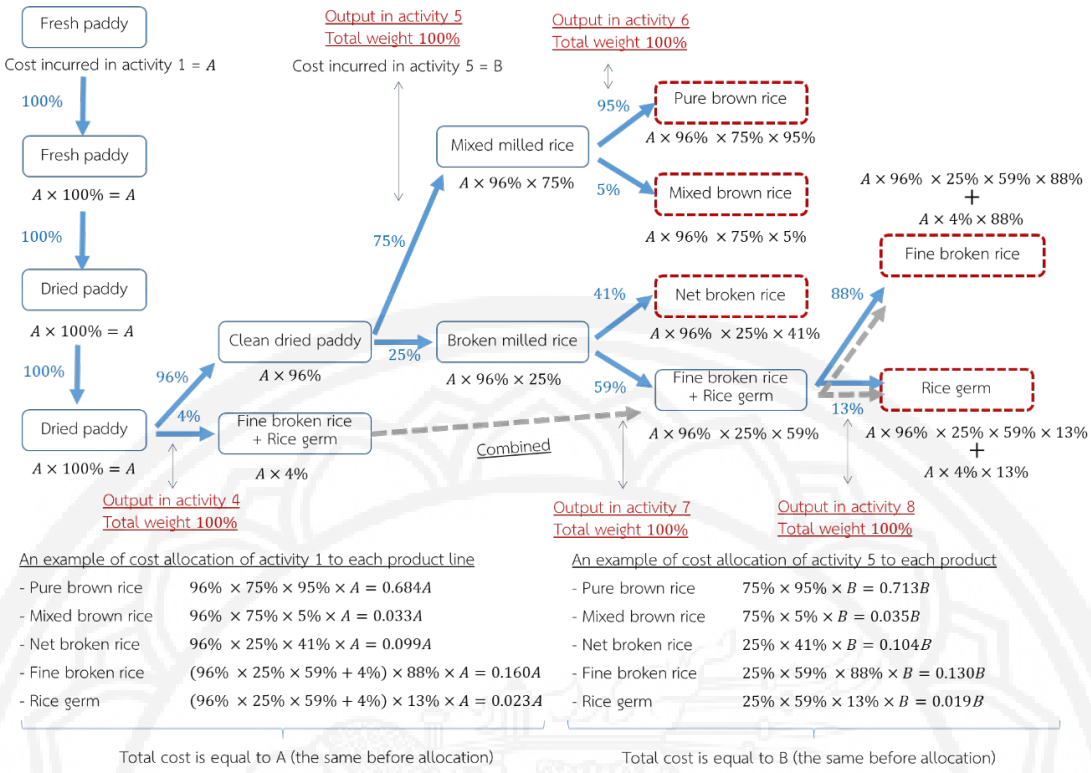

Figure 3 The Concept of Allocating Activity Cost to Each Product Line.

Table 2 Activity Unit Cost for Each Product Line Simulated from the 100 Kgs of the Fresh Paddy at the Beginning Process

