Economic structure analysis in the development of skipjack tuna (*Katsuwonus pelamis*) fisheries industry in Jayapura City, Papua, Indonesia

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Abstract. The skipjack tuna (*Katsuwonus pelamis*) fisheries sub-sector has both the potential and opportunities to support the economic growth and regional development in the City of Jayapura. It can also encourage and leverage economic sectors in this *K. pelamis* production city. The aim of the study was to calculate the structural strength and interaction between the *K. pelamis* fisheries sub-sector and the other marine fisheries, other marine products, the food and beverage industry sector, trade, transportation, hotels, and restaurants and other sectors. The Input-Output (I-O) analysis was used to analyze GDRP 2016 as secondary data. The results showed that the *K. pelamis* fisheries sub-sector has a contribution to encourage and leverage other sectors. *K. pelamis* sub-sector was not provided an optimal contribution to the economic growth which reached 1.94%; however, it had an impact on the backward and forward linkages of 1.3234% and 1.3779%, respectively. The strength of the structure and the interactions within the *K. pelamis* fisheries sub-sector still need to be further investigated and developed. The *K. pelamis* fisheries sub-sector has an impact on employment and community income.

Key Words: structural strength, economic sectors interaction, economic growth, production, leverage.

Introduction. Jayapura City is the center of economic growth and regional development in the Papua Province, Indonesia. The contribution of Port Numbay's economic growth to the Papua Province in 2017 reached 7.23%, with the capture fisheries sector contributing 4.67% (Jayapura City BPS 2017). The volume and value of production was 49,093.81 tons and 20,750,919.56 USD (DKP Jayapura City 2018).

One of the leading capture fisheries commodities in the City of Jayapura to date is skipjack tuna (*Katsuwonus pelamis*). The production volume of *K. pelamis* from Jayapura City reached 6,230.76 tons, with an economic value of 2,826,296.71 USD (BPS Jayapura City 2017).

The *K. pelamis* fisheries commodity performs a multiplier effect in the form of increased public income, employment, development of the trade sector and food and beverage industry. The *K. pelamis* fishery commodity is a type of fish that has competitiveness and is traded in national and international markets. The researches conducted by Hutajulu et al (2019) and Suhana et al (2016) showed that the commodity of *K. pelamis* in the City of Jayapura and in the territory of Indonesia are very competitive. This shows the growing contribution of *K. pelamis* fisheries to the capture fisheries sector in Jayapura City, so this sector is very suitable to be pushed to become the main sector in the context of improving the welfare of the fishing community in the city nicknamed as Port Numbay.

One form of excellence and competitiveness of *K. pelamis* fisheries is the value of sector output efficiency which reaches 62.71%. This value is much higher than the average value of the same variable in all other sectors (39.66%). Even so, the value of the contribution of the *K. pelamis* fisheries sub-sector to the economic growth of Jayapura City is still low. In 2017 the contribution of the *K. pelamis* fisheries sub-sector only reached 1.94% of the total contribution of the capture fisheries sector and increased to 2.05% in 2018 (Jayapura City BPS 2019). The low contribution of the *K. pelamis* fisheries sub-sector also occurs in other parts of Indonesia, such as in Sibolga Regency with 2.48% (Lumbantobing et al 2016) and Gunung Kidul Regency by 1.01% (Adinugroho 2016). This shows that the utilization of the *K. pelamis* fisheries sub-sector has not been optimal in contributing to regional economic growth, but is expected to potentially become a leading sector in the City of Jayapura.

Many local people in Jayapura City consume *K. pelamis* as one of the main food sources. The average per capita consumption level of *K. pelamis* fish in Jayapura City reached 18.00 kg/capita/year in 2016, experiencing an increase in 2017 to 19.26 kg/capita/year (DKP Jayapura City 2018). The increase in food consumption needs of *K. pelamis* fish has resulted in faster fishing rates. The consumption level is still lower than in Manado City which reached 29.08 kg/capita/year (John et al 2014) and the average consumption in Indonesian urban areas is 23.80 kg/capita/year (Ariani et al 2018). This shows that the level of consumption of *K. pelamis* in various regions in Indonesia has increased every year.

