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# Mitigating Risk in the Tuna Supply through Traceability System Development

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## Abstract

This study concerns the mitigation of risk based on advances in food product traceability technology. A case study of the supply, processing and distribution of wild catch tuna on the island of Sulawesi in Indonesia provides the backdrop for describing and analyzing risk agents and how they are interrelated in the supply chain. The purpose of this study is to develop an inductive, empirically based model concerning risk mitigation in seafood supply networks. It builds upon the seminal works of Forrester's understanding of information distortion, Alderson's transvection model and Thompson's interdependency theory.

**Keywords:** risk management, traceability, complete supply chains, transvection, food, tuna

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## Introduction

Conducting business requires an integrated network of firms competing with each other in "supply chains" (Christopher 2011). No single firm can stand as an "island" isolated from a network of business services (Richardson 1972). Scholars were seeking to conceptualize all the facets of distribution, from end to end, by the 1950s and 1960s (Forrester 1958, Alderson 1965, Thompson 1967). Their insights are still highly relevant and fundamental to the theoretical development of the management of end-to-end supply chains and provide the analytical framework for this study.

Adopting an end-to-end perspective entails strategic thinking that encompasses the flows of food from harvesting, fishing or hunting to end-use (Engelseth 2012). It also concerns the integration of marketing with logistics and SCM (Engelseth and Felzensztein 2012). While supply chain management (SCM) involves integration from an end-to-end supply chain perspective (Lambert and Cooper 2000), research has paid less attention to conceptualizing and understanding the risks from the same end-to-end perspective. The emergence of food product traceability requirements within the food industry in the past two decades has had a synergetic effect with integration (Engelseth 2013). As electronic traceability systems have evolved to address risk mitigation associated with food safety and quality concerns, the food industry has become aware that achieving supply efficiency requires the participation of all the actors involved in transforming foods in the end-to-end supply chain. Developing food product traceability is therefore not only a logistical and marketing issue, from a developmental aspect, but clearly also an SCM issue (Engelseth 2009). Integration encompasses in long-linked end-to-end supply chains an often coincidental translation through a series of markets from raw material to consumption revealing how SCM and marketing issues are intertwined from this complete perspective (Engelseth 2016). In this picture of structural complexity traceability is an information resource enabler of integration.

Developing food product traceability is a common practice that needs organization (Vanany et al. 2015). Traceability encompasses features of risk mitigation. While risk is associated with features of transformation in the supply chain, traceability concerns the potential for providing information about goods' transformation in the supply chain, that is, whether production is carried out in accordance with the food safety and quality requirements. The concept of risk management in the food industry is not new. Numerous academic publications discuss risk management in relation to food safety and contamination. Jacxsens et al. (2010), for example, discuss knowledge-based modeling systems and risk assessment to identify the impacts of anticipated climate change and globalization on the microbiological food safety of fresh produce. Gonzales-Barron and Butler (2011) consider the use of meta-analytical tools in risk assessment for food safety, and it has become generally accepted that it is possible to apply the principles and methodologies developed for the risk assessment of toxicological substances to food allergens as contaminants (Crevel et al. 2014). Other publications assess risk by focusing on just one component of the food chain, such as production, postharvest processing, distribution or consumption (Yeung and Yee 2003, Lagerkvist et al. 2013). These examples present risk management from a single-firm perspective. It is necessary, however, to develop food product traceability through an integrated and coordinated multi-organizational effort and to organize traceability systems from an end-to-end perspective, from the upstream to the downstream stages of the supply chain, since product transformation encompasses the entire flow of foods from the raw material source to retail. A proposed notion concerns the interweaving of the development of food product traceability with the mitigation of risk: developmental efforts that are carried out at the same time. Vanany et al. (2015) describe a case study of the mango supply for exporting; the company in this case intentionally integrated the monitoring of product quality with the development of the traceability function from a multi-tier supply chain perspective. This study seeks to build on this research by elaborating further on the features of risk and risk management associated with an-end-to-end perspective. The purpose of this study is to develop an inductive, empirically based model of risk mitigation in seafood supply networks.

The study develops a concise research approach through a literature review built on the concept of risk and risk mitigation in food chains, supply chain management within the entire chain and the modeling of risk management in complete networks from a micro-level decision-making perspective in the context of an end-to-end supply chain. It applies the framework to develop a case study of the tuna supply from wild catches to exporting on the island of Sulawesi in Indonesia. Indonesia is a developing economy; Vanany et al. (2015), however, stress that the same food safety, quality and traceability requirements are required in a globalized marketplace. Indonesian fishermen, producers, distributors and exporters therefore need a clear business blueprint to trace and mitigate the risks that may hamper the achievement of food product safety, quality and traceability objectives.

## Analytical Framework

The topic of risk in networked food supply chains is an emerging area within the domain of supply chain risk management. Academics' and practitioners' attention to the subject has increased during the last decade (Whipple et al. 2009, Dani and Deep 2010, Marucheck et al. 2011, Diabat et al. 2012). This networking-based approach to risk management in the food industry raises the level of complexity and dynamism of risk management. The approach is founded on business changes associated with increasing speed in new product creation to supply diversifying and globalizing markets (Christopher 2011). It has been resulting in increasingly globalized flows of food ingredients and products and the need to satisfy changing and variable consumer and governmental demands with respect to food safety, animal welfare and environmental impacts (Trienekens et al. 2012).

Risk management involves perceiving the future uncertainties of a business and dealing with these uncertainties today. A common conception of supply risk is in line with Zsidin's (2003) definition as "the probability of an incident associated with inbound supply from individual supply failures or the supply market occurring, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to consumer life and safety" (Choi and Krause 2006, Cooper et al. 2006, Kull and Closs 2008, Neiger et al. 2009). Risk assessment consists of identification, assessment and evaluation. Risk is associated with a managerial approach that involves taking account of the future supply today. A range of metrics and approaches account for risk as a phenomenon by taking into consideration the attitudes and observable outcomes of a particular risk. "Risk" is, however, never straightforward. "People's perceptions and attitudes are determined not only by the sort of unidimensional statistics used in tables, but also by the variety of quantitative and qualitative characteristics ..." (Slovic 2000: 231).

 

Stone et al. (1994) point out that even when objective data are available to support decision-making, their interpretation may cause bias when assessing the strength of the risk. March and Shapira (1987) propose viewing risk from either a managerial or an economic perspective. The managerial perspective involves accounting for the probability of negative outcomes. The concept of risk widens from the economic perspective to encompass probabilities of both negative and positive outcomes. The economic perspective concerns the probabilities of variation regardless of the perceptions of attractiveness. Zsidisin et al. (2000) classify risk as being associated with supplier capacity constraints, product quality, product technology changes, product design changes and disasters. Juttner et al. (2003) suggest that risk sources fall into one of three categories: 1) Environmental risk sources, 2) Network-related risk sources or 3) Organizational risk sources. Risk classification in a supply chain may involve three categories, which Juttner et al. (2003) further sub-divide to produce a total of five categories: internal risk including 1) process and 2) control risk, risk that is external to the firm, consisting of 3) demand and 4) supply risks, and 5) risk that is external to the network, covering the environmental factor (Christopher and Peck 2004). Rao and Goldsby (2009) also explain five supply chain risk factors: environmental, industry, organizational, problem-specific and decision-maker factors. Tang and Nurmaya Musa (2011) classify risk into three groups: 1) material flow risk, which involves physical movement within and between supply network elements, 2) financial flow risk and 3) information flow risk. While Tang and Nurmaya Musa's classification of risk is process-oriented, Juttner et al. (2003) and Christopher and Peck's (2004) definitions are associated with the risk source and its location in the supply chain from the perspective of a single firm. Figure 1 combines these perceptions of risk to develop a comprehensive model showing the origin of risk and the type of process, information flows supporting goods flows, with which it is associated.

