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Cost Structure and Function of Smoked Skipjack Fish Processing Business in North Sulawesi Province

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ABSTRACT: This research aims to analyse the cost structure of the smoked skipjack fish processing business in North Sulawesi Province, with a focus on determining the cost function and its effects. Eighty-one skipjack-smoked fish producers were censused and interviewed using questionnaires that had been prepared before. The analysis method used in this research consists of descriptive analysis and Cobb-Douglas cost function analysis, in which the cost function is modelled in the short term. The result showed that the cost of fresh fish, supplementary materials, and labour largely dominated the skipjack smoked fish processing cost. These costs account for 98.86% of the total cost; the remainder is variable costs, namely depreciation costs. From the regression analysis, the production volume and firewood price significantly affect production costs, while others do not.

Keywords: cost function, skipjack, smoked fish

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INTRODUCTION

Indonesia has high biodiversity and abundant natural resource potential. In addition to being an agrarian country, according to the Ministry of Marine Affairs and Fisheries (2014), Indonesia is also the largest archipelagic country in the world as Indonesia has the largest number of islands and coastal areas in the world. Indonesia has a powerful potential for fisheries development where the coastal area and long coastline make it very possible to develop the fishery sector (Jamal, 2014). Marine resource potential in Indonesia is quite large and increasing. In 2016, the volume of marine capture fisheries production in Indonesia amounted to 6,351,480 tons of fish, an increase from 2015, which was 6,204,668 tons of fish (General of Fisheries Directorate, 2017).

North Sulawesi is one of the provinces that has considerable fisheries potential, which is strategically located directly adjacent to the Maluku Sea and the Philippines. The General of Fisheries Directorate issued the number of Capture Fishery Production and cultivation in North Sulawesi, in 2016 was 302,798 tons, an increased from the previous year which only produced 285,265 tons of fish. These marine resources generated from the province of North Sulawesi include skipjack.

Skipjack (*Katsuwonus pelamis L.)* is an important pelagic fishery resource and is one of the non-oil and gas export commodities. Skipjack is found in almost all Indonesian waters, especially in the Eastern part of Indonesia including Nort Sulawesi Province. According to the Ministry of Maritime Affairs and Fisheries, the value of skipjack tuna catch in 2021 was IDR 833,228 million, with a production volume of 42,171.57 tons (KKP, 2022). This volume and value decreased to 13,479.74 tons with a value of IDR 263,649 million in 2023. This decline could be because of extreme weather, reduced time at sea, and unstable prices for capture fisheries products.

Besides being sold and marketed in the form of fresh fish, skipjack fish are also marketed in the form of smoked fish, locally known as cakalang

fufu. The advantage of selling smoked skipjack tuna over fresh fish is its longer shelf life and distinctive flavor. Smoked fish has a lower water content, which inhibits the growth of spoilage bacteria, thus preserving it longer. Furthermore, the smoking process imparts a unique flavor and aroma that many people enjoy (Kaban et al., 2019). The smoked skipjack tuna processing business is located on the coast, using raw materials obtained largely from local fishermen. The smoked skipjack tuna is processed using simple equipment or technology which usually pays less attention to sanitation and hygiene aspects. To produce smoked Cakalang fish, production inputs are needed both as the main raw material and as a helper to obtain smoked skipjack. These production inputs are mainly fresh tuna, firewood, woka leaf, and labor besides supplementary inputs, such as water, clamp bamboo and food coloring. Mangantar, Adolfina & Baramulli's (2015) research shows that Cakalang Fufu's business is feasible because of the raw materials availability, marketing aspects, and financial aspects that are considered to meet investment valuation criteria, such as a positive Net Present Value, Internal Rate of Return above the free interest rate risk, Payback Period is faster than investment and B/C ratio is greater than one. However, producers of skipjack fish do not mean they have any challenges or problems, one of which is minimizing their production costs at the level or scale of certain production and technology. Therefore, research aimed at examining and analyzing the structure of the cost of the fish processing business is very knowledgeable to be accomplished to increase the profitability and sustainability of this smoked fish processing business.

