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The Application of Supply Chain Risk Management Assessment in Small-scale Fisheries in Bangka Belitung, Indonesia Using Probabilistic Risk Analysis (PRA) Method

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Abstract
Indonesia's small-scale fisheries contributed as the second large fishing country which create an economy of scale throughout the food security. However, fish capturing from the indigenous livelihood weighed an inefficiency on the production volume due to limited resources and knowledge. The research aims to benefit by applying supply chain risk management on fishery products in Bangka Belitung, Indonesia across its regencies with product-hub placement. The objective is to identify the local risk distributions and most vital causes to cumulative losses for specific fish commodities. The research would specify the least to most common risk occurred. The research is a triangulation method consisting of probabilistic risk analysis, interviews, and direct observations. The result showed there is a significant level of risk outspread around each municipality in Bangka Belitung, showing from the capture, sampling, and fishery businesses production data. The lead time in days and price per unit became the two main factors as it validates the risk occurrence. The government strategy was limited on the high number of volume and potentials, a case would be shrimps. Indeed, there is an indication that high risks are occurring in most small lead time fishery businesses across Bangka Belitung with mackerel fish as the main spoilage, followed by crab, and yellow-tail scads. The findings showed there is an average of 35,00% risk inside 30,36% fishery businesses in Bangka Belitung and the risk impact per business capture ranged between 0,33 to 0,77 probability. The total risk for price reached 94.78% of the total fish commodities.

Keywords—Probabilistic Risk Analysis; Product-Hub; Risk Management; Small-Scale Fisheries; Supply Chain

Abstrak
Perikanan skala kecil di Indonesia berkontribusi sebagai negara perikanan terbesar kedua yang menciptakan skala ekonomi dalam ketahanan pangan. Namun, penangkapan ikan dari mata pencaharian masyarakat adat menyebabkan inefisiensi volume produksi karena terbatasnya sumber daya dan pengetahuan. Penelitian ini bertujuan untuk mendapatkan manfaat dengan menerapkan manajemen risiko rantai pasok pada produk perikanan di Bangka Belitung, Indonesia di seluruh kabupaten dengan penempatan product-hub. Tujuannya adalah untuk mengidentifikasi sebaran risiko lokal dan penyebab utama kerugian kumulatif pada komoditas ikan tertentu. Penelitian ini akan menentukan risiko yang paling sedikit hingga paling umum terjadi. Penelitian ini merupakan metode triangulasi yang terdiri dari analisis risiko probabilistik, wawancara, dan observasi langsung. Hasil penelitian menunjukkan terdapat tingkat penyebaran risiko yang signifikan di setiap kotamadya di Bangka Belitung, yang terlihat dari data produksi usaha penangkapan, pengambilan sampel, dan produksi perikanan. Lead time dalam hari dan harga per unit menjadi dua faktor utama yang memvalidasi terjadinya risiko. Strategi pemerintah terbatas pada tingginya jumlah volume dan potensi, salah satu contohnya adalah udang. Memang benar, terdapat indikasi bahwa risiko tinggi terjadi di sebagian besar usaha perikanan skala kecil di Bangka Belitung dengan ikan makarel sebagai pembusukan utama, diikuti oleh kepiting, dan ikan ekor kuning. Temuan menunjukkan rata-rata terdapat 35,00% risiko pada 30,36% usaha perikanan di Bangka Belitung dan dampak

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risiko per usaha penangkapan berkisar antara 0,33 hingga 0,77 probabilitas. Total risiko terhadap harga mencapai 94,78% dari total komoditas ikan.

Kata kunci—Analisis Risiko Probabilistik; Pusat Produk; Manajemen Risiko; Perikanan Skala Kecil; Rantai Pasokan

I. INTRODUCTION

Indonesia is the second largest fishing country after China, with around 21 million metric tons in total fisheries product (World Bank, 2021). Fish and seafood has conjugated more than 52% for national demand, 16% above the global average. Despite the good deeds for production, the fishery lasts for short-term growth assurance. Indonesia has been ranked 10th for exporting fish worth 4.8 billion USD or only 3% of the global market (FAO, Duke University and WorldFish, 2022).

The fisheries management in Indonesia is widely positive in potential, but not utilized clearly due to development constraints and thorough rigid process. The positives arose from its marine economy potentials across Indonesia's archipelago region. In Indonesia, more than 90% of the fishers are categorized as small-scale fisheries (SSF). The SSF is characterized by low technological advancement, labor-intensive fishing practices, and relatively low capital funds (Sowman, 2006). Consequently, the data inputs for maintaining the fisheries sustenance are inconstant. The data reliability and data variability are also underperformed which creates a large gap between the actual status and its fishing performance for risk management.

SSFs generate economic value for coastal areas (Sari et al., 2021) and generally, it plays a significant part in livelihood food security and poverty reduction (Sowman, 2006; Food and Agriculture Organization of the United Nations, 2010). Therefore, the fisheries in Indonesia have a mutual relationship on behaving through its local fishing manner in terms of catchment and production.

The Indonesian government attributes success is also to promote economic development and food security in the livelihoods. However, a research study has found that the current government program for SSF is actually threatening the fisheries' lifecycle in the data visibility of overfishing and unsustainable production trends (Warren and Steenbergen, 2021; Jaya et al., 2022).

The preliminary direct research has been conducted through interviews from School of Business and Management, Institut Teknologi Bandung in June 2022, highlighting the Bangka Belitung Marine and Fisheries Department tend to generalize the solution for the SSF challenges and it creates a displaced strategy (Ardiatika et al., 2022). SSF must first define the rules of conduct, marine protected areas, and other local area management to pursue local compliance and ownership (Jaya et al., 2022). A statement also strengthened the trade-offs between fisheries management and costs were statistically significant to the risk (Dowling et al., 2013).

The framework for supply chain risk management assessment helps the drivers for proper fundamentals. It also made an effective fisheries management plan to strengthen the environmental ecosystem through socio-demographic and socio-economic equity (Stacey et al., 2021; Jaya et al., 2022).

The small-scale fisheries' successes are determined by long-term project through value chain analysis including stricter regulation of catch limits, monitoring schemes, post-harvest facilities, seasonal closures, social enterprises support, investment fund facilities, and marine protection (Stacey et al., 2021). Therefore, the objective of applying the supply chain risk management framework is to create a *product-hub* as a central point for lead time optimization and price stability qualify fisheries successes on longer-term approach with minimum exploitations (Stacey et al., 2021).

II. LITERATURE REVIEW

The Indonesian fisheries supply chain is divided into two models: aquaculture fish and sea catchment supply chains (Guritno and Tanuputri, 2017). Small-scale fishing in Bangka Belitung is dependent on sea catchment. *Tier* 1 is the primary role in the process for pre-fishing and post-fishing activities. In practice, indirect engagement of fishermen has occurred several times, affective socio-economic disparity toward.