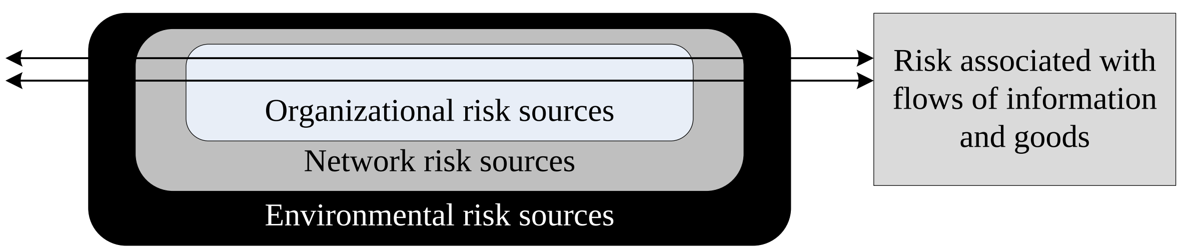


**Figure 1**. Process and Location Factors Associated with Risk

Food supplies have industrial particularities that also affect the types of risks and the features of these risks. Engelseth et al. (2009) assert that the food supply is necessarily ethically laden since food consumption is a vital aspect of human well-being. They therefore consider the food industry to be more strongly embedded than most other industries in a cultural context involving how food is produced, how it is distributed and how it is consumed. It is a relatively *less* modern, more "traditional" industry following Giddens's (1990) understanding of "modernity." The food industry balances food safety, a societal aim embedded in the traditions of a culture, with economic and quality product supply, representing business aims (Engelseth et al. 2009). The concept of "safety" in the food supply signifies food product features that are measurable through the supply chain in relation to human well-being dependent on the technicalities of the food supply, whilst "quality" involves product attributes measured in relation to customer value (Van Rijswijk and Frewer 2008). Food safety includes a number of procedures to be followed to avoid potentially severe health hazards. Various systems and standards, like the HACCP (Hazard Analysis Critical Control Point) system and the ISO 22000 standards, constitute the international and local legislation enforced on this issue to avoid the consumption of contaminated food. Becker (2000) states that food product quality consists of three aspects: 1) product-oriented quality, 2) process-oriented quality and 3) consumer-oriented quality. These features entail three actors or "locations" of quality: 1) the food supplier, 2) the food product itself and 3) the consumer. It is necessary to consider three important food-industry-specific challenges in food supply chains: 1) food safety, 2) food quality and 3) sustainability (Akkerman et al. 2010). These challenges are associated with the food supply purpose, which integrates the societal, ethical and business perspectives (Engelseth et al. 2009). Safety is concerned with ethics, quality with business and sustainability with society and the environment at large. Clearly these considerations are interdependent and interwoven; it is not a clear-cut classification that is in focus here, but the consideration of what constitutes the food supply purpose, taking a wider view than simply focusing on microeconomic business objectives. Food safety, quality and sustainability emerge as prominent aggregate-level risk factors in food chains.

Risk perceptions in food chains are also associated with the way in which actors interact and are dependent on the degree of supply chain integration. "Risk" does not only emerge technically in association with an event; it is also perceived and then communicated to others. A low degree of complete supply chain flexibility and supply requirements exists in the food supply (Adebanjo 2009). Increased inter-organizational collaboration in the food supply, according to Bijman et al. (2006), is due to: 1) the rise of food safety as a prominent societal issue, 2) the raw material in food distribution often closely resembling the finished product and 3) foods to varying degrees always being perishable goods. Fresh foods, such as bananas, represent perishable products, with a limited shelf time frame. The particularities of the fresh food supply include: "… 1) fresh products are not standard and subject to quality deterioration, 2) there is a lack of clear product descriptions and coding standardization, 3) information requirements differ per customer, making standardization complex, and 4) a relatively low degree of automation of farmers" (Van der Vorst and Beulens 2002). These considerations point to a need to model risk management from a complete network perspective. Van der Vorst and Beulens (2002) as well as Taylor and Fearne (2006) in the food management literature indicate the need to model an end-to-end food supply network based on features of seasonality, perishability, safety and traceability factors. Intermediary trading organizations in the food industry face challenges in coordinating retail promotions with lead time requirements. The logistical particularities of foods are concerned with achieving an ethical and safe supply of foods.

The next step is to embed these evoked particularities of the wild-catch seafood supply in the context of supply chain management (SCM) thinking. SCM places the focus on inter- as well as intra-firm integration. It is therefore well suited to acting as a conceptual foundation for considering risk management from a network perspective. SCM thinking can trace its origins to Forrester's (1958) bullwhip effect as well as Alderson's (1965) writings on marketing channels. Especially Forrester's (1958) work is seminal as the foundation for developing the core concept of SCM thinking: "integration." Forrester notes how sales information was distorted due to weak integration when communicating stepwise through tiers of actors organized in a common supply chain. Oliver and Webber (1982) first use the term "supply chain management" to describe the management of flows of materials across organizational boundaries. The focus on SCM involves the study of the synthesis of business and resource networks, the opportunities and barriers to developing synergies between actors in supply chains and the synchronization of activities and operations across supply chains (Bourlakis and Bourlakis 2004). The complete end-to-end modeling of a supply is still weak in SCM; the focus is mainly on immediate supplier relationships.

Alderson (1965) develops the transvection model to depict the logic of the supply from raw material to consumption from an end-user perspective. This approach, together with Thompson's (1967) interdependency theory, is applicable when considering business actor roles and business actor interaction in a complete network. This involves highlighting considerations of interdependency types explained in relation to power, legitimacy and urgency, all of which are vital when considering the mitigation of risk. Alderson (1965) models the flow of goods as a long-linked set of integrated goods-transforming processes. Transformations are directed by intermittent decision-making events termed "sorts" in this piecemeal picture. The transvection in the marketing channels literature (e.g. Rosenbloom 1995) represents an early and unique balancing of transactions with operations through enhancing the logistics side of these channels. While transactions provide a customer-oriented purpose to flows, the transvection places an increased focus on logistical descriptions of sequentially dependent decision-making events supporting value creation through goods transformations (operations). This view evokes the importance of achieving customer value through a model of physical distribution conceived in the early 1960s. In accordance with the transvection model, a sequence of utility-providing operations creates product value by transforming the time, place and form features of goods through a series of decision-making events that Alderson (1965) terms "sorts." Figure 2 models the transvection from a SCM perspective as collaboration associated with logistics.