Efforts to support increased consumption through increased production, the fishermen in Jayapura City developed FADs which can increase the number of fish caught by local fishermen. The bad impact due to the use of FADs has caused a decline in *K. pelamis* stocks. Until now there have been no studies that prove the use of FADs has resulted in a decrease in the stock of *K. pelamis* in the City of Jayapura, only the results of Sala (2017), which study stated that the use of FADs has an impact on the decline in *K. pelamis* in Fakfak and Sorong Regencies. This fact is also reinforced by several studies that examine the relationship between FAD use and decreasing stock of *K. pelamis* in various other regions (Mallawa et al 2017, 2018; Asruddin 2018; Bromhead et al 2003; Dempters & Taquet 2004).

There are indications of a decline in *K. pelamis* stocks, but the potential for *K. pelamis* fisheries has not been maximally utilized to support the supply of goods and services in the economy. Therefore the analysis is needed that can take a comprehensive picture of information about goods and services that occur between economic sectors, and show the allocation of output produced by a sector and the input structure used by each sector.

The I-O analysis used in this study refers to I-O developed by Leontief (1986). Similar research has been carried out in Indonesia by Dault et al (2009), Juanti et al (2014), Huda et al (2015), Panggabean (2016), Nurhadi & Sumarsono (2017). This method has also been used in international research (Leung & Pooley 2001; Jin et al 2003; Hoagland et al 2005; Bhat & Bhatta 2006; Seung & Waters 2006; Roy et al 2009; Dyck & Sumaila 2010).

The I-O analysis approach in this study was used to analyze the economic structure and the relation of *K. pelamis* sector fisheries with other sectors in the economy of Jayapura City, Papua. The discussion of structural strength and interaction between *K. pelamis* sector and other sectors in Jayapura City is very important to do in order to realize *K. pelamis* fisheries sector into a leading sector and produce a multiplier effect on the regional economy. The purpose of this study is to perform an economic structure analysis of *K. pelamis* fisheries industry in Jayapura City, Papua, Indonesia.

Material and Method. This research was conducted in Jayapura City in May-July 2017. The data used were secondary data in the form of the Papua Province I-O 2010 data which had been sent down to Jayapura City I-O and updated to 2016 using the RAS technique. The number of 84x84 sectors in Papua Province IO was aggregated into 8 sectors for Jayapura City I-O in 2016, which consisted of: *K. pelamis* fisheries sub-sector, other marine fisheries, other marine products, food and beverage industry, trade, transportation, hotels and restaurants, and other sectors. This study used a non-survey technique in the form of Simple Location Quotient (SLQ), the purpose of which is to show sectors that are superior or which provide the greatest contribution to the economy of Jayapura City.

This study will look at the structure and interaction between economic sectors that can produce a correlation coefficient. Interaction between sectors consists of: forward linkages, backwardness, dispersion power index, sensitivity degree index, type I & II income multipliers, type I & II labor multipliers which will be explained in depth below:

Direct-forward linkage analysis. The direct-forward linkage developed by Langham & Retzlaff (1982) was as follows:

$$Fi = \frac{\sum_{j=1}^{n} x_{ij}}{Xi} = \sum_{j=i}^{n} a_{ij}$$

Where:
Fi: Direct forward linkages
X_{ij}: The number of sectors-*i* outputs used by sectors-*j*
X_i: Total output of sector-*i*
a_{ij}: Element of the technical coefficient matrix

Direct-backward linkages. The direct-backward linkage formula developed by Langham & Retzlaff (1982) was as follows:

$$Bj = \frac{\sum_{i=1}^{n} x_{ij}}{Xj} = \sum_{i=i}^{n} a_{ij}$$

Where:
Bj: Direct backward linkages
X_{ij}: The number of sectors-*i* outputs used by sector-*j*
X_j: Total output of sector-*j*
a_{ij}: Element of the technical coefficient

Distribution coefficient. According to Bulmer & Wiley (1982), the mathematical formula of the coefficient of distribution is as follows:

$$Bd_j = \frac{n \sum_{i=1}^{n} C_{ij}}{\sum_{i=1}^{n} \sum_{j=1}^{n} C_{ij}}$$

Where:
B_{dj}: Distribution coefficient of the sector-*j*
C_{ij}: Leontief (1986) inverse matrix element