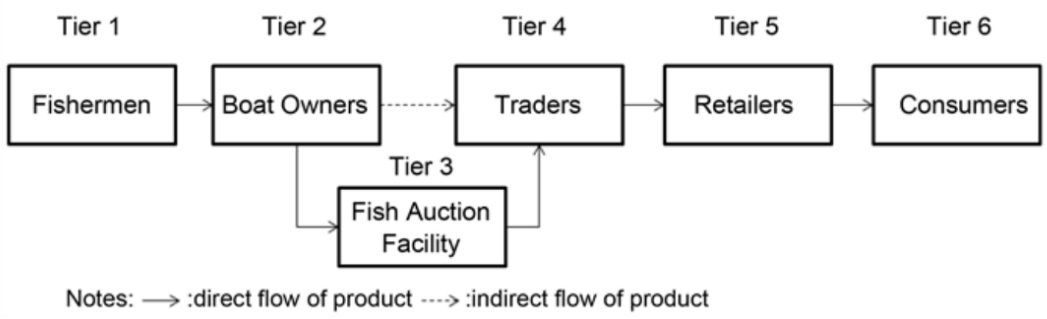

Fig. 1. Indonesia Fisheries Supply Chain (Source: Guritno and Tanuputri, 2017)

A low education leads to prior experience than to integrate knowledge for a longer term. The majority of small-scale fisheries were still limited towards technology, and it is more into basic fishing tools (Jiddawi and Öhman, 2002). It is handled manually in poor environments, resulting in fish spoilage and fish oversupply.

On financial side, the knowledge of having formal training is not an extent for access to financial aid (Purcell et al., 2018; Yanfika et al., 2019; Abiodun, 2021). Lack of formal training or assistance from the government also led to decline in developing countries for SSF. It resulted in low technological advancement and preferring traditional fishing techniques to catching, processing, and storing (Mramba and Mkude, 2022).

Onto the production processes, shortened lead-time indicates a positive relation between demand and risk reduction (Vendemia, Patuwo, and Hung, 1995). According to a French operation consulting firm, Picomto (2023), cycle time or lead time is indicated with the number of units produced with time available.

Probabilistic Risk Analysis referred here, an operation scenario refers to not considering all events rather than simply the most important ones (Kumamoto and Henley, 1996). Probabilistic risk analysis (PRA) emphasizes the complexity to identify disruptions and analyze likelihood and impact on the system performance in tandem with risk management elements. The risk assessment is numerical calculation measured within the production scale which becomes data-set dependent for constraints and insights. The PRA consists of two visualizations, the cumulative distribution function (CDF) and probability density function (PDF).

Starting from 1970s, PRA was used in high occurrence and high consequences like the healthcare industry (Paté-Cornell et al., 1997; Wreathall, 2004). Fisheries in Indonesia are characterized as high occurrence and high impact, as evidenced by its marine potential which accounts for the country's second biggest fish-producer after China (Baron and Statista Research Department, 2021).

The PRA are considered to be *cumulative and exhaustive*, meaning that *N* scenarios impact the overall risk contributions of the total sample $\{Si\}N\ i=1$. It signifies that the situation can occur at any moment but is restricted to only one at a time. This templated to pdf, probability distribution function, $P(S = Si)$ indicates the probability that corresponds to *Si* whereas *S* represents random probability. For each possibility *Si*, the estimation of the value *V* will be less than the total outcome. For instance, $P(V \leq v \mid S = Si)$. Therefore, to calculate the sample using cumulative distribution function (cdf) of *V* is:

$$P(V \leq v) = \sum_{i=1}^{N} P(S = s_i) \times P(V \leq v | S = s_i).$$

Fig. 2. Cumulative Distribution Function Theoretical Formula (Source: Paté-Cornell, 1997)

The overall objective of PRA is to acknowledge the risk by number so that the value can be seen for trade-off actions. Equation on Fig. 2 relies on no assumption rather to actualize the data. In short, the concept is also connected to the probability distribution function (PDF) where V is equal to 1 until 0 to represent the working state of the system to see the likelihood. The calculation is similar, what differs is CDF is linear cumulative to 100% and probability holds around the mean, making the midpoint as the most occurred. Therefore, it represents

a generalization of the reliability probability theory that relies on the cdf of V. The closer to 1, the more likely to happen.

The technical side is on the Supply Chain Risk Assessment (SCRA) framework. It iss intended to help key players make management decisions by understanding the risk drivers in the supply chain. The framework is evaluated through a variety of analytical techniques that result in output. It consists of **four steps**: Define the Supply Chain and Performance Value, Identifying the Risk, Risk Quantification, and Risk Management (Deleris and Erhun, 2011).

According to Dr. Mursyid Hasan Basri from School of Business and Management, Institut Teknologi Bandung, *"The product-hub concept is simply a form of place to gather all products or waste in centralized storing. It is a platform to shorten the supply chain process and making it efficient and effective through waste consideration from production."* Since this is a new form of concept, product-hub is a place to gather all related to product management state from the entry level until the end processes (Hardy, 2021). It consists of four aspects:

1. Competitive-products mapping
2. Product development
3. Product-hub storing
4. Customized market

III. RESEARCH METHODOLOGY

The methodology of this research will be a triangulation method, combining quantitative assessment as the initial state and proceeding with qualitative exploratory measure for risk mitigation output. The mixed method term aimed to escalate research comprehensively from a multiple reference standpoint to discover the undefined. (Ajemba and Arene, 2022). A strong statement highlighted that triangulation is a form to increase the trust and accuracy for research validation hindering from subjectivity and biases (Cohen et al., 2017). The manner of exploratory is used to scrutinize a subject in particular characteristics to develop new ideas from the analysis or provide latest recommendations within the specific area (Swedberg, 2020). The researcher limits the research to lean on methodological triangulation where it is objected to have the same target, by using two or more than numerical data measures to validate the phenomenon to be precise. Furthermore, the data generated from desk study, interviews with stakeholders, physical observation with Bangka Belitung SSFs is cohesively attached by data conversion, minimizing its generalizability, but to increase the variations. (Ajemba and Arene, 2022).

The researcher would like to mention that there will be no hypotheses for the calculation process as it does not account for finding the relationship between, though, to define the system and base its value. The whole research process of data collection and analysis will be rooted on the theoretical frameworks of Supply Chain Risk Assessment (SCRA) and Probabilistic Risk Analysis (PRA) as the supported flow for SCRA and continued with the qualitative on Product-hub system.