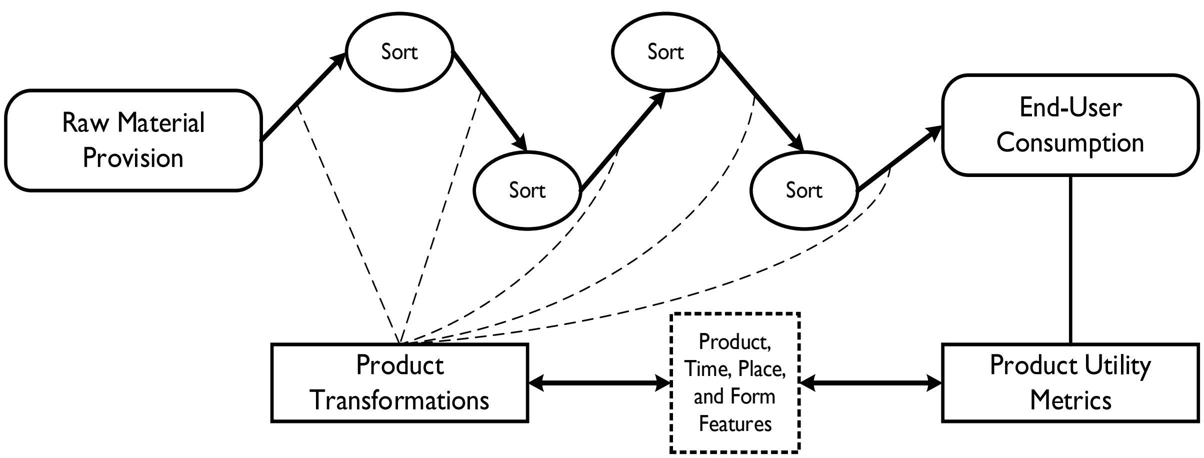


**Figure 2**. The transvection (the arrows between sorts indicate value-creating transformations of product features) (Engelseth and Felzensztein 2012).

The inquiry involves research following the flow upstream from the end-use state of the finished product through intermediary locations to the upstream initial "conglomerate resources" (raw materials) in accordance with the transvection approach. This indicates, in line with Richardson (1972), an organized series of complementary processes that are dependent on business relationships to facilitate food supply coordination. The transvection model exposes sequential interdependencies that are typical of the food supply. The supply is always represented by a combination of sequential, reciprocal and pooled dependencies according to Thompson (1967).

 

The sequential interdependencies are predominant, with pooled and reciprocal interdependencies, in the case of analyzing the food supply through the lenses of interdependency theory. The transvection model, which concerns physical distribution, and therefore at core logistics, accordingly models the technicalities of sequential interdependencies. It provides an analytical approach to the detailed operational-level modeling of physical distribution. Risks are perceptions, so in the transvection model they are associated with sorts. Using the transvection model accordingly takes risk management from the strategic to the operational level. This discussion leads to the proposal of a model of risk management with interdependencies from the perspective of the Aldersonian sort. The model follows Christopher and Peck's (2004) supply chain risk model, which accounts for actor-associated risk rather than the sequentially dependent decision-making entity as food in the food supply. Figure 3 shows how a sort as a decision-making event is embedded in a layer of contexts associated with production through a flow of foods. Given that risk is perceived at sorts, the embeddedness that Figure 3 models directs attention to what exerts an impact on risk and how it may be managed.

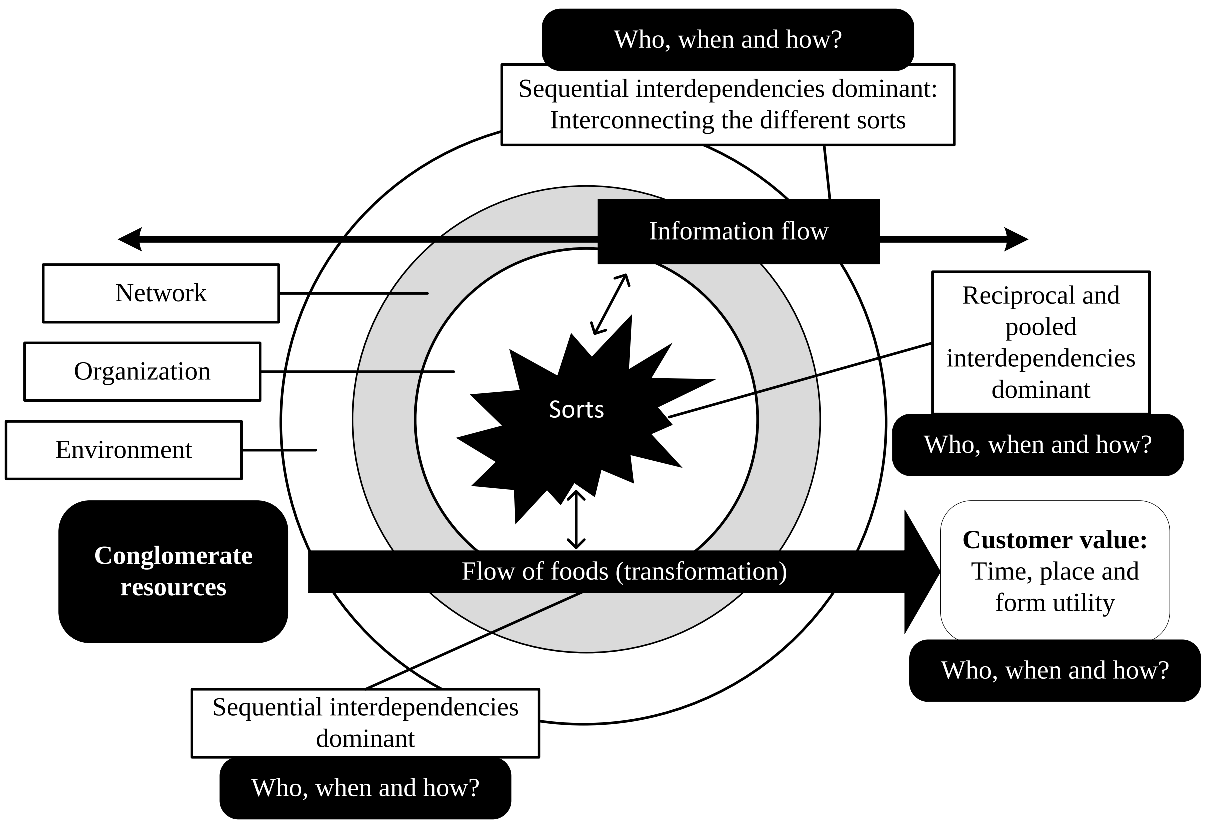


**Figure 3**. The Transvection Sorts Embedded in the Supply Network

The flows of both information and foods are associated with risks. This widens the concept of food safety and quality to encompass features of information about these foods: the quality of their traceability. Decision makers need to perceive these changes at sorts since risk is a perception. As sorts are predominately reciprocally interdependent and involve information pooling, risk management is thereby understood as predominately managing information. The model evokes that this communicated information is related to the interdependent flows: foods and information. *Risk mitigation*, the purpose of risk management, in the food supply therefore involves managing the sources of risk at different locations in the flow of these goods, their severity and their probability. This entails managing risk in relation to the supply, organization and customers from a quality perspective.