Spread sensitivity. The mathematical formula of the spread sensitivity by Bulmer & Wiley (1982) is as follows:

$$F_{di} = \frac{n \sum_{j=1}^{n} C_{ij}}{\sum_{i=1}^{n} \sum_{j=1}^{n} C_{ij}}$$

Where:
F_{di}: Spread sensitivity of the sector-*i*

Income Multiplier Type I. The mathematical formula of the income multiplier type I by Bulmer & Wiley (1982) is as follows:

$$MI_j = \frac{\sum_{i=1}^{n} a_{n+i,1}.C_{ij}}{a_{n+i,j}}$$

Where:
MI_j: Type I income multipliers of sector-*j*
C_{ij}: Leontief (1986) inverse matrix element = $(I - A)^{-1}$
$a_{n+i,j}$: Input coefficient of salary/household wage of sector-*j*.

Income Multiplier Type II. The mathematical formula of the income multiplier type II by Bulmer & Wiley (1982) is as follows:

$$MI.\ II = \frac{\sum_{i=1}^{n} a_{n+1,j}.D_{ij}}{a_{n+1,j}}$$

Where:
$a_{n+1,j}$: Salary/household wage of sector-*j*
Dij: Closed Leontief (1986) inverse matrix element = $(I\text{-}D)^{-1}$

Employment Multiplier Type I. The formula of the type I employment multiplier by Bulmer & Wiley (1982) is as follows:

$$ML.I_j = \frac{\sum_{i=1}^{n} W_{n+1,i}.C_{ij}}{W_{n+1,j}}$$

$$W_{n+1,i} = \frac{Li}{Xi}$$

Where:
MLI_j: Employment multiplier type I of sector-*j*
W: Line vector of the employment coefficient (person/unit of US$)
W: $(W_{n+1,1}, W_{n+1,2}, \dots \dots . W_{n+1,n})$
$W_{n+1,i}$: Employment coefficient of sector-*i* (person/unit of US$)
$W_{n+1,j}$: Employment coefficient of sector-*j* (person/unit of US$)
X_i: Total output (unit of US$)
L_i: Employment component of sector-*i*
C_{ij}: Leontief (1986) inverse matrix element

Employment Multiplier Type II. The type II income multipliers are used to calculate the direct and indirect influences. They are also used to determine the effect of induction. The formula, according to Bulmer & Wiley (1982), is as follows:

$$ML.II_j = \frac{\sum_{i=1}^{n} W_{n+1,i}.D_{ij}}{W_{n+1,j}}$$

Where:
W: Line vector of the employment coefficient (person/unit of US$)
W: $(W_{n+1}, W_{n+1,2}, \dots, W_{n+1,n})$
$W_{n+1,i}$: Employment coefficient of sector-*i* (person/unit of US$)
$W_{n+1,j}$: Employment coefficient of sector-*j* (person/unit of US$)
X_i: Total output (unit of US$)
D_{ij} :Closed Leontief's inverse matrix element = $(I\text{-}D)^{-1}$

Results and Discussion

The economic structure of Jayapura City. The economic structures concerned in this study were consisted of the demand and supply, primary input, and efficiency of output creation. Based on the structure of demand and supply in each sector within the regional economy of Jayapura city, the results showed that the *K. pelamis* and other marine fisheries sector were still less determined that other sectors: however, these were expected as a leading sector in the future. The overview of the economic structure of Jayapura City can be seen in Table 1.

Table 1

Structure of demand and supply according to activity sectors in Jayapura City (USD)

Sector	*Intermediate demand*	*Final demand*		*Provisions of inputs*		*Total demand/Supply*
		Domestic	*Export*	*Import*	*Domestic*	
Skipjack fisheries	14,833,549	35,590,436	10,546,099	46,876	50,423,910	60,970,100
Other marine fisheries	49,814,389	108,022,602	41,345,632	164,066	157,836,990	199,182,622
Other seafood	12,592,623	84,194,021	9,111,827	32,335	96,786,644	105,898,470
Food and beverage industry	22,880,341	248,676,863	21,208,773	223,651,482	271,557,203	292,765,976
Trading	43,435,709	351,206,654	268,593,222	-	394,642,363	663,235,585
Transport	123,840,873	231,358,728	64,591,697	139,630,722	355,199,600	419,791,298
Hotel and restaurant	1,437,958	276,615,098	-	214,492,524	278,053,056	278,053,056
Other sectors	630,965,771	2,107,562,414	211,360,573	894,286,722	2,738,528,185	2,949,888,758
Total	899,801,213	3,443,226,815	626,757,822	1,472,304,727	4,343,027,951	4,969,785,774

Source: Table I-O Papua 2010 processed in 2017.