Firstly, the first step framework (Deleris and Erhun, 2011) will define its boundaries and parameters of the supply chain. It varies from the **production volume, commodities prices, revenues, and lead time.** The scope is to see the visibility of the trend to create connections between operational measures. Moreover, the performance value, *V*, can be multidimensional. The stock availability and price stability can be considered as the fundamentals for value. Following the matter, performance measures can be highlighted through **lead time, fish catches volume, and costs.** The model will advance to evaluations for the given output of the supply chain. In other words, the model is $P(V \leq v \mid S = Si)$, see Fig. 2.

The researcher begins the defining the supply chain and performance value by having a direct visit in June 2022 along with lecturers. The direct observation lasts for 7 days, and it was guided by Bangka Belitung Marine and Fishery Department representative. The quantitative data is obtained from a Memorandum of Agreement (MoA), and it was partially received in a form of raw actual data of all fisheries production in Bangka Belitung from 2017-2020.

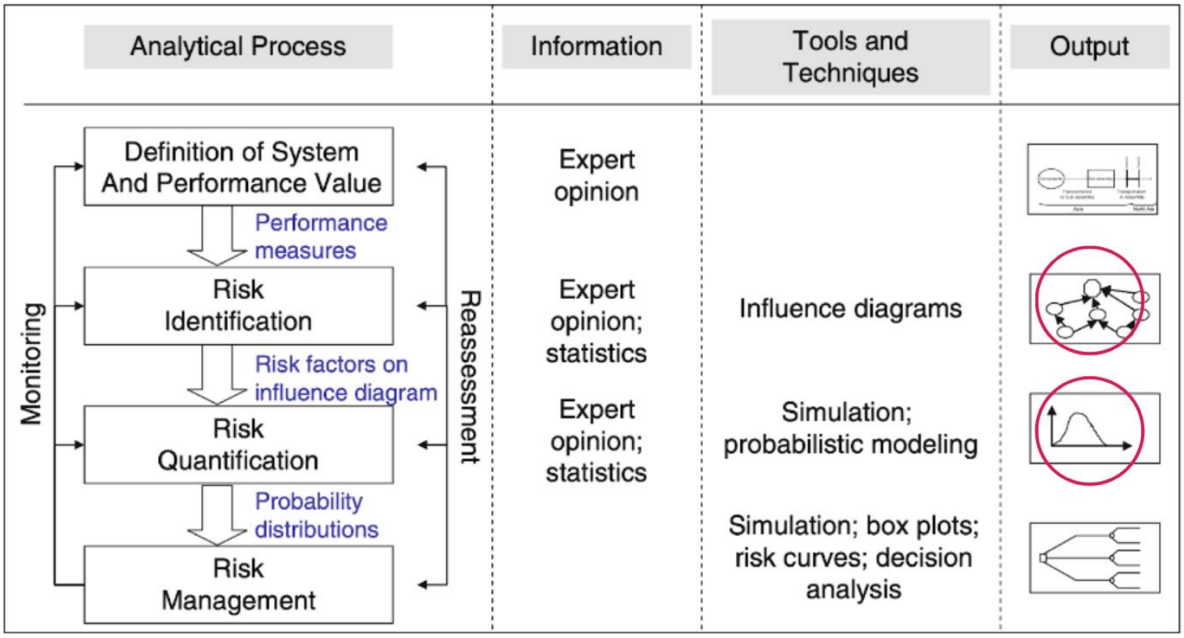

Fig. 3. Supply Chain Risk Assessment Flowchart and Proposed Framework (Source: Deleris and Erhun, 2011)

The initial supply chain is formed through direct observations, it follows the supply until the end-process. In this research, it will be focused on fishery related from supply to produce section. A variable that will be used accordingly is production value in kg/month, number of workers, number of working days, and price per kg in IDR. The thorough calculation is to have a performance measure in lead time and cost. A variable that will be used accordingly is production value in kg/month, number of workers, number of working days, and price per kg in IDR.

Therefore, it defines lead time by denoting:

- ***VL1*** = ***Production Value/Number of Working Days***
  = Daily Capacity to Produce in kg

(Source: Sarkar, 2016)

- ***(VL1 / 1) / Number of Workers*** *or (Daily Capacity/1) / Number of Workers*
  = Lead Time in Days to Produce

(Source: Indeed Editorial Team, 2023)

For the total cost per unit is relied on given data from the government on price/kg

- ***VC*** = *Price per unit in kg on the commodities*

(Source: Bangka Belitung National Statistics, 2022)

As for the second step, the framework (Deleris and Erhun, 2011) is meant to identify the probable risk events that may disrupt the supply chain. The events will be inputted through the estimation of probability distributions to support the scenarios, i., P($S = Si$), see Fig. 2. The list of risk events are qualitative measures upon the characteristics of the research location.

The risk factor is connected into two subcomponents: production and cost. An external analysis, PESTEL (Political, Economic, Social, Technological, Environment, and Legal) will be used for the initial list of events that occurred in Bangka Belitung fisheries. The implementation is in interview with 12 stakeholders in Bangka Belitung, consisting of fishermen, fish processors, SMEs, middlemen collector, local trade and industry

department, local marine and fisheries department, local one-door investment department, and the local heads respectively. The process of conducting the interview is acknowledged and helped by the government with the MoA as their responsibility to help the researcher. There are 60 questions created by the researcher, but due to effectiveness, it is clustered according to the characteristics and location of each respondents' profile. The list of question and profile is stated below.

Table 1. Respondents' Profile.

No	Profile	Name and Business Location
1	Fishery Processors	Mrs. Puan (Kricu Batu Belubang) Location: Central Bangka
2	Marine and Fishery Department	Mrs. Suti Location: Bangka Belitung (7 municipalities)
3	SMEs Seafood Snack Processors	Owner of Bahek Ewaki Location: Central Bangka
4	Head of Marine and Fishery Department	- Location: Pangkalpinang
5	Head of One Door Investment Department	- Location: Pangkalpinang
6	One Door Investment and Department	Respective Staffs Location: Pangkalpinang
7	Fishery SMEs in Bangka	Mrs. Yuni Location: West Bangka
8	Middleman for fishers in Bangka	- Location: West Bangka
9	Fishery SMEs in Central Bangka	Owner of Sehati Location: Central Bangka
10	Industry, Trade, and Retail Department	Co-head Location: Pangkalpinang
11	Indigenous Head Fishermen	Mr. Bachtiar Location: Central Bangka
12	Indigenous Fishermen	Mr. Bachtiar friends Location: Central Bangka

Source: Ardiatika et al., 2022

Table 2. Clustered Interview Questions.