## Methodology

The case study involves interviews with a set of 26 informants within the tuna supply network in Bitung on Sulawesi Island, Indonesia. The interviewees consisted of 8 informants representing fisheries, 4 traders, 5 processors, 5 business owners, 3 government officials and 1 exporter. Since the study provides data from the upstream portion of the studied supply network, the authors decided to commence the study not from the end-user perspective, following the transvection principle (Alderson 1965), but rather from the raw material source. Accordingly they held interviews with the industrial food processors and finally the intermediaries.

This case study aims to study tuna product operations in a supply network context (Voss et al. 2002). The interviewers made the purpose of the interviews explicit to the informants at the outset, that is, to describe activities focusing on risks associated with their business. The interviews covered logistical factors as well as features of trading based on the analytical framework. This included evoking features of business relationships. The authors used these data to create a detailed and rich case description (Lincoln and Guba 1985) and sought the features of risk management in interviews with informants who were unfamiliar with the concept of “risk management.”

These narrative descriptions are based on the informants’ accounts of their past experiences or of possible risk-related futures as the primary data (Corsaro and Snehota 2012). The authors accordingly study risk management predominately retrospectively based on the informants’ expressions provided in the interviews. The study elicited how the informants perceive their risk-related operations as well as the perceived likelihood and severity of each event.

The interviews lasted on average for 1 hour and included observations of on-site activities, namely fishing, delivery, market trading and fish processing. The interviewers conducted a further interview with a representative of the Bitung municipal fisheries administration to provide an overview of risk-associated issues as well as examples of the challenges and conflicts encountered in the studied supply network. The interviews themselves took place in a context of high mutual trust and resembled a conversation within an inter-subjective and mutual learning atmosphere. The researcher learned about the process to which the informant had access, and the informant learned about the concepts and theories driving the research. The researcher taped and transcribed these interviews and asked the informants brief additional questions after their interviews when clarification was needed. Although each interview produced a limited number of transcripts, these transcripts include great detail. These actual circumstances add to the credibility and accuracy of the research and enable a rich and “thick” description of the events through a mutual frame of understanding (see e.g. Lincoln and Guba 1985, Eriksson and Kovalainen 2008).

The following text narrative, based on this case study of the tuna supply from fishing at Bitung in Indonesia for exporting or domestic retail, provides a basis for analyzing this form of supply by applying the developed research model. This case narrative provides a fundamental description of the network structure and flows of goods as a foundation for more detailed descriptions of prominent risk as perceived by various supply chain actors: fishermen, seafood markets, producers and distributors/exporters.

## The Tuna Supply Case

*Overview*

Figure 4 provides an overview of the described tuna seafood network. The left side represents the interconnected actors while the right side represents the flow of the food process, showing the sequentially interdependent upstream transformation of tuna from a complete chain perspective.

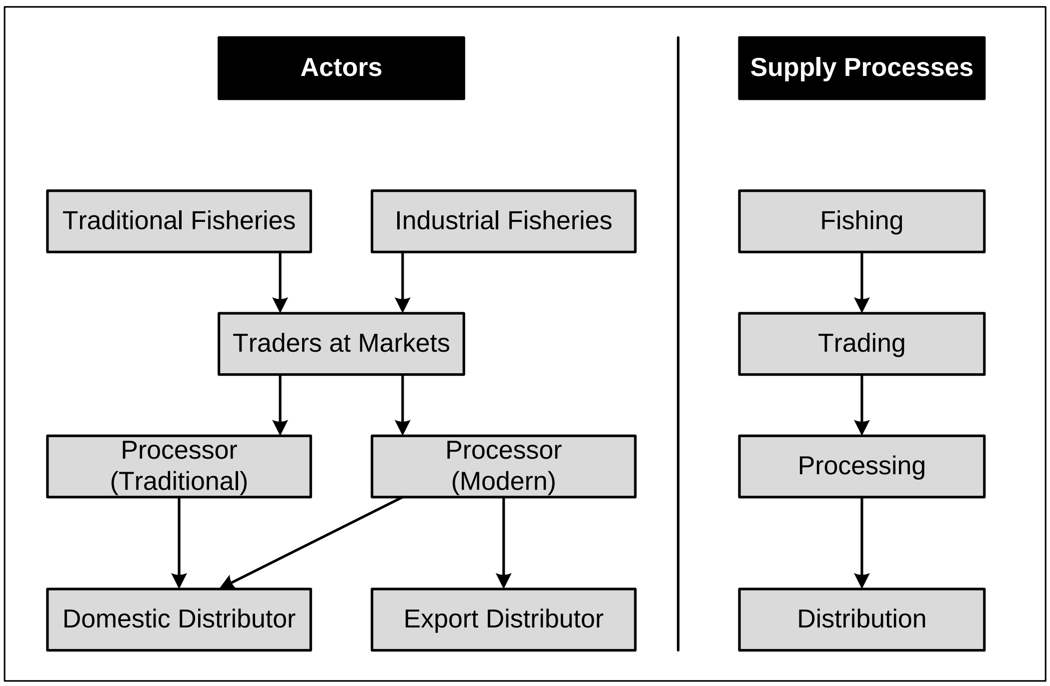


**Figure 4**. The Studied Tuna Supply Network

*Catching and Delivering Tuna*

Tuna is a saltwater finfish that belongs to the tribe Thunnini, a sub-group of the mackerel family (Scombridae). Thunnini comprises fifteen species across five genera: slender tunas, frigate tunas, little tunas, skipjack tunas and true tunas. The sizes of tuna species vary, ranging from the bullet tuna (max. length 50 cm, max. weight 1.8 kg) to the Atlantic bluefin tuna (max. length 4.6 m, max. weight 684 kg). The bluefin averages 2 m (6.6 ft.) and reputedly can live for up to 50 years. The tuna is an active and agile predator with a sleek, streamlined body and is among the fastest-swimming pelagic fish. It lives in warm seas and is extensively fished commercially. Overfishing has reduced the stocks of some tuna species, such as the Southern bluefin tuna, to the point of extinction.

Bitung is a municipality in the northern part of Sulawesi Island in Indonesia. Bitung's fishermen catch tuna daily in the Celebes Sea. These fishermen are divided into traditional and industrial fishermen. The traditional fishermen are dominated by local residents who have tuna fisheries as their main livelihood. Hand-line as well as pole and line are the main fishing methods applied here. Hand-line is the oldest technique. It is commonly practiced in fishing in Bitung, where a fishing line is held in the hands. The hand-line fishing method uses a small vessel with a maximum tonnage of 40 gross tons (GT) when fishing for tuna. The crew of such a fishing vessel is usually made up of several people, including the captain, the fishing master and the general crew. The fishing master acts as the determiner of the fishing ground. Fishing grounds are usually closely located to a fish aggregation device (FAD) that the fishermen had previously deployed. FADs are man-made objects used to attract ocean-going pelagic fish, such as marlin, tuna and mahi-mahi (dolphin fish). They usually consist of buoys or floats tethered to the ocean floor with concrete blocks.

