

Dairy Business Sustainability, Market Risk Management Resilience and Stability Strategies

Kheiry Hassan M. Ishag

Canadian Marketing and Business Consultant, Calgary, Canada

Email: kheiryishag@hotmail.com

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Abstract

The dairy business and industry in Oman grapples with complex challenges, from wavering milk prices and escalating input costs to ever-shifting market dynamics; all factors that can significantly impact business profitability and stability. The supply chain disruption due to COVID-19 pandemic and regional market system resistance was also investigated. Dairy business must, therefore, implement potent strategies to enhance cash flow and safeguard financial viability and move to market system resilience. This article delves into key methods designed to analyze dairy business risk assessment and market dynamic channelings and efficiency to boost profits in dairy operations and improve cash flow management. The study applied Stochastic Monte Carlo Simulation Budget and scenarios approach to calculate market risk premium and reform market strategies and align them with acceptable risk tolerance comfort level of the stakeholders' perceptions. Three production levels, products mix models, were tested under two different scenarios to verify coronavirus impact and to measure market risk and corporate system resilience. The net profit probability distribution skewed to the left for all models in the study and 5% net profit probability distribution of Country sale shift from RO (318k) loss in year 2020 to RO 230k profit in 2023. The analysis shown that Country sale has resilience ecosystem recovery although coronavirus crisis results in a complete lockdown continued for 10 months in 2020 and could achieved stability in year 2023. The cumulated distribution function (CDF) graph was constructed to quantify market risk and indicate the range and shape of profit probabilities distribution for six different production volumes and marketing alternatives. The stochastic efficiency with respect to a function (SERF) analysis used to calculate certain equivalent (CE) figures to rank alternative market's scenarios under uncertain situations. The analysis showed dairy business net profits in 2023 are sustainable alternatives than COVID-19

year in 2020, and Factory Area are better and stable market region than Capital Area. Tornado sensitivity analysis showed that products unit cost, followed by regional market demand and market incentives, are highly sensitive to profit in integrated complex system. Quadrant analysis was performed to understand dairy products market shares and market growth potential and accordingly management could develop comprehensive market strategies to achieve business objectives. The risk premium value for total Country sales in 2020 and 2023 recorded a CE of RO 707,490 for risk neutral decision makers and reduced to RO 443,459 for extreme risk averse decision makers. The Factory Area market risk premium value for year 2020 and 2023 record CE of RO 258,785 for risk averse decision maker and increased to 396,253 for extreme risk averse decision maker and confirmed Factory Area as a market system resilience. Stop Light chart for lower and upper target net profit value constructed to rank dairy market efficiency. The total country business achieves 98% profit above upper target profit RO 100 thousand after supply chain disruption settlement compared to 29% during COVID-19 period. The analysis showed total country sales achieved consistent and reliable financial sustainability and market recovery efficiency and system resilience capacities. In addition to finance and operations risk management, the corporate should include resilience in the central of organization strategic process and move from risk reporting to more advanced foresight capabilities and adopt comprehensive strategic prospective to meet challenges of next disruption over the horizon. Understanding risk statistical measures is essential for making informed decisions in dairy business and risk management, as they provide insights into the behavior of profit distributions and the associated risks.

Keywords

Dairy Market Volatility Risk, Stochastic Efficient with Respect to Function (SERF), Certain Equivalent (CE), Market Risk Premium Analysis, Monte Carlo Simulation, Absolute Risk Aversion Coefficients (ARAC), Profit Sustainability, Ecosystem Resilience and Stability, Risk Tolerance

1. Introduction

This template, Dairy industry now a days face a lot of challenges in operation, supply chain disruption and marketing dynamics challenges. Oman's dairy industry depends on feed material, machinery and medicine import from outside and any supply chain disruption impact operation efficiency. The dairy market in Oman characterized by high demand for quality dairy products and estimated by 268,182 tons derived by steady population growth, high income and changing in dietary preference. The dairy sector in Sultanate of Oman produced 236,000 tons in year 2023 compared to 224,000 tons in year 2022 with annual growth 5.4%, as per MAFWR report 2023, [1]. Dairy farms feed the cows with high cost of feed concentrates made from raw material, premix and vitamins imported from outside and imposed to price variation and cost increased due to shift from bulk to

container shipping during COVID-19 crisis. Dairy business encompasses various critical stages such as farm operation, supply chain disruption, milk processing units, cold transportation and long route market distribution channels and retail which had been interrupted. Dairy products and their derivatives are perishable and require strict storage conditions and efficient distribution network management. The short shelf life of fresh milk products with (5 - 7) days expiry is one of main challenges in dairy business and increase unit cost during COVID-19. This type of business is exposed to risk and creates low net profit as main raw materials and technologies imported from outside and exposed to high capital cost, supply chain disruptions, operation constraints and sale price uncertainties. Moreover, marketing challenges and cheap dairy products imported from different continents and sold at low prices create high pressure for dairy business economic sustainability. The dairy unit cost increase, market dynamic and uncertainty, and sale revenue volatility remain challenging and jeopardize dairy business to achieve sustainable growth.

The adaptation of the new dairy I5.0 technology is a promising opportunity. Malik, M. *et al.* 2025, [2] outlines operational efficiency, productivity, animal health and product quality, sustainability and environmental impact are the main tools to achieve business sustainability. This study revealed that operation efficiency and productivity are the main significant factors impact on adoption of the new I5.0 technology. In addition to I5.0 technology adaptations and practices the Country face supply chain disruption due to COVID-19 crisis. The global supply chain disruption started in early 2020 and complete lock-down in most of the countries including Oman experienced by the first half of 2020. Moreover, international situation and Ukraine Russian conflict increased feed raw material price and impact on food security, as highlighted by Christiana Ukaoha, 2023, [3]; Kheiry Ishag 2024 [4] and Ben Hassen, *et al.* 2025, [5]. Market volatility and uncertainty factors and risk parameters in dairy business are the main challenges for business owner to make informed and good decisions and need to be analyzed, said Danilo Simões *et al.* 2014, [6]. Dairy farming at costal area of Sultanate of Oman uses colling systems in summertime to avoid heat stress problems and farm net profit reduction. Although new control houses reduced mortality rates in summertime, cow daily milking yields decreased and feed consumption inefficiency are still observed and created marketing challenges, (Kheiry Ishag 2020 [7]; Chen L. *et al.* 2024, [8]) investigated heat stress effect on decreased dry mater intake, energy corrected milk, and milk protein concentration, and reveal significant association of these factors with increasing temperature humidity index (THI). He calls for the implementation of mitigation strategies in heat-stressed herds due to the substantial decrease in productivity. Regional market risk in terms of products consumption preference in various regions, complicated distribution routes network, promotion, and per capita consumption for each region incorporated in study models as alternative risk scenarios.

This study investigated dairy yield volatility risk and its effect on market demand and business net profit by using Monte Carlo Simulation analysis. Although

it is not possible to predict future accurately, simulations analysis allows us to create risk profiles by generating a large number of iterations, including extreme scenario cases, such study allow us to identify the effects of marketing and unit cost factors variation on dairy business profitability in term of probabilistic way, (Albright and Winston, 2019, [9]; Lehman and Groenendaal, 2020, [10]). With the right strategy, tools and approach, businesses can turn what appears to be a poor dairy market situation into greater profitability and improve market positioning in the long term.

Supply chain disruption is one of dairy business risk assessment factors identified in this study to understand the impact of global and macroeconomic uncertainty on business production volume level and products sale price. The marketing uncertain incorporated in this study by using cumulative distribution function (CDF) to test effect of market sales and quantify risk and uncertainty on profit, Lima, R., Sampaio, R. 2018, [11]. The market demand for each product mix i.e. fresh milk, flavor milk, Laban and yoghurt products and sale price discount for promotion were also incorporated in the study. The risk of poor technical practices performance and marketing parameters volatility required strategic decision that covers production and marketing risk and constraints, Chavas *et al.* 2004, [12]. The study calculated risk premium that compensates for poor dairy business and market uncertainties and estimates extra return to investors over risk free business cash flow and quantified risk premium for different marketing strategies. The Monte Carlo Simulation models are used as a tool to quantify risk and uncertainty of the related business by many studies (Luiz Silva *et al.*, 2014, [13]; Gray E. Machlis, *et al.* 1990, [14]; Niloufar M. *et al.* 2024, [15]).

Dynamic models give a range of results that can mitigate and reduce operation risk and sale revenue decline impacts through a range of uncertain inputs estimate and generate accurate results for policy advisers and decision makers. The study used stochastic efficiency analysis to rank dairy business scenarios under different production level and marketing constrain over a range of absolute risk aversion coefficient level. Hardaker *et al.* 2004a, [16] structured and used technique of stochastic efficiency with respect to a function (SERF) to rank risk alternatives options models. Gregory K. *et al.* 2012, [17] also used (SERF) to appraise modified genetic maize crop in South Africa. Mohammad K. *et al.* 2014, [18] used (SERF) to rank different beef calving and feeding practices in western Canada. Kheiry Ishag 2019, [19], used (SERF) and CE figures to rank poultry farming systems and feeding practices strategies according to feeding cost and feed availability. Stochastic efficiency with respect to function (SERF) technique consists of ranking risky alternatives in terms of utility function and equal ranking of alternatives with (CE) certainty equivalent figures. The certainty equivalent (CE) is explained as the sure sum of return or wealth at present rather than unsure of the high return in future. Hardaker *et al.*, 2004b, [20] argued (SERF) rank risky alternatives in terms of (CE) for a defined range of risk aversion simultaneously and not pairwise as in (SDRF). Irene Tzouramani *et al.* 2011, [21] used stochastic efficiency with respect to func-

tion (SERF) to test the economic viability of organic and conventional sheep farming in Greece and found both sheep farming systems are viable. The (SERF) also used to compare and rank alternatives at level of decision maker preferences for different absolute risk aversion coefficient (ARAC), Richardson J. W. *et al.* 2008, [22]; Khakbazan, M. *et al.* 2022, [23] use SERF and certain equitant (CE) figures to rank silage-based feed diet and cattle breeding efficiency for beef backgrounding steers. Risk analysis of agriculture production systems investigated by using stochastic efficiency with respect to function (SERF) in many studies, Lien G., *et al.* 2007, [24]; Ascough II. J. C. *et al.* 2009, [25], and Eihab M. Fathelrahman *et al.* 2011, [26]. The (SERF) technique used in study to assess dairy business sustainability of different marketing strategies models. Six stochastic models were worked out to represent net profit distribution function for each marketing alternative model. Risk premium (RP) analysis performed to measure excess return required by decision makers to compensate change and shift from market risk-free profit to potential uncertain future market return. The study identified dairy marketing alternative strategies according to risk-efficient profit and verified models' sustainability.

