Identification and Evaluation of Risks in Supply Chain of Milk (A Case Study)

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Abstract: The purpose of present research was to identify and analyze the potential risks in the milk supply chain network by using the Failure Mode, Effects and Critically Analysis approach during 2016 until 2018. The criteria of severity, the probability of occurrence and the severity of the diagnosis were used to assess these risks. The research findings showed that the most important risks belong to sub-systems of ranchers and then milk processing factories. Main risks were prioritized and addressed that needed to focus and employing different risk management strategies to improve the performance of the chain. Government policies fluctuations related to producers was determined as the most important negative risks of the whole chain. Potential impacts of main risks have been identified in the form of impact on costs, quality, and production. Seasonal fluctuations in supply and demand, the elimination of production subsidies, the ineffectiveness of the pricing, the dependence of production on subsidized government was the potential causes of the main risks in the studied chain.

Keywords: Milk supply chain, Risk Management, Failure Mode, Effects and Critically Analysis (FMECA)

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This paper is a part of PhD thesis findings to use and combining with agent based simulation method for designing favorable model of milk supply chain in a cities of Iran (Zahedan city).

1 Introduction

Supply chain can be defined as a network of the autonomous organizations such as suppliers, producers, distributors, and retailers through which the raw materials are supplied, changed, and delivered to the customers. The purpose of supply chain is developing agility and independence as well as group cooperation of the companies so that the overall costs can be reduced and their competitiveness in the market is increased in such a way that the product delivery time is reduced, agility and flexibility for meeting the customer demands is increased, and the costs are minimized (Christopher 2000; Fox et al. 2000; Fang and Chen 2005; Swaminathan et al. 1998; Iannone et al. 2007). Like any complex network, a supply chain is subject to a wide variety of risks that can result in significant economic losses and negative impacts in terms of image and prestige for companies (Mzougui, 2020)**.** Risk is generally understood as a negative impact on the objectives of a company that is associated with disadvantages, damages, and losses (Ali and Shukran, 2016). According to the definition of the project management association, the risk occurs as an uncertain event or a collection of the conditions and influences achievement of one or more organizational goals (Project management association, UK, 2004). A comprehensive quantification of supply chain risk sources will assist supply chain professionals to evaluate and priorities them because it will eventually lead to risk transfer, financing, and mitigation strategies (Alora and Barua,, 2019). Some of researchers classifies the risks into five categories: (1) Demand, (2) supply, (3) regulatory, legal, and bureaucratic; (4) infrastructure, and (5) critical (Mital et al., 2018). In relation to risk, there are two main types of concern: The need for creating values on the one hand and protection on the other (Aven, 2019). Supply chain management without consideration of the risk and its outcomes in a systematic perspective and their impact on the chain performance criteria leads to inefficient results and inconsistent processes (Tuncel and Alpan 2010). Identification of potential sources of risk and implementation of appropriate strategies to reduce vulnerability to them, through concerted actions among the chain's members is known as supply chain risk management (SCRM) (Kamalahmadi and Parast, 2016). Like all processes, supply chain risk management has steps to be followed. Various authors, such as Pfohl et al. (2010), Li (2012), Rangel et al. (2014), Guo (2011), Norman and Janson (2004) and Keren et al. (2012) have described a process consisting of four steps: identification, evaluation, mitigation and control (Dias et al. 2020).

The first step is risk identification. risk identification is the process of determining and specifying the events that if occur can negatively or positively influence the chain goals.

The second step includes the risk evaluation process, which refers to the risk taking probabilities of the events in the chain and determining effects of these events specified in the previous step.

The risk management measures are implemented in the third step. This step is the process of planning for responding to risks with the aim of selecting a set of actions that can reduce exposure to risks with minimal cost.

Finally, the fourth step is monitoring risk, where the system is monitored to identify risks when it occurs, and in other words, it is the step of the ongoing process of implementing risk response programs, tracking and following-up the known risks, monitoring the remaining risks, identifying new risks, and assessing the effectiveness of the risk process throughout the chain.

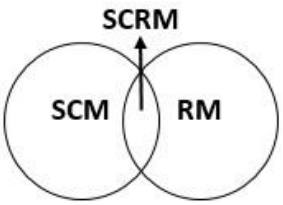

Figure 1. Relationship between SCRM, SCM and

Figure (1) indicates supply chain risk management relationship with supply chain management Spread of activities of supply chains for fresh agricultural products makes these networks more vulnerable to various negative risks so that the decision makers and actors in these chains are forced to understand, evaluate, and adopt appropriate strategies for coping or reducing financial and social effects of these risks. Therefore, identification and proper analysis of the risks is inevitable for success of supply chain networks to achieve their goals and guarantee the success and peace of the business actors or at least for warning and awareness of them against the potential problems and events. Food supply chains have special characteristics compared to other chains. The main difference between food supply chain and other supply chains is constant change in the quality of the food products over the chain. It is specifically very important for supply chain of fresh products such as milk, so that special considerations are needed in terms of product health (in terms of microbial load) and product quality (dry material weight and fat percentage). In addition, growing demand for such products in statistics of agriculture ministry in different countries has been supported, which indicates demand for fresh products including milk and dairy, vegetable, and like that has been considerably increased compared to other traditional products. Hence, it is necessary to specifically study this area. Overall, here are two types of supply chain for agricultural and food products. One supply chain is for fresh products such as raw milk, fresh vegetables, flowers and fruits, and the other supply chain is for processed food products, such as canned products, dessert products, processed dairy products, and so on. This research focuses on the supply chain of fresh agricultural products, and in particular on the supply chain of raw milk.