The majority of industrial fishermen catch tuna using the pole and line method. It consists of a bamboo rod or fishing rod, line and hook. The length of the bamboo is about 2.5 m with a diameter on the bottom of around 5 cm, smaller at the ends. The line used should be shorter than the length of the rod. This helps in the swinging process and in releasing the fish from the hook when caught. The applied hooks are different from the commonly used fishing hooks since they are not inverted, making it easy to release the fish when caught on the hook. The hook is covered with chicken feathers or an elusive rope to camouflage it and fish will attempt to bite this. Catching also uses live bait combined with water spray. Live bait will lure fish to the surface and the spray will hinder their sight so they are unable to distinguish between the bait and the hook. The type of vessel used in this form of fisheries is generally 61-120 GT with a modified bow that is used as a seat for fishing. Fishing in Bitung may also involve the use of fishing gear such as a long line, purse seine and gill net to catch tuna.

The tuna fishing process includes sequentially 1) preparation before going to sea, 2) capture, 3) treatment and handling on the vessel and 4) delivery and unloading at the port. The preparation process at the port includes preparing the fishing gear, organizing the crew, securing the food logistics for the time at sea and choosing the type of vessel. The tuna catch varies based on the type of fishing gear used. The handling on the vessel demands cold and clean storage to secure food safety. After the crew members have caught the tuna and landed it on the vessel, they clean the fish by cutting off the head and discarding the gills as well as the entrails. They then wash the fish to remove bacteria that may cause decomposition and contamination, rinse the whole fish to remove mucus and pack it in ice. Good freezing could hold tuna for up to 6 months. The crew members should provide crushed ice cubes with an equal volume ratio to the fish. The ice should be of the same size and avoid a pointed figuration. The crew members lay the ice first in the holding space, then place the fish on it and finally cover the top of the fish with more ice. They store large tunas in single layers and smaller fish in multiple layers.

Fishing vessels vary in size, holding capacity as well as the ability to freeze goods. Some of the potential problems that can emerge during fishing include a shortage of ice for freezing goods, non-standard treatment of tuna, limited bait and insufficient capacity for cold storage. Some indirect problems also contribute to the tuna catch quality, such as handling ports that permit tuna to come into contact with direct sunlight when unloading, the use of nets for catching that results in many small tunas being caught, illegal fishing by foreigners, either using their country's flag or using the local fishermen as a way to catch fish in Indonesia, and finally unpredictable weather conditions. Some other challenges include erratic monitoring of the volume of the catch, a lack of government fisheries control officers, the complexity of vessel permit administration and a lack of seafood controllers at the port who can determine the quality of the tuna. Climate change also contributes to the tuna supply chain's problems because the available equipment still cannot detect the weather accurately. The government budget allocation to promote the tuna commodity is limited and does not allow this commodity to develop optimally.

*Trading at Bitung Fishing Port*

The fishing vessels land their catch at the Bitung Port for sale, at the port of Pelabuhan Perikanan Samudera (PPS)/Oceanic Fishing Port of Bitung or at the private jetty (Dermaga Untuk Kepentingan Sendiri – DUKS). The PPS is a central agency under the supervision of the Ministry of Marine Affairs and Fisheries, while DUKS is controlled by the Department of Marine Affairs and Fisheries, North Sulawesi Province. The landing of tuna at the port includes the unloading of the fish from the vessel at the port. The unloading process must take into consideration the principles of temperature, speed, cleanliness and food safety in general. The potential hazards during the unloading of the catch that could arise in the landing process, for instance, are having to wait to unload because of the limited handling capacity of the port, the tuna goods coming into contact with sand and unclear procedures for unloading the goods.

Traders purchase the catch at the port. These traders function as intermediaries connecting the fishermen with industrial processors. The intermediaries consist of three groups. One type of purchasers consists of local individuals with no formalized status who have limited skills in determining seafood safety and quality features. It is a traditional family-oriented activity handed down through generations. Their financial capacity is very limited. They deal directly with fishermen and processors based on the fluctuating market price. They do not have a permanent office and generally have no other formal occupation. This relationship represents traditional actor bonding with trust developed over time. The second group of purchasers consists of enterprises usually run by more than one person with an office location. Their management skills are still relatively weak. The owner of this kind of trading business can be a local person who has some capital or outsiders who invest in Bitung. These traders are often termed "collectors" or "middlemen." The third group contains industrial food manufacturing firms. This group has always represented the interests of the company for which it works. These purchasers have the highest degree of management skills of the purchasers, including fish quality control and assessment. Representatives of the processing firms make the purchasing decision.

The trading of tuna takes place at a local seaport auction. This auction facility is operated by the municipal government. It involves determining the quality grade of tuna, namely A, B or C to represent the best, mediocre and worst quality levels. Some tuna receive the lowest grade due to poor handling on the vessel. Lower quality entails a lower price. The limited capacity for storing and handling tuna auctions in the ports, no cold storage and no separation between clean and dirty areas in the port can also affect the quality of the tuna. Pick-up cars then deliver the tuna to the processor for the next processing stage.

*Processing*

Second to fishing, the processing of tuna at a food manufacturing facility is one of critical points in the tuna supply chain. Processors are primary processing companies that produce a slightly refined tuna product. These firms are large, professional organizations. Primary tuna processing produces fresh and frozen tuna. Fresh products can be tuna GG (GG – gilled and gutted, completely cleaned, but with head on), tuna HGT (HGT – headed, gutted, tail off), tuna loins (the boneless portion cut lengthwise from either side of the backbone of a large, round-bodied fish, the back portion of the fillet having had the belly section removed), pocket hand-cut and hand-cut cubes (cubes generally, IQF individually quick frozen cubes cut into various sizes from 4 mm upwards; IQF – individually quick frozen). Frozen tuna includes tuna loins, tuna saku, tuna steaks (steak – a cross-sectional slice of a fish, usually 0.5 to 2 inches thick and containing a section of the backbone), tuna cubes, tuna kama/jaw, ground meat, tuna bellies, tuna cheek and tuna heads.

The manufacturing process is very detailed and the quality is dependent on standards. The Hazard Analysis and Critical Control Point (HACCP) is an important quality manufacturing standard used by these types of firms. The use of the HACCP standard is vital since it has an impact on the tradability and price of the finished products. Customers usually request traceability information including details of the handling process from the catching location. Failure to follow these traceability demands can lead to the rejection of tuna products and economic loss. Mistakes in the processing include such hazards as contaminated substances, human error or processing failures. These companies emphasize a strict “standard operational procedures” (SOP) system. Since the cold storage facilities and plant capacity are limited, a general aim of tuna processing is high processing speed.

*Distribution*

The processor or a third-party distributor may handle the distribution from the primary processor to the customers. Producers themselves distribute the products sold on the domestic market, while exports are handled by a logistics company. Bitung channels these goods through either the Bitung Oceanic Port or the Sam Ratulangi International Airport. Fresh tuna products are transported by air and frozen products by sea. The tuna from Bitung is a relatively limitedly transformed good, a primary product, which many overseas customers will further distribute through many tiers of intermediaries prior to its final consumption. In the export market this raw material may end up as a retailed fish product, on the menu of restaurants, and it may undergo further processing, such as tuna canning. One of the challenges in this transport process is that there are no direct cargo flights to international destinations from Manado Airport, even though it is classified as an international airport. All products must therefore undergo transit handling at one of the other Indonesian airports, such as Jakarta, Denpasar or Surabaya. Such limited transport and handling facilities influence the product’s freshness due to terminal procedures that are often erratic. Companies use refrigerated containers to ship by sea.