Dairy business entrepreneurship is inherently filled with risks and uncertainties. However, successful risk-takers possess a unique combination of characteristics that enable them to navigate dairy business challenges effectively by cultivating resilience system, adaptability, strong vision, optimism, a willingness to learn, decisiveness, and strong networking skills, entrepreneurs can position themselves for success in an ever-changing landscape, Baler S. 2024, [27]. Management by embracing these traits not only enhances their ability to take calculated risks but also contributes to sustainable business growth and increase resilience capacities. Using advanced technologies to control and monitor market adaptability and evaluate supply chain risk management addressed by many studies (Yangxuan Liu *et al.*, 2017, [28]; Cecilia Nginga Da C. Miranda 2025 *et al.*, [29]; Armijal, W A Marlina *et al.*, 2023, [30]; Rimhanen, K., 2023 [31]).

2. Methodology

The dairy business net profit is calculated to quantify the economic performance of alternative production level and product mix scenarios that achieve business sustainability. The conventional normal approach used in business evaluation to calculate the best estimate available data for cost and revenue for each dairy products level, regional demand and production mix don't consider business risk. The single value of net profit generated by conventional methods doesn't reflect risk of cost of production, sale product volume and market demand uncertainty. It doesn't also reflect regional market demand environment risk in terms of market segmentation and range of products sold with different prices and products volume sold due to COVID-19 crisis supply chain disruption. The (Weibull) distribution is used to test dairy market risk in terms of volatility and products quality rejection and supply chain disruptions. The (Weibull) distribution is tested by

(Bestfit) function in @Risk 8.7 program. Dairy business in this study was exposed to a significant loss due to sale volume and revenue decreased and considerable regional market risk and uncertainty. Price volatility, regional changing demand for dairy products and factory locationbased alternative incorporated in study models. A mixed research method was employed to gather data from primary and secondary sources and form stochastic budgeting models. Accordingly, the model was constructed to estimate a range of unit dairy product cost, sale volume decline and market demand parameters risk and quantify marketing uncertainty and its effect on dairy business net profit. The Factory Area population is 462 k with uncomplicated route network distribution whereas Capital Area population 1,703 K with complicated consumer preference and channels distribution. The dynamic simulation model-based probability distribution functions of net profit are used to evaluate risk volatility and economic sustainability and to compare different market segmentations, products volume, product mix and discount given for each dairy product to increase net profit and achieve business sustainability. Simulation probability distribution function model built for different regions i.e. Factory Area and Capital Area and total country sales and profit to test consumer preference, dynamic demand and products mix impact on profit. The stochastic budgeting and stochastic efficiency methods are used to consider operation and market risk and uncertainty variables in the model presented in study area. Technical farming practices such as water and land resources intensive, feed efficiency, cow yield, and its impact on products production level, market share and market growth were also investigated in this study.

2.1. Products Cost and Marketing Data

The dairy business data used in this study is collected from primary and secondary sources and X Dairy Company in Sultanate of Oman. The stochastic budgeting data includes production level, product mix combination and market sale revenue for country sales, Factory Area and Capital Area (regional market demand). Cost of production data and marketing data are also collected to calculate net profit and test operation performance efficiency under different market scenarios. The sale of fresh milk, Laban, yoghurt and juices products has a significant impact on market demand and business profit. The demand shift to high quality products is a good opportunity for dairy business in Oman if management could meet regional market specifications and satisfy crucial factors to achieve market potential demands. These factors were studied to understand dairy farm operation efficiency parameters and thereby enhance customer satisfaction and business sustainability.

Understanding historical companies' market share and market potential demand will also help decision makers to optimize business performance. The market demands parameters such as customer products preferences, market share and market growth data were collected and analyzed by using scatter plot analysis. The Market demand is not fixed, but changes over time and across different market

segmentation and it represents the maximum potential sales that company can achieve in the market. The impact of coronavirus which reached Oman on 24 February 2020, and complete lockdown were imposed by June 2020 were evaluated by using (Weibull distribution) in the model to calculate business net profit for three regions i.e. total country sale, Factory Area and Capital Area during and after coronavirus crisis.

2.2. Net Profit Multiple Simulation Models

The Net profit was used as an economic performance indicator for all country sales, Factory Area and Capital Area sales. The uncertain parameters such as product price and cost, production level, sale revenue, incorporated in the model to calculate margin and business net profit. The net profit calculated by subtracting the total cost of products from the total sale revenue to obtain simulated business net profit probability distribution. The model used two-sided Weibull distribution for forecasting extreme loss at the tail end and conditional Value at Risk business profit forecasting, prior to as well as during and after the recent COVID-19 crisis. Two different scenarios are used, and each scenario has three product volumes and product mix alternatives. The first scenario represented COVID-19 period 2020, potential return within supply chain disruption market conditions, whereas the second scenario represented market risk, demand volatility parameters and resilience in market systems. Product cost, sale volume and revenue, and discount given to sale over products were collected from different sources and included in the Model. If net profit is a function of both deterministic and stochastic variables, the resulting outcome gets a range of values instead of a single value obtained in a conventional deterministic financial evaluation. Net profit for scenarios (1) and (2) for three market demands, production levels and product cost were constructed for each model as per below formula.

2.3. Multiple Simulation Model Equations

$$N^{\sim} \text{ Profit 2020} = (\tilde{Y}_a^* \tilde{P}_a + Y_b^* \tilde{P}_b + Y_c^* \tilde{P}_c + \dots) - (Co Y_a + Co Y_b + Co Y_c + \dots) \quad \text{Scenario (1)}$$

$$N^{\sim} \text{ Profit 2023} = (\tilde{Y}_a^* \tilde{P}_a + Y_b^* \tilde{P}_b + Y_c^* \tilde{P}_c + \dots) - (Co Y_a + Co Y_b + Co Y_c + \dots) \quad \text{Scenario (2)}$$

where:

N^{\sim} : Profit Net profit probability distribution for net profit.

\tilde{Y}_a : Fresh milk product stochastic sold in Litr.

\tilde{P}_a : Fresh milk product stochastic market price RO.

Y_b : Flavor product stochastic sold in Litr.

\tilde{P}_b : Flavor product stochastic market price RO.

Y_c : Laban product stochastic sold in Litr.

\tilde{Y}_c : Laban product stochastic market price RO.

$Co Y_a$: Fresh product stochastic cost for sale products.

$Co Y_b$: Flavor product Stochastic cost for sale products.

$Co Y_c$: Laban product Stochastic cost for sale products.

2.4. Operation and Marketing Uncertain Variables and Simulation Risk Analysis Model

The study used Monte Carlo simulation model to evaluate risk and uncertain input variables of a model. The model identified and tested the effects of main uncertain variables on the business performance and net profit. Product mix unit cost, production volume, market segmentation and demand were tested and evaluated by testing two scenarios during coronavirus 2020 and after-market resilience in 2023. The uncertain variables range determined for main variables in model by using Standard Deviation (SD) that describes the range of spread uncertain variables around mean, whereas variable distribution function describe variable shape and behaviors as pointed in **Table 1** and **Table 2**. The below variables are used to calculate randomly generated input values taken from the probabilistic distribution function for each variable. Variable distribution best fit selected by using (Bestfit) function and presented below. The model merge inputs data to generate estimated outcome value for each market. The process used @Risk 8.7 program to run simulation net profits for each market segmentation with iteration of 10 thousand times.

Table 1. Uncertain parameters for products price and cost of production models for year 2020/2023 in RO.

Uncertain Variable	Distribution	Price 2020	Cost Range 2020	Price 2023	Cost Range 2023
Fresh Milk	Risk Pert	0.535 - 0.551	0.455 - 0.500	+3%	0.520 - 0.600
Flavor Milk	Risk Pert	0.558 - 0.561	0.520 - 0.550	+1%	0.500 - 0.580
Laban	Risk Pert	0.525 - 0.649	0.510 - 0.550	+24%	0.550 - 0.600
Yoghurt	Risk Pert	0.547 - 0.624	0.550 - 0.620	+14%	0.600 - 0.650
Juices	Risk Pert	0.480 - 0.648	0.535 - 0.690	+35%	0.630 - 0.700

Table 2. Uncertain parameters for products volume, total country and region market sales percentage 20/23.