Minimizing cost analyses can be approached by deriving the cost function from the total cost and expressing it as a constrained optimization problem. The cost function corresponds to the minimum cost of producing a given level of output for some fixed input prices (Zil, 2004). Hence, the cost function is a multivariate function derived from the production function. This approach has been applied to many studies, including research on profitability in Greek banking (Louzis & Vouldis, 2015), health care services (Dlouhý & Flusserová, 2007), cargo handling service in multi-purpose port terminals (Tovar, Jara-Díaz, & Trujillo, 2007), cost function in Academic Research Library (Liu 2002) measuring the level of labor productivity (Zil, 2004), and among others. However, research using the cost function approach in small and medium enterprises in Indonesia, especially in food processing is very limited or very difficult to find. Two studies found using the cost function approach were Putri & Anna's (2014) research on aquaculture with cages in reservoirs and Nizar, Siswati & Putri's (2016) on corn farming with a cubic cost model. This is the main reason for the importance of research on the cost function in food processing businesses, especially in small and medium enterprises (SMEs). In addition to enriching science in the field of economic modeling, the results of this study can be used as input for policy design for the development and sustainability of SME businesses engaged in food processing.

Departing from the above discussions, this research is aimed at examining the cost structure of smoked skipjack fish processing in North Sulawesi Province. This commodity is one of the exotic indigenous foods in North Sulawesi province that still faces several problems as other SMEs, especially related to limited marketing and business working capital. Minimizing costs to maximize profits is an important effort to maintain the sustainability and development of this fish processing business to be very significant. Therefore, this study also aims to determine the factors that influence the level of production costs incurred in the process of producing skipjack smoked fish.

MATERIALS AND METHODS

This research is conducted in North Sulawesi Province by censusing 81 smoked skipjack fish producers. Data collected involve all costs incurred in smoked skipjack processing. In this research, the cost structure of smoked skipjack fish processing in North Sulawesi Province consists of fixed and variable costs as suggested by Lipsey, et al. (1995). Thus, the total cost is the sum of fixed and variable costs. It can be written as follows:

Where TC = total cost, TFC = total fixed cost, TVC = total variable cost in the smoked skipjack fish processing business.

The cost function for the Smoked Skipjack fish processing business in North Sulawesi can be explained briefly as follows:

Because these costs incurred in skipjack smoked fish are based on one production process, the cost function is the short-run cost model, which consists only of total variable cost (TVC). The total variable cost is written as follows:

$$TVC = \sum_{i=1}^{n} P_i X_i \qquad (1)$$

The total variable cost in equation (1) is minimised subject to production as follows:

$$\alpha_0 + \sum \alpha_i X_i = Q_0 \qquad (2)$$

where X_i is the i-th production input used, and Q0 is the total production. Then, following Sheppard (1970), the Lagrangian function can be written as follows:

$$L = \sum P_i X_i - \lambda\left(\alpha_0 + \sum \alpha_i X_i - Q_0\right) \qquad (3)$$

To minimise production cost, equation (3) is derived partially concerning the input used and then set equal to zero (Pindyck & Rubinfield, 2001). It will result in:

$$P_i - \frac{\lambda\left(\alpha_0 + \sum \alpha_i X_i\right)}{X_i} = 0 \text{ for i= 1, 2, 3, ..., n} \quad (4)$$

and

$$\alpha_0 + \sum \alpha_i X_i - Q_0 = 0 \qquad (5)$$

Solving equations (4) and (5) simultaneously and substituting into equation (1), the short-run cost function of smoked skipjack fish, in line with Silberberg (1978), can be written as:

$$TVC = f\left(P_i, Q\right) \qquad (6)$$

Equation (6) shows that total variable costs (TVC) may be expressed as a function of input prices and production, neglecting the level of input use. In the smoked skipjack fish production process, production inputs include fresh skipjack fish, ice cubes, food coloring, clean water, clamp bamboo, woka leaf, firewood, and labor. Thus, the TVC function can be written as follows:

$$TVC = f\begin{pmatrix} P\_FISH, P\_ICE, P\_COLOR, P\_WATER, \\ P\_BAMBOO, P\_LEAF, P\_FIREWOOD, \\ P\_LABOR, Q_0 \end{pmatrix} \quad (7)$$