Table 1 shows that the Jayapura City area is only able to provide *K. pelamis* fisheries sector production of 50,423,910 USD from all product supply, the total shortfall of 46,876 USD cannot be supplied by local production alone, so the supply shortage must be imported from outside of Jayapura City. Areas that supply *K. pelamis* include the Bitung, Ternate, Bau-Bau, Sorong and Ambon areas. This fact reveals that output from the *K. pelamis* fisheries sector is more likely to be used to meet direct consumption by the community, rather than being used as input in the production process by other sectors.

Analysis of the structure of the final demand for the *K. pelamis* fisheries sector shows that the level of utilization of *K. pelamis* in Jayapura City has not been optimal, and has not been able to produce a contribution to the formation of GDP properly. The highest value of utilization of *K. pelamis* was dominated by household consumption of 70.51%. The other final demand is for export activities of 29.84%. This means that the level of utilization of the *K. pelamis* fisheries sector is still dominated in the form of fresh fish and smoked fish. Other forms of utilization include canned fish, fish filets, fish meal, and various other forms that are not yet available in Jayapura City.

The limited utilization of the sub-sector of *K. pelamis* fisheries by other sectors in the economy has resulted in not maximized economic growth in Jayapura City. Therefore a strategy is needed right in order to maximize this role.

The sector producing the lowest primary input was the *K. pelamis* fisheries sector with 38,236,671 USD, while the total primary input reached 1,970,922,047 USD (Table 2). According to Panggabean (2016), the number of primary fisheries inputs in Sibolga City was 115,379,425 USD. Isaac & Jerry (2012) studied the primary input value of fisheries sector revenues which was 27 million USD with additional revenues of 23 million USD and 385 jobs in the economy of the United States (an increase by 25%). These results indicated that the fisheries sector could have a large multiplier effect on the regional economy and the community welfare.

Table 2

Primary input values according to economic activity sectors in Jayapura City

No.	*Sector*	*Value (USD)*	*Distribution (%)*
1	Skipjack fisheries	38,236,671	1.94
2	Other marine fisheries	100,907,688	5.12
3	Other seafood	80,521,032	4.09
4	Food and beverage industry	32,025,183	1.62
5	Trading	247,462,312	12.56
6	Transportation	133,377,298	6.77
7	Hotel and restaurant	42,893,993	2.18
8	Other sectors	1,295,497,910	65.73
	Total	1,970,922,086	100.00
	Average per sector	246,365,261	12.50

Source: Table I-O Papua 2010 was processed in 2017.

The efficiency of output creation. Efforts in reaching efficiency in the creation of output have always been the target of the activities in the *K. pelamis* fisheries sector. The efficiency of fishing businesses continues its increment to generate large profits. More complete information relations can be concluded from Table 3.

Table 3

Efficiency in creating output according to sector activities in Jayapura City

No.	*Sector*	*GVA (USD)*	*Output (USD)*	*Distribution (%)*
1	Skipjack fisheries	38,236,671	60,970,010	62.71
2	Other marine fisheries	100,907,688	199,182,622	50.66
3	Other seafood	80,521,032	105,898,470	76.04
4	Food and beverage industry	32,025,183	292,765,976	10.94
5	Trading	247,462,312	663,235,585	37.31
6	Transport	133,377,298	419,791,298	31.77
7	Hotel and restaurant	42,893,993	278,053,056	15.43
8	Other sectors	1,295,497,910	2,949,888,758	43.92
	Total	1,970,922,086	4,969,785,774	39.66

GVA - Gross value added. Source: Table I-O Papua 2010 processed in 2017.