No	Questions
1	What is the most affecting factor when it comes to the fishery production process?
2	What do you feel about the current situation going on now?
3	What other fishing activities are in Central Bangka?
4	What are the competitive advantages or added values does Central Bangka have?
5	What is the most decline or problem you face now?
6	What are your future thoughts or recommendations in sustaining the fishery production?
7	What do you think about the cold storage condition in Bangka Belitung?
8	Is there any specific requirement for fishery business to have?
9	What is the overview you can highlight on small-scale fisheries?
10	What do the government offer to the fishery people?
11	In summary, what challenges or opportunities in the department perspective?
12	What fish did you use to process?
13	How is the raw material condition used for production?
14	Which part of the fish you don't use for production? Or which waste is it?
15	As a fishery business, what challenges, regulation criteria, and findings you can give to Bangka Belitung department?
16	What do you think about the commodities advantage or region advantage?
17	What investment do you know related to marine and fisheries capture in Bangka Belitung?
18	What action would you do in order to increase the investment in Bangka Belitung?

19	What do you think about a concept of sharing for storing waste and related inventory measures for Bangka Belitung fishery?
20	How is the production and financial lending going on in fishery SMEs?
21	How is the coordination between other fishery SMEs players?
22	What differs you from the other players in the fishery sector in Bangka Belitung?
23	What is the most challenging part of fisheries when it comes to production site?
24	How do fisherman manage its capture along with quality and quantity?
25	What would be the wants from the fishermen according with the help of external stakeholders?

Source: Ardiatika et al., 2022

The interview result will be depicted into two from, PESTEL and influence diagram. However, the use of an influence diagram will only illustrate the qualitative measures and focus on the risk management focus context after calculation. The questions were also translated into Bahasa Indonesia.

Risk quantification will be the third flow of methodology. This stage serves as a bridge between the preceding descriptive risk characteristics into the quantitative assessment. The purpose of the supply chain structures is to have expected value and loss through performance metrics with the estimation of Cumulative Distribution Function (CDF) of Fig. 2. (Deleris and Erhun, 2011).

The objective of using the theoretical framework mentioned previously is to identify the current value of each SSF's production across 7 whole municipalities in Bangka Belitung. However, the overall datasets are in null for most columns, matching the characteristics of SSFs to an extent of **data-limited** with a diffuse effort in stock assessment and survey (Samy-Kamal and Teixeira, 2023).

The available data for calculating lead time and cost per unit for the framework fulfillment is 4 out of 7 regencies after pivoting the raw government data from 6000 row to only 1272 samples: Belitung (a big island separation), East Belitung, West Bangka, and Central Bangka.

To illustrate with a case, the data in one municipality consist of production value in kg/month and number of workers, while the other consists of other variables, nulling and partial missing in monthly sales and investment value. Countably, one constitutes to condition A, one to B, and C and varies in cases. The researcher cannot proceed with pivoting the data table as it will diminish the whole sample in one municipality onto another. As a consequence, the goal and limitation of these mixed methods is to testify and propose the advanced development for the SSF's area in Bangka Belitung, Indonesia in general, but the researcher reversed the action from taking the specific data of fishery SMEs to identify the SSFs capability and future actions.

Therefore, to acknowledge the reasoning of components and data visibility, the researcher is taking the data from the fishery SMEs. The data is more concentrated as the official department regularly updates from each small business to accumulate and justify the overall volume and value in detail. In accordance with the actual condition from the direct research, SSFs in Bangka Belitung are also dual-positioned to the SMEs themselves, the business process continued with the family wife or big family.

An assumption is given that the researcher will use the same variable for municipality, it will be close to data validation and fulfill the actual condition happening throughout Bangka Belitung, consisting of production value in kg/month, number of workers and working days, and price per unit/kg.

To calculate the data analysis for CDF and PDF, mean and standard deviation from the X value is taken. In the data analysis, volume capture and money value are the X value respectively. Both are distributions; therefore it is needed for normal distribution cumulative for risk impact and exact one sample for likelihood.

For the detailed excel calculations,

1. Mean = AVERAGE(x:x)
2. Standard Deviation = STDEV.S(x:x)

**S stands for sample*

Afterwards, the CDF formula is stated below,

3. CDF = NORM.DIST(x;$X MEAN$;$STDEV.S$;TRUE)

**True indicates the cumulative linear relationship*

For PDF formula is stated below

4. PDF = NORM.DIST(x;$X MEAN$;$STDEV.S$;FALSE)

**False indicates for the skewed around the mean to see the most likely to happen, it objects the linear cumulative*

Afterwards, data visualization depicts that CDF is using histogram with pareto line, while PDF is with scatter plot. All these calculations are also applied to the specific calculation, where **lead time** and **cost per unit** are becoming the X variable.

To visualize, the summarized triangulation content is described below with table as follows:

Table 3. Triangulation Content Summary for Research.

Direct Interviews	**Quantitative Numerical Data**
1. 12 supply chain key players 2. 60 questions (clustered) to 25 3. Limited to current condition, challenges, potential related to production, storing, investment, pricing decisions, cold storage, and other related processes. It simplifies to supply, production, storage, transportation, and demand. As a result, there will be different clustered questions and the number of samples/questions might differ.	The raw data consists of: (partially) 1. Number of workers 2. Production value kg/month 3. Investment Value in IDR 4. Capital (partial) 5. Monthly Sales/Turnover (mostly null) 6. Net Profit (mostly null) 7. Production value/unit (null) 8. Production value/total (null) 9. Production kg/yearly (null) 10. Product price /kg in IDR (East Belitung)

Source: Ardiatika et al., 2022

Following up, after the data collection, the researcher along with the expert lecturers are willing to listen and help the needs of the fishermen and socialize the plan to create a product-hub system as risk planning and mitigation. The scope of the framework is to hinder overstocking, overproduction, loss efficiency, inventory management, waste disposal, and cost-related decisions factor to price fluctuation over supply and demand. The data analysis will be taken first as the initial base and risk configuration.