Domestic distribution involves both sea and air transport. The customers may be restaurants or traditional marketplaces that sell tuna for household consumption. There is no evidence of compliance with standards in the processing in the domestic market, but in general domestic consumers can distinguish directly between good and damaged fish. Customers will purchase fish that are of inferior quality for consumption at a very low price and can further process it into feedstuff for animals.

The decline in the overseas demand is currently affecting the distribution for the export market. Overseas customers who have received tuna have rejected it in some cases due to packaging damage, contamination or documentation errors, including missing traceability information. Another factor that causes problems for the exporter is the high quality expectations of foreign customers. This is especially true for Japanese importers. Furthermore, economic downturns in export markets lead to a lower demand. The fishermen are also unaware of these export customers' often unusually high quality concerns.

The final exported tuna product appears on supermarket shelves or in restaurants in sushi, sashimi or tuna rolls. Europe, Japan and America dominate the tuna export market. These foreign customers follow their home market's strict rules for traceability and product safety and quality. Awareness of the sustainability of tuna fishing has an impact on the demand in some foreign markets, since the media in these countries regularly report on tuna's status as an endangered species. The price of tuna on the export market is clearly differentiated from that in the domestic market. Export prices can be up to double the domestic tuna price. The Bitung processers are limited to domestic distribution if they do not follow the international standards. This includes following quality procedures involving catching, handling, washing, sorting, grading, freezing and transporting fish through the entire supply chain. An important factor causing the rejection of fish is insufficient cleaning. The rejection of tuna results in economic loss all along the flow of tuna, including the processor. The consumer for exports could be distribution centers, supermarkets or restaurants.

## Analysis

The preceding case narrative concerns the flow of tuna from origin to destination through four major processes: catch, trading and processing followed by distribution to the domestic and export markets. These data provide ample grounds for analyzing the risk associated with production and thereby the supply risk. Figure 3 depicts the four main components associated with the analysis in this study: 1) customer value, 2) flows of foods, 3) flow of information and 4) sorts. The study proposes these as interdependent components with unique features that exert a combined impact on risk. The analysis will first consider each of these four components individually, thereby providing a foundation on which to consider risk mitigation in food networks.

Firstly, customer value is, in accordance with Alderson's (1965) transvection, ultimately associated with the end-user; the perception is associated with the supply purpose. The intermediaries, however, also function as customers and may therefore be associated with intermittent customer value perceptions. As perceptions are involved it is difficult to determine whether the sequence (timing), pooling or reciprocity is more important in forming customer value perceptions. Interdependencies clearly exist, but for now the researchers consider them as balanced in relation to understanding the nature of customer value. All suppliers, furthermore, perceive customer value, since it is the purpose of supply. Fisheries only vaguely consider the requirements of the end-user (customer value) in this long-linked chain of events (sorts). The chain of actors, however, conveys the food quality requirements; there are ample grounds for information distortion following Forrester's (1958) line of thought. Fisheries experience a simple perception of tuna's physical features in the market, in which traders advocate their customers' requirements. Tuna, being a food product, is embedded in traditions of food culture. The degree to which this culture influences consumer preferences is not known. Such data, which are highly relevant to determining the nature of tuna supply, would clearly enhance this analysis. The data in this study indicate that the demand for tuna in its weakly processed state, as described in the case, is relatively stable. It is a type of food that is not subject to strong market fluctuations. This may in part be due to the fact that the study does not consider the processing of tuna into branded food products. The initial-stage processed product described, still only moderately processed, can produce a wide range of finished products. This functions as logistical buffering between market demand fluctuations and supply. It is apparent based on this understanding of the "who", "what", "when" and "where" factors related to customer value that the demand risk is relatively stable. As the data concerning customer value in this study are rather limited, this analysis needs further elaboration in other studies. As an example, further analysis can be connected to marketing, applying both a business marketing and a customer marketing approach considering the nature of customer value through tiers of intermediaries to the ultimate tuna product end-user.

The flow of tuna (goods) in the studied case represents the core feature of production leading to product realization and thereby grounds for assessing customer value. This is, following Thompson's (1967) conceptualization, a "long-linked" form of value creation that flows through different actors in the supply network: a chain of sequentially interdependent activities guided by sorts. Alderson's (1965) transvection model is clearly applicable as a conceptual research model in such supply structures. These activities are relatively simple technically speaking and involve a limited degree of pooled and reciprocal interdependencies. The safety and quality of tuna depend on transformation processes organized into what the flow metaphor can describe appropriately as production. The risk in this flow is predominately associated with the process of transforming the tuna in its movement towards the end-user. The flow of tuna is technically often only indirectly associated with sorts in practice since decision making in more modern settings takes place independently of tuna goods' physical identification and observation. Risk is therefore associated with the factors inhibiting the production, including the sustainability and safety factors associated with goods transformation. The flow of tuna is not limited to features of the network, but also involves the environment.

The flow of information is weakly studied in this case, limiting the detail in the analysis. It concerns the transfer of documents moving both upstream and downstream. These are predominantly documents about the tuna flow. This flow is clearly less sequentially interdependent than the flow of goods that it seeks to describe and thereby establish traceability. Information pooling is a core feature of this flow to create documents adapted to various uses, including product history information associated with traceability. The same information may also be duplicated, and information is created through this flow to facilitate the decision making at sorts. Risk in this flow is therefore associated with *the quality of information* provided at sorts: the degree to which the information alerts decision makers about hazards in the flow of tuna.

 

Traceability is the key to mitigating this form of information-related risk. The information flow encompasses more than traceability; it also includes information about customer orders and market information in general: the downstream and future perspective of the flow of goods. Risk in the information flow is associated with how information interconnects the customers and the flow of goods with sorts and with information about the future, present and past state of goods.

Traceability is as an information resource associated with that part of the information that may mitigate risk; descriptions of the product history in the upstream portion of a supply chain form the perspective of a particular sort. It is possibly a continuous effort to develop traceability that may enhance the product quality and thereby mitigate risk, in line with Vanany et al. (2015). This means that developing food product traceability, according to Engelseth (2009), encompasses features of informing about the *past, present and future states* of foods. The information flow favors risk mitigation as it supports product realization through production via the flow of goods directed by sorts. The prime question is whether the information communicated to sorts reveals the features of potential events before they take place so that actors may work to mitigate the risk. These risk events appear in the future and therefore are not directly associated with traceability. When developing and using any traceability system, however, synergies in the form of avoiding unwanted events and developing resources to handle such events if they occur may be organizationally interlinked with a traceability system. This means that not only integrating fisheries with local markets and processors with exporters will encompass informing about product history, but the action of registering production from fishing vessel to exporter is likely to have synergetic effects. Simply evoking the need for traceability in the tuna chain will stimulate the awareness of the people carrying out the production and distribution activities to be more quality and safety conscious. The act of identifying goods and controlling and registering their quality in a traceability system will promote improved quality since it functions as a control mechanism. The question remains of whether the management understands this incremental use of sorts strategically.