Economic sectors having efficiency values with the highest efficiency category limits are other marine products 105,898,470 USD, followed by *K. pelamis* fisheries and other marine fisheries. Analysis of Cahyo et al (2014) showed that the total output of the capture fisheries sector in West Kalimantan was 83,344,970.10 USD. According to Oktavia et al (2016), the value of the output of the marine fisheries sector in East Java was 1,122,684,588.94 USD. Briggs et al (1982) found that the total output of the capture fisheries sector in the US was 100,000 USD. According to Dyck & Sumaila (2010), the world fisheries output value was 225-240 billion USD per year. The findings above showed that the capture fisheries sectors, especially *K. pelamis* fisheries, are very likely to could be managed into business and agro-industry, which are very efficient and competitive.

The efficiency of these sectors as one of the strategic values should be taken into consideration for interacting. Efforts to realize efficient business, namely by improving the availability of adequate fisheries infrastructure more adequately, the quality of human resources, the use of environmentally friendly and ecologically based fishing gear, adhere to fishing rules. Factors of return on business investment, interest rates, security should also be considered in Jayapura City and Papua Province as well as the sociopolitical aspects. These aspects are keys that must be considered in the face of interactions between economic sectors.

Descriptive analysis

Backward and forward linkages. The measurement used to determine the direct and indirect backward linkages of sectors in the economy was the spread power index. The results showed that the transport sector generated the highest direct and backward linkage values of 1.6231% and 1.5895% respectively, while the *K. pelamis* fisheries sector had forward and backward linkages values of 1.3779% and 1.3234%. Oktavia et al (2016) showed that the marine fisheries sub-sector had forward and backward linkage>1, meaning that the output of the transport sector widely used *K. pelamis* fisheries sector and other sectors as input in economic activities (Table 4).

The backward linkage value indicated that there was an increase in the final demand in the sectors of transportation and *K. pelamis* fishery of 74.74 USD, while the final demand for other sectors remained constant. The economic output of each sector will increase by 118.80 USD and 98.91 USD respectively. This is due to an increase in the allocation of the transportation and *K. pelamis* fisheries sector to other sectors, which sector is more upstream (sector input). Output of this sector will become input for other sectors that are more downstream. According to Nurkholis et al (2016), the value of the backward linkage of capture fisheries in Indonesia amounted to 132.96 USD. Failler et al (2014) mentioned that the value of backward linkages influencing the non-fisheries sector was greater than those of forwarding linkages in fishing processing and trading. This value meant that other sectors such as transportation and other marine fisheries can cause an increase in the value of output from other economic sectors in various regions which will be more significant compared to other sectors.

The sectors producing the highest spread (IDP) were other marine fisheries, food and beverage industry, trade, transportation and hotels, and restaurants, each of which having values above one. Meanwhile, the *K. pelamis* sub-sector had a value of 0.9123. According to Tajerin et al (2010), Syarief et al (2014), Huda et al (2014) the IDP values of the fisheries sector in Indonesia, Indramayu Regency, and East Java amounted to 0.88, 0.90 and 0.63. These results meant that sectors outside the *K. pelamis* sub-sector were able to increase the growth of the upstream industry (for example, the fishing and purse seine industries).

The highest IDK values were observed in the other sectors, transportation, and other marine fisheries sectors having the ability to encourage the production growth of other sectors. Also, the use of the output of these sectors was very large. The skipjack fishery sector was only 0.9499. According to Arifin & Suryawati (2013) corroborates the results of the above analysis, namely the IDK value of the fisheries sector in Gorontalo Province amounted 0.8249, while the different conditions found in Trenggalek Regency generated 1.028 IDK value (Nurhadi & Sumarsono 2017). This means that the ability of the fisheries sector including the *K. pelamis* fisheries sub-sector to encourage production growth in other sectors is still low.

The highest and potential sectors in driving the growth of the downstream and upstream sectors or with IDK and IDP>1 were called the leading sector. The leading sectors were other marine fisheries and transportation sectors, while non-superior sectors were the *K. pelamis* fishery sector, other marines products, the food and beverage industry, trade, transportation and hotels, and restaurants. Similar conditions also occurred in Indramayu Regency where the transportation sector, the private sector, and the non-oil gas industry were the leading sectors, while the fisheries, restaurants, and trade sectors are not superior (Syarief et al 2014).