IV. RESULT/FINDING

4.1 Supply Chain Risk Assessment

4.1.1 Step 1 Defining the system value

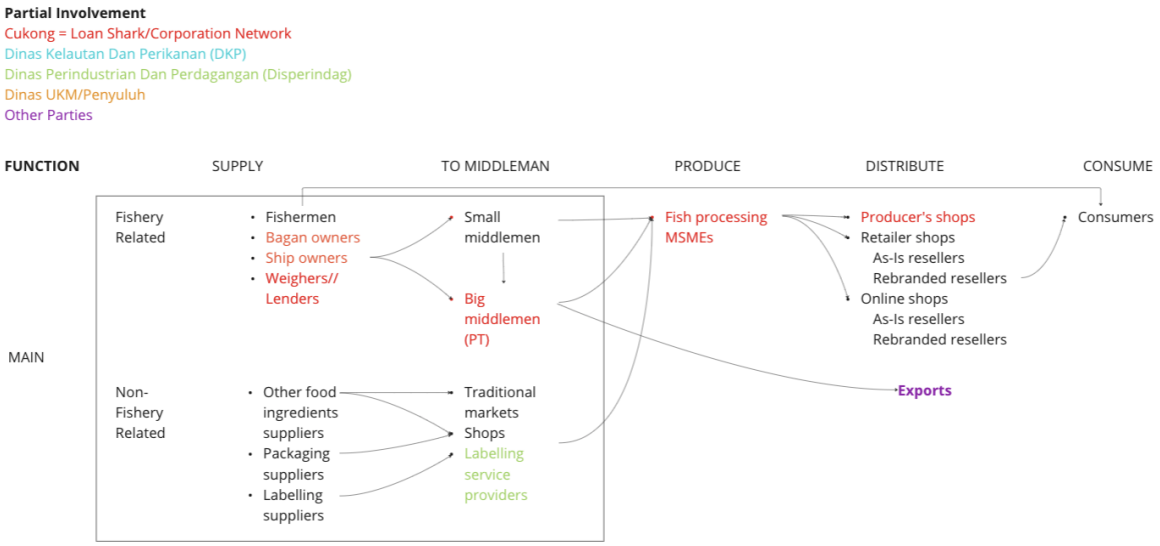

Fig. 4. Bangka Belitung Fishery Supply Chain, 2022 (Source: Ardiatika et al., 2022)

The initial supply chain is formed through direct observations, it follows the supply until the end-process. In this research, it will be focused on fishery related from supply to produce section. A variable that will be used accordingly is production value in kg/month, number of workers, number of working days, and price per kg in IDR.

4.1.2 Step 2 Identifying the risk and condition

To identify the risk, a PESTEL analysis will be used to list the events relevant to supply chain disruptions. The data is received from interviews among 12 stakeholders in Bangka Belitung. The keyword inputs are to an extent characteristics specification of Bangka Belitung.

Table 4. Bangka Belitung PESTEL External Analysis from Interviews.

Category	Examples
Operational/Technological	Quality disposal, overfishing, demand errors, supply errors, management discrepancies, inventory loss, waste disposal, indigenous advancement, partial fishing, high production price, capacity bottleneck, efficiency, delays in waste manufacturing, budget overrun, contractual terms
Social	Expat/Non Local Labor, loss guidance development, spreaded integration, missed coordination between stakeholders, individuality, human error, social coverage
Natural/Hazard	Constant rains, moon seasonal catch, hurricane, storm
Economy/Competition	Financial Lending, Paid distribution, market entry saturation, seasonal profit loss, gov target loss, market entry loss, illegal middleman, diversification, investor interests, product exchange fluctuation
Legal/Political	Manual book entry, data loss, illegal surveillance, strict SOPs, cold storage mininum lending, private lending wins, inspection delay, conflict of interest

Source: Ardiatika et al., 2022

From the interviews, operation and economical aspects remain to become the most determinants in risk distribution and will likely have an impact on the lead time and cost per unit results. The results can be quantified in the number of examples received above on the table. The examples are represents the occurences on Bangka Belitung fish management.

4.1.3 Step 3 Quantifying risk

To start with data validation to pass the criteria, it is managed from the Desk Study BPS Bangka Belitung 2022. The volume capture and money value are received to confirm whether the research is valid for the upcoming lead time and cost per unit calculation in the regencies.

The calculation is also in line with the choosing the priority and scenario in which it determines the most likelihood or impact to occur in a specific municipality. There are 7 municipalities in total, and it gives the value only on Volume (Ton) and Value (Indonesian Rupiah). It consists of total marine capture in 2022 and one specific sampling from the most available fish data, Eastern Little Tuna. The focus of these comparisons is to see how the general variation correlates and aligns with the specific commodity.

Table 5. Production Volume and Value of Fish Capture in Bangka Belitung 2020.

Production and Production Value of Fish Capture by Regency/Type of Captures, 2020
From: Desk Study BPS Babel 2022

	Marine Capture						
Regency	**Volume (Ton)**	**Value (Rp)**	**Mean for Vol**	**CDF for Vol**	**Mean for Val**	**CDF for Val**	**PDF for Capture**
Pangkal Pinang	1099	IDR39.388.755	32222,71429	0,04391	IDR983.129.451	0,025595	5,0967348E-06
West Bangka	19342	IDR1.216.696.082	**Stdev for Vol**	0,23995	**Stdev for Val**	0,685302	1,70485E-05
Central Bangka	27956	IDR1.102.577.435	18232,42294	0,40749	483997760,7	0,597466	2,12899E-05
Bangka	34945	IDR1.220.831.323		0,55935		0,68833	2,16384E-05
East Belitung	40329	IDR1.287.200.013		0,67170		0,735079	1,98217E-05
South Bangka	45129	IDR622.966.192		0,76049		0,228395	1,70316E-05
Belitung	56759	IDR1.392.246.355		0,91081		0,801025	8,84713E-06

	Eastern Little Tuna						
Regency	Volume (Ton)	Value (Rp)	**Mean for Vol**	**CDF for Vol**	**Mean for Val**	**CDF for Val**	**PDF for Capture**
Pangkal Pinang	18	IDR535.320	756,1428571	0,21937	14615709,00000	0,224491	0,000310098
Central Bangka	31	IDR769.925	**Stdev for Vol**	0,22342	**Stdev for Val**	0,228288	0,00031336
Bangka	137	IDR2.926.289	953,2588716	0,25801	18597495,57668	0,264822	0,000338918
West Bangka	174	IDR5.221.890		0,27070		0,30674	0,000347309
East Belitung	879	IDR17.637.720		0,55127		0,564542	0,000415042
South Bangka	1572	IDR23.577.330		0,80396		0,685052	0,000290161
Belitung	2482	IDR51.641.489		0,96489		0,976754	8,1269E-05

Source: BPS Bangka Belitung 2022 and Author (for calculation)

Given the sample data, a calculation relied on PRA to quantify the base value on cumulative distribution function. It will generalize the risk probabilities and how it contributes to the likelihood in the current state. There are no assumptions rather to represent the system value and given loss.

Belitung, South Bangka, and East Belitung were initially chosen, without considering the data availability in fishery SMEs. The generated risk and impact reach from about 67,1% up to 91,08% for marine capture.