Milk is the only food that alone can provide for the specified age all the requirements for the growth and maintenance of the living organism. That is why milk is said to be the most complete food of nature. Even if just the economic issues are taken into account, the milk is among the limited products that if the government provides subsidiary for it and all people adequately consume it, then, the profit resulting from the workload and drug consumption reduction and treatment costs decrease simply justify the subsidiary provision (Ehsani, 1997). Now that more than ever the domestic and international trade of milk and its products has flourished, if the supply chain performance problems, such as risks associated with this chain cannot be managed, a fair share in domestic and export market of these products, as well as the optimal use of this product will not be realized.

Sistan and Baluchestan province is the largest province in the south east of Iran, where the agricultural and livestock sector is one of the most important economic sectors. More importantly, due to its proximity to the countries of Afghanistan and Pakistan, as well as the countries of the Indian Ocean, it provides a very good opportunity for supplying the purchase market for the inputs and sales of products. Other specific conditions of the province include the warm and dry climate, high rates of unemployment and poverty, low per capita income and the unjust distribution of wealth in it. Stockbreeding is common in four ways of industrial semi-industrial, rural, and nomadic in the province. The province's performance level in the province's milk production is ranked twenty-nine in comparison with other provinces of the country. Zahedan city as the capital city of the province with population of 622,855 is the most populous city of the province, which is geographically located in the center of the province. Comparison of milk production, consumption need, and daily shortage at the province and city level (Diagram.1) and seasonal milk production trend in the province (Diagram.2) suggests that consumption need of Zahedan city is 67,268 tons based on average national consumption of 108 kg per year. According to the amount of milk produced in the city, 39297 tons of production deficit is estimated (the deficit of physical balance of milk in the whole province is estimated as 161882 tons), although according to the estimates, per capita consumption of milk in the region

is lower than 50 kg per year (Annual Report of Sistan and Baluchestan Province Agricultural Organization, 2019).

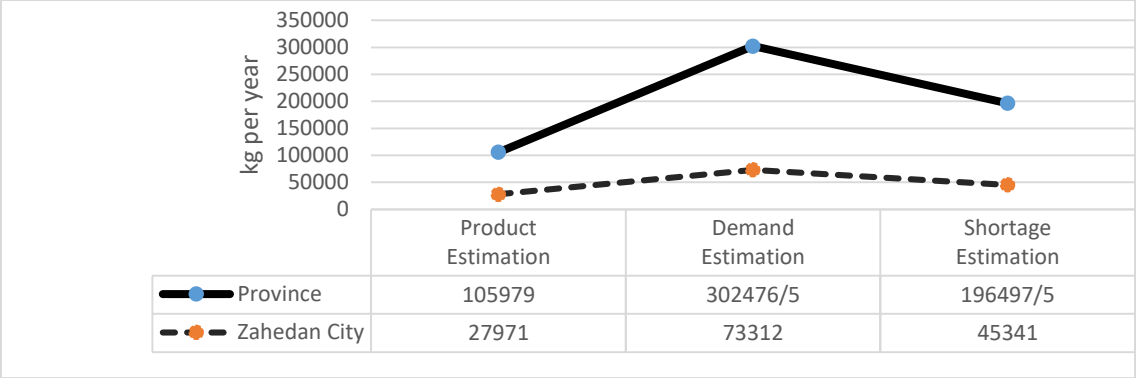

Diagram 1. Comparison of milk production level (first point), consumption need (middle point) and daily shortage (end point) at province and city level