	1. Transporting Fresh Paddy	2. Drying Fresh Paddy	3. Transporting Dried Paddy	4. Cleaning Dried Paddy	5. Milling Dried Paddy	6. Screening Mixed Milled Rice	7. Milling Broken Milled	8. Sifting for Rice Germ	9. Vacuum Packaging	10. Packing for Shipping	11. Shipping Products
(1) Activity Unit Cost (baht/kg)	0.12	0.33	0.15	0.40	0.72	0.99	0.58	0.64	5.19	0.15	0.05
(2) Output Weight (Kg) *see Figure 1	100.00	97.45	97.45	77.39	63.29	47.31	15.98	12.53	45.12	45.12	45.12
Total Activity Cost (1 x 2) (Baht)	12.35	32.57	14.62	31.04	45.34	46.94	9.27	7.99	234.04	6.61	2.26
Cost Allocation by Output Weight (baht)											
A Pack of the Rice Product	8.45	22.28	10.00	21.23	32.32	44.76			234.04	6.61	2.26
The Mixed Brown Rice	0.41	1.08	0.49	1.03	1.57	2.18					
The Broken Rice	1.23	3.25	1.46	3.10	4.71		3.82				
The Fine Broken Rice	1.98	5.21	2.34	4.97	5.89		4.77	6.99			
The Rice Germ	0.28	0.74	0.33	0.71	0.84		0.68	1.00			
Activity Unit Cost for Each Product Line (baht/kg)											
A Pack of the Rice Product	0.19	0.49	0.22	0.47	0.72	0.99			5.19	0.15	0.05
The Mixed Brown Rice	0.19	0.49	0.22	0.47	0.72	0.99					
The Broken Rice	0.19	0.49	0.22	0.47	0.72		0.58				
The Fine Broken Rice	0.18	0.48	0.21	0.45	0.54		0.44	0.64			
The Rice Germ	0.18	0.48	0.21	0.45	0.54		0.44	0.64			

Table 2 illustrates how the activity unit cost for each product line is calculated. First, each total activity cost is multiplied with the cost allocating multipliers. For example, the 100 kgs of fresh paddy incur the activity cost of 12.35 baht in the first activity. The total cost is then allocated by the cost allocating multipliers into each product line: a pack of rice product, 8.45 baht (0.684 x 12.35); the mixed brown rice, 0.41 baht

(0.033 x 12.35); the broken rice, 1.23 baht (0.099 x 12.35); the fine broken rice, 1.98 baht (0.160 x 12.35); and the rice germ, 0.28 baht (0.023 x 12.35) (see Figure 3).

Next, the activity unit cost in each product line is calculated by dividing its allocated cost with its own weight at the end process (see Figure 1). For the 1st activity, the activity unit cost in each product line can then be determined: a pack of rice product, 0.19 baht/kg (8.45/45.12); the mixed brown rice, 0.19 baht/kg (0.41/2.19); the broken rice, 0.19 baht/kg (1.23/6.58); the fine broken rice, 0.18 baht/kg (1.95/10.97); and the rice germ, 0.18 baht/kg (0.28/1.57).

2.3 Raw Material Unit Cost for Each Product Line

Material cost is separated from the structure of activity cost so that the enterprise can take advantage of the cost information for decision making. The paper focuses on Sung-Yod rice, one of the six rice species produced by the enterprise, as an example. The enterprise bought Sung-Yod rice at 15 baht/kg and sold it for 60 baht/kg. Thus, the fresh paddy of 100 kg cost a total of 1,500 baht. The paper simulates the cost allocation of the raw material in 3 criteria: 1) the end weight of each product line (kg); 2) the market price of each product line (baht/kg); and 3) the market value or revenue of each product line (baht/kg).

Table 3 exhibits the cost allocation of the raw material in 3 criteria. It is found that the allocation using the end weight gives the raw material unit cost equal at 22.58 baht/kg, which is unreasonable. Meanwhile, the market price criterion highly deviates the raw material unit cost among the product line, for example, the main product is only at 5.02 baht/kg but the rice germ is very high at 723.51 baht/kg. For the market value criterion, it provides the reasonable unit cost of raw material such as the moderate deviation of unit cost with the fair margin for each product line. In conclusion, the market value or the revenue wins the most reasonable criterion for cost allocation of raw material.