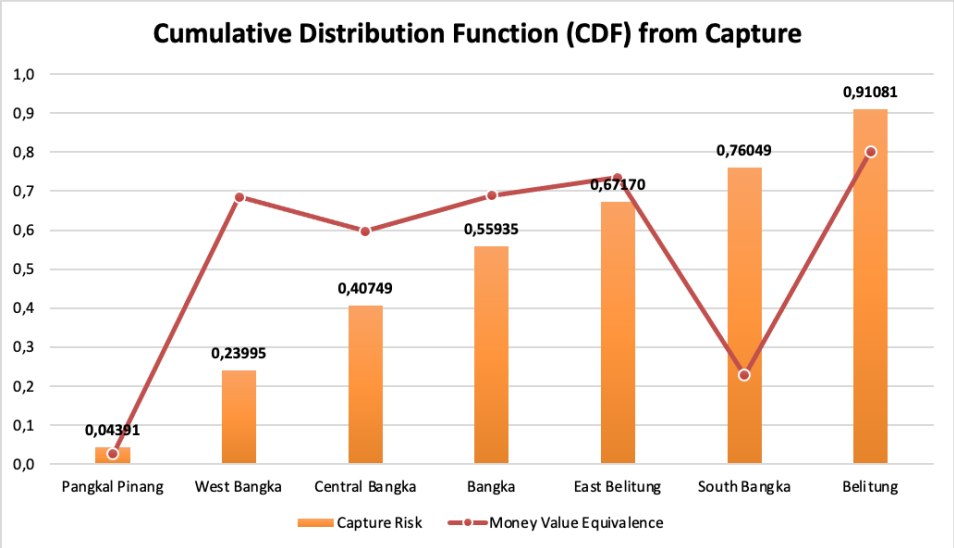

Fig. 5. CDF from Capture by Regency/Capture, 2020 (Source: Ardiatika et al., 2022)

Visualizing the data above, Belitung, South Bangka, and East Belitung are high in volume catch and its CDF. This indicates that risk would have much impact accumulated through all fishery business in Bangka Belitung according to the number of captures. The more it reaches to 1, there is a shock for diminishing return, overstocking, and overfishing. The researcher will demolish South Bangka as the data, as the variable has 0 data in fishery SMEs pivoted from the government data, meaning that the respective government didn't input the data comprehensively, and the money value equivalence correlates to the lowest compared to its catch. Further auditing and inputting data for evaluation is needed from the government (Ardiatika et al., 2022).

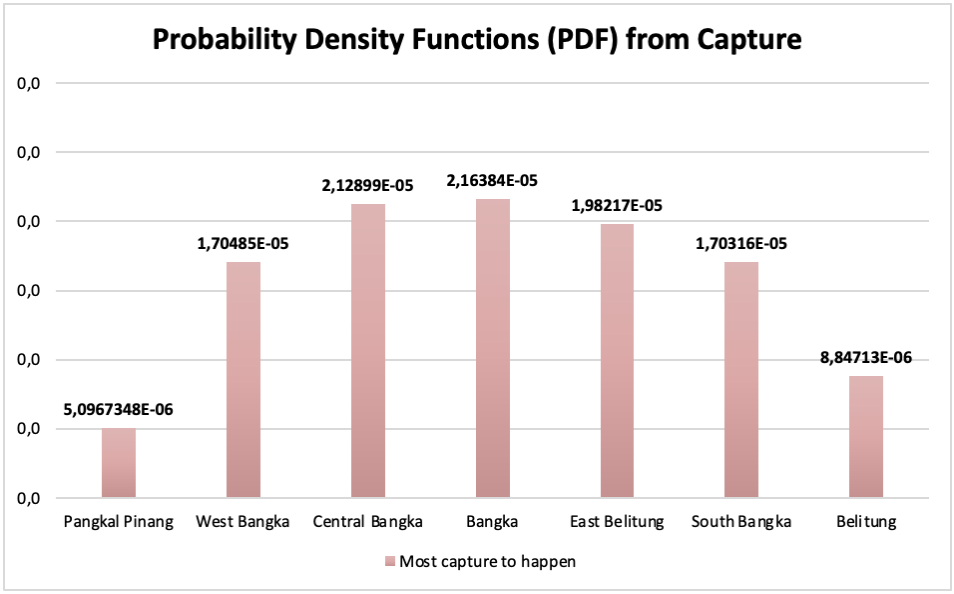

Fig. 6. PDF from Capture by Regency/Capture, 2020 (Source: Author)

By looking onto the capture occurrence risk above, the majority regencies experience risk mostly on Bangka, Central Bangka, and East Belitung. However, it does not mean that they have a higher risk contribution. The most contributing cumulative risk with sensitive and high impact are Belitung. It is categorized as the most catch volume with the high-risk measures happening.

As mentioned previously in the data collection availability, the fishery SMEs are data-limited and variables are partial for lead time and cost per unit calculation. The importance of scenarios will be given from these illustrations. There are 3 scenarios, the **most contributed risk,** the **most likely to happen in common**, and the **least-to-medium risk**. From measuring these, it can make a general decision and conclusions for Bangka Belitung. It is reported that now, Belitung, East Belitung, West Bangka, and Central Bangka are the chosen and most available ones. The exceptions came from Bangka, where it shows a null variable es for counting the lead time and cost per unit since it does not have the production value in kg/month and number of workers.

In quantification of risk, it will be accounted for by 4 calculations in 4 regencies for lead time and 1 calculation for cost per unit. A difference in sample size (n) might differ due to the data availability and pivot table results. The calculation will come from the least to most sensitive risks. The sample size in West Bangka n=524, Central Bangka n=263, East Belitung n=307, and Belitung n=178 samples.

Table 6. Summary Statistics for Bangka Belitung Distribution for Lead Time and Cost.

Bangka Belitung (Distribution Lead Time and Cost)					
Source: All Calculations from fishery SMEs Bangka Belitung					
	Minimum	**Median**	**Maximum**	**Mean**	**Std. Dev.**
Bangka Belitung in AVG	**0,15**	**2,89**	**244,43**	**8,77**	**25,09**
Belitung (n=178)	0,10	1,19	14,29	1,89	2,35
East Belitung (n=307)	0,35	6,06	880,95	24,53	85,54
West Bangka (n=524)	0,08	2,73	68,18	6,70	10,58
Central Bangka (n=263)	0,05	1,59	14,29	1,97	1,87
**Lead time distribution are relied on production value, number of workers, working hours/working days*					
Cost per unit (in IDR)					
East Belitung	11000	50000	3300000	98249	219870
**Represent that cost per unit are likely the same across Bangka Belitung municipalities*					
**The cost per unit is defined from the price per kg for the products. The data availability is in East Belitung*					

Source: Ardiatika et al., 2022

From the summary statistics, it is highlighted that municipalities vary in lead time. The likelihood of the impact occurring, East Belitung has skewed and uneven distribution for fishery businesses. It reflects the actual condition where East Belitung is where most fisheries have captured the sea catchment mostly after Belitung. However, the distribution is not depicted specifically onto the risk in lead time and cost since the number of samples in the maximum could present less than 5 samples, shown by all data analysis from CDF and PDF.