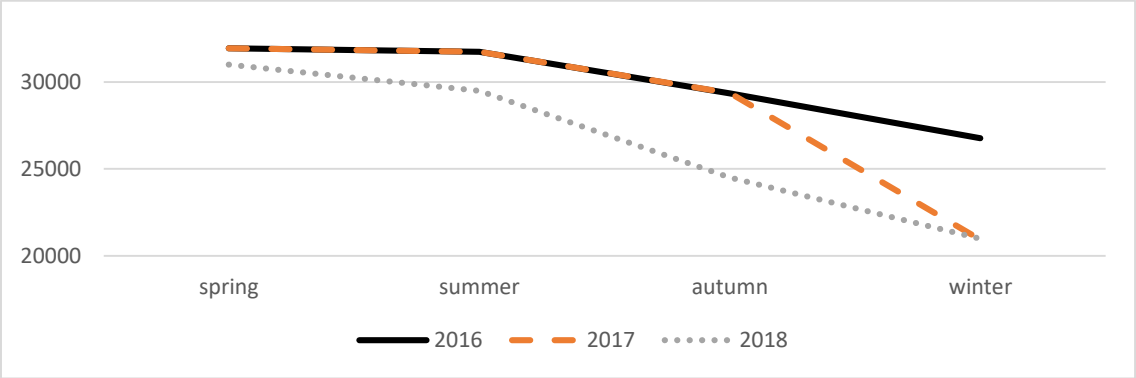

Diagram 2. Seasonal milk production trend in province during 2016– 2018

A review of the research literature suggests that while food supply chain risk management has been rapidly evolving across global research areas, the common characteristics used to prioritize risks have been the subject of critique and controversy among researchers in the field. In addition, various and complexity risk management practices and related tools have been developed and are generally based on two concepts of probability and effect that have been evaluated by different approaches of quantitative or qualitative. Research over the past eleven years in three key areas of the supply chain, including distribution management (DM), risk management (RM), and decision-making strategies was investigated by Mor et al. (2018). Ho et al. (2015) develop a review of the literature on supply chain risk management, agreeing on the variables of analysis for risk assessment. Zavala et al. (2020) analyze the main techniques for risk assessment and propose rating scales such as the probability-impact matrix. The risk factors in the company of Pegah Industrial Company were determined and their impacts were analyzed in a study by Raissi et al. (2014) which was titled "Identifying and Ranking Dangers in Supply Chain of Dairy Products Using Structural Equation Modeling", in order to avoid risks by providing preventive policies. Their findings indicated that the risks associated with suppliers were more important than the rest. The probability and the effect of the risks in a study by Zubair et al. (2015) entitled "Identifying and Assessing Supply Chain Risks associated with Dairy Products" was ranked through the completion of the questionnaire. The risks were classified into severe, moderate, and weak levels with the help of the 2 * 2 (Slotted) Risk Matrix Risks of competition, diseases, terroristic attacks, quality of raw materials, natural disasters were identified as severe risks that were necessary for dairy industry stakeholders to reduce them.

The risks of supply chain of services with the theoretical approach to the Rough Collection were evaluated in a case study by Sadeghi Moghadam et al. (2018) about companies which are payment service providers to banks. The researchers used two methods of focus group and Q-CERT to identify the risks in their studied supply chain, its output was to identify 10 components of the most important risks as situational characteristics in Rough modeling. Curkovic et al. (2013) underline that analyses performed by methodologies such as Failure Mode and Effect Analysis (FMEA) and Failure Modes, Effects and Criticality Analysis (FMECA), provide substantial benefits in evaluating risks, globally improving the performance level of a supply chain. Tuncel et al. (2010) in their case study on an electric device production unit identified and evaluated risks in this industry using FMECA method, and then they combined this technique with Petri Net time models in order to assess adjustment measures of risk management in the chain under study. Tang et al. (2019) in an article entitled "Risk Identification and Quantitative Evaluation Method for Asset Integrity Management of Offshore Platform Equipment and Facilities", combined a model with the advantages and shortcomings of the conventional FMECA, then this method that named (SFMECA) was put forward to achieve the risk identification and evaluation for the equipment and facilities on offshore platform. Mzougui et al. (2020) investigated Supply Chain Risks assessment and compiled a comprehensive list of specific risks related to the automotive industry to extend the set of most commonly considered risks and also proposed an alternative way of calculating the Risk Priority Number (RPN) within the FMECA framework by means of an integrated Multi-Criteria Decision-Making (MCDM) approach. For a more detailed review of the literature one may refer to Ho et al. (2015).

The structure of the supply chain studied as a network at three upstream, middle stream and downstream levels includes seven subsystems as described in Figure 1. Sub-systems include: 1. Primary input suppliers. 2. Producers (including traditional and industrial ranchers), 3. Milk collection centers, 4. Processing and packaging factories (including industrial factories and traditional factories), 5. Retailers, 6. Final consumers, 7. Internal (from supplier to producer) and external (from producer to consumer) transporters. These subsystems are an example of a classical supply chain, and milk producers have been considered as the focal point of decision making in the chain.

A: The main activities of the upstream supply chain include: Purchase and reception of primary agricultural inputs, production of stock feed (forage), product sales as production inputs and receiving money, storage and maintenance, transportation, inventory management, receiving information from the middle level.

B: The main activities of the middle chain include: Source finding and supplier selection, purchase and reception of primary livestock inputs, conversion of inputs purchased from suppliers to outputs from the time when the raw material enters the organization until the final product moves to the outside of the organization (product production), transportation of inputs, input and product quality control, payment to the supplier, collection, processing, packaging, storage and maintenance of inputs, receipt of funds from distribution and customer centers, inventory management, receipt of information from the downstream level.