Table 4

Direct linkages to the front, backward, deployment power index (IDP), sensitivity degree index (IDK), income multipliers type I & II, labor multiplier type I & II

Multiplier	*Indicator*	*Skipjack fisheries*	*Other marine fisheries*	*Other seafood*	*Food and beverage industry*	*Trading*	*Transport*	*Hotel and restaurant*	*Other sectors*
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Forward and Backward Linkages	BLE	1.3234	1.5558	1.2171	1.4727	1.5518	1.5895	1.4650	1.4298
	FLE	1.3779	1.4684	1.1480	1.0653	1.1598	1.6231	1.0035	2.7592
	IDP	0.9123	1.0725	0.8390	1.0152	1.0697	1.0957	1.0099	0.9857
	IDK	0.9499	1.0123	0.7914	0.7343	0.7995	1.1189	0.6918	1.9021
Criteria		Not superior	Superior	Not superior	Not superior	Not superior	Superior	Not superior	Not superior
Multiplier Income	Total	0.7663	0.7289	0.4851	0.4347	0.3084	0.4078	0.3025	0.4181
	Type I	1.3005	1.5054	1.1878	1.5729	1.9714	1.6207	1.8804	1.4165
	Type II	3.2729	3.4100	2.4511	2.5786	2.3364	2.6270	2.2345	2.4933
Labor Multiplier	Total	0.0086	0.0054	0.0086	0.0040	0.0031	0.0031	0.0040	0.0043
	Type I	1.2972	1.5264	1.1647	1.7113	1.8751	1.7238	1.5629	1.4070
	Type II	2.1862	3.1142	1.6733	3.1674	3.3137	3.4813	2.4718	2.4760

Source: Table I-O Papua 2010 processed in 2017.

The *K. pelamis* fisheries sub-sector also produced a multiplier effect on the economy including income multipliers and labor multipliers. The highest type I income multiplier values were in the *K. pelamis* trade and fisheries sectors 1.9714 and 1.3005, respectively meaning that if there was an increase in the final demand of 74.74 USD, then the income in all economic sectors would increase by 147.34 USD and 97.20 USD. According to Juanti et al (2014), the value of type I income multiplier in the fisheries sector in Sidoarjo Regency was 0.18. The difference explained that the capture fisheries sub-sector (*K. pelamis*) in Jayapura City significantly contributed to the increase in people's income compared to Sidoarjo Regency.

The highest type II multiplier value was in the other marine fisheries sector with 3.4100, meaning that if there was an increase in household consumption working in other marine fisheries sectors 74.74 USD, the income in all economic sectors would increase by 254.86 USD. Juanti et al (2014) and Panggabean (2016) demonstrated that the value of income multipliers in the capture fisheries sector in Sidoarjo Regency and Sibolga City reached 0.74 and 1.08 respectively. The two studies explained that the capture fisheries sector (*K. pelamis* fisheries) can generate income for fishing communities.

The impact of the multiplication of other *K. pelamis* fisheries sub-sectors was in the form of employment. The number of types I labor multipliers in the *K. pelamis* fisheries sector was 1.2972. According to Arifin & Kepel (2014), labor multiplier in the fisheries sector in Gorontalo amounted 1.1401. Meaning that the *K. pelamis* fishery sector was not reliable enough to generate employment for the community. The type II multiplier of the transportation and *K. pelamis* fisheries sector were 3.4813 and 2.1862 respectively. According to Huda et al (2014), labor multipliers in East Java amounted to 4.0087. Sapanly et al (2018) showed that the multiplication of employment opportunities in the fisheries sector in Indonesia caused an increase in employment opportunities by an average of 0.1451. According to Lee & Yoo (2014), the aquaculture sector produced more labor multipliers than capture fisheries in Korea. The difference between the above studies was caused by the level of economic progress in each region.

Conclusions. The I-O analysis showed that the structure and interaction of the *K. pelamis* fisheries sub-sector were still weak, but it had a high economic growth. The weak structure and interaction of the *K. pelamis* fisheries sub-sector were also indicated by the small values of IDP and IDK (>1). Factually, these results showed that the value of its contribution to the economic growth of Jayapura City was still low with the backward linkage value of 92.83 USD and forward linkage of 96.41 USD, and a level of income multiplier of 97.20 USD. Those proved that the sector was able to absorb labor.

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