Talking onto the number of samples, it is hypothesized that the smaller tend to react better to the distribution for minimum to maximum. Sample from 150 to 250 in total would illustrate closer standard deviation to the mean. It means that the data is reliable enough for further calculation and equally represented through all variables as neatly as possible. However, the lesser number of samples or contradictory does not specify that one will fall for greater risk and vice-versa.

The cost in Bangka Belitung overall, presented a higher price for a kg of fish. These illustrate correlate between each other onto the same qualitative measures in Step 2. Furthermore, in the risk analysis by each municipality, it

is shown that the risk factor varies from each specific fishery business. Therefore, a summary of cumulative risk and samples taken are to illustrate deeper.

Table 7. Summary Statistics for Bangka Belitung Fisheries Risk.

Total Risk Sample	Generated Risk	Sample Taken	Range Risk Impact (CDF)	Lead Time	Commodities (Left-to-right by volume rankings)	Production & Workers	Prioritization Ranking
AVERAGE	**35,00%**	**30,36%**					
Belitung (n=178)	30,00%	24,15%	0,45 to 0,58	2 days	Mackarel fish, squids+eggs, shark fin, dried shrimp	1-10 workers (avg), production varies from 30-400kg monthly/fishery businesses	#2
East Belitung (n=307)	30,00%	30,29%	0,39 to 0,41	2 days & 4 days	**L2** Mackerel fish, crab, small shrimp, squid eggs, shark **L4** Mackerel fish, crab, birai (local fish)	**L2** 1-2 workers, for crab 7-12, production reach 100kg monthly /fishery business, for crab 450kg/crab fishery **L4** 1-2 workers, for crab 6, production reach 85-150kg monthly/fishery business, for crab 450kg monthly/crab fishery	#3
West Bangka (n=524)	20,00%	23,28%	0,33 to 0,34	2 days	Null, for qualitative, Mackarel fish and torpedo scad	1-2 workers, production varies from 50-150kg monthly/fishery businesses	#4
Central Bangka (n=263)	60,00%	43,72%	0,62 to 0,77	3 days & 2 days	**L3** Mullets fish, yellowtail scad **L2** Crab, some in mullets/yellowtail scad, mackerel fish	**L3** 5 workers, production monthly around 333kg/fishery business **L2** Around 2 woerks, production varies low to very high monthly/fishery business	#1
Cost Per Unit / kg	**11,3%**	*assumed is distributed equally for all by 45/4*					
East Belitung	45,00%	43,31%	*condition in East Belitung is the same as whole Bangka Belitung for pricing *Interviews*				
Total Risk Sample for Cost per Unit	**94,78%**						

Source: Ardiatika et al., 2022

In simple words, generated risks are made up of the % of fishery businesses within the municipality. Therefore, to reduce the risk cumulatively, it is necessary to focus and look for the right number of samples. The least sample with high generated risk, meaning it is better for government or other intervention to apply effective risk management, because with small effort and small-focused, it will make a strong trade-off for added-value or even competitive advantage (Ajemba and Arene, 2022).

On Bangka Belitung average, there is 35% generated risk from 30,36% sample production, indicating that in a vital few or one variable, there is 35% risk inside the 30% total fishery business in Bangka Belitung. If the government focuses on the 30% sample, it can reduce the overall 35% risk and the remaining trivial cumulative risk.

Central Bangka are chosen to become the first priority because of the lesser sample, but higher risk is accumulated. Belitung has come second for it. The cohesion also aligns with the range risk impact CDF per fishery business whereby in Central Bangka and Belitung they have a range approximately above 0,50 or 50%.

An interesting finding also indicates that 2 lead time days in Bangka Belitung accounts to be risky, meaning that small fishery businesses have become more volatile. Risky lead time tends to rely around the mean and to the median. The PDF rule does hold that in Bangka Belitung, the common to happen also contributes the most risk moderately. All municipalities are similar in the characteristics where impacts from CDF are occurring around the most common and moderate-to-high impact with moderate likelihood.

Different samples in the municipality portrays a positive sign for comparative approaches as the number of sizes did not object to the cumulative risk and sample taken. Where the smallest samples are not always accounted for having high generated risk with small numbers of samples and vice-versa. Both sizes, low or high, contribute evenly and rationally. In 3 and 4 lead time days, it is also happening in Bangka Belitung. The researcher would like to make a statement that the biggest lead time, even though the worker is 1-2, with high volume, does not

account for the risk contribution as it is categorized as trivial. The impact is indeed high, but there is only about 1 fishery business inside 1 municipality, so that it is not the priority to apply risk management there but to audit with strict regulations.

Moving onto specific detail, Central Bangka is indeed the least-to-common sample if taken from the general data capture and sampling. Reversely, it does contribute the highest risk among all municipalities. It can be a false movement if their government sees only the number of volume and money equivalence. If seen onto its production and workers, it proves that workers are relatively small, and production variable is inconsistently spreaded across businesses.

For Belitung, it shows consistency where high impact but it shows a low occurrence in CDF and PDF. It proves that from the previous capture risk of 0,91 it represents that risks are high with a small number of samples, n=178.

For East Belitung, it also shows alignment where it is categorized as high impact, but moderate low probability. Subsequently, it shows that from the capture risk, it depicts that moderate sampling can produce enough risk to be justified.

For West Bangka, it shows that the capture risks are least in overall, but risks are high in catch sampling. If it takes a small volume, the risk will become sensitive. This is due to limited data for commodities as the region showed a potential only on mackerel fish and torpedo scad fish. It is from the least to most common because fishermen are intended to focus only on those two main exploits. Still, it proves the impact value is genuinely small compared to other municipalities with a broad range of commodities, production capacity, and workers.

Overall, the summary statistics present a comprehensive picture from lowest scenario to the highest scenario. There will be findings of risk partially on the small businesses lead time with few workers. For the total risk sample cost per unit, cost was claimed to be full, the majority problem for all fisheries in Bangka Belitung for its price fluctuation. It varies from lower to higher prices, with more than 94,78% in the variation. It correlates, with production capacity, the trade-off for impact value is moderately high so that the risks generated are equal to the sample taken. For the commodities, it shows similarities across municipalities, contributing mackerel fish and crab, for instance, to always experience sensitivity.