C: The main activities of downstream supply chain includes all processes involved in the product distribution and delivery to the end customers. The activities include purchase of product from producers and processors, inventory management, product sale, maintenance, transportation, and receipt of funds from the customer, receiving information from consumer.

In Figure (2) only the major stakeholders of milk supply chain in the region are considered. Other stakeholders such as the capital producers, producers of stock breeding systems and so, are not considered for simplicity modeling and analyzing the chain network. Raw materials are supplied

by suppliers S1, S2, and S3, respectively, and they are delivered to the traditional stockbreeders D1, and industrial stockbreeders D2 by corresponding transporters. When the raw materials are given to the (traditional and industrial) producers, the milk product is produced during an uncertain period of time (usually 9-10 months from an 11- month activity period). The qualitative and quantitative amount of milk production varies depending on the season, the length of the day, the livestock breed, the age of the livestock, the type of stock breeding (traditional or industrial), the stockbreeder's capacity, the feeding method, the livestock's place (the village of livestock or outside the village elsewhere in the area), way of milking, storage and collection containers, transportation, and some other factors (about 305 days are the average lactation period for each cow). After 7 months of pregnancy, about two last months the cow gets dried (lack of milk production). Following delivery, the cow is under special care for about 60 days (Open Days), and less milk is produced in this period. After production of the product in stock breeding units and processing, storing, pasteurizing, and packaging in the milk collection centers and factories, the product should be inspected and controlled in terms of quality (microbial load, fat percentage, dry matter weight). Finally, the end product is transferred to the retailers by the external transporters where the end customers can provide their needs.

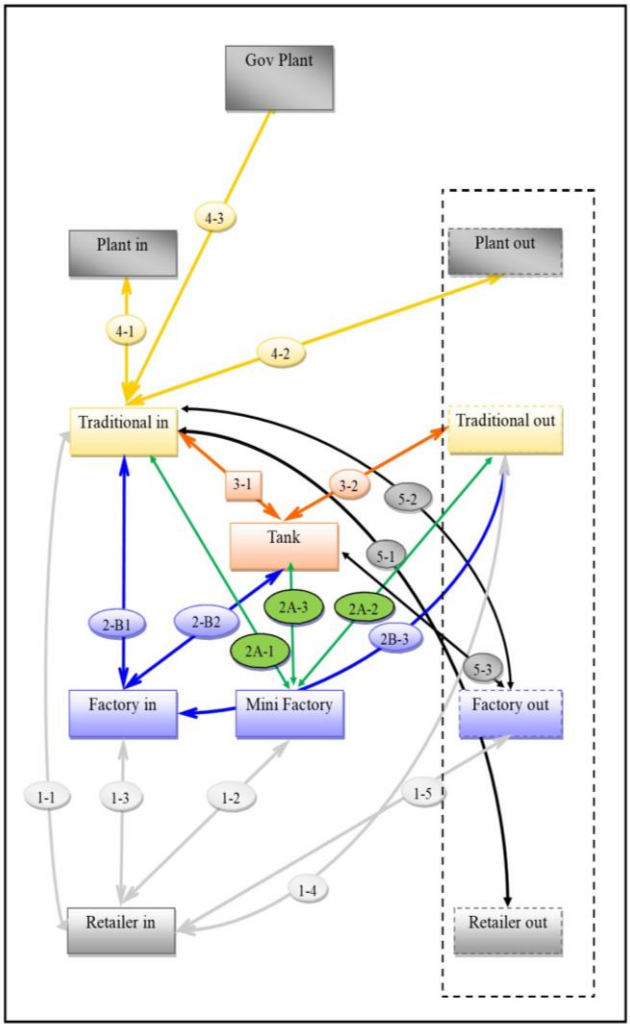

Figure 2. Overall structure of milk supply chain network in the region under study

The present study seeks to identify and analyze potential risks in the fresh supply chain network in the study area, so that by analyzing them accurately by using the FMECA technique, it is possible to anticipate and design the necessary measures to adequately address these risks and minimize their likelihood of occurrence and also, their potential impacts can be minimized.

2 Materials and Methods

In this research, FMECA technique was used as a tool for identifying and assessing the risk inherent in a supply chain network.