Table 3 Comparision of the Cost Allocation of Raw Material (RM) in Three Criteria

	Product line of Sung-Yod Rice					
	A Pack of Rice Product	Mixed Rice	Broken Rice	Fine Broken Rice	Rice Germ	Total
1. The End Weight (kg) *see Figure 1	45.12 (67.92%)	2.19 (3.30%)	6.58 (9.91%)	10.97 (16.51%)	1.57 (2.36%)	66.43 (100%)
2. Market Price (baht/kg)	60.00 (15.11%)	15.00 (3.78%)	12.00 (3.02%)	10.00 (2.52%)	300.00 (75.57%)	397.00 (100%)
3. Market Value (baht) (1 x 2)	2,707.00 (79.65%)	32.90 (0.97%)	78.96 (2.32%)	109.67 (3.23%)	470.00 (13.83%)	3,398.75 (100%)
4. Allocation with End Weight (baht)	1,018.87	49.53	148.58	247.64	35.38	1,500
5. RM Unit Cost (baht/kg) (4/1)	22.58	22.58	22.58	22.58	22.58	
6. Allocation with Market Price (บาท)	226.70	56.68	45.34	37.78	1,133.50	1,500
7. RM Unit Cost (baht/kg) (6/1)	5.02	25.84	6.89	3.45	723.51	
8. Allocation with Market Value (baht)	1,194.80	14.52	34.85	48.40	207.43	1,500
9. RM Unit Cost (baht/kg) (8/1)	26.48	6.62	5.30	4.41	132.12	

2.4 Unit Cost for Each Product Line

The addition between the activity unit cost (Table 2) and the raw material unit cost (Table 3) gives the total unit cost for each product line. Table 4 demonstrates the unit cost of each product line that is presented

by the process activities for the Sung-Yod rice and the average of all six rice species (i.e., Sung-Yod, Riceberry, Lep-Nok, Hom-Baiteoy, Hom Pathum, and Kor Khor 43).

For the activity cost of the rice product, the packing activity incurs the highest cost at 5.19 baht/pack (1 kg/pack). In other words, the 100 kg of the fresh paddy contains 234.04 baht of the packing process out of 443.03 baht of all processes, giving the cost proportion as high as 52.8% (see Figure 2). The resource cost mostly consumed in the given activity is a vacuum plastic bag that costs 2.8 baht/bag. When the repacking is needed, the unit cost is increasing significantly. In the overall view of cost structure, the raw material cost takes a far higher portion than all activity cost. In the case of the 100 kg of Sung-Yod rice, the raw material cost is about 1,500 baht (77.2%) while the activity cost is around 443.03 baht (22.8%) in which it gives the approximate odd ratio as 3:1.

Table 4 Unit Cost Exhibited for Activities and Product Lines

	1. Transporting Fresh Paddy	2. Drying Fresh Paddy	3. Transporting Dried Paddy	4. Cleaning Dried Paddy	5. Milling Dried Paddy	6. Screening Mixed Milled Rice	7. Milling Broken Milled Rice	8. Sifting for Rice Germ	9. Vacuum Packaging	10. Packing for Shipping	11. Shipping Products	** Raw Material Unit Cost	Unit Cost
Sung-Yod Rice													
A Pack of the Rice Product	0.19	0.49	0.22	0.47	0.72	0.99			5.19	0.15	0.05	26.48	34.95
The Mixed Brown Rice	0.19	0.49	0.22	0.47	0.72	0.99						6.62	9.70
The Broken Rice	0.19	0.49	0.22	0.47	0.72		0.58					5.30	7.97
The Fine Broken Rice	0.18	0.48	0.21	0.45	0.54		0.44	0.64				4.41	7.35
The Rice Germ	0.18	0.48	0.21	0.45	0.54		0.44	0.64				132.40	135.33
Averaged from Six Rice Species													
A Pack of the Rice Product	0.19	0.49	0.22	0.47	0.72	0.99			5.19	0.15	0.05	24.96	33.43
The Mixed Brown Rice	0.19	0.49	0.22	0.47	0.72	0.99						7.02	10.10
The Broken Rice	0.19	0.49	0.22	0.47	0.72		0.58					5.62	8.29
The Fine Broken Rice	0.18	0.48	0.21	0.45	0.54		0.44	0.64				4.68	7.61
The Rice Germ	0.18	0.48	0.21	0.45	0.54		0.44	0.64				140.42	143.52

3. The Excel Cost Simulation Program

The cost simulation program is established to ease the enterprise operation for two main reasons: 1) the complication of cost analysis; and 2) the change of some resource costs over time (e.g., seasonal purchasing price of paddy, the change for wages). The enterprise may recalculate the unit cost with difficulty. The program is thus designed to accommodate a friendly interface and flexibility. The program can be downloaded from the link provided in the appendix. The details of the program are explained as the following.