It is assumed that the total variable cost function has the Cobb-Douglas functional form which is then transformed into a natural logarithm model as:

$$\begin{aligned} lnTVC_t = {} & \beta_0 + \beta_1 lnP\_FISH + \beta_2 lnP\_ICE_t \\ & + \beta_3 lnP\_COLOR_t + \beta_4 lnP\_WATER_t \\ & + \beta_5 lnP\_BAMBOO_t + \beta_6 lnP\_LEAF_t \\ & + \beta_7 lnP\_FIREWOOD_t + \beta_8 lnP\_LABOR_t \\ & + \beta_9 lnQ_0 + \mu_t \end{aligned} \qquad (8)$$

where, P_FISH = fresh skipjack fish price, P_ICE = ice cubes' price, P_COLOR = food colouring price, P_WATER = clean water price, P_BAMBOO = clamp bamboo price, P_LEAF = *woka* leaf price, $P\_FIREWOOD$ = firewood price, P_LABOR = labour wage, and Q_0 =total output, μ_t= error term

RESULTS AND DISCUSSION

Characteristics of Respondents

A statistical description of skipjack smoked fish producers' characteristics is briefly presented in Table 1. There were 81 skipjack-smoked fish producers in North Sulawesi Province. The majority of smoked fish producers, i.e. 59%, were at the age of 44-59 years. On average, they were 48 years old. This indicates that the skipjack-smoked fish producers were at a productive age (≤ 50 years). Age relates to physical performance, and many researchers have also concluded that age and physical performance of farmers are significant factors determining technology adoption as stated by Lavison (2013). A study by Mignouna et al, (2011), as well as Kariyasa & Dewi (2011), also concluded that older farmers get better knowledge and experience over time than younger farmers so they are better able to evaluate and adopt the technology.

Skipjack-smoked fish producers relatively have low levels of education. The majority of producers, i.e. 75.3%, have an education level of Elementary School and Junior High School. With a low education level, it is presumable that producers have a low ability to minimize production costs, and in turn, it will lessen their business performance. In other words, a lower education level is often related to a low level of business performance, and vice versa. Many empirical studies demonstrated that there was a positive and significant relationship between education and business performance, for instance, a study by Agiomirgianakis et al., (2002). Current

research by Magoutas, Papadogonas & Sfakianakis (2012) has also concluded that the level of education as a proxy of human capital has a positive and significant impact on the growth rates of firms in Greece.

Table 1. Characteristics of Skipjack Smoked Fish Producers in North Sulawesi Province

No	Description	Frequency	Percentage (%)	Mean
1	Age (year)			
	27 – 43	26	32.10	
	44 – 59	48	59.26	48
	60 – 74	7	8.64	
2	Education level			
	Elementary School	25	30.86	
	Junior High School	36	44.44	
	Senior High School	17	20.99	
	Diploma and Bachelor	3	3.70	
3	Family Size (person)			
	1 – 3	53	65.43	
	4 – 6	25	30.86	3
	7 – 8	3	3.70	
4	Business experience (Year)			
	4 – 17	50	61.73	
	18 – 31	26	32.10	17
	32 – 45	5	6.17	

Another important factor that determines business performance is business experience as reported by Chrisman, McMullan & Hal (2005). They concluded that previous experience is an important factor for small firm achievement. In addition, a study by Chiliya & Robert-Lombard (2012) found that factors such as work experiences, owner education levels, and age have a significant impact on business profitability. Looking at Table 1, skipjack smoked fish processors have 17 years of experience in processing tuna fish. This indicates that smoked fish producers have long experience in the smoked fish processing business. This will certainly help them in managing their businesses.

Family members are often the main source of labor for businesses or home industries in Indonesia, including the smoked fish processing industry in North Sulawesi. The number of family members also affects the number of family needs, both food and non-food, which must be met. Therefore, the number of family members is important to be revealed and analyzed. On average, the family size was 3 people. This indicates that they are a small family. It is very difficult to find research that links family size and business performance. Research highlights more on the influence of families in decisions for business or not. Daryani, Samizadeh, & Tajeddin (2010), for example, examined the relationship between family characteristics on the creation of family businesses. They concluded that family size and disagreements are not effective in the creation of family businesses. Different results for family relationship factors, family goals, family resources, and family vision influence the establishment of a family business.