The FMECA is composed of two separate analyses, the Failure Mode and Effects Analysis (FMEA) and the Criticality Analysis (CA). The FMEA must be completed prior to performing the CA. (Z-BRE4K Consortium report, 2019). FMEA identifies failure modes of a product or process and their effects, while Critical Analysis ranks those failure modes in order of importance, according to failure rate and severity of failure. (Carpitella et al., 2018). One of the features of the FMECA technique is the compatibility of this method as an analysis tool with simulation modeling techniques, Petri Net and so on for assessment of the efficiency and other performance indexes of supply chains. In this method, following review of the previous studies, for identifying the major risks of milk supply chain in the region, a regular set of in-depth and

structured interviews with the experts, job managers and directors related to the chain (n = 24) was done so that primary information and data can be extracted. Following conducting the interviews and collecting data, the FMECA table is planned, then, the main analysis is done so that ranking is done based on the priority of the identified risks using Occurrence Probability (O), Severity (S), and Diagnostic Difficulty (D) criteria, and it is recognized as the Risk Priority Number (RPN). Thus, to use the Risk Priority Number (RPN) method to assess risk, the analysis team must: (1) Rate the severity of each effect of failure. (2) Rate the likelihood of occurrence for each cause of failure. (3) Rate the likelihood of prior detection for each cause of failure (i.e. the likelihood of detecting the problem before it reaches the end user or customer) (Kim and Zuo, 2018).

$$RPN_i = S_i \times O_i \times D_i \quad , \forall_i \qquad \text{equation (1)}$$

For the risk (i), the higher risk priority number denotes higher importance of the risk. Therefore, the risk priority number serves as the system analyzer or director of attention of the chain managers to the more important activities for elimination or reduction of the potential risk. In this technique, following steps are taken:

Step1. In this step, based on the field studies and interviews, each sub-system is considered as a factor of the supply chain that may be exposed to various risks.

Step2. For each factor specified in the previous step a series of related risks is considered that are identified from the interviews with the experts and chain practitioners.

Step3. The potential effects of each probable risk are determined and given in this step. The effect of each potential risk on the overall chain performance is investigated and tested systematically (econometric models), and severity (S) index is given for each related risk in a specific column of the table. The severity index (S) is used for classification of relative significance of the effects resulting from the risks. The econometric models, engineering of the expert judgments and record of the stored histories in the databases are used for determining this index.

Steps 4 and 5. The potential causes of the risks are determined in this step, and listed in the specific column in the table. In addition, using the information obtained from the statistical data sources of the previous time periods about the process such as the quality control results in the milk factories, veterinary organization laboratories, laboratories of the food and drug deputy of the medical sciences universities, monthly supervisory reports of these organizations, and results of daily operation performance evaluation, the probability and likelihood is assessed and given in the respective column. Occurrence rate (rate of event occurrence (**o)**) is the estimate for the probability of occurrence and related effect.

Step6. Risk diagnosis and appropriate and possible measures for prevention of the cause and occurrence of the potential risk scenarios are determined as the diagnostic and control measures. Some measures of the process control that are listed in this step have been implemented in the past by the agents involved in the chain. They can be used for identification and diagnosis of the risks or for prevention of the risk occurrence causes. However, some other measures are the proposed control processes that can be also used for the same purpose.

Step7. In this step, feasibility of the control and diagnostic measures for identification and control of risk is evaluated so that the success probability of the determined control and diagnostic processes for diagnosis of causes of a specific potential risk or its weak points are specified. Higher rank represents weaker probability that the factor of a risk can be controlled or diagnosed. This is common for the assignment of a number from scale 1 to 10 for severity index (S), occurrence probability (O) and diagnostic difficulty (D). The higher assigned number denotes the higher importance of the risk according to the relevant index.

Step8. In the last column of the table, an important analysis is done to prioritize the identified risks. This ranking is obtained by multiplying the values of the indices (S), (O) and (D) in each other under the heading of Risk Priority Number (RPN). For a higher risk (RPN), higher (i) is much more important risk. Thus, this index helps the analyzer, the system manager determines focus of the activities for elimination, or reduction of the potential risks' effects (Tuncel and Alpan 2010).

Finally, the FMECA table will provide us with valuable information, above all, Risk Priority Number (RPN), reveals critical risks for each of the stages of the study process. Using analysis of the column resulting from the third step, the main (more important) indexes for evaluation of the system performance under different risks are specified, which can be considered as the major indexes among different indexes in the stage of simulation of different programs and scenarios reducing the risks. Steps 5-7 provide valuable information about root of the risks and possible measures (various risk management strategies), which can be applied.