3.1 Sheet for Scenario Selection and Summary

Figure 4 exhibits the Excel sheet named "Scenario" that the enterprise can estimate to update the unit cost by changing some scenarios. The yellow cells are the dropdown list of various scenarios in which the enterprise can select them to simulate the new unit cost. For the ultimate benefit, some extra scenarios are further added such as three different packing sizes, six rice species, purchasing price varied by paddy humidity from 14-30%, and

so on. After setting the scenarios, the program provides some summarized information that is important to the enterprise for decision-making. The important information is described as followed.

- Unit cost separated into unit activity cost and unit raw material cost for each of five product lines.
- Total cost for each of five product lines simulated from the 100 kg of fresh paddy.
- Total activity cost and total raw material cost simulated from the 100 kg of the fresh paddy.
- Profit margin simulated from the 100 kg of the fresh paddy.

3.2 Sheet for Resource Input

The Excel sheet, named "input", allows the enterprise to update the resource cost so that the program recalculates and reports the summary in the sheet "Scenario". The enterprise can update the input in 2 sections: 1) general information such as a per-unit charge of electricity, a yearly quantity of pure brown rice, purchasing prices of fresh paddy from agricultures, selling price of each product line; and 2) resource costs in each activity such as wages, material cost. The program prevents the error in case that the enterprise may replace the given formula in Excel by only allowing the green-font cells for the input update.