Cost Structure

Cost Structure describes all costs incurred to operate a business. Mulyadi (2005) stated that cost structure is the composition of costs incurred in producing goods or services. In this research, all costs incurred in producing skipjack smoked fish can be categorized into 2 types, fixed and variable costs.

Fixed cost components incurred in smoked skipjack fish processing only consist of depreciation costs of the production equipment used. The average depreciation cost is IDR 63,300 per production process. Depreciation of cars used for transportation dominated total fixed costs. These costs account for approximately 77% of the

total fixed costs that the producer must incur. The smallest fixed cost incurred was a wooden table, i.e., 0.58% of the total fixed cost or IDR 366 per production process. This wooden table is used as a base for splitting and cutting skipjack before being cleaned and smoked.

Table 2. Average Variable Costs for smoked skipjack fish processing in North Sulawesi Province.

Description	Cost (IDR/process)	Percentage (%)	Percentage of Total Cost (%)
Fixed Cost			
Freezer	3,846	6.08	0.07
Cold box	2,889	4.56	0.05
Styrofoam box	1,454	2.30	0.03
Wooden table	366	0.58	0.01
Blades/knives	712	1.12	0.01
Para-para smoking	480	0.76	0.01
Basket	525	0.83	0.01
Motorcycle	3,551	5.61	0.06
Car	48,727	76.98	0.88
Other (Scales, fan)	750	1.18	0.01
Sub-total (TFC)	63,300	100.00	1.14
Variable Cost			
Fresh Skipjack Fish	4,667,469	84.97	84.00
Ice Cube	69,969	1.27	1.26
Food Coloring	13,775	0.25	0.25
Clean Water	11,354	0.21	0.20
Clamp Bamboo	16,840	0.31	0.30
Woka leaf	40,062	0.73	0.72
Firewood			
a. Coconut leaves	106,031	4.23	1.91
b. Timber	126,215		2.27
Labor	441,420	8.04	7.94
Sub-total (TVC)	5,493,135	100.00	98.86
Total Production Cost (TC)	5,556,435		100.00

The Total variable cost incurred in smoked skipjack fish is presented in Table 4. The highest variable cost sacrificed is for the purchase of fresh fish, as the main input for this smoked skipjack processing business. The cost of purchasing fresh fish reaches 84.97% of the total variable cost or IDR 4,667,469 per production process. Other significant variable costs incurred by these smoked fish producers are labor costs and firewood costs. Labor costs account for a considerable portion of the overall variable cost structure. It contributes 8.04% of the total variable cost. Meanwhile, firewood which is burned to produce heat for smoking cleaned and cleaved skipjack contributes 4.23% of the total variable cost per production process.

Total costs (TC) are defined as the overall costs incurred to produce a given output(product). As presented in Table 2, the total cost consists of total fixed cost (TFC) and total variable cost. The total production cost of smoked skipjack fish processing is IDR 5,556,435,- per production process. This cost is spent mostly on the variable cost (TVC), i.e., 98.86% while fixed cost (TFC) is only 1.14%. The high variable costs are reasonable since these costs are incurred for the company's operations to be able to produce. Generally, the higher the variable cost, the higher the amount of smoked fish produced. Costs

incurred for the purchase of fresh fish, labor payments, and firewood have a significant share of the total production costs. These three types of costs each absorb 84%, 7.94%, and 4.18% of the total production costs (TC) respectively (see Table 2).

Estimation of Cost Function and Hypothesis Testing

The estimated cost model coefficients and the associated standard errors are presented in Table 3. The value, i.e. 294.967, is higher than it indicated that all independent variables in the model simultaneously significantly affect the total variable cost incurred in smoked skipjack fish processing. This result also implies that the model is a model that is correctly specified and able to apply in describing changes in the variation of the dependent variable which can be explained by changes in the variation of the independent variables in the model. Furthermore, there is also no multicollinearity problem in the model. Using the Correlation Matrix of Coefficients, there is no high correlation value pairwise correlation among independent variables. Multicollinearity may be present if the pairwise correlation value is higher than 0.8 (Gujarati & Porter, 2008).