3 Results and Discussion:

3.1: Prioritizing chain risk based on the importance of each subsystem

By analyzing the results from the eighth step in the table (FMECA), out of the 56 identified risks in the early stages of the research, 36 risks with higher RPN were collected in Table (1). The results of this table indicate that in the study period, the most important risks in the middle stream level of the chain belong to the subsystem of ranchers and then milk processing factories. Other risks are then related to the subsystem of retailers, milk collection centers, suppliers of primary inputs and transportation at other levels of the chain and are prioritized by the attention of chain managers who need to make the right decision in dealing with these risks. In other words, ranchers are exposed to the most significant risks while processing factories are exposed to the most risks in terms of number. As it was discussed earlier in the literature section of the research, findings from the study Raissi et al. indicated that the hazards related to the suppliers of the company of Iran milk Industries were more important than the rest of the factors. Since the suppliers of milk industries are actually ranchers and primary producers of milk, they are consistent with the outcomes of the present research. As it can be seen from the results presented in table (1), the fluctuations of government policies (including pricing, subsidies, and tariffs) against (raw and processed) milk producers and then the risk of bankruptcy and rancher withdrawal from productive activity have been one of the most important risks in the whole chain, also, the low quality of input raw milk to the processing plant, seasonal fluctuations in market demand in retail sector and milk collection centers, the shortage of initial high quality inputs (animal feed) as well as manpower errors in the transport subsystem are among the top-priority risks in the overall chain which can have a negative impact on the performance of each of the sub-systems and the overall performance of the whole chain. Therefore, the focus of risk management activities in the whole chain should be addressed to them. In terms of ranking of risks, the findings of the present study are different from the outcomes of the research conducted by Zubair et al. in Pakistan, which showed that competition, disease, terroristic attacks, raw material quality and natural disasters were the most important risks. This is to some extent due to the differences in supply chain conditions in the two studied areas.

Table1. Prioritizing chain risks based on the importance and each subsystem

Total Supply Chain Sub-systems											
Input supplier		**Rancher**		**Milk Collection Center**		**Milk processing center**		**Retailer**		**Transport**	
RPN	**Risk title**	**RPN**	**Risk title**	**RPN**	**Risk title**	**RPN**	**Risk title**	**RPN**	**Risk title**	**RPN**	**Risk title**
210	Lack of input (R01)	***448***	Fluctuations in government politics(***R21***)	280	Market demand fluctuations(R25	294	Poor quality of raw milk(R31)	294	Market demand fluctuations(R51)	210	Manpower error(R44)
180	Fluctuations in input prices(R05)	***294***	Bankruptcy and exit from activity(***R18***)	252	Fluctuations in the price of milk(R26)	245	Fluctuations in government politics(R38)	280	Plumbing and closing the unit(R54)	168	Fuel price fluctuations(R47)
175	Low quality of input(R02)	216	Manpower error(R19)	245	Poor quality of raw milk(R23)	224	Market demand fluctuations(R42	216	Rapid changes in customer expectations(R52)	147	Unexpected events(R48)
112	Reduce the level of trust and communicati on(R08)	192	Climate fluctuations and natural disasters(R20)	196	Production fluctuations and shortages(R24)	210	Fluctuations in the price of milk(R39)	180	Price fluctuations(R53)	120	Technical problems of the car(R43)
96	Climate fluctuations and natural disasters(R04	175	Foot-and-Mouth Disease(R11)	168	Problems determining the quality and price of raw milk(R22)	140	Production fluctuations and shortages(R33)	180	Loss of market share(R49)	60	Traffic congestion and road closures(R45)
60	Exchange rate fluctuations(R03)	140	Supply fluctuations (production) (R09)	144	Lack of clean water(R28)	140	Reducing the level of trust and communication with ranchers(R40)	168	Product corruption (milk cut) (R56)	30	Road failures(R46)

Source: Research findings

3.2: Potential effects of chain risks:

Based on the outcomes of the fourth step in the FMECA approach, it is observed that the potential effects of identified major risks have emerged in the form of impact on increase of costs or reduction of profit, quality, production, increase of likelihood of exit from the production activity, shortage or accumulation in inventory, bullwhip effect, disruptions in scheduling and planning activities, violations of contracts, loss of customer and market share. Therefore, these indicators can be used to evaluate the overall performance of the studied chain for the application of different risk management strategies. The results of 17 more important risks have been collected in Table (2).

Table2. Potential effects of main chain risks in terms of sub-systems

Row	Risk	**Chain** subsystem	**Potential effects**
1	R21	Rancher	Cost, Quality, Deception
2	R18	Rancher	Supply, Employment, Exit activity
3	R31	Milk processing center	cost, quality, Losing customer & market share
4	R51	Retailer	Inventory (Shortage or surplus), bullwhip effect, Scheduling and planning
5	R25	Milk Collection Center	price fluctuations, Inventory (Shortage or surplus), bullwhip effect
6	R54	Retailer	Cost, Losing customer & market share
7	R26	Milk Collection Center	cost, bullwhip effect
8	R23	Milk Collection Center	cost, quality, Losing customer & market share
9	R38	Milk Collection Center	Cost, importation, Deception
10	R42	Milk Collection Center	price fluctuations, Inventory (Shortage or surplus), bullwhip effect
11	R19	Rancher	Cost, Quality, Inventory (Shortage or surplus), Animal diseases
12	R52	Retailer	Cost
13	R39	Milk Collection Center	Cost, bullwhip effect, Scheduling and planning, Competitive capability
14	R01	Input supplier	Cost, Losing customer & market share, efficiency, delay, Breach of contracts
15	R44	Transport	Cost, delay
16	R24	Milk Collection Center	Cost, Losing customer & market share, efficiency
17	R20	Rancher	Cost, Supply, product Breach of contracts, bullwhip effect

Source: Research findings

3.3: Major causes of main chain risks and possible measures against risks

Based on the results of steps 5, 6, and 7 in the FMECA approach which have been summarized in Table (3), valuable information about the major causes of significant risks as well as possible measures against risks are provided. Causes of risk taking can be of interest to chain managers in order to identify origin of risks, thus, various risk management strategies can be applied in order to reduce the effect or probability of occurrence of risks.