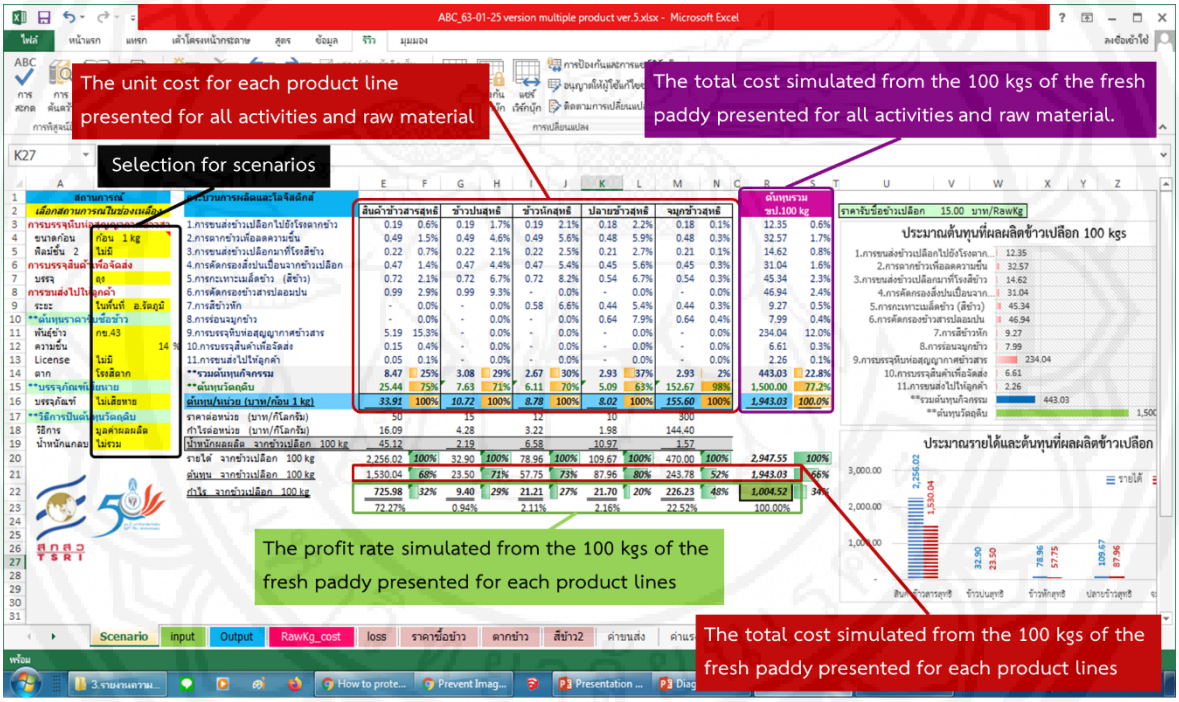

Figure 4 Sheets "Scenario" for Select a Situation and Summarize the Information.

3.3 Sheets for Cost Analysis

Other sheets include the cost information, retrieved from the interview, and the field observation within the production and logistics processes, which link with a lot of formula across the sheets to produce the summarized results in the sheet "Scenario".

4. Training the Excel Cost Simulation Program for the Enterprise

The research team delivered and trained the program for the enterprise. The result reveals that the enterprise was able to use the program to simulate the updated cost and profit margin. The team tried assigning the new situation for the enterprise to solve, for example, what the cost and profit margin should it be if the purchasing price changed or if the size of the main product changed to 0.5 or 2 kg/pack. After the training, the team followed

up and found that the manager of the enterprise had regularly demonstrated how to use the program for visitors. This demonstration implies the capability of the enterprise for using the program.

Conclusion and Discussion

Based on the research objective, the key conclusion and discussion are provided as the following.

1. The unit cost for each product line averaged by six rice species is revealed as a pack of rice product, 33.43 baht/kg; the rice germ, 143.52 baht/kg; the mixed rice, 10.10 baht/kg; the broken rice, 8.29 baht/kg; and the fine broken rice, 7.61 baht/kg. The given unit cost for each product line goes in line with their selling price that provides a profit margin. The main reason that leads to achieving the appropriate unit cost is the criterion used in the cost allocation of raw material since it takes a high proportion in the overall cost. In contrast, if the market price is applied, the raw material unit cost is unreasonably fluctuated according to their market price, for example, the rice germ has a higher unit cost than its market price. Nonetheless, if the sales value is applied, the raw material unit cost for each product line is proportionate to their market price that can generate their profit margin. The concept of the cost allocation criterion using sales value is that each product should generate enough revenue to cover its own cost reasonably (Hansen et al., 2009).

2. Based on the cost structure averaged by 6 rice species, the odd ratio between the raw material cost (76.3%) and the activity cost (23.7%) is about 3:1. For the activity cost, it was found that the unit activity cost as: 1) Transportation of paddy from fields to the drying area, 0.12 baht/kg; 2) Drying of the paddy for humidity reduction, 0.33 baht/kg; 3) Transportation of the dried paddy from the drying area to the mill's warehouse, 0.15 baht/kg; 4) Screening of dirt from the dried paddy, 0.40 baht/kg; 5) Milling of the dried paddy, 0.72 baht/kg; 6) Screening of the mixed milled rice, 0.99 baht/kg; 7) Milling of the broken milled rice, 0.58 baht/kg; 8) Sifting for the rice germ, 0.64 baht/kg; 9) Vacuum packaging of rice product, 5.19 baht/kg; 10) Packing for shipping, 0.15 baht/kg; 11) Shipping the packs of products to the customer, 0.05 baht/kg. It is seen that the packing activity takes the most portion in all activity cost, which is as high as 52.8%. The vacuum plastic bag is the main resource that hugely cost as 2.8 baht/pack in the packing activity. Thus, the product needed for repacking will incur an additional unit cost by 15%. The manager revealed that the packaging damage was regularily found in the form of vacuum loss. It was usually found at the beginning and at the end of the packing activity, where the sealing machine may not be ready yet for operating. It may sometime be found when the sealing machine works too long hours. Besides, the broken package can be found during the transportation that may be resulted from the inappropriate arrangement of items.