4.1.4 Step 4 Risk Management Approach

In overall, risk management approaches help to place back onto the previous management decisions from the government. The alignment makes an effective way in terms of reducing all risk capture, increasing value-added for products and investors, as well as the price decrease.

Fishermen in Bangka Belitung from the interview, Mr. Bachtiar mentioned the trust issue on government intervention. Therefore, a question is addressed for this, how does it work and how can it add value?

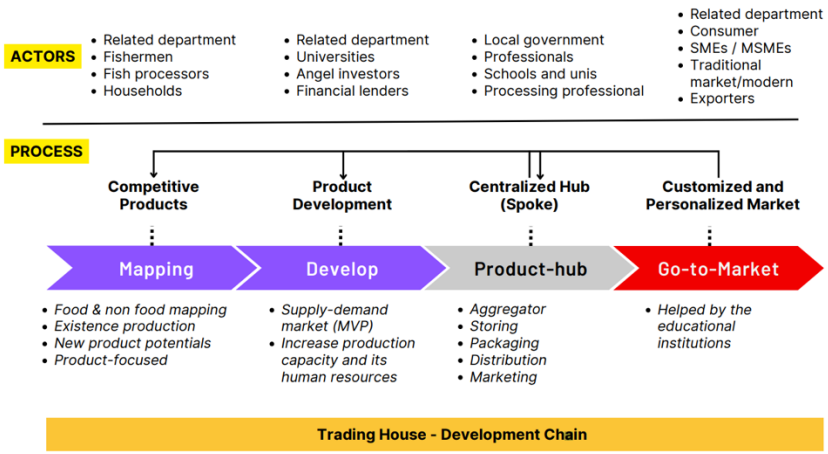

Fig. 7. Alternative Supply Chain Product-hub (Source: Ardiatika et al., 2022 and group observation)

Figure 7 shows that the addition of product hub will place a centralized point for fishery industry in Bangka Belitung. The current condition was strongly on aggregator, a bidding market where buyer can negotiate directly to the fisherman. With the presence of product hub, the fisherman will be able to store and rely on its selling without any price fluctuations, with neat design and value for customer. The product-hub actors started from schools and universities which can follow the trend for millennials and gen z to spread the words. While the local government can also consult the discussion by inviting stakeholders with private consortium, fishery-related experts, and also Gen Z college students with the help of education institutions to imply the creation of product hub as the main gateway for putting waste and production in one place. This enables the condition of cold storage to become fairly distributed as well.

The product-hub was placed between the manufacturing (processing) and consumer market. The reasoning behind this is due to the accessibility of price transparency and product supply availability according to the demand either for the fishermen and consumers. By having these in the middle, it will make a utilized production and price will not fluctuate. It is making all coordination as seen from key actors in every process. It will create a right strategy in the right focus commodities, in the right location, with the right market, and right knowledge. Though, further research after this topic might be needed for multiple observations and reliability.

V. DISCUSSION

The intervention should be focused onto municipalities that generated the most risk with few fishery businesses. For the current event, it is preferable to choose Central Bangka as the focus for piloting the product hub concept. It is known that in each municipality the risk differs, decisions must be applied according to each specific case. Some will rely on cost-effectiveness, but some will have to regulate the sample size as well.

For high lead time days in production because the workers account for 1-2, it is not applicable for risk management, but it has to be diminished as it collapses to the regulation of overfishing policies. The gentil alternative intervention can be the increase of workers. Apart from that, it is categorized as insignificant to the overall risk in 1 municipality. The fairest decision is to take off the business right away.

The risk management measure is applicable for small lead time days businesses as the production volume is still in the acceptable range, but workers are still trivial. Therefore, Bangka Belitung needs to also focus on the workforce with each business. For the fish types, mackerel fish should be on top of priority.

VI. CONCLUSION AND RECOMMENDATION

Reflecting on the results, it is clear from both quantitative and qualitative measures that there is a significant level of risk in relation to the SSFs in Bangka Belitung, shown from the general data of capture and sampling. Also, with the fishery specific SMEs production data across municipalities. The risk is spread equally across in the region, with lead time in days and price per unit in kg being the two main determinants for validating the risk and qualitative measure.

From the risk assessment, it can be implicated that Central Bangka even with the lowest volume catch experienced a high-risk scenario. This helped to develop a proper risk management placement before assuming putting management decisions on the most volume catch in terms of PDF and CDF. The focus of municipality placement, commodities, workers and production volume variation is inclusive to see the allocation for reducing the percentage of risk with percentage of businesses inside the regency. It can be seen throughout all factors in production as well for cost reduction. From the risk assessment, it also enhances various steps depending on the needs whether to maximize for all risk or choosing the suitable few samples to hinder from high operational cost.

There is a strong indication that high risk impact and occurrence are happening in small lead time fisheries. It is limiting that even though these fisheries may be efficient in production, they are still exposed to the level of high risk with the most contribution for generated cumulative risk. For further research, the researcher strongly suggests plotting on the transportation lead times and raw material prices from Indonesia market on fish products, to strengthen the coefficient in between.

The cost per unit of fish production also shows an ultimate fluctuation with 94,78% variance. These align with the information received from interviews, where production and economical costs are struggling the most.

The research implication relies heavily on mitigating and planning a strategy before it is concluded from the government. The impact spreads around from the main players until the end-process. Fisheries should go both ways not only from the upper, but it should be taken care of from the bottom as the focus. The originality of this research is implied by looking on the small-scale fisheries area in Indonesia. Previous research was mostly done on areas outside Asia-Pacific region, like the Sub-Saharan Africa region. Bangka Belitung was the suitable object to look for because it is not the main fishery area in Indonesia, but it has the most islands with most potential value that is still untapped. From the direct observation, it triggers the other external stakeholders that the current program is not well supervised. Therefore, it helped the fishery department in Bangka Belitung and it successfully gathered the MSMEs department and One-door investment department to collaborate within the community.

For technical recommendations, it is recommended to take a sensitivity analysis in making the sample size equally between municipalities. For example, make n to be around 100-250, then the lead time uses 2 decimals to present more precise pareto distributions. The greater number of samples indicates the risk generated to be equal as the sample complementing each other. Therefore, limiting to 250 samples showed a significance in min to max lead time closing the mean between standard deviation.

To summarize the remaining research questions, risk management helps to gather all connections from before newest models of the supply chain with optimal risk reductions. The benefit of waste management, stakeholder integration, distribution, storing, and incentive alignment helps to tackle most of the problems in Step 2. Indeed, it will increase value-added for products and investors, as well as the price decrease because there is a wide system of using the raw material supplies efficiently and effectively, in the mode sake of transparency and collectivism. Therefore, risk assessment and risk management are lining from the misplacement onto the products and proper location strategy with the right time, right value, and right fish commodities.

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