Table 3. Major causes of main chain risks and possible measures for reducing the likelihood of occurrence and the effect of risks

Risk	sub-system	Potential causes	Control / Diagnostic measures
R21	Rancher	Supply and demand fluctuations, price fluctuations, Eliminating or reducing production and consumption subsidies due to government budget problems, Inefficiency of the pricing system, Focus on decisions, Unrealistic statistics, sanctions	Risk acceptance that requires long-term strategies as well as reduction of risk including: the diversification of activities and revenue sources, Creating MIS and Information Systems, Establishing strong business associations (cooperation and integration of activities in the chain), Marketing contracts, reforming pricing and decision making systems, creating input and product banks
R18	Rancher	Increasing costs and decreasing revenues, dependence on government subsidized support and eliminating subsidies from 2013 onwards, increase in deferred bank debt, low competitiveness	Avoiding risk by eliminating risk factors or termination of activity),Risk transfer (insurance),Increasing government incentive and subsidized support, boosting supply chain performance, Creating input and output banks, training, diversifying activities and revenue sources
R31	Processor	Unsafe Milk production process, improper feeding of livestock, unsafe milk storage and milking, lack of clean water for washing, animal diseases, including mastitis, environmental contamination	Avoiding Risk and Removing Causes, Holding necessary training courses, promoting investment , equipping health facilities and improving infrastructure such as water supply networks, incentive subsidies, etc.
R51	Retailer	Seasonal fluctuations, changing consumption habits	Accepting and limiting risks, diversifying activities, Innovation in sales and marketing, insurance, education, informing
R25	Collection Center	Seasonal fluctuations in demand, changing consumer habits of the community	Acceptance and limitation of risk, Improving prediction methods, alternative clients, Information sharing, advertising, R & D, training, futures and marketing contracts
R54	Retailer	Order of deputy of Food and Drug of Medical Sciences because of health issues or the outbreaks of diseases such as brucellosis	Avoiding Risk and Removing Causes, Increasing health measures, Increasing investment and upgrading equipment, Obtaining required standards, income insurance
R26	Collection Center	Seasonal fluctuations in supply and demand, lack of production, fluctuations in milk quality	Accepting and limiting risks, improving prediction methods, Alternative Clients, Information Sharing, Risk Sharing, Insurance, Product Bank

...continued table 3

Risk	sub-system	Potential causes	Control / Diagnostic measures
R23	Collection Center	Unsafe milk production process (milk storage and milking station), Inappropriate feeding of livestock, poor water supply, livestock diseases including Mastitis disease and environmental contamination	Avoiding risk and eliminating the causes, holding required training courses, promoting investment and equipping health facilities, improving infrastructure such as water supply networks, incentive subsidies, etc.
R38	Processor	Eliminating production subsidies due to government financial and budget problems of government, Lack of fair pricing system, concentration on decisions, inefficient	Acceptance and risk mitigation that requires long-term strategies (similar to R21)
R42	Processor	Seasonality of demand, the changing taste of customers	Acceptance and risk reduction, improvement of predicting methods, alternative customers, (similar to R25 and R51)
R19	Rancher	Inefficiency of manpower, lack of motivation, lack of experience or inadequate training, hard working conditions, job dissatisfaction, staff disagreements	Avoiding Risk and Removing Cause, Risk Acceptance, Training, Analysis of Work Conditions of manpower, Social and Psychological Actions, HRM
R52	Retailer	Socioeconomic status of the society and technological development, globalization	Acceptance and restriction of risk, Education, Advertising
R39	Processor	Seasonal fluctuations in supply and demand, scarcity of inputs	Acceptance and reduction of risk, improvement of predicting methods (similar to R26).
R01	Input supplier	Shortage of production, market holidays, Short durability, Whipping effect, Lack of information, monopoly, legal contracts, Natural disasters, climate change, exchange rate fluctuations.	Avoiding risk by eliminating the cause or ending the activity, promoting methods of predicting, Share information and communication between suppliers of input and milk producers
R44	Transportation	Nervous pressure on workforce, long working hours, lack of adequate training	Avoiding risk and eliminating the cause, Risk Acceptance, Training, Less Working Hours (Similar to R19)
R24	Collection Center	Lack of full capacity of the center and delivery vehicle of product to the factory, Increasing cost scales, price fluctuations, low profits, loss of market share	Avoiding risk by eliminating the cause or ending the activity, Acceptance and restriction of risk Improvement of predicting methods, investment promotion, reliable contracts with milk suppliers
R20	Rancher	Natural disasters and climate change, Human error, Prediction errors, Inappropriate infrastructure, Inefficiencies in the production and storage of inputs and products	Transfer of risk (insurance), acceptance and restriction of risk, Increasing government subsidized support for generating and providing inputs, Creating input and output banks, improving infrastructure, upgrading the production chain