3. The loss of all output weight during the production process is primarily associated with the final unit cost. Based on the field observation, the end weight of all product lines was reduced to 66.43% of the initial weight of the fresh paddy. In other words, the material unit cost was increased to 1.51 times (1/0.6643) of the purchasing cost of the fresh paddy. When comparing with the dried paddy, it was about 68.16%, which is close to 68.70% researched by Rice Department (2016). Additionally, the remaining weight of the pure rice to the dried paddy is around 46.44% which is also close to 42.32% reported by Khonkaen Rice Seed Center (2015).

4. The main reasons for establishing the Excel simulation cost program are in two concerns. First, there will be an opportunity for the cost changes accounted by resource changes (e.g., the purchasing price of fresh paddy, material cost, and wages) as well as options in the operations (e.g., different purchasing price when buying from the agriculture with JAP license or from other kinds of rice species, the second warping of the packaging). Second,

the update in those resource changes makes the enterprise difficult to recalculate the new unit cost. Therefore, the program allows the enterprise to update those inputs to simulate the tentative unit cost and the profit margin. This would enhance the enterprise's management in terms of time efficiency and accuracy. The training for the program revealed that the enterprise can employ it very well when the research team tried giving the new scenario setting. Besides, the manager could even demonstrate the use of the program for visitors. However, the program contains some limitations, for example, any new resources would not be added to the existing calculation performed by the program.

Recommendation

The findings can be suggested for the enterprise as presented below.

1. The Emphasis on Cost Control in Raw Material

Based on the unit cost structure, the odd ratio between the raw material and activity cost was around 3:1 (75%:25%). Additionally, the end weight was lost during the production process. This implies the primary significance of cost control in the raw material. The enterprise should realize that an additional 1 baht/kg of the raw material price will cost more than that at the final unit cost. The research found that it additionally cost 0.5 baht/kg. Thus, the enterprise should investigate the causal sources for the broken rice during the production process such as the physical characteristics of paddy, and the paddy humidity just right before the production process (Maneerat, Chomchuen, Bucha, & Wisitsirikun, 2015).

2. The Emphasis on Cost Control in the Most Costly Activity

For the main product, the packing activity consumed 52.8% of all activity costs, the most costly activity. The enterprise may especially focus on that activity such as considering other suppliers for the cheaper vacuum plastic bag and sticker. Also, the enterprise should investigate the cause of the damaged package such as the appropriate way for item arrangement during transportation and the appropriate warming-up time of the sealing machine.

3. The Different Views of the by-Product Cost and the Value-Added

This paper also allocated the activity-based cost into the main product and the by-products so that the enterprise can realize the unit cost for all product lines. When new product development is derived from by-products, the enterprise can estimate the new product's cost more accurately by summing the given unit cost of the by-product with some further activity costs. To realize the tentative unit cost of the by-products, the enterprise could have a different viewpoint toward the by-products. For example, the rice germ used to see as worthless scraps can be considered a valuable material used in the new product development since the enterprise could realize its cost. Recognizing the by-product cost will lead to the accurate costing of the developed product.

4. The Enterprise's Managerial Decision Making Enhanced by the Cost Simulation Program

The enterprise can apply the Excel cost simulation program to support its decision-making regarding cost management. The enterprise can adjust the selling price and the cost input to simulate the tentative unit cost and profit margin before making a decision. For example, when the purchasing price of the fresh paddy is increased according to the seasonal demand and supply, the enterprise can try the new selling price in the program to retain the same profit margin.

Acknowledgement

The research is the sub-project under the contract research project No. RDG61A0033-001 funded by Thailand Science Research and Innovation (TSRI) and Thaksin University.