The transvection provides a perspective of interaction associated with production. Sorts are decision-making events (Alderson 1965) also entailing a conglomerate of actors' risk perceptions at an operational level. Not only should SCM consider how people and companies are integrated into networks, but is it also possible to suggest that the way in which events are networked is important in mitigating risk. The actors in this case network the decision-making supporting the flow of tuna to mitigate risk together as a collective. Different sorts that different actors with varying perceptions of purpose (e.g. customer value) frequently carry out are timed logically in relation to each other. The sort itself is, however, an event that implies a strong degree of pooling of information resources as well as people. The importance of reciprocal interdependencies increases with increasing uncertainty. This interdependency is found both within and between firms. As the tuna product flows towards the end-user directed by a sequence of sorts, actors make decisions to direct this flow as well as to handle unexpected challenges. It is in this flow, a dynamic system, that the authors propose risk mitigation as embedded information-supported administrative tasks.

The sort always encompasses a certain degree of reciprocally interdependent decision-making in the supply chain and is therefore clearly dependent on the human knowledge resource. People as knowledge, and the way in which people interact with other knowledge components in a network, influence the decision outcome at sorts. Decisions are not isolated to a single "responsible" decision maker. They are nested in a system of decision makers and interests. Sorts therefore both mitigate and may even create risk. It is therefore in the interest of a supply chain actor to provide quality decision making and this may be the core to risk mitigation based on Figure 3. The quality of sorts is highly dependent on the pooling of people and information. Sorts, since they evoke the people's role and divergent perceptions, also represent the challenges of divergent interests and imbalanced power in the supply network. The decision making of actors who may be characterized as "agents" becomes evident as a supply chain role at the sort. Therefore, supply chain integration as a management principle is highly pertinent in facilitating daily operations associated with risk mitigation and this involves aligning the divergent perceptions and interests of the supply purpose. These supply agents at different locations, with different perceptions of the flow of foods and handling different aspects of information about the transformed foods need to collaborate to trace foods. The model shown in Figure 3 has guided the investigation into the tuna supply network and provided an initial analysis revealing how actors can systematically comprehend risk management from a network perspective. The study develops the following empirically based model grounded on this analysis.

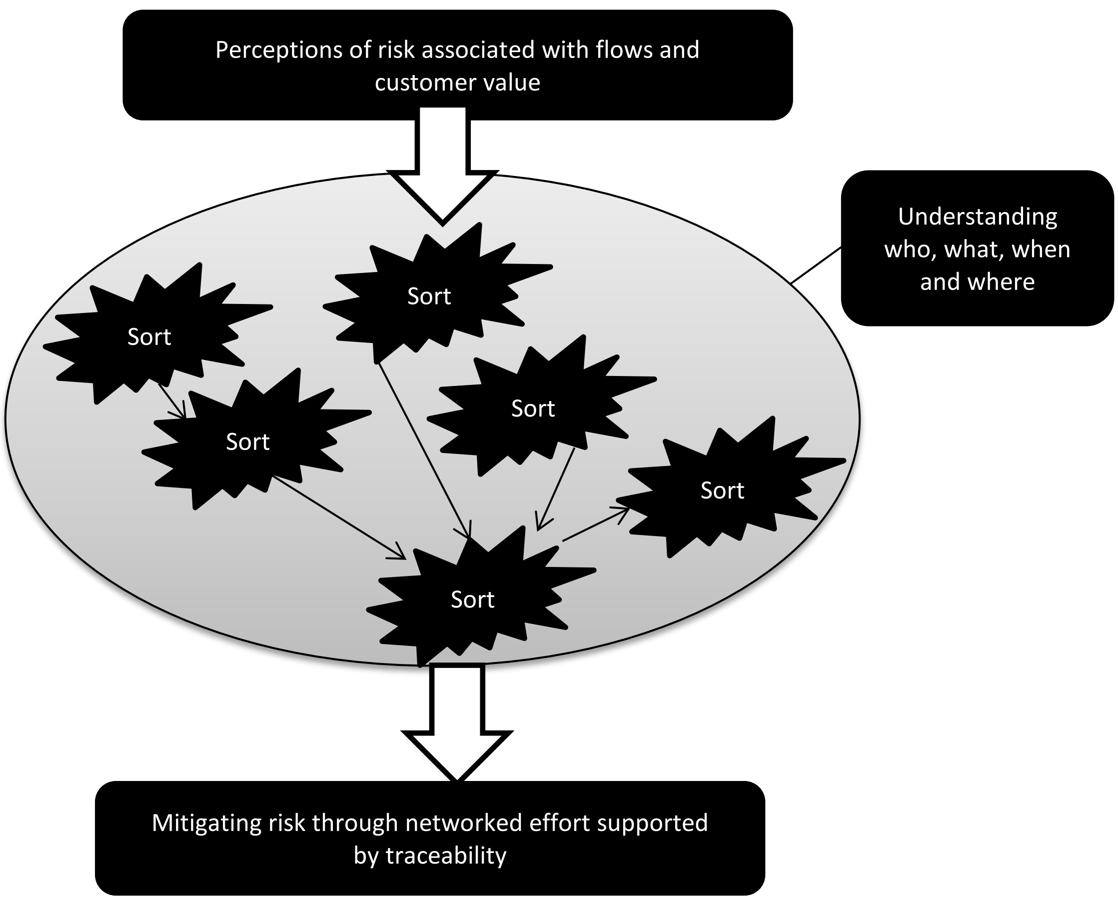


**Figure 5**. Risk Management in a Supply Network

Figure 5 evokes risk management as networked sorts, the vital sequentially interdependent decision-making events in the food supply network, supported by traceability (involving skills, activities and system). However, these sorts are not purely sequentially interdependent themselves, since they involve predominately information resource pooling and reciprocal interdependencies associated with information exchange. Sorts are enabled through the strategically founded use of the traceability system, tools for problem solving and hence also risk mitigation. A network analysis provides grounds for understanding the context of this model and how actors may develop a network atmosphere (Gadde et al. 2010) that facilitates operational-level daily risk mitigation procedures. Mitigating risk from this picture is essentially associated with developing an agile supply since it enhances the data capture processes as well as thought-through multiplex information use (Engelseth 2013).

The supply chain actor seeks clarity in how risk may be mitigated from a business perspective. The preceding discussion suggests that understanding risk management is a complex concept. The discussion sheds light on managing risk in food chains. Food safety is ethically laden. The supply network being a business entity, economic concerns are also important. Risk is associated with balancing these two factors. The food supply is therefore associated not merely with network concerns, but also with environmental concerns. These involve a wide range of issues related not only to food safety concerns but also to sustainable fishing and production and human welfare in general through job creation in local environments, as some examples of a wide range of environmental issues pertinent to the tuna supply. Table 1 provides an overview of the risk agents (sources), their impact and how such risk may be mitigated.

Risk mitigation, following Table 1, is associated with first classifying the four types of processes: 1) fishing/catching, 2) trading, 3) processing and 4) distribution. Different forms of risk may be pinpointed within these types of processes. These forms of risk are associated with different metrics, termed in Table 1 as their "impacts." Finally it is essential in risk management not only to describe and understand the types of risk, but also to consider how to mitigate the risk. The treatment of a risk agent is basically preventive and associated with decision-making that may be termed as sorts. If immediate action is not taken, the potential risk would turn into a *risk event* that would result in a greater impact. Mitigation involves approaching the risk agent at its location including addressing both the people at the sorts and the production associated with transforming the tuna product. A number of methodologies to manage risks are available in the literature. Pujawan and Geraldin (2009) propose an approach called the House of Risk that the supply chain players can use to prioritize actions systematically to address the risk agents.