Source: Research findings

As it can be seen in Table (3), the seasonal fluctuations in supply and demand of milk in the region, elimination or reduction of production subsidies, the ineffectiveness of the pricing and decision making system, the dependence of production on government subsidies and the low competitiveness of milk producers and processing factories were among the potential causes of the main risks of the studied chain. Diversification in activities and income sources has been one of the commonplace measures in the region to deal with the risks and origins of them. The studies have shown that the chain performance in the region can be improved by adopting appropriate strategies, including formal and legal tools such as the use of marketing and future contracts, as well as local tools.

4 Conclusion and Recommendations

Given the wide range of activities in the supply chain of fresh food such as milk, these networks are increasingly exposed to a variety of negative risks in such a way that decision makers and those who are active in business in these chains have to recognize and assess the risks, the effects and causes of their occurrence, and the adoption of appropriate solutions for coping or reducing the negative financial and social impact of these risks and their likelihood of occurrence. As it was previously mentioned, the present study uses the FMECA approach, which can be combined with simulation techniques, to identify the potential risks in the supply chain of milk in Zahedan. Therefore, prioritizing the risks was done considering the three criteria of severity, the probability of occurrence and the difficulty of diagnosis. The most significant risks were determined in the three upper, middle and lower levels of chain and among the subsystems of the chain to attract the attention of chain managers in order to improve the efficiency and overall performance of the chain to these major risks.

According to the analysis of the results, since the activities of milk production and distribution are inherently accompanied by some of the inevitable risks (environmental and out of chain risks, be accepted by those who are involved in chain and the activity should continue with these types of risks. Short-term operational measures cannot be successful in confronting them, except that it limits their such as market regulation policies of government, natural disasters and climate fluctuations), these kinds of risks have to effect to some extent. Instead, this type of risks which is often referred to as risks outside the chain, requires long-term strategies and large investments in improving the infrastructure. Some risks can also be avoided by eliminating the cause of their occurrence with taking appropriate measures or the impact of risks can be limited to the minimum and the severity of their occurrence can be diminished. Among these risks, it can be referred to risk of low quality of raw milk, lack of forage and product inputs, livestock diseases, human errors, seasonal fluctuations in production of raw milk and the risk of bankruptcy. However, with regard to important risks such as rancher bankruptcy, in case the causes of the risk cannot be eliminated, it is logical to stop continuation of activity in the previous manner. It is important to note the significance of difference between the risks of R21 and R38 (fluctuations of government policies in the sub-system of ranchers and milk processing factories in the region respectively). Comparing these two shows that the risks with same name have a more damaging effect on the sub- system of raw milk producers in comparison with the sub-system of milk processing units in the region which suggests a greater vulnerability in this segment at the upstream level of the chain. It is essential that policy makers, make the necessary predictions on motivational and compensatory payments in the production, processing and consumption sectors in the five-year development plans and annual budget laws in the region in addition to modification of the pricing system and milk market regulation programs, by considering the importance of producing and consuming the mentioned product in the country, especially the deprived and vulnerable regions such as the studied region in this research in order to provide.

better conditions for producing, distributing, increasing product quality and its consumption, as well as reducing the negative effects of seasonal fluctuations in supplying and demanding in the region.
In addition to government, incentive and supportive payments to high levels of the chain it can also be allocated from large processing factories, as well as the systematic retail chain at the bottom of the chain. Since in most of the subsystems of the chain, price fluctuations, demand and production have been accounted as very important risks, it is suggested that data, price information and markets are collected and updated by creating a comprehensive marketing information system (MIS). Moreover, it is recommended that information is provided for various chain-linked sub-sections through mass media and social networks to control and limit the effects of these risks. In addition, it is proposed to provide an insurance basket for the entire milk supply chain in the region so that a range of low, moderate and high risks is incorporated. Creating large-scale tanks and warehouses is recommended for livestock inputs in the area so that they are stored in seasons with surplus inputs while they are used in the seasons which are required. Finally, as it was mentioned earlier that the consumption of this product plays an important role in the health of different parts of the community and also due to production of milk because of potential of the region which has a significant role in employment, added value and increased incomes of the people of the region, it is essential to modify the pricing system and motivational as well as subsidized payments in a dynamic and efficient way so that The negative effects of inefficient and destructive policies can be prevented on the various stakeholders involved in the chain and the promotion of the overall performance of this product as well as fair distribution of income and risks among the various stakeholders in the region can be observed by taking into account the increase in the efficiency of the whole chain instead of an isolated and part-oriented view.

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