Appendix

The cost simulation program is available at the following URL.
https://drive.google.com/file/d/16PqnPlGeiXlVaweHezc-5BNMPfVMnyq9/view?usp=sharing

References

Brierley, J. A., Cowton, C. J., & Drury, C. (2008). Investigating Activity-Based Costing in Manufacturing Industry. *Cyprus International Journal of Management*, *13*(1), 21-33. https://doi.org/10.2139/ssrn.728363

Chapko, M. K., Liu, C.-F., Perkins, M., Li, Y.-F., Fortney, J. C., & Maciejewski, M. L. (2009). Equivalence of Two Healthcare Costing Methods: Bottom-Up and Top-Down. *Health Economics*, *18*(10), 1188-1201. DOI: 10.1002/hec.1422

Garrison, R. H., Noreen, E. W., & Brewer, P. C. (2018). *Managerial Accounting* (16th ed.). New York: McGraw-Hill.

Hansen, D. R., Mowen, M. M., & Guan, L. (2009). *Cost Management: Accounting and Control* (6th ed.). Ohio, USA: South-Western Cengage Learning.

Hugos, M. H. (2011). *Essentials of Supply Chain Management* (3rd ed.). New Jersey: John Wiley & Sons. DOI: 10.1002/9781118386408

Khonkaen Rice Seed Center. (2015, May 15). *Do you know how many Kilograms of White Rice will be Obtained from Milling 100 Kilograms of Paddy Rice?* Retrieved from https://www.facebook.com/soonkhow/photos/รู้หรือไม่-ถ้าสีข้าวเปลือก-100-กิโล-จะได้ข้าวสารกี่กิโลปัจจัยหลากหลายที่มีผลกระท/1154502461242058/

Kingphadung, K., & Woottichaiwat, S. (2017). Application of Activity-Based Costing to Pasteurization Milk Production: A Case Study in Small Dairy Industry. *Veridian E-Journal, Silpakorn University*, *10*(1), 1661-1679. Retrieved from https://he02.tci-thaijo.org/index.php/Veridian-E-Journal/article/view/89476

Maneerat, C., Chomchuen, K., Bucha, W., & Wisitsirikun, S. (2015). The Study of Suitable Humidity in Paddy for Rice Process. In *The 2nd Kamphaeng Phet Rajabhat University National Conference, Research and Development Institute, Kamphaeng Phet Rajabhat University, 22 December 2015* (pp. 213-219). Kamphaeng Phet: Research and Development Institute, Kamphaeng Phet Rajabhat University. Retrieved from https://research.kpru.ac.th/sac/fileconference/5652018-05-04.pdf

Office of the Permanent Secretary, Ministry of Commerce. (n.d.). *Exports of Important Thai Commodities by Revenue*. Retrieved from http://www.ops3.moc.go.th/export/

Office of the Royal Development Projects Board. (2013). *A Guide to Successful Application of Sufficiency Economy Philosophy: A Category in the New Royal Theory "Khaw Khunkha Chawna Khunatham Community Enterprise"*. Retrieved from http://www.rdpb.go.th/th/Download/หนังสือเศรษฐกิจพอเพียง-c121/คู่มือตัวอย่างความสำเร็จการประยุกต์ใช้ปรัชญาของเศร-v5943

Rice Department. (2016). *Rice Knowledge Bank*. Retrieved from http://www.ricethailand.go.th/rkb3/title-index.php-file=content.php&id=6-2.htm

Sowcharoensuk, C. (2019). *Thailand Industry Outlook 2019-2021: Rice Industry*. Retrieved from https://www.krungsri.com/bank/getmedia/54e68479-172d-4bca-bc66-ab768c85faa5/IO_Rice_190814_EN_EX.aspx

The Secretariat of the House of Representatives. (2018). *Academic Focus: Promoting and Developing Community Enterprise from Governmental Sector*. Retrieved from https://library2.parliament.go.th/ejournal/content_af/2561/aug2561-4.pdf