Risk management means avoiding reactive action after an undesirable event occurs by addressing 1) how actors may design processes from a long-term perspective because the risk has occurred and 2) how actors use the information flow from an operational perspective to support the flow of goods throughout the supply chain processes. Risk mitigation concerns both strategic and operational levels. These are quite different in practice. Table 1 focuses on the operational-level risk mitigation associated with the flow of goods. Clearly these operations that mitigate risk demand an agile supply network that is again dependent on flexible resources available at sorts. Mitigating risk at the strategic level is associated with developing an agile supply, which involves developing flexibility in resource design, interaction and use. Flexibility's criticality in a dynamic supply chain is much discussed in the recent literature. Pujawan (2004) proposes, for example, a framework to assess and improve supply chain flexibility. Angkiriwang et al. (2014) point out that companies need to have an appropriate level of flexibility to deal with uncertainty.

 

Uncertainty exists in supply, demand and internal processes, and depending on the uncertainty typology, companies may need different strategies to meet the required level of flexibility. This study points out traceability as an enabler of flexibility in supply chains.

**Table 1**. Risk Agents, their Impacts and Mitigation in the Studied Tuna Supply Network

| Process | Potential Risk Agent | Potential Impact | Risk Mitigation (Agent)/Preventive |
|---|---|---|---|
| **Fishing/ Catching** | Lack of bites<br>Poor treatment while in boat<br>Bad weather<br>Limited availability of fish<br>Illegal fishing | Limited catch<br>Damaged fish<br>No fish<br>Limited catch<br>Low income | • Increase the fish aggregating device (FAD) units<br>• Certify the handling process of fish on board<br>• Apply the standard operational procedure (SOP) strictly<br>• Complete the fishing vessels with refrigeration facilities according to the standards required<br>• Arrest and sink the fishing vessels that operate illegally |
| **Trading** | Open port<br>Cold storage unavailability<br>Sand-contaminated product<br>Unavailability of a dedicated market for the product | Damaged fish<br>Damaged fish<br>Low price<br>Uncompetitive price | • Provide a landing place and auction space specifically for tuna<br>• Provide shared ownership of cold storage |
| **Processing** | Human error in processing<br>Limited cold storage<br>Low-quality packaging<br>Low market demand<br>Product rejected by a foreign customer<br>Electricity supply problem | Bad quality<br>No safety stock<br>Damaged fish<br>Low income<br>Loss of profit<br>High-cost operation, quality problems | • Increase training of labor for tuna processing<br>• Maintain adequacy and stability of the electricity supply |
| **Distribution** | Unavailability of direct flights<br>Problems with the logistical infrastructure<br>Unavailability of fresh product transportation | Fish products have to transit<br>High-cost product, delayed distribution<br>Quality problems | • Improve service quality and flight connectivity<br>• Provide refrigerated cars |

Table 1 shows that extending the use of fish aggregating devices (FADs) can mitigate risk in the process of fishing/catching to overcome the shortage of bait. FADs are temporary structures or devices made from any material and used to lure fish. Before the fishermen fish for tuna in a predetermined location, they head out to obtain bait using FADs. More FADs will increase the amount of bait and increase the chances of catching the tuna. The strict application of the standard operation procedure (SOP) can improve the lack of handling after catching the tuna and all tuna fishing should be certified regarding how it handles tuna on board. Standard refrigeration should also be available on fishing vessels to handle tuna properly. To mitigate the risk due to illegal fishing, which results in lower earnings for the fishermen and the Government, the Indonesian authorities will arrest and then sink fishing vessels if they are not able to show an official fishing license. The Indonesian Government has lately carried out such strict measures to reduce cases of illegal fishing.

Regarding the process of landing the tuna, actors can carry out risk mitigation by designing a special port for tuna, so that they can avoid exposure to sunlight and sand contamination. Limitations in cold storage facilities degrade the quality of tuna. Fishermen collectively owning cold storage facilities can improve the quality. The fishermen can keep their catch and maintain the quality of the tuna, which affects the low purchase price received from the tuna processing plant. This shows how strategically driven investments may mitigate risk. Freezing tuna provides the option of buffering the supply since it is possible to store the frozen fish. Such investments, however, are hampered by the inadequate electricity supply, including the occurrence of power cuts. Preventive actions are possible through increasing the supply of electricity or considering power generation from other sources, such as solar or other power sources. This also implies that the Government plays a contextual role in the strategic development of risk mitigation. Investing in cold storage facilities is of little use if the operation of these facilities is prone to risk associated with an unstable and limited power supply. To mitigate the risk involved in the processing of tuna, it is also necessary to train the human resources in tuna companies and improve the quality of the product. This is associated with the decision-making at sorts and should minimize the occurrence of human errors in processing. The quality of service and flight connectivity also sets constrains on the distribution of both fresh tuna and processed tuna products. International flights are not always available, causing products to wait in the existing schedule. Providing a refrigerated vehicle that better preserves the quality of fresh tuna during transportation can improve its distribution.

## Conclusion

This study considers risk management at the inter-organizational network level. It projects two levels of risk mitigation: 1) strategic and 2) operational. The preceding discussion evokes how these levels are layered and intertwined. The study proposes an approach to mitigating risk that involves the strategic use of a traceability system to mitigate risk at the operational level in line with this understanding. The analysis shows how actors may mitigate some risks through investment in better facilities used in the flow of goods. The main contribution of this study, however, lies in the provision of a foundation for further studies essentially associated with developing a traceability system as a core feature of any information system used in long-linked goods supply as pathway to risk management. This means that the way in which traceability systems are designed to accommodate information concerning the past, present and future states of goods encompasses risk mitigation. It also implies the need for case studies of the strategic development of traceability systems designed to provide food product traceability functionality and to encompass a wider range of supply chain functionalities predominately associated with the flow of foods as well as marketing. This includes further investigation directed towards evoking the nature of actors' perceptions associated with the operational-level risks related to individual sorts in the studied supply network. Sorts are sequentially organized, and studying the potential domino effect of risk perceptions may account for how different actors more or less seamlessly communicate product information to mitigate risk or carry out some form of crisis management when product discrepancies or other problematic events occur. Studies may also consider information instruments integrating different sorts within and between firms in further detail. This implies a focus on information technology and its use to integrate the supply chain and thereby mitigate risk through the development of efficiencies at sorts.

Further studies may also elaborate on the understanding of risk management as collective action at the strategic level to determine how the supply network can better facilitate agile supply operations through the development of an enhanced traceability system. The decision-making events directing the flow of tuna, for example, the sorts in a transvection, should be focal in developing strategic risk management tools. This involves developing competence in using reciprocal interdependencies and pooling resources as well as interconnecting sorts. People must improve their ability to exchange information through an enhanced traceability system that is not limited to registering product history information. Finally, future studies should elaborate the role of risk perceptions, how actors communicate and perceive risk agents at sorts as well as how the environment and networked interests challenge this perception and influence the quality of risk mitigation. It is no longer a *true* "traceability system" but a wider supply chain management system configured upon the fundamental logic of a traceability system: that is, identifying and registering the transformation of goods. The difference is that the informational focus is not limited to the past but encompasses the present (whenever that is) and predictions about the future state of goods, in which a marketing perspective encompasses the goods to be dispatched.

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