Products	Distribution	Regional Sales/000 Litr during 2020 and 2023					
		Total 20	Factory 20	Capital 20	Total 23	Factory 23	Capital 23
Fresh Milk	Risk simtable	14,164	67%	12%	16,449	66%	13%
Flavor Milk	Risk simtable	369	24%	24%	577	15%	25%
Laban	Risk simtable	5009	23%	13%	7,105	13%	13%
Yoghurt	Risk simtable	7934	22%	21%	11,284	21%	21%
Juices	Risk simtable	3860	18%	24%	4819	18%	29%

2.5. Products Mix, Production Volume Alternatives and Marketing Scenarios

Products mix combination and regional marketing operation plan play a key variable for business performance and net profit. Fresh milk products face challenges

as a freshable products have a short shelf-life duration and need efficient route network operation. Cold and refrigerated transportation route network structure and operation efficiency play a major role in increasing product cost and reducing business net profit. The impact of high products expiry and increasing supermarket shelf rent rebates on business margin during coronavirus period and after are investigated.

To compare economic performance of alternative production and market segmentation, model assumptions determined variables that would change from one scenario to another to identified decision's variables. Different production and market uncertain variables values for each scenario modelled with (RiskSimtable) functions. The Multiple Simulations Function is run by using @Risk 8.7 program to pick up production and marketing variable value for each simulation model. COVID-19 crisis scenario analysis used as holistic approach to test market risk and to assess system resilience capacities in a downturn time.

2.6. Stochastic Efficiency with Respect to a Function (SERF)

Simulation model is used to investigate dairy business and marketing alternatives strategies, and formal marketing channels supports policy to be introduced by Government Authorities. The risk management failure could be measured in financial terms of getting a negative Net Profit. A stochastic efficiency model performed to compare the Net Return for two scenarios and three models for each scenario. Stochastic efficiency with respect to a function (SERF) is used to rank the risky alternatives simultaneously with different risk aversion preferences. Risk Premium is also calculated by subtracting CE Certainty equivalent for less preferred dairy business and market policy alternative from dominant alternative. Given a utility function $u(w)$, a random wealth variable X , and an initial level of wealth w_0 , the certainty equivalent equation used in the models is:

$$CE = u^{-1}\{E[u(X + w_0)]\} - w_0.$$

The risk premium measures the minimum amount of money that needs to be paid to decision maker to justify a switch from present marketing strategy to another less risky alternative. The model simulated the costs and returns for keeping and maintaining dairy business under different market strategies. The Net Return is calculated and probability distributions generated by the simulation model. The model used to rank the best alternative policy across a full range of RACs. The study finally performed CE analysis to estimate premium price should be given to business stakeholders to keep their dairy business at a less risky business system and utilize resources in a sustainable manner.

3. Result and Discussion

3.1 Dairy Production and Marketing Comparative Analysis

The present study aimed to compare production parameters data for year 2020 and 2023 such as sale volume and sale revenue and market segmentation for each market region. The total country's sale volume for 2023 increased by 28%, Factory

Area by 14% and Capital Area by 39% compared to year 2020. The total country sale revenue for 2023 increased by 46%, Factory Area by 30% and Capital Area by 54% compared to year 2020. The data analysis confirmed that Capital Area sale had recovered from lockdown through intensive marketing programs and generate more sale revenue compared to coronavirus crisis in 2020. While total country's sale volume of fresh milk increased and grew by 16% the sale revenue increased by 24.4% and Laban and yoghurt sale volume increased by 41.8% and 42.2% respectively. The total country's juice products sale volume percentage increased by 24.8% and sale revenue increased by 75.9%. The Capital Area's sale volume increased by 39.2% and sale revenue increased by 54.1% with improvement on juices sale revenue increased by 111% and Flavor milk for schools by 94%. The Capital Area market segmentation analysis shows Laban, yoghurt and flavor milk are more favorable than fresh milk. The market share growth and price adjustment were the main reasons for margin increase. Marketing risk for regional policies and profit increase will be quantified by additional risk analysis tools in this study.

3.2. Dairy Production Volume and Product Mix Net Profit (PDF) Simulations Analysis

The descriptive statistics analysis was performed to quantify risk and calculate the net profit of three different regions for year 2020 and 2023. The probability distribution functions (PDF) analysis performed for three levels of production for year 2020 and 2023 to calculate net profit probability distribution during COVID-19 crisis and after. The net profit probability distribution skewed to the left for all models and 5% net profit probability distribution of country sale shift from RO (318 k) loss in year 2020 to net profit of RO 230 k in 2023, as shown by **Figure 1** and **Figure 2**. The analysis shown that Capital Area region has low market system resilience capacity but stable recovery system although coronavirus crisis had a complete lockdown continued for 10 months in 2020. The market system resilience coped with crisis in terms of market dynamic interactions of persistence, adaptation and transformation.

Net profit simulation analysis performed for three different production volumes and products mix for two scenarios. Scenario No (1) represents year 2020 COVID-19 Crisis with three models, Total Country sale, Factory Area and Capital Area sales. Scenario No (2) represents year 2023 represents a recovery year with three regions. The country's total sale volume increased by 8,898 thousand Liters and country sale revenue increased by RO 7,088 k. The analysis showed significant improvement in net profit of total county and Capital Area region and reduction in Factory Area region net profit with higher standard deviation SD than COVID-19 crisis period 2020.

The net profits probability distribution functions (PDF) of three production alternatives are performed to evaluate risk volatility and economic sustainability for 2020 and 2023. The economic performance simulation analysis of alternative

production and marketing strategies and risk factors identification showed that low standard deviation (SD) and net profit range of RO (249,098) for Capital Area 2020 compared to higher standard deviation (SD) and a wide range of net profit RO (303,301) for year 2023 as presented in **Table 3** below. This analysis showed that Factory Area is more stable due to low cost of route network operation compared to Capital Areas and more competitors interfering with market risk management. Market risk management can improve business opportunities by producing quality value products such as Laban and yoghurt rather than increasing

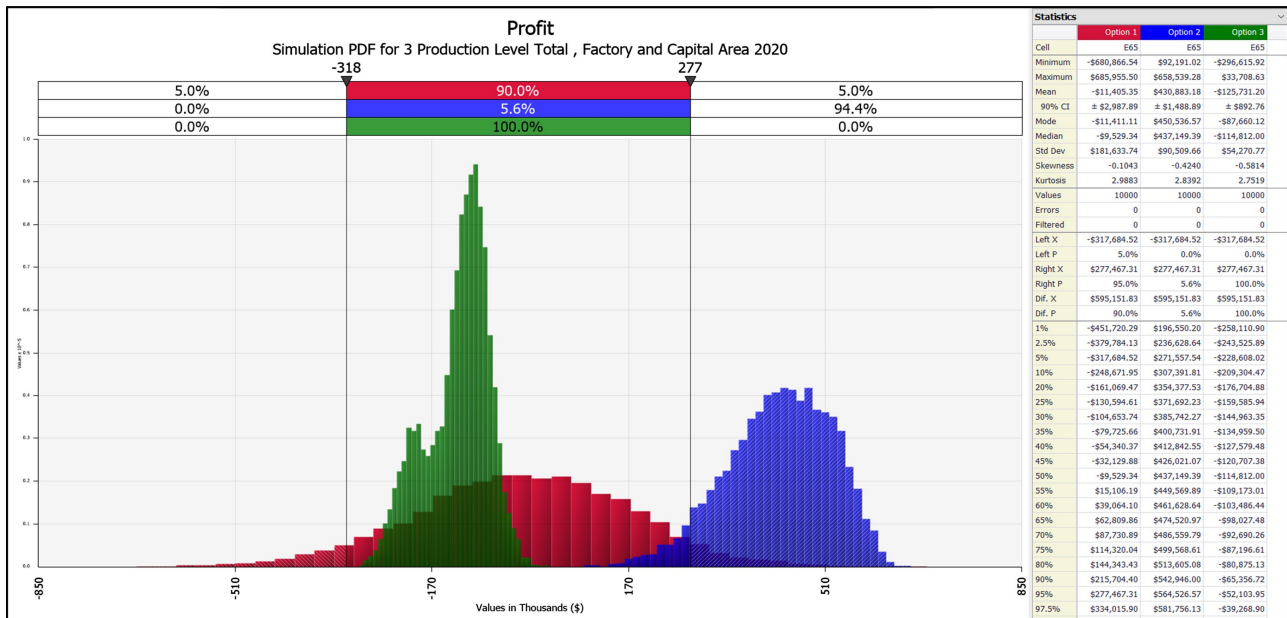


Figure 1. Dairy business net profit PDF for three regions and market segmentation in 2020.

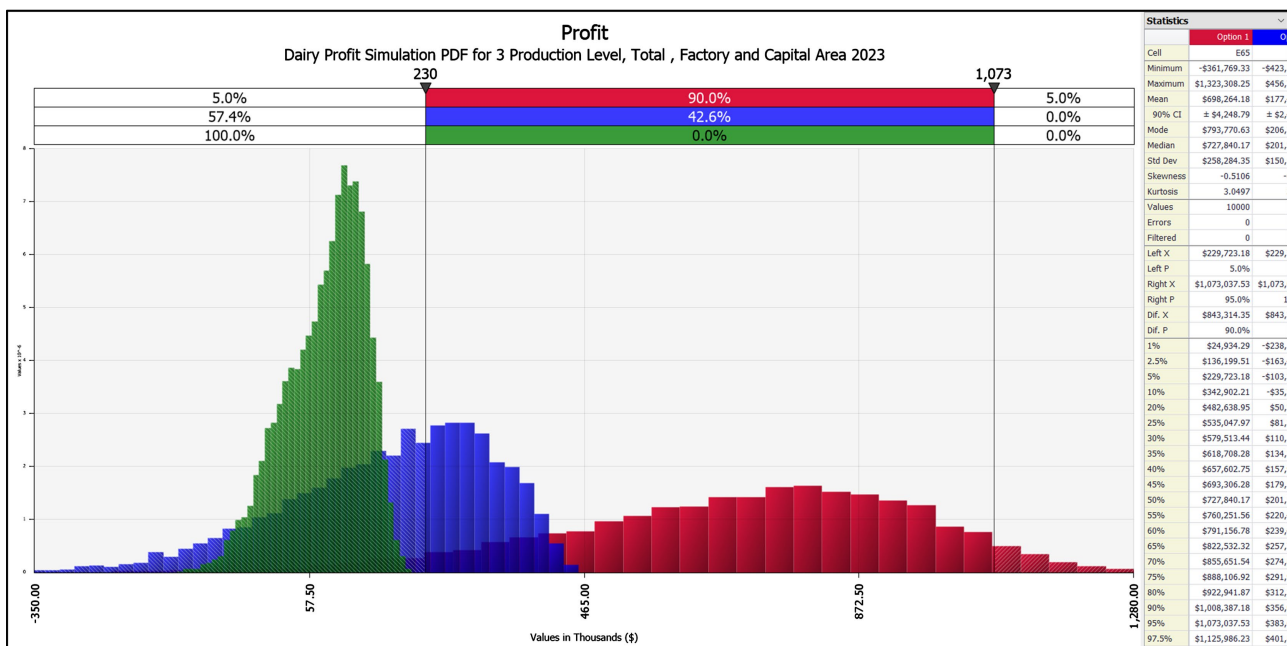


Figure 2. Dairy business net profit PDF for three regions and market segmentation in 2023.

Table 3. Statistical result of dairy performance under market uncertain challenges scenario model.

Item	Total 20	Factory 20	Capital 20	Total 23	Factory 23	Capital 23
Net Pofit RO	(9523)	432,998	(125,034)	697,967	174,213	78,836
Minimum	-507712	168,520	-266772	-125291	-280486	-97974
Maximum	464,543	624,218	-17674	1,321,055	444,017	205,327
Profit SD	180,579	88,060	53,645	260,416	151,733	59,739
CV	-1896	20.337	-42.904	37.311	87.096	75.777
Skewness	-0.044	-0.370	-0.498	-0.487	-0.629	-0.461
Kurtosis	-0.415	-0.413	-0.372	-0.085	-0.053	-0.529

whole fat fresh milk and increasing market share of undesirable low margin products. Net profit bimodal distribution for Capital Area may explain some customers group making frequent small purchases from nearby small shops and another customer group making infrequent large purchases due to coronavirus crisis lockdown by concern Authority's.

Although standard deviation (SD) is an attractive measurement to calculate risk, it is used to measure total risk, which includes the downside and upside tail end risk, and it is not a powerful tool for differentiation non-symmetric probability distribution function of production levels' net profit. The large negative volatility at downside and business loss movement is harmful and needs to be investigated and controlled by dairy business team through optimizing production level with dynamic marketing activities. Downside risk analysis is performed in this study to quantify the worst-case loss due to uncertain production and marketing variables in case of market deterioration and stress situation during coronavirus crisis. The demand for yoghurt, flavor milk and juices in the Capital Area was more effective on net profit due to lockdown impact on market demand and consumer preference of hotel, restaurant, and catering services (HORECA) channels. **Figure 1** and **Figure 2** show two scenarios with three different market regions models of dairy production and marketing sale profit. Production level, product mix and different marketing strategies modeled to present market segmentation for each region. **Figure 1** revealed the net profit distribution functions (PDF) stimulated three production level and products mix options for 2020 and showed the probability of achieving 45% profit of country sales and 100% profit for Factory Area and 99.8% loss for Capital Area during COVID-19 Crisis and complete lockdown. **Figure 2** represents year 2023 and showed the probability of achieving 99.2% profit of country sales and 86.6% profit for Factory Area and 89% profit for Capital Area after COVID-19 Crisis recovery from complete lockdown. Marketing competitor analysis was performed to analyze company competitors' marketing strategies and identify their strengths and weaknesses. The marketing team-imposed marketing competitor analysis in terms of price, prod-

ucts mix, market region location and promotion to avoid competitors' pitfalls and take advantage of missed opportunities to optimize marketing plan after coronavirus crisis.

Investors and dairy business decisions makers will depend mainly on stakeholders' risk appetite and business risk tolerance to understand which risk to accept for each market region, and which production level and products mix that balance between potential benefit and threats according to market dynamic situation for each region.

3.3. Downside Risk and Tornado Sensitivity Analysis

Downside simulation tornado sensitivity analysis performed to test tail-end distribution for three production level alternatives and rank uncertain operation and marketing parameter effect net profit for 2020 and 2023. The sensitivity and tornado analysis for total country sales shows that unit cost of fresh milk, yoghurt, juices and Laban have high impact on profit followed by demand of fresh milk, Laban, yoghurt and flavor milk demands during year 2020. On the other hand, dairy product cost per unit has high impact on profit for 2023 followed by market promotion for juices and yoghurt products. Operation team should work out a plan to reduce dairy products unit costs and improve marketing promotion by marketing team. The marketing strategies should monitor and observe sale revenue of fresh products and control contract expenses such as refrigerated transportation cost, supermarket shelf rent cost, products expiry and return cost and review product cash flow to prevent unexpected overrun and negative affect on organization financial health. The production team should monitor unit cost saving plans for fresh and other products to extend market demand and market shares and achieve sustainable business growth rate.

Sensitivity analysis performed for Capital Area region and showed unit cost of juice, yoghurt and fresh milk are the main factors impacted net profit followed by products demand during COVID-19 Pandemic 2020. In year 2023 after coronavirus crisis recovery, the capital market area tornado analysis revealed that incentives and unit cost of fresh milk, yoghurt and juice has a major impact on profit followed by market promotion, **Figure 3**. Product demand reduction in the Capital Area during crisis jeopardized business profit and forced marketing teams to give more incentives and promotions to Capital Area customers to increase demand share and reduce losses. Juice sale volume increased by 500 thousand liters, generating additional RO 464 k sale revenue. Juice products price increase and adjustment marketing strategies were the main reasons behind making profit in the Capital Area region. The competitors' low pricing strategies are the main problem facing company market share and growth and unit cost reduction issues need to be monitored and controlled to enhance profitability in a challenging dairy business landscape.

The strict complete lockdown including commercial activities i.e. Supermarket, Malls and small shops effect country dairy sale activities and reduce probability of profit to 48% only. Company business Manager are researching for adequate strat-

egies for revamping production and marketing patterns to meet consumer demand at Factory Area. The probability of achieving profit for Factory Area was 100% and for Capital Area 0.02% only due to broken transportation links and route networks. Factory Area marketing data were analyzed and reveals unit cost of fresh milk, yoghurt, and Laban are the main inputs that affect profit during and post-COVID-19 pandemic era. The Value at Risk (VaR) model introduced as an objective quantitative measure of downside risk especially when the random payoffs are not normally distributed with negative skewness (-0.044) and (-0.415) kurtosis. VaR calculates the worse cause loss and recorded RO (-318 k) for country sales during 2020 with confidence level of 95%. VaR measures downside risk at various levels of risk aversion level according to decision makers' willingness and ability to pay for risk.

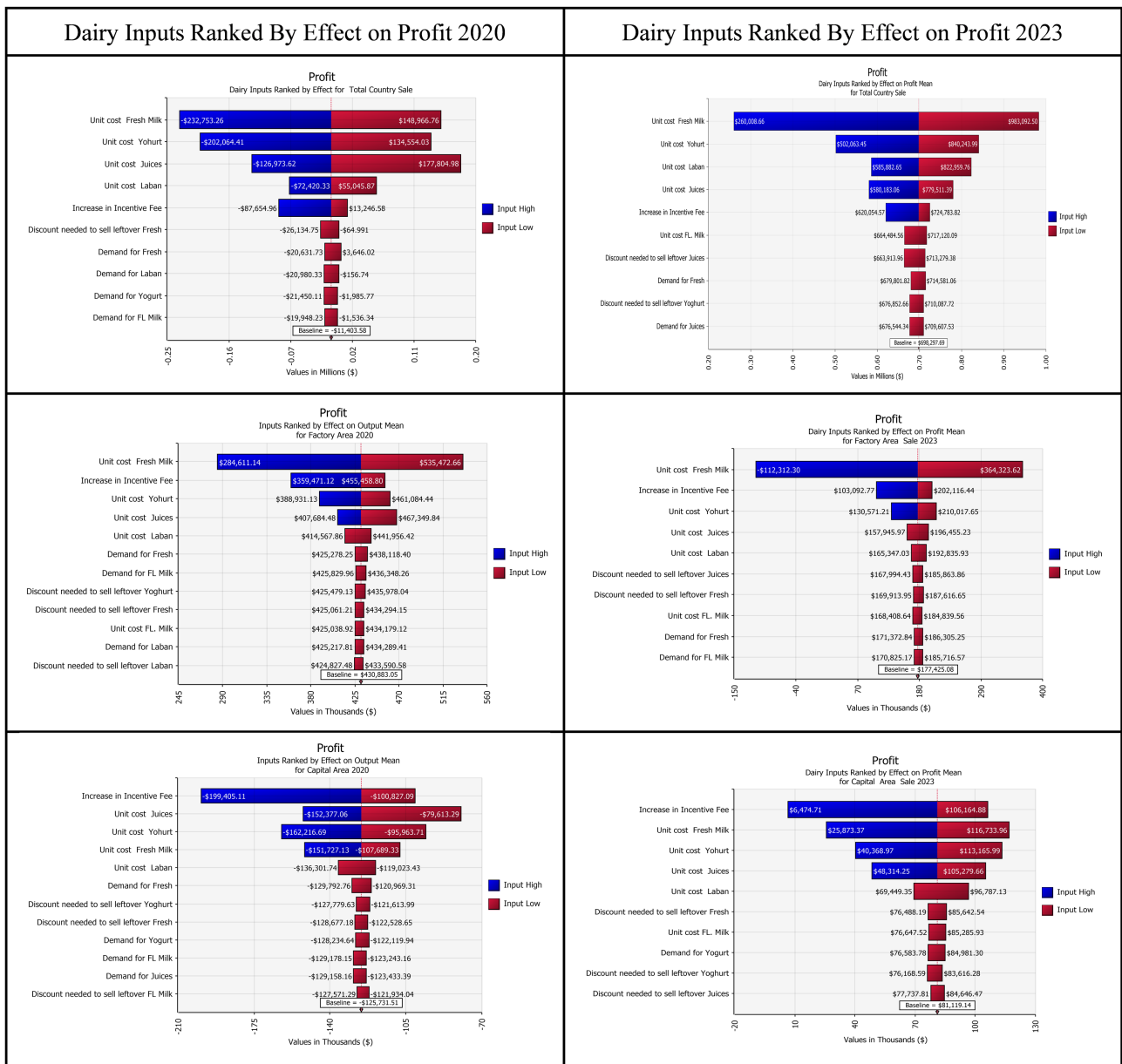


Figure 3. Comparison sensitivity analysis for inputs impacts on dairy profit for year 2020/2023.

3.4. BCG Matrix Tool Analysis and Market Strategy

The marketing team should work out a plan to increase demand for fresh and value-added products and sign a hedging contract with catering services companies to mitigate sale price volatility risk. Promotion programs should also carefully be calculated and monitored to maximize net profit from the sale of leftover products to reduce product expiry through balancing marginal cost with marginal revenue figures. **Figure 3** ranks inputs variables and shows quantitative figures' impact of each variable on target net profit.

Fresh milk is a major cash product represents 45.2% of total production in 2020 and about 40.9% in 2023. The Boston Consulting Group (BCG) Matrix analysis performed to test fresh milk market demand share and market attractiveness at different market regions. The aim of the analysis is to identify alternative production and marketing strategies of fresh milk on regional market share and products competitiveness and marketing strength. The scatter plot analysis was performed by collecting stochastic budgeting data and simulated fresh milk market demand shares on net profit. Product market demand stress analysis examined low and high demand reductions effect on net profit revealed high impact on market profit with market demand reduction. The study performed quadrant analysis to examined fresh milk market demand compared to profit for three regions during 2020 coronavirus pandemic and after 2023. The different market demand stress positions also performed by using quadrant analysis and result presented at **Table 4**.

Table 4. Net profit vs market demand share for fresh milk products and market stress analysis for (2020-2023).

Item	All Value	Demand Reduction	Demand Reduction	All Value	Demand Reduction	Demand reduction
		70% - 80%	30% - 40%		70% - 80%	0% - 10%
		Fresh Milk 2020			Fresh Milk 2023	
Mean X (Demand) 000	16,217	16,285	16,173	16,217	16,285	16,066
SD X	93,650	9,555	7774	93,651	9555	20,444
Mean Y (Profit) RO	-11402	-26849	1640	698,261	708,675	686,633
SD Y	183,778	187,502	182,170	256,656	260,044	259,484
Correlation Pearson	0.0018	0.031	-0.0049	0.0113	-0.0203	-0.0328
Quadrant I	24.6%	47.6%	00.0%	26.2%	55.2%	0.0%
Quadrant II	26.5%	00.0%	53.1%	27.7%	00.0%	52.9%
Quadrant III	25.0%	00.0%	46.9%	23.8%	00.10	47.1%
Quadrant IV	23.9%	52.4%	00.0%	22.3%	44.8%	0.0%

Quadrant analysis is a business strategic tool used to evaluate organization products' strategical position to build effective market strategy. The analyses divide data into three marketing regions based on two situations during and after

COVID-19 era. By visualizing the relationships between fresh milk demand and profit in a scatter chart, marketing team can better understand the dynamics of their products and make right adjustments to reduce risk while maintaining a satisfactory level of company profit. The company also can understand COVID -19 supply chain disruption impacts and form strategies to overcome crisis. Understanding the elements and characters of each dairy products and combination within the market region will enhance decision makers process and achieve organization objectives. Understanding investor and stakeholders risk tolerance approaches are essential in determining dairy business strategies with business objectives.

Fresh products showed high market demand share and potential profit growth. It is cash cows generated products and needs to be supported by the marketing team to maintain healthy financial. The fresh milk leveraged its strong presence in local Factory Area market through retail and grocery stores and home delivery for year 2020 and 2023, whereas a sharp market decline observed for fresh milk in Capital Area market starting from April 2020 onwards due to coronavirus lockdown. Capital Area market struggles with limited products variety, quality and price competition with mass-produced big dairy brands companies. Value added products such as Laban, yoghurt and juices showed low market shares and low growth, and Mangment should invest to increase potential growth and sustain profit growth. The stress analysis confirmed that fresh milk (is cash cow) and demand reduction has a significant negative impact on total country's sale net profit and Capital Area regions' net profit.

The fresh products exposed to unstable potential larger return risk despite the possibility of substantial and significant losses. The risk management decision making process can lead to significant stress and challenges during market downturns and complete lockdown restrictions due to pandemics. The Capital Area market record expiry of fresh products of 337,746 Liters and 23% of total country expiry in 2020 and reduced to 241,100 Liters and 17% of total country expiry in 2023 due to lockdown procedures during coronavirus pandemic. The strategies for fresh products, high risk and uncertain challenges should include market diversification and increase yoghurt and Laban sale during Ramadan time to avoid high loss of expiry and short duration of shelf live. While low risk tolerance products such as flavor milk market strategy should balance market stability and growth. Both operation and market risk measures and quantification enabled organization to address new marketing strategies and fresh products repositioning.

3.5. Net Profit Bimodal Distribution and Downside Risk Management

The net profit frequency distribution shape is one of important tools to assess and manage dairy business risk. Managers like good uncertainty market products because they increase the potential for gain and increase net profit and dislike bad uncertainty market as they increase likelihoods of sever losses. The (Weibull) distribution is used to test dairy market risk in terms of volatility and products rejec-

tion and supply chain disruptions. The variance of risk premium measured by skewness distribution business participation and asymmetric views of profit and market uncertainty. The skewness risk premium measures the spread between upside and downside net profit components of variance risk premium. Simulation net profit distribution analysis revealed that all dairy marketing regional profit models are skewed to left with the left tail end probability of net profit falling below the mean. It is concentrated on the profit opportunity results and loss from profit decrease due to supply chain disruption, products unit cost change and market demand revenue decline consequent to market conditions deterioration due to pandemic lockdown.

Skewness analysis performed to measure the degree of variability of a frequency distribution of net profit in all three-market regions with different production scenarios. Regional market net profit skewed distribution showed bimodal distribution with a range between $(-0.044) - (-0.498)$ in 2020, and more skewed figure in year 2023 ranged between $(-0.461) - (-0.629)$. This means the net profit data is concentrated toward higher values, with a few extreme low values pulling the tail to the left and negative excess kurtosis. The wider skewed range figures in 2020 showed significant variability in profit with bottom business performing loss and top business having substantial earnings, whereas skewed range in 2023 showed less variation in net profit and achieved business sustainability and business resilience.

The Capital Area profit probability distribution showed a sharp bimodal distribution in 2020 with two peaks profit which represent market segmentation. That means different people in the Capital Area have different reasons and different motivations for buying Company's products and it also may explain market depiction of two different processes marketing area, two suppliers' of raw materials, shift from container shipping to bulk carriers, operators, and shifts could all ultimately be two or more distinct marketing processes especially during COVID-19 crisis 2020 for Capital Area, **Figure 4**. Operation and market team need to investigate and use geographic and location marketing to tailor their marketing strategies to identify customers' needs for each location. The study shows that urbanicity and consumer behavioral in Capital Area has an influence on the kind of products people buy, and their motivations for buying them even during COVID-19 pandemic restricted period. Marketing segmentation means breaking down regional target sales into smaller groups with common needs and characteristics, then creating marketing messages that address the needs of each of these groups and return market resilience after COVID-19 era.

Kurtosis analysis obtained test distribution peakedness and record negative excess kurtosis figure between $(-0.372) - (-0.415)$ in 2020 with excess kurtosis close to 0 between $(-0.053) - (-0.529)$ in 2023. Short and medium decisions makers need to look for skewness and kurtosis figures to judge net profit distribution shape because they consider the extremes data sets at short time period rather than average figures which will take long time period to happen. Kurtosis figures are

negative for all market regions and represent thinner peaks and lighter tail distributions. Capital Area in 2020 has negative excess kurtosis with flatter peak histogram in the middle and higher histogram towards its left tail. The higher histogram at the left tail disappeared in 2023 resulting in distribution closer to normal distribution. Total Country's sale net profit in 2020 has a higher peak in the middle and became closer to normal distribution in 2023. Capital Area market shows fatter tail for 2020 compared to 2023. VaR recorded RO (318 k) loss in 2020 compared to RO 230 k profit in 2023 for Country sales. The potential maximum loss in 2020 indicates a higher market profit volatility and risk due to supply chain disruption.

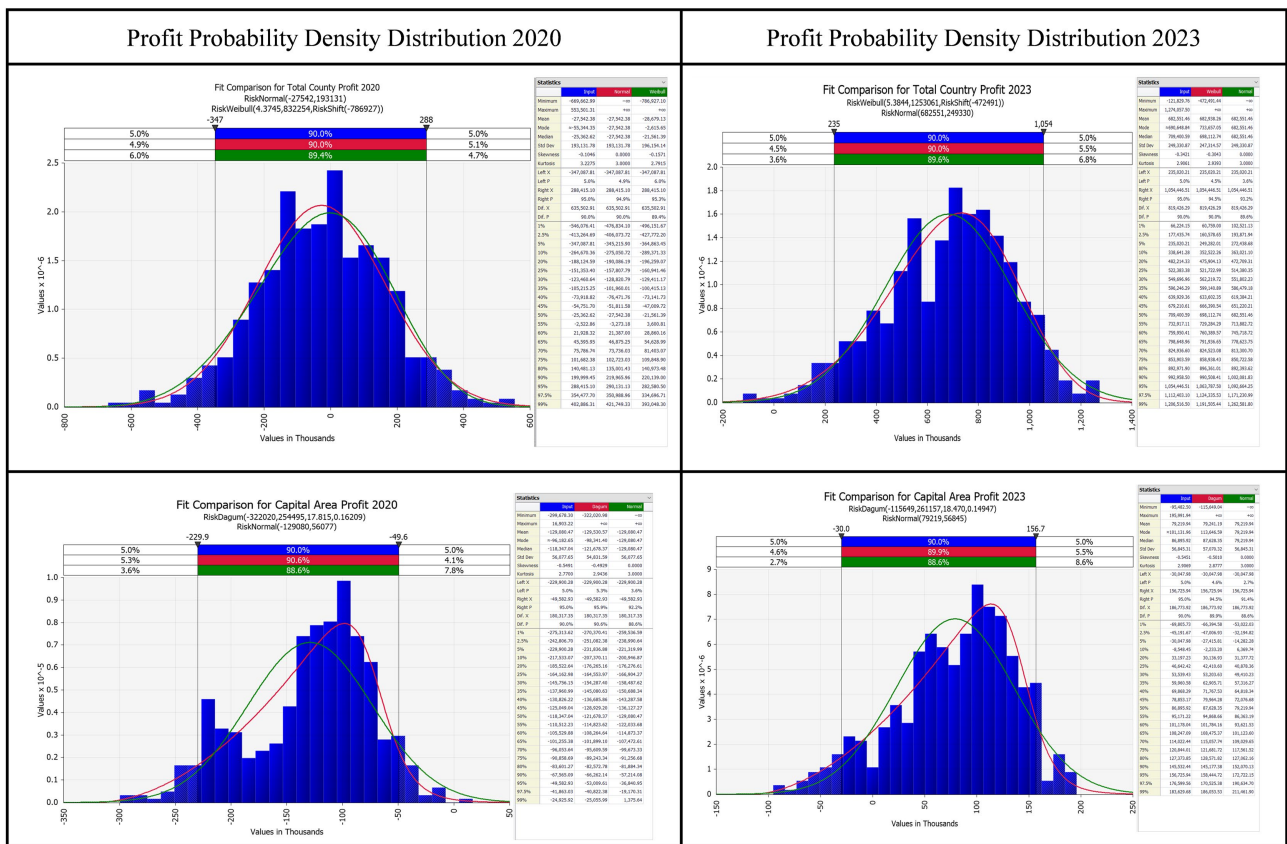


Figure 4. Comparison of total country and capital area net profit bimodal distribution for year 2020/2023.

3.6. Technical and Market Risk Quantification and Cumulated Distribution Function Analysis

Dairy market uncertainty described by cumulated distribution function (CDF). The entire change of CDFs is quantified in terms of the net profit difference between six CDFs. Net profit of each market strategy developed in this study reflects the relative impact of distributional changes of inputs, market demand, production volume on the change of output distribution (net profit). The study tested sustainability of three dairy production levels and products mix under two scenarios before and after coronavirus in 2020. Each scenario included three market

region alternatives models.

This study constructed the cumulated distribution function (CDF) graph to quantify market risk and indicates the range and probabilities of net profit value for six different production volume and marketing alternatives, **Figure 5**. Due to cumulated distribution function (CDF) lines crossing in the graph, we could not be able to rank operation and market alternatives risk accord with their economic sustainability by using the first and second stochastic dominance with respect function (SDRF) and use (SERF) analysis instead. Accordingly, stochastic efficiency with respect to function (SERF) analysis has been used for a better risk ranking analysis. The analysis showed dairy business net profit in 2023 are sustainable alternatives than COVID-19 year in 2020, and Factory Area net profit are better and stable market than Capital Area market. The uncertain market conditions need to be monitored and controlled to form dynamic market strategies and risk efficient alternatives as shown in **Figure 5**.

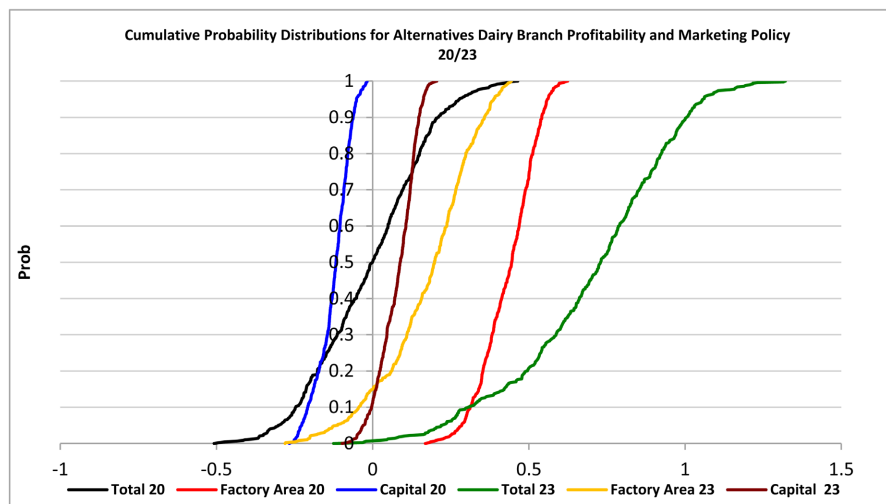


Figure 5. Cumulated distribution functions of total country, capital and factory areas for year 2020/2023.

3.7. Certainly Equivalent Coefficient and Market Risk Premium Analysis

The study calculated stochastic efficiency with respect to a function (SERF) by using SIMETAR program developed by Richardson *et al.* (2008), to evaluate risk-efficient of dairy product mix, production volume level and market demand instabilities. The analysis compared basic scenario (total country 20) which represents COVID-19 crisis in year 2020 with other market scenarios for year 2023. The Certainty Equivalent (CE) is calculated to test dairy business performance of coronavirus pandemic impact with current operation practices (2023) and marketing demand volatility. Three different production groups examined with different product and marketing regions sales. Net profit alternatives options for three different production levels and market demand compared by using multiple simulation models and construction (SERF) and CE analysis. The CE is guaran-

teed low net profit that corporate decision makers would accept now rather than taking risks on a higher uncertain profit in the future. The corporate decision maker's risk tolerance level recognized and considered both sides of the equation the willingness and financial ability that stakeholders are ready to lose and take the risk. The study investigates dairy business risk and in terms of production level and market risk that safeguards financial stability and achieves growth objective and proved financial recovery for year 2023 and Factory Area market resilience.

Dairy business risk tolerance level influenced by financial position such as revenue, expenses, debit obligation and cash reserves. A Company with strong financial positions and sufficient cash flow may have a higher risk tolerance to pursue market growth opportunities. The corporate strategic objective in terms of market expansion, developing products and managing risk would have a higher ambition to gain opportunity out of risk tolerance. Moreover, business market dynamics characterized by rapid technology and market dynamic need a high-risk tolerance investor to adapt to market changes and competition. The (SERF) recognize the most risk-efficient alternative of production and market demand level for a range of risk preferences by ranking alternatives in terms of (CE) figures. financial sustainability for different product unit cost and marketing parameters performed to evaluate risk efferent alternative option for a range of risk preference for all absolute risk aversion coefficient (ARAC). SIMETAR program calculated Certainty Equivalent value and constructed graphs to rank net profit of different production levels, market demand scenarios and unit cost of production level across the specified range of ARAC values. Across two or several alternatives, a higher CE, with the same level of ARAC is considered as the best risk management alternative, **Figure 6**. Total Country 2023 CE value is best alternative followed by Factory 23 Area and Capital Area 23 alternative at all ARAC.

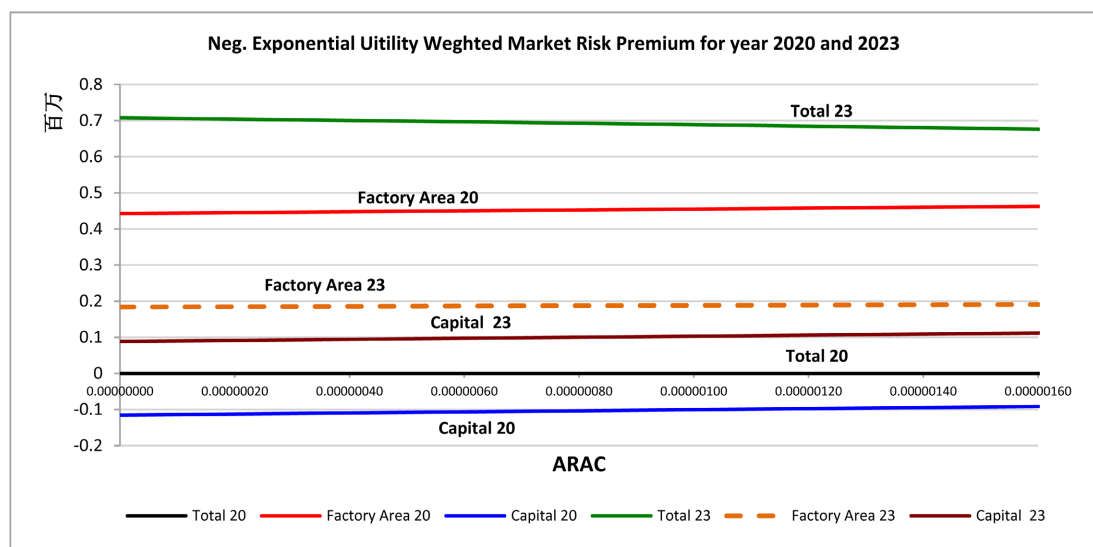


Figure 6. Stochastic efficiency with respect to a function (SERF) and market certainty equivalent for all ARAC.

Risk premium is a measure of excess return that is required by decision makers

to compensate for being subjected to uncertain marketing and operation risk. The risk premium of total Company's sale profit in 2023 is distinct from other region sale profit risk premiums for year 2023 and year 2020, as a result the region market risk premium is calculated to quantify coronavirus risk impact. The market risk analysis showed positive correlation between production level and regional market demand Certainty Equivalent (CE) values for Country and Capital Area market. The production volume increased from 31,330 k liters in 2020 to 40,234 k liters in 2023 for total country sale profit and from 4,970 k in 2020 to 6,929 k liters for Capital Area market. Accordingly, the CE value increased from RO (9,523) to RO 697,967 for Country sales and from RO (125,034) to RO 78,836 for Capital Area market, table No (5). The Factory Area 20 record CE value of RO 432,998 and reduced with sold volume increase to RO 174,213 in year 2023. The risk premium for Factory Area 20 and Factory Area 23 is RO 258,785 which represents risk premium of COVID-19 supply chain disruption impacted at neutral risk averse decision makers. The risk premium for Capital Area 20 and Capital Area 23 record RO 203,870 which reflect sever market downturn in Capital Area due to COVID-19 supply chain disruption for neutral risk averse decision makers. The reason for negative correlation between products sold profit and CE value at Factory Area is due to coronavirus supply chain disruption and restricted lockdown at Capital Area market and Company managed to sale 42.33% of plant production at nearby Factory Area market with a reasonable cost and increasing home delivery. Company risk averse decision maker would pay RO 707 k to avoid COVID-19 crisis impact.

The new market strategies after COVID-19 increased market share and CE value for total Country sales in 2023 and increased risk premium value by RO 707,490 for risk neutral decision maker and reduced to RO 443,459 for extreme risk averse decision maker. The Factory Area market risk premium value record RO 258,785 for risk averse decision maker and increased to 396,253 for extreme risk averse decision maker. The Capital Area market risk premium record RO 203,870 for risk averse decision maker and reduced to 198,122 for extreme risk averse decision maker. The risk premium value increased with all absolute risk aversion coefficient (ARAC) for Factory Area indicates selling most of the products with a reasonable cost compared to Capital Area market and route network lockdown restriction. The corporate decision maker accepted loss of CE value RO (125,034) for Capital Area 2020 and achieve 432,998 CE value of Factory Area in 2020 rather than taking uncertain profit at Capital Area market in 2020 with risk premium of RO 307,964. **Figure 6** ranked market efficiency according to stochastic efficiency with respect to a function (SERF) and certainty equivalent values for all market risk averse alternatives at absolute risk aversion coefficient (ARAC).

Market risk premium is a difference between high-risk market plans characterized by potential substantial returns paired with significant volatility and low-risk market plan with stability lower returns. This comparative analysis explores these differences to aid investors in choosing the best path for their financial goals. By

accounting for the unique risks associated with a specific company market plan, investors can better estimate the value of the company's market shares and make more informed decisions about their investments. The high value of CE at the same level of ARAC indicates a preferred alternative. Absolute risk aversion coefficient (ARAC) values ranging from 0.0000 to 0.00000162 were used in the (SERF) analysis to calculate CE values for each production level and market region. The CE value and market risk premium for each model is summarized at **Table 5**.

Table 5. Ranking net profit's certainty equivalent and risk premium for all absolute risk aversion coefficient.

Variables	Production 000 Liters	CE			Risk Premium (2020-2023)		
		Neutral (0.00000)	Moderate (0.000008)	Strong (0.000016)	Neutral (0.00000)	Moderate (0.000008)	Strong (0.000016)
Country sale 23	40,234	697,967	397,877	214,629	-	-	-
Country sale 20	31,330	-9523	-133595	-228830	707,490	531,472	443,459
Factory Area 23	15,135	174,213	65,730	-29967	-	-	-
Factory Area 20	13,263	432,998	400,019	366,286	258,785	334,289	396,253
Capital Area 23	6929	78,836	63,724	47,902	-	-	-
Capital Area 20	4970	-125034	-137245	-150220	203,870	200,969	198,122

3.8. Stop Light Chart and Dairy Business Profit Target Analysis

Stop Light chart for lower and upper target net profit value constructed to rank dairy market efficiency. The target lower net profit value of (RO 25 K) and upper value of (RO 100 k) determined by decision maker to rank dairy market efficiency according to their net profit value during coronavirus year 2020 and year 2023. The Company total country sale revenue for year 2020 and 2023 revealed an increase in total country sale revenue by RO 6,265,135 i.e. 40.3% and Capital Area sale revenue by RO 1,280,268 i.e. 54.1% by adoption COVID-19 disaster recovery plan. The total country business achieves 98% profit above upper target profit RO 100 thousand after supply chain disruption settlement compared to 29% during COVID-19 period. The analysis showed total country sales achieved consistent and reliable financial sustainability and market recovery and system resilience capacities, as per **Figure 7**.

Due to total lockdown during COVID-19 pandemic crisis and supply chain disruption, the Capital Area dairy business record loss in 2020. However, Capital Area achieved 43% of the profit above upper target RO 100 thousand in 2023 compared to 100% below target profit RO 25 thousand during COVID-19 Crisis. The shift from fresh milk to value added products such as Laban and yoghurt and juice increased sales revenue. Dairy market in the Capital Area is competitive market control by larger regional companies trying to get a more significant share of the market, they set the prices of their products to attract customers and keep prices

low. The large companies also improve their products' quality and services because of the tough competition. Although Capital Area market penetration is a crucial strategy for business and market share growth, branding work, strong distribution channels and cost-effective route network remain a big challenge.

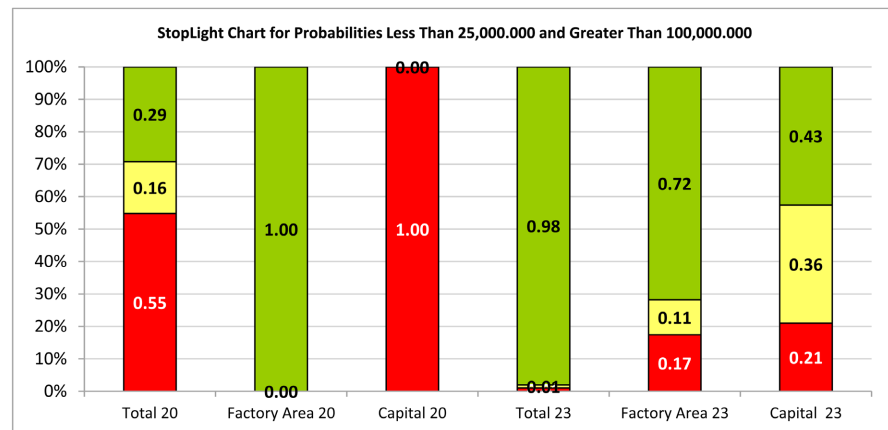


Figure 7. Stop light chart for net profit probability less than 25 k and greater than 100 k for dairy market regions.

Factory Area market is a cash generation market and has a cost-effective route network and distribution channels. The new marketing policy for 2023 reduced fresh milk volume sale by 3% and Laban volume by 2% and increased sale revenue by 1,9 million rials equal to 45.7% from 2020. The sale revenue increased because of price increase and quality improvement for juices, and promoting nutrient and health products such as yoghurt and Laban products and increasing their market share. The Factory Area gained real value of market power through increasing customer penetration, winning market share, and taking advantage of competitive dynamics. The risk management strategy enabled Company to secure steady cash flow, even during the off-peak season and downturn market situation.

The Factory Area dairy market is ecosystem resilience system and has a capacity to withstand and adapt to supply chain disturbances in terms of raw milk collection from neighboring farms and market the products in cost effective manners. Factory Area market is also stable market and has an ability to return to an equilibrium state rapidly after supply chain disruptions. A comparative analysis performed to compare market resilience and stability during COVID-19 2020 and year 2023. The analysis shows Company marketing and operation teams could manage to increase total country sale volume by 7.09 million Litr i.e. 22.6% and Capital Area sale volume by 1.59 million Lit 39.2% by adopting COVID-19 disaster recovery plan and market risk management strategies.

4. Conclusions

The dairy business and industry in Oman grapples with complex challenges, from wavering milk prices and escalating input costs to ever-shifting market dynamics; all factors that can significantly impact business profitability and stability. Dairy busi-

ness must, therefore, implement potent strategies to enhance cash flow and safeguard financial viability and achieve ecosystem resilience. This article delves into key methods designed to analyze dairy business risk assessment and market dynamic channelings and efficiency to boost profits in dairy operations and improve cash flow management. The study examined and explored a strategic approach aimed at bolstering not only short-term profitability but also ensuring long-term growth. By embracing and implementing market risk management strategies, dairy business can deftly navigate risks and uncertainties, carving out a path towards sustained financial success even amidst the highly competitive landscape of dairy marketing challenges.

The study stimulated net profit for different alternative product mix and marketing strategy by using @Risk 8.7 program to investigate operation and marketing risk assessment. Simulation risk analyses were performed to test operation performance sustainability of alternative marketing demand, sale revenue, unit cost of products and salable dairy products level parameters. Sensitivity analysis showed that products unit cost is the most factor effect profit followed by market demand and sale promotion. Interdiction of new technologies and products shelf-Life extension can reduce costs and eliminate risk of extreme losses. The analysis identifies factors that affect business ecosystem resilience and stability and measure market risk premium to control risk and avoid opportunity loss in future.

Stochastic Efficiency with Respect to a Function (SERF) constructed and used to estimate Certainty Equivalent (CE) and market risk premium (RP) values for three market regions during and after COVID-19 era. The market risk premium represents the additional return investors expect to earn for bearing the systematic risks associated with the overall market system resilience under uncertainty and volatility. This study presents an evaluation of market system resilience of three dairy production levels and products mixed under different marketing uncertain parameters and marketing strategies.

The probability distribution functions (PDF) analysis performed to quantify market risk for three levels of production for year 2020 and 2023 to calculate changes in net profit probability distribution due to COVID-19 crisis and after. The net profit probability distribution skewed to the left for all models and 5% net profit probability distribution of Country sale shift from RO (318 k) loss in year 2020 to RO 230 k profit in 2023. The analysis shown that Country sale has resilience system recovery although coronavirus crisis had a complete lockdown continued for 10 months in 2020 and achieved stability with (kurtosis close to zero) in year 2023. Market resilience is recognized as its ability to prevent and adapt to negative impacts of crisis shocks by collecting raw milk from nearby farmers and benefit from the lower agreed price. The company also managed to sell products in Factory Area at a reasonable cost and avoid additional distribution costs due to restricted procedures in Capital Area and reduce products expiry cost.

Simulation net profit distribution analysis revealed that all dairy marketing regional profit models are skewered to left with the left tail end probability of net profit falling below the mean. This means there are more lows values that are sig-

nificantly smaller than the majority of profit data. The net profit is concentrated on the loss opportunity results from a net profit decrease due to supply chain disruption, products unit cost change and market demand revenue decline consequent to market conditions deterioration due to pandemic lockdown. The wider skewed range figures in 2020 showed significant variability in profit with bottom business performing loss and top business having substantial earnings, whereas skewed range in 2023 showed less variation in net profit and increased resilience capacity and business sustainability.

The (Weibull) distribution is used to test dairy market risk in terms of volatility and products quality rejection and sever supply chain disruptions. Capital Area net profit distribution showed sharp bimodal two peaks profit distribution represents market segmentation during COVID-19 time in 2020 and 2023. That means different people in the Capital Area have different reasons and different motivations for buying Company product. The market team need to investigate and use geographic and location marketing to tailor their marketing strategies according to market segmentation and identify customers' needs for each market location. Consumer behavior in Capital Area has an influence on the kind of products people buy, and their motivations for buying products even during COVID-19 pandemic restricted period. Marketing segmentation in terms of breaking down regional target sales into smaller groups with common needs and characteristics and then creating marketing messages that address the needs of each of these groups and return market resilience after COVID-19 era is highly recommended.

The sensitivity and tornado analysis for total country sales showed that unit cost of fresh milk, yoghurt, juices and Laban have high impact on profit followed by market demand during 2020. On the other hand, dairy product cost per unit has high impact on profit for 2023 followed by market promotion for juices and yoghurt products due to lockdown released. Sensitivity analysis for Capital Area region and showed unit cost of juice, yoghurt and fresh milk are the main factors impacted net profit followed by products demand during COVID-19 Pandemic 2020. In year 2023 post COVID-19 crisis recovery, Capita Area market characterized by growing demand for quality products, expansion into retail and increasing competition from local and external producers, as a result promotion and incentives has a major impact on profit followed by unit cost of fresh milk, yoghurt and juice as shown by tornado sensitivity analysis.

Product demand reduction during crisis jeopardized business profits and forced marketing teams to give more incentives and promotions to all market regions with more attention to Capital Area customers to increase demand share and reduce losses. Juice sale volume in Capital Area increased by 500 thousand liters, generating additional RO 464 k sale revenue, whereas country sales volume increased by 959 K liters and generated 1.3 Million rials. Juice quality improvement and price adjustment strategies were the main reasons behind making profit after COVID-19 era. The competitors' low-price strategies are the main challenges facing company and market share growth, as a result, unit cost reduction issues need

to be monitored and controlled to enhance profitability in a challenging uncertain dairy business landscape.

Stochastic efficiency with respect to function (SERF) analysis has been used for better ranking alternatives and to quantify dairy market demand uncertainty and indicated the range and probabilities of net profit value for six different production volume and marketing alternatives. Net profit of three market strategies for 2020 compared with year 2023 to measure the relative impact of supply chain disruption on net profit. The (SERF) analysis revealed that Country net profit of 2023 is better and more sustainable alternative than Country net profit for coronavirus year 2020 followed by Factory Area market 2020 and Factory Area market 2023. The Factory Area market recognized as resilience system and had a capacity to withstand and adapt to supply chain disturbances in terms of market volatility control, raw milk collection from neighboring farms and marketing the products in cost effective manners. Factory Area market is also stable market and has an ability to return to an equilibrium state rapidly after supply chain disruptions.

Risk premium measured the excess return required by decision makers to compensate for being subjected to uncertain marketing and operation risk. The risk premium of total Company's sale profit in 2023 is distinct from other region sale profit risk premiums for year 2023 and year 2020, as a result the region market risk premium is calculated to quantify coronavirus risk impact. The market risk analysis showed positive correlation between regional production level and regional market Certainty Equivalent (CE) values for Country and Capital Area markets. The new market strategies after COVID-19 increased market share and CE value for total Country sales in 2023. The risk premium value for total Country sales in 2020 and 2023 recorded a CE of RO 707,490 for risk neutral decision makers and reduced to RO 443,459 for extreme risk averse decision makers. The Factory Area market risk premium value for year 2020 and 2023 record CE of RO 258,785 for risk averse decision maker and increased to 396,253 for extreme risk averse decision maker. Stop Light chart for lower and upper target net profit value constructed to rank dairy market efficiency. The total country business achieves 98% profit above upper target profit RO 100 thousand after supply chain disruption settlement compared to 29% during COVID-19 period. The analysis showed total country sales achieved consistent and reliable financial sustainability and market recovery efficiency and ecosystem resilience capacities.

The marketing team should monitor and observe sale revenue and control contract expenses such as transportation cost, supermarket shelf rent cost, products expiry returns cost and review cash flow to prevent unexpected overrun and negative financial impacts. The use of advanced technology such as IA, ML and IoT will improve risk management and provide real time data for informed decisions. Amare M, Abay KA, Hatzenbuehler PL., 2023, outline how digital technologies, financial tools, and insurance products can intersect to create a comprehensive resilience roadmap [32]. The production team should concentrate on monitoring unit cost saving plans and improve efficiency to extend market demand share and

achieve business sustainability and improve growth rate. Moreover, controlling market share enables the company to measure its competitiveness and its ability to attract and retain customers compared to its competitors. The Management and operation team should work closely to reduce cost of production and optimize product mix, whereas the marketing team should understand product market share and growth to mitigate risk as shown by study result. Marketing promotion and market risk premium should also be monitored and calculated carefully to control risk and obtain higher gain under high dynamic market challenges. Real time data monitoring enables management and marketing teams to make informed decisions incorporating market dynamic changes for country and regional dairy market and adapt sustainable resilience strategies accordingly. The large negative volatility at downside and business loss movement is harmful and needs to be investigated and controlled by dairy business team through optimizing production level with dynamic marketing activities as steady small profits can be wiped out by one significant catastrophic event.

Market simulation analysis help Company to identify their market standing, track their performance over time, and benchmark themselves against competitors. Study results and information help the Company gauge their market penetration and identify opportunities for growth and areas that require improvement. Study results and recommendations help businesses make informed decisions regarding production levels, pricing strategies, market segmentation, marketing campaigns, and resource allocation. Moreover, the corporate should include resilience in the central of organization strategic process and move from risk reporting to more advanced foresight capabilities and adopt comprehensive strategic prospective to meet challenges of next disruption over the horizon.

When profit models are characterized by left skewness and negative kurtosis, it suggests a scenario where the most profits are high, but there is a risk of rare significant losses that could skew the average profit downwards. The absence of extreme values (negative kurtosis) may lead to underestimating the risk associated with these rare losses, making it crucial for stakeholders to consider both the potential for high profit and the risks of infrequent but severe downturns. Understanding these statistical measures is essential for making informed decisions in dairy business and risk management, as they provide insights into the behavior of profit distributions and the associated risks. Despite the challenges, the future of the dairy industry remains promising. Companies that proactively address the supply chain issues and adapt to changing market dynamics will be well positioned for long-term success.

Availability of Supporting Data

The dairy business data used in this study is collected from primary and secondary sources and Dairy Companies published data in Sultanate of Oman.

Conflicts of Interest

The author declared no conflict of interest.

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