Table 3. Estimated Cost Function of Smoked Skipjack Fish

Variable	Coefficient	Standard Error	t-statistic
$ln\,Q_0$	1.0893	0.02246	48.51***
$ln\,P\_FISH$	0.3855	0.5255	0.7337
$ln\,P\_ICE$	0.1064	0.07313	1.455
$ln\,P\_COLOR$	0.0365	0.1341	0.2725
$ln\,P\_WATER$	0.0133	0.02944	0.4531
$ln\,P\_BAMBOO$	0.0178	0.01809	0.9843
$ln\,P\_LEAF$	0.0963	0.08887	1.083
$ln\,P\_FIREWOOD$	0.1722	0.07132	2.415**
$ln\,P\_LABOR$	0.0608	0.04336	1.403
Constant			-8.1893
R^2			0.9740
F-statistic			294.967***

Notes: ***, **, * are significant at 99%, 95%, and 0% respectively

The coefficient of determination is used to determine how much the relationship and the influence of the independent variables in the model influence the dependent variable. Hill, Griffiths & Lim (2011) also state that the coefficient of determination will explain how much change or variation in a variable can be explained by changes or variations in other variables. From estimation, the value is 0.974, meaning that 97.40% of the total variable cost variation can be explained by all the independent variables in the model. The remaining, i.e. 2.60%, is described by other unobserved variables.

All independent variables included in the model have an expected sign, i.e., a positive sign. The positive sign implies that an increase in production quantity and the price of production inputs will increase total variable costs. These findings are in line with cost theory. Output quantity, for instance, has a positive relationship with production cost, especially variable cost. The larger output produced requires a large amount of production inputs, which in turn affects an increase in total variable cost. Similarly, increasing input prices will result in an increase in production cost, especially total variable cost, and vice versa.

Even though all variable has an expected sign, only the quantity produced (output) and the Firewood variables are statistically significant, while the other variables are not. The positive and statistically significant effect of the variable amount of output on total variable costs is a reasonable finding. In the production economic theory, the increase in output requires an increase in the number of production inputs used which in

turn will increase the variable costs incurred by producers. The study by Zil (2004) also found that the amount of output affected the total production costs in the case of the manufacturing industry. Firewood is the main input processing smoked skipjack in addition to the fresh fish itself. Firewood is used to smoke fish that have been cleaned and filleted. This means that this wood must be present in the processing of baked skipjack. Of course, the higher the price of firewood used the higher the production costs that must be spent, and vice versa. Therefore, the finding that the price of firewood has a positive and significant effect statistically on the total variable costs is reasonable. So far, there have not been many studies that have tried to examine the impact of firewood (fuel) prices on total production costs.

Other price factors, except labor, are factors of production that are only supplementary production ingredients. The existence of these production inputs is insignificant. In addition, the use of these inputs is small and their contribution to the total cost is also small and insignificant. The average cost incurred is less than 1% of the total production cost (see Table 2). Therefore, if the variable price of input production is insignificant to the increase in the total variable costs, it is reasonable. According to Takalamingan et al (2017), fresh fish and labour are the main production inputs for the continuity of fish processing industries at home industry scale.

CONCLUSION AND SUGGESTIONS

The conclusion of this study states that the total variable costs incurred by smoked tuna processing businesses in North Sulawesi Province reached 98.86% of total production costs. Three types of production input costs account for a significant percentage of expenditure: the purchase of fresh tuna (84%), firewood (7.94%), and labor. The remaining 1.14% are fixed costs, dominated by depreciation of transportation equipment.

Two independent variables have positive signs and significantly influence the total variable costs used in smoked tuna production. These are the quantity of smoked tuna produced and the price of firewood. Meanwhile, the price of fresh tuna, labor wages, ice cubes, clean water, bamboo tongs, and woka leaves did not have a statistically significant effect. However, these variables have positive signs, as expected.

This study's findings imply that it is crucial for smoked tuna producers to consistently increase productivity and minimise production costs to maximise business profits. Increased productivity is closely linked to minimizing production costs. Therefore, smoked tuna producers must consistently monitor the use of production costs. Monitoring input prices and finding cheaper raw materials are some ways to reduce production costs. Furthermore, productivity can be increased by adopting better production technologies and expanding the market for smoked tuna products.

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