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Broiler Production Systems Risk Management Sustainability and Feed Subsidy Policy Analysis

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Abstract: *Broiler farmers at costal area at Salalah and Batinah Regions of Sultanate of Oman breed and produce poultry at their farms and feed them with ready-made concentrates and sold the live poultry birds at local market and generate low profit. The high temperature and relative humidity increase heat stress to broiler and increase mortality and reduce growth, daily weight gain and feed intake and reduce farm net return. The study use (SERF) techniques to investigate broiler production systems risk efficiency and risk management sustainability at different risk aversion level. The result indicated the effectiveness of short time breed duration practices to NR economic viability and improve farm net return stability at downside risk area and mitigate heat stress risk at hot climate farm location. The feed subsidy policy is also evaluated under different production system. Feed incentive shift farm's NR means to right and increase the range of profit (C%) by 125% and increase business stability and risk efficiency for short time breed duration and reduce loss for long time breed duration. The study indicated risk premium price of RO 7,155 per house (RO 0.038 per bird) is required to persuade farmers to shift from un-subsidized feed program to feed subsidized production system. The certainty equivalents (CE) analysis is calculated and shows payment of RO 0.116 per bird to local farmers is needed to protect them against cheap import poultry price. The study finds that broiler farmers in Oman are increasingly exposed to a wide range of risks while the availability of risk management instruments lags behind. The Government feed subsidy program and availability of cooperatives, insurance and financial institutions are highly required to mitigate risk of net return loss and improve poultry business growth and economic sustainability.*

Key words: *Stochastic Efficiency with Respect to a Function (SERF), broiler production system, risk efficient, simulation model, heat stress, net return, economic sustainability.*

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I. Introduction

Broiler farmers at costal area at Salalah and Batinah Regions of Sultanate of Oman produce and breed poultry at their farms and feed them with ready-made concentrates and sold the live poultry birds at local market. However, this type of broiler production system generates a very low profit as farmer could not offer sufficient feed, medicine and modern environment control houses from his own pocket. Farmers in this poultry local production system engaged in Government jobs and other economic activity not related to farming to cope with yield and price risk and increase their income.

The local poultry production contributes significantly to socio-economics development and nutritional requirement of rural area. Poultry products (eggs and meat) are preferred for their good taste, price and health characteristics. This has encouraged Government to enhance a long-term national development program to improve living stander of the rural area. However, few farmers practices modern intensive poultry production systems and benefited from Government support to provide latest technologies such as high yield poultry breed, modern environment control houses, equipment and readymade concentrate feed. The risk and uncertainty factors in broiler production projects is the main constrains facing farmers and decision makers and needs to be investigated, Danilo Simões et al. (2014).

The heat stress in term of high environmental temperature and relative humidity effect broiler performance in Gulf Region and Oman which is located at (15-27°) north latitude with long summer season. The summer season in Salalah Region is extended for six months followed by a warm winter and high relative humidity. Broilers dissipate heat to environment through condition, radiation and evaporation, but at 28 °C temperature and above the only mechanism available for bird to dissipate heat is evaporation through panting. Many farmers stop poultry breeding during summertime due to heat stress and farm net return reduced drastically. The modern climate control houses could reduce mortality during heat stress summer period, but reduction in average daily gain and feed efficiency are still observed.

May J. D. et al. (2000) compared the effect of five temperature regimens on growth and FCR up to 21 days of age and shows that temperature has a dramatic effect on growth and feed conversion after 3 week, and the effect is progressively greater with increasing body weight. The other research also shows value of improving environmental conditions increases as body weight increases, (May et al., 1998).

I. Zahoor et al. (2016) test the effect of two treatment on broiler performance and muscle quality. He defined cool temperature by a theoretical model that determined the environmental temperature that would enable heat generated by the bird to be lost to the environment. This research found that no differences in growth and feed intake between the cool temperature and optimum ambient temperature regimens. Breast muscle quality improvement was also not noticed and achieved due to control optimum climate zone; the research argued.

Joseph L. et al. (2012) use regression analysis to study the effect of THI on heavy weight broilers performance and growth. The study compared a range of dry-bulb temperature (15°C, 21°C, and 27°C) and relative humidity (50%, 65%, and 80%), and show that as THI exceeds 21°C, bird performance significantly declined and body temperature increased up to 1.7°C above nominal body temperature for broilers (41°C). However, this study use simulation analysis to investigated risk of high Temperature-Humidity Index on broiler performance reared for 35 and 42 days of age and analyzed NR and feed subsidy policy on economic sustainability.

Broiler production management decisions are always made in the face of uncertain consequences. Poultry breeding decisions are generally made before a price and yield for the poultry breed has been set and long before production yields are determined. Inputs required for production are also uncertain in term of quantities and value. Following Hardaker et al. (1997), uncertain consequences and especially unfavorable consequences are broadly defined as risk. Hardaker et al. (1997) divide risk sources into five general categories: production risk, price or market risk, institutional risk, human or personal risk, and financial risk. The broiler breed production risk in this study refers to uncertain production yields due to input quality and quantity and biosecurity and vaccination application. The environment parameters changes during the year such as temperature and relative humidity has also significant risk impacts in broiler production systems and business net return. The effect of reducing broiler breeding duration from 42 days to 35 days on farms’ NR is also investigated in this study.

Agriculture production systems risk analyses using stochastic efficiency with respect to function (SERF) have been covered in many studies (Ascough II. J. C. et al. 2009; G. Lien, et al. 2007 and Eihab M. Fathelrahman et al. 2011). These studies use economic budget data, experimental and filed plot data to understand problems involving in agricultural risk and economic sustainability.

Problem statement :

Due to low performance of local broiler production breed and high cost of feed and other inputs the Government introduced poultry and animal feed subsidy program in year 2011 and reduce poultry feed price by 12%. The Government Authorities stopped poultry and animal feed subsidy in year 2016 due to international feed ingredients raw material price decrease and poultry production exposed to yield, feed input price volatility risk and climate changes risk.

During hot season broiler breeding required more attention from farmers to parameters such as stock density reduction, final depletion bird weight reduction, control house ventilation and equipped houses with evaporation cooling systems which may not be available to local farmers. All these addition equipment and measurements will increase operation and investment cost and reduce farming net return. The risk of poor performance during hot weather required strategic decision from farmer and need to be considered by decision maker.

The study investigated the effect of different broiler production systems and feed subsidy policies on broiler production viability and aims to identify the most sustainable broiler production system within farm location. The study evaluated feed subsidy policies on alternatives production system that can be implemented by Government Authority to support poultry production and improve business profitability in hot weather area.

Literature review :

Investment in broiler production agribusiness needs a long-term investment decision with uncertain yield and meat production, cost of inputs and product market price. Broiler production sustainable practices should ensure system ability to maintain productivity in spite of major environmental, technical and economic constrains and disturbance. Farm production net return and financial viability can be taken as a measurement to choose between different production systems and input subsidy policy alternative, Lien G. et.al (2007). Stochastic and dynamic nature of broiler production systems can be model to get the probability of getting viable economic net return for each production system.

The Monte Carlo simulation model is used as a quantitative analysis tool to understand and quantify risk and uncertainty of the related entrepreneurship and addressed by many researchers. The dynamic model provided a range of outcomes that can reduce the risk of product revenue and inputs cost uncertainty and give more reliable results for decision makers and policy advisers. The stochastic efficiency analysis can rank alternative broiler production systems and feed subsidy policy over a range of risk aversion level. This technique developed by Hardaker et al. (2004a) and called stochastic efficiency with respect to a function (SERF). Gregory K. et al. (2012) used SERF to evaluate genetically modified maize in South Africa. Mohammad K. et al. (2014) use SERF to rank risky alternative beef calving and feeding systems in western Canada. The SERF analysis and techniques is based on the notion that ranking risky alternatives in terms of utility which is the same as ranking alternatives with certainty equivalents (CE). The certainty equivalent is defined as the sure sum with the same utility as the expected utility of the risky prospect, Hardaker et al., (2004b). Irene Tzouramani et.al (2011) used (SERF) to explore economic viability of conventional and organic sheep farming in Greece and found both conventional and organic sheep farming are viable. SERF also used to rank and compare level of decision maker preferences including risk neutral, moderate and high risk averse, J. W. Richardson et al. (2008). In this research, the (SERF) technique is applied to assess a set of alternative broiler production systems and feed subsidy policies.

Product revenue and input cost were calculated for each broiler production system model. Six stochastic simulation models were employed to estimate farm net return distribution. The main objective of this paper is to investigate farm NR economic sustainability of alternative broiler production system and recognize the most risk efficiency one over a range of risk aversion level.

II. Methodology

2.1 Farm Net Return

The evaluation of broiler production system depends on estimation income and cost values to calculate economic net return with uncertain outcome given the stochastic yields, price and production cost. The probability range of net return with relative preference and utilities of decision makers need to be considered for economic viability and risk efficiency assessment.

Six stochastic simulation models were used to incorporate farm location in term of heat stress risk impact and uncertain variable and parameters can be generated for each broiler production model. The Net Return for each model is calculated by identifying key parameters and variables and subtracting the variable and fixed cost from the product revenue.

2.2 Monte Carlo Simulation

Monte Carlo simulation is a computational algorithm designed to evaluate the variability or stochastic of the input variables of a model. It can be used to model the effects of key variables on the Net Return of a given proposal. The process involves identification and assessment of the key variables. For each key variable, we fit a probability density function that best describes the range of uncertainty around the expected value.

In this study, we test and evaluate three production scenarios to represent cold environment model, heat stress model, and feed subsidy policy models. Each scenario contains two broiler production period i.e. (42 days with 15 days rest period) and (35 days with 12 days rest period), Table (1) below shows the three production scenarios and six broiler production models' parameters and technical data for each model.

Table (1) : Broiler production scenarios and models parameters and feed subsidy price per ton :

Items	Cold environment scenario		Heat stress scenario		Feed subsidy scenario	
Model	Model SD (1)	Model SD (2)	Model DF (3)	Model DF (4)	Model DF (5)	Model DF (6)
Production period	42 days	35 days	42 days	35 days	42 days	35 days
Rest period	15 days	12 days	15 days	12 days	15 days	12 days
Cycle No.	6.4	7.7	6.4	7.7	6.4	7.7
Chicken/batch	24,000	24,000	24,000	24,000	24,000	24,000
Feed/Kg/Bird	4.702	3.290	2.587	2.251	2.587	2.252
Live Weight/kg	2.918	2.235	1.470	1.410	1.470	1.410
FCR	1.611	1.472	1.759	1.597	1.760	1.600
Dressing %	74%	73%	64%	64%	62%	64%
Temperatures °C	≤20	≤20	28-40	28-40	28-40	28-40
Humidity % range	50-60	50-60	55-90	55-90	55-90	55-90

Monte Carlo simulation model is currently recorded as the most powerful technique for economic net return risk analysis, Kheiry (2016). It is useful when there are some variables are significantly uncertain. The model including these variables is then calculated using randomly generated input values taken from the underlying probabilistic distribution function. The computer model combines these inputs to generate an estimated outcome value for economic net return and process is repeated for (five thousand times). The @Risk

7.6 from (Palisade Corporation, Ithaca, New York) add-in for Excel was used to calculate the stochastic nature of key variables in the Monte Carlo simulation model.

2.3 Data collection

Data collected to perform broiler farm budget analysis for alternatives scenarios and production systems. The broiler breeding performance parameters such as meat yield, production duration period, daily growth rate, FCR, live bird weight and dressing percentage were collected from commercial broiler farm located at Salalah Region and data presented in table (1).

The commercial broiler farm is located at Salalah the capital of Dhofar Region with daytime temperature reaches 32-33 °C in April, May and June and goes down to 27-29 °C in July and August during Kharef season and increase again to 31 for the remain months of the year. The humidity % is above 50% and reach 75% in May and increase to 90% during July/September. The Farm has 48 breeding houses with a dimension of (L84XW14) meter and 12 Fans.

Broiler production data for each model were collected from enterprise budget of commercial farm data record for year 2018 and 2019. The farm was using a production period of 42 days and 15 days interval between batches in year 2018 (Model DF1) and moved to a short production period of 35 days and 12 days interval between batches (Model DF2) in March 2019. These two models represent heat stress scenario models.

The cold environment scenario data and parameters such as feed consumption, FCR, Live weight and dressing % were collected from literature, Aviagen (2015-2016-2019). Product sale revenue and inputs cost data were constructed from commercial farm located at Salalah Region to represent model (SD1) and (SD2). Feed subsidy model parameters were constructed from farm enterprise budget and feed subsidy price programs.

Market information such as fresh and frozen meat sale price, cost of inputs and other operation cost for each model were collected from farm enterprise budget and market survey. The study used Monte Carlo Simulation analysis to identified stochastic variables to be incorporated in the model such as yields, input cost, and output prices. The study also identified the probability distributions of the risky uncertain input variables and normal distribution is used to estimate Cumulative Distribution Function (CDF) of the output (NR) for each model.

The study performed Stochastic Efficiency with Respect to a Function (SERF) analysis to evaluate different production strategies and generates Certainty Equivalent (CEs) figures and rank risky production alternatives within different risk aversion level. The Certainty Equivalent (CEs) value used to calculate risk premium need to be paid to farmers for policy application and encouragement.

2.4 Model Structure

The modeling process started by defining inputs and parameters effecting broiler breeding income and return. The broiler production performance parameters, cost of operation and incomes affect each breed activities models are obtained. The qualitative risk analysis used in this study can provide a high level of understanding of risks of broiler production system alternatives. Such analysis may increase attention of poultry farming advisers, policy decision makers and poultry feed subsidy adviser to the top risks they need to manage effectively. In this analysis, we have investigated the economic viability of three production scenarios and six production system models under different risk aversion level. The six production systems models are summarized as under :

The main production systems under risk and uncertainty variables identified models were :

- Model SD (1) – Cold temperature broiler production 42 days and 15 days rest period and No feed subsidy.
- Model SD (2) – Cold temperature broiler production 35 days and 12 days rest period and No feed subsidy.
- Model DF (3) – Heat stress broiler production 42 days and 15 days rest period and No feed subsidy.
- Model DF (4) – Heat stress broiler production 35 days and 12 days rest period and No feed subsidy.
- Model DF (5) – Heat stress broiler production 42 days and 15 days rest period with feed subsidy program.
- Model DF (6) – Heat stress broiler production 35 days and 12 days rest period with feed subsidy program.

The simulation model is presented below :

$N\tilde{R} = (\tilde{Y}_a * \tilde{P}_a + Y_b * \tilde{P}_b + \ldots\ldots) – FC − V\tilde{C}$

Where :

$N\tilde{R}$ Probability distribution for net return.
$\tilde{Y}_a$ Stochastic yield sold per year for fresh broiler meat.
$\tilde{P}_a$ Stochastic market price for fresh broiler meat sold.
Y_b Stochastic yield sold per year for frozen broiler meat.
$\tilde{P}_b$ Stochastic market price for frozen broiler meat sold.

FC Fixed cost for Broiler production farming (Labour, utilities, housing, administration, marketing expenses…)
V˜C Stochastic variable cost for Broiler production (checks, vaccination, medicine, feed concentrate with or without subsidy,…).

2.5 Stochastic Efficiency with Respect to a Function (SERF)

Simulation model is used to investigate production system and feed subsidy policy sustainability. The production system failure could be measured in financial terms of getting a negative NR (Hansen and Jones, 1996).

A stochastic efficiency model performed to compare the NR of three broiler production systems scenarios by forming six models. 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 broiler production systems alternative from dominant alternative. Given a utility function u (·), a random wealth variable X, and an initial level of wealth w0, the certainty equivalent is :

$$CE = u^{-1}\{E[u(X + w0)]\} - w0,$$

The certainty equivalent is a guaranteed low net return that decision maker would accept now, rather than taking a risk on a higher uncertain net return of production system in the future. Put another way, the certainty equivalent is the guaranteed sure low amount of NR that a farmer would accept and consider rather than unsure high NR could have been achieved by increasing investment to change production system techniques.

The risk premium measure the minimum amount of money needs to be paid to farmers and decision maker to justify remaining at present production climate zone area rather than to switch to risky high return production system with high risky climate zone alternative. The model simulated the costs and returns for keeping broiler Ross breed at 48 houses at the farm located at Salalah Region. The Net Return is calculated, and probability distributions generated by the simulation model. The model used to rank the best alternative production system and feed subsidy policy across a full range of RACs. The study finally performed CE analysis to estimate premium price and feed subsidy should be given to farmers to keep their broiler production system at a less risky production system and utilize farm resources in a sustainable manner.

III. Result and Discussion

1.1 Cost of Production and Farm Net Return Analysis

The cost of production and net return analysis performed and result shows that cold environment scenario obtained the highest net return. Long breed duration of 42 days with no feed subsidy program (Model SD 1) got mean net return of RO 8,582,962 and Short breed duration of 35 days with no feed subsidy program (Model SD 2) got RO 7,501,276 mean net return.

Short breed duration of 35 days with feed subsidy program (Model DF 6) got the third mean net return RO 520,325, and Short breed duration of 35 days without feed subsidy program (Model DF 4) got 4th farm mean net return RO 120,885. The long breed during of 42 days with and without feed subsidy programs (Model DF 3) and (Model DF 5) go a negative mean net return. The analysis showed that farmers could manage and mitigate heat stress risk by reducing broiler breed duration to 35 days with 12 days rest period. The feed subsidy program which reduce feed price by 12% could manage to increase net return of short breed duration of 35 days by 330% as shown in table (2) below. The feed subsidy policy analysis indicated the effect of implementing and freezing feed subsidy on farms' NR and business sustainability. The freezing of this program effected broiler breeding farming net return sharply and high attention needs to be given to research finding by policy advisers to avoid policies contradictions.

Table (2) : Sale revenue, cost of production and net return of three scenarios and six models in Rial Omani :

Scenarios	Cold environment scenario		Heat stress scenario		Feed subsidy scenario	
Production System Model	Model SD (1)	Model SD (2)	Model DF (3)	Model DF (4)	Model DF (5)	Model DF (6)
No. Bird/ year	7,372,800	8,870,400	7,372,800	8,870,400	7,372,800	8,870,400
Live Weight/kg	2.918	2.235	1.470	1.410	1.470	1.410
Dressing %	74%	73%	62%	64%	62%	64%
Total meat/kg	14,646,616	13,314,701	6,182,004	7,398,797	6,182,004	7,398,797
Fresh meat price/kg	1.544	1.533	1.538	1.548	1.538	1.548
Frozen meat price/kg	0.980	0.980	0.985	1.092	0.985	1.092
Fresh meat sold %	65%	63%	60%	65%	60%	65%
Total Revenue RO	19,723,133	17,687,116	8,140,463	10,272,490	8,140,463	10,272,490
Feed cost/ ton	165	165	165	165	145	145
Variable Cost RO	4,720,066	4,172,939	5,388,342	6,169,894	5,006,862	5,770,454

Fixed Cost RO	2,475,478	2,475,478	2,711,550	2,168,764	2,711,550	2,168,764
Sale & Distribution	1,972,313	1,768,712	814,046	1,027,249	814,046	1,027,249
Administration RO	1,972,313	1,768,712	601,858	785,698	601,858	785,698
Total Cost RO	11,140,171	10,185,840	9,515,796	10,151,605	9,134,316	9,752,165
Net return RO	8,582,962	7,501,276	1,375,333	120,885	-993,853	520,325
Total Production/ton	14,647	13,315	6,182	7,399	6,182	7,399
Variable cost/ton	322	313	872	834	810	780
Fixed cost/ton	761	765	1,539	1,372	1,478	1,318
Price/ton	1,347	1,328	1,317	1,388	1,317	1,388
Unit cost/Revenue/ton	56%	58%	117%	99%	112%	95%

1.2 Probability Distribution Function Models Run Results

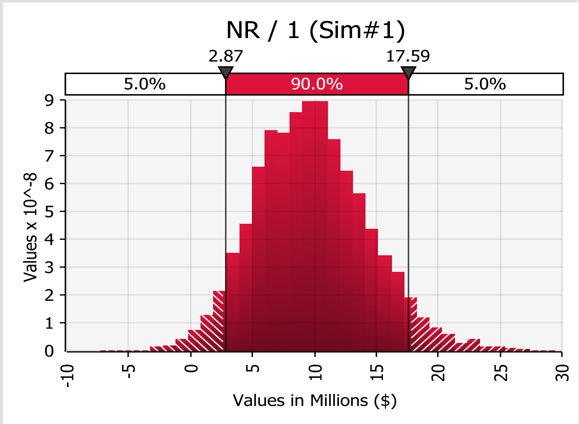
The study investigated broiler production systems economic performance and sustainability and perform farm net return probability distribution function analysis. The charts presented in Figure (1) indicate that cold temperature scenario has a positive NR and a fat tails distribution, and this refer to relative high probability of extreme net return risk. The probability distribution function of long-time breed duration for 42 days (Model SD 1) imply that 90% of the net return distribution range between 2.87 Mn. And 17.59 Mn. Rials Omani. Whereas short-time breed duration for 35 days (Model SD 2) imply that 90% of the net return distribution range between 1.89 Mn. and 16.30 Mn. Rials Omani.

The long-time breed duration models in heat stress scenario without feed subsidy (Model DF 3) and with feed subsidy (Model DF 5) have a negative skewed net return distribution. It is characterized by many small gains and a few extreme losses and has a long tail on its left side. The PDF analysis indicate that probability of getting negative net return for heat stress scenario without feed subsidy is (84.1%), whereas probability of negative net return with feed subsidy policy (Model DF 5) is (83.8%).

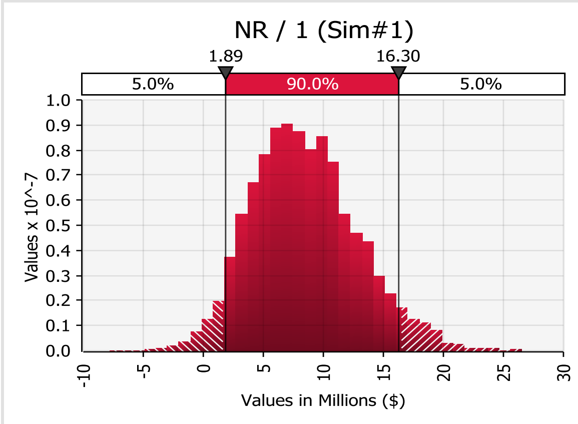
The short-time breed duration models in heat stress scenario without feed subsidy (Model DF 4) and with feed subsidy (Model DF 6) have a positive net return skewed distribution. It is characterized by many small gains and a few extreme profits and has a long tail on its right side. Any Probabilities based on such a distribution will underestimate the actual number of net return loss at the lower end of this skewed distribution while overestimating the number of profits at the higher end of the distribution. The PDF analysis indicate that heat stress without feed subsidy (Model DF 4) and with feed subsidy program (Model DF 6) have a probability of positive net return of (88.6%) and (88.4%) respectively. The result indicated the effectiveness of short time breed duration practices to NR viability and improve net return stability at downside risk area and mitigate heat stress risk at hot climate farm location. Insurance Company is a suitable risk management strategy for such scenario.

While farmers cannot change climate but can manage their response to it and control the uniformity (CV%) of a flock as it is an essential part of good broiler management. According to uniformity and live weight gained at farm level, Farm Management can determine the age at which birds could be depleted to meet environmental climate, customer requirements and sustainable economic models. The Government policy also must address challenges such as increasing productivities growth at different climate zone by adoption reliable farm production strategies and techniques to reduce climate changes effect.

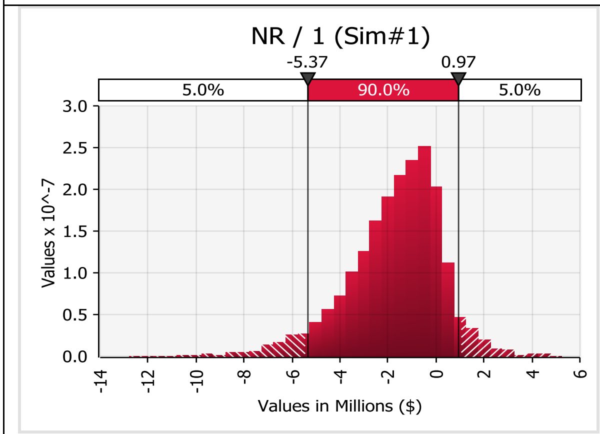
42 Days prodution period & 14 Days rest period	35 Days prodution period & 12 Days rest period



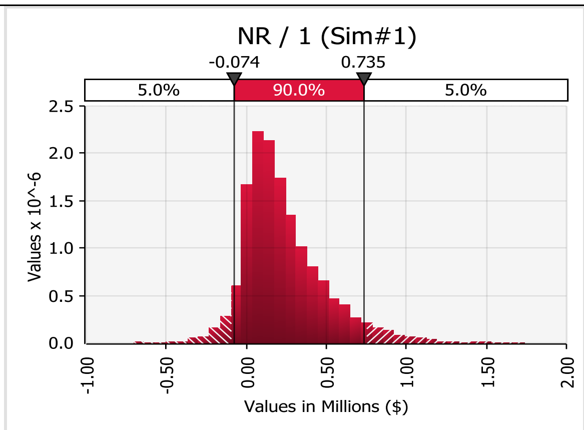
Model SD (1) Cold Environment Scenario



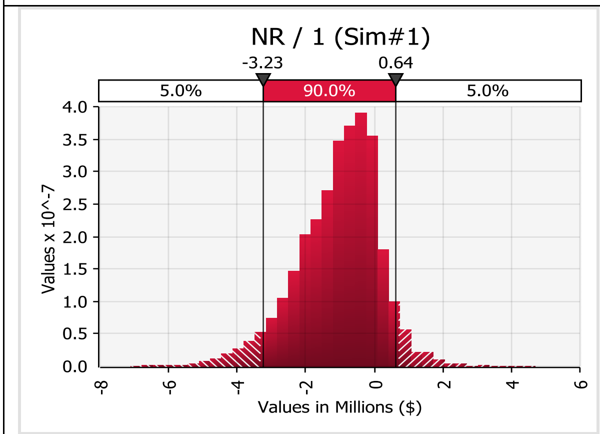
Model SD (2) Cold Environment Scenario



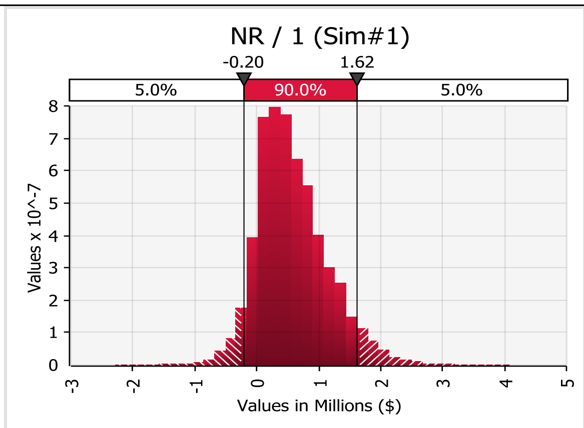
Model DF (3) Heat Stress Scenario



Model DF (4) Heat Stress Scenario



Model DF (5) Heat Stress Scenario & Feed Subsidy



Model DF (6) Heat Stress Scenario & Feed Subsid

Figure (1) : Probabilty Distribution Funtion of Broiler Production System Net Return in Million RO (000,000):-

The statistical analysis performed to calculate NR means, standard deviation and coefficient on of variation of the probability distribution of farm net return for each broiler production systems. The net return of cold temperature scenario longtime breed duration (Model SD 1) got a highest net return, whereas short time breed duration with feed subsidy program (Model DF 6) got the highest net return in heat stress scenarios, Table (3).

However, these results indicate that local broiler breed farmers can improve farm NR viability by practicing shot time breed strategy and control flock poor uniformity, health problems, improve house ventilation, nutrition and enhancing economic performance measurements.

Table (3) : Broiler breed production systems and feed policies Net Return statistics analysis summery :

Scenarios	Cold environment scenario		Heat stress scenario		Feed subsidy scenario	
Models	Model SD1	Model SD2	Model DF3	Model DF4	Model DF5	Model DF6
Mean	9,691,003	8,510,555	(1,760,855)	241,086	(1,089,603)	584,539
StDev	4,489,853	4,399,925	2,006,320	259,379	1,209,217	563,491
95 % LCI	9239587	8068181	-1962574	215008	-1211179	527885
95 % UCI	10142419	8952930	-1559137	267165	-968026	641193
CV	46.330	51.700	-113.940	107.587	-110.978	96.399
Min	-7337258	-4195995	-10370983	-470064	-6697731	-836636
Median	9624028	8426208	-1490334	181332	-938032	464619
Max	27361293	21844824	4112528	1734947	3600175	3015825
Skewness	0.364	0.278	-0.771	1.216	-0.506	0.981
Kurtosis	0.780	0.084	1.584	3.064	1.696	1.839
Autocorrelation Coefficient	-0.01508	-0.00055	-0.01346	-0.08783	-0.02491	-0.08891
Max- Min range	14,483,511	34,698,551	60,739,370	16,688,522	26,986,428	3,852,461

1.3 Broiler Breed Production Systems and Cumulated Distribution Function Analysis

To test broiler production systems and breed duration strategies sustainability the Cumulated Distribution Function CDF graphs performed to illustrate the range and probabilities of net return value for different alternatives production system. Due to CDF lines cross in the graph we could not ranked production system according to their sustainability by using first degree stochastic dominance, and Stochastic Efficiency with Respect to a Function (SERF) is used to have a better ranking analysis. The analysis indicates cold environment scenario models are the most risk efficient followed by short time breed duration models as its distribution line located on the right and preferred to those on the left line production systems, Figure (2).

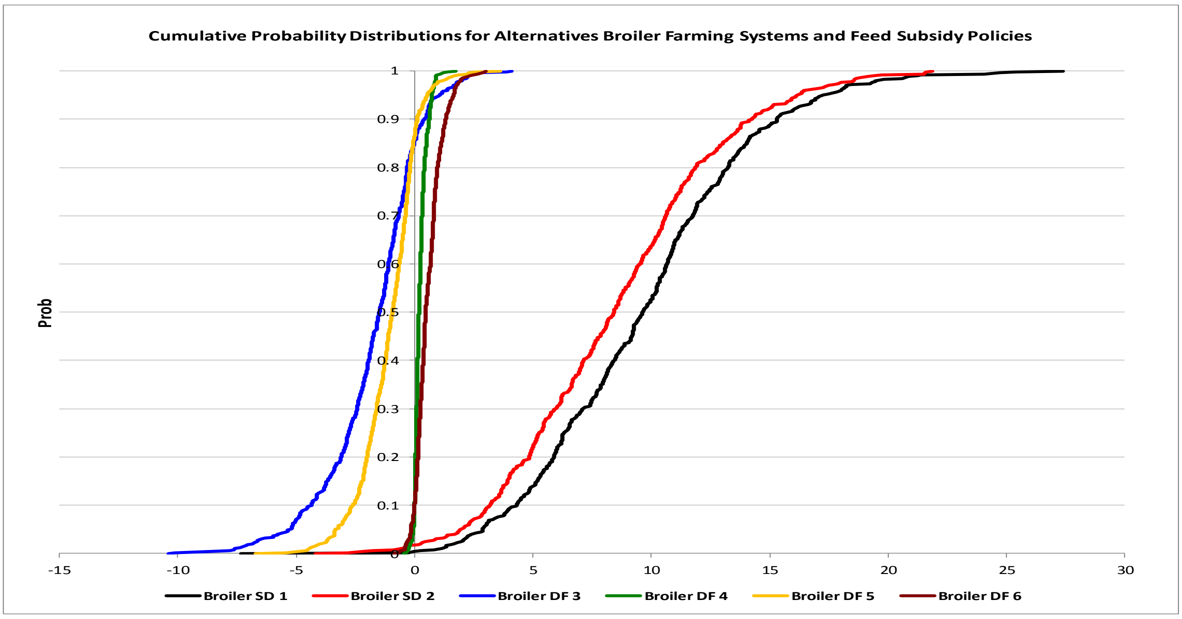


Figure (2) : Comparison of 6 CDF of NRs of Broiler Production Alternatives and Feed Subsidy Policies.

3.4. SERF Analysis and Certainly Equivalent

The SERF method used to calculate Certainly Equivalent CE values over a range of absolute risk aversion coefficients (ARACs). The ARAC represents a decision maker's degree of risk aversion. Decision makers are risk averse if ARAC > 0, risk neutral or risk normal if ARAC = 0, and risk preferring if ARAC < 0. The ARAC values used in this analysis ranged from (0.00) represent risk neutral to (0.00000105) represent high risk averse. The cold temperature scenario Model SD (1) obtained high CE values of RO 9,691,003 followed by Model SD (2) RO 8,510, 555, whereas short time breed duration Model DF (6) obtain RO 584,539, and Model DF (4) got RO 241,086 the second highest CE respectively at neutral risk aversion coefficient. The long-time breed duration strategy Model DF (5) and Model DF (3) are less risk efficient and got a negative CE values for all degree of risk aversion as shown in Figure (3). Giving feed subsidy incentive will not help long time duration broiler breeders.

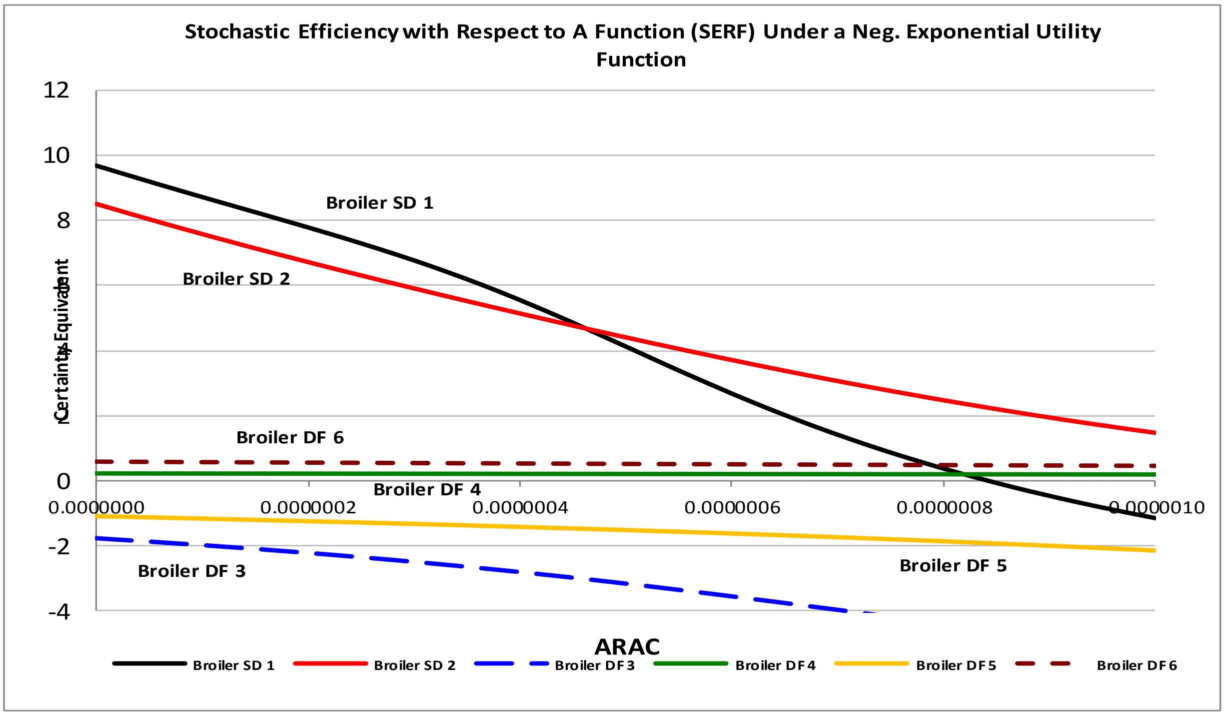


Figure (3) : Stochastic Efficiency with Respect to Function SERF for Alternative Production Systems and Feed Subsidy Policies.

1.4 Certainty Equivalent Value and Assessment of Present Broiler Production System

Two models formed to present existing long-time breed duration strategy i.e. (Model DF 3) and (Model DF 5) and result shows a negative mean NR value for the two models. The short time breed duration production strategy i.e. (Model DF 4) and (Model DF 6) are also examined for risk efficiency and economic sustainability by using SERF analysis. The analysis proved that short time breeding practices are risk efficient and mitigate downside risk area. Feed subsidy incentives help upside risk farmers to achieve higher mean NR.

Risk premiums analysis is calculated by using SIMETAR program to measure CE for different breeding groups and evaluate feed subsidy program alternatives. The analysis shows risk premium price of RO 7,155 per house (RO 0.038 per bird) is required to persuade farmers (with short time breed) to shift from traditional open house system to high yield environment control houses. Feed incentive program will encourage farmers to introduce modern environment control houses and supported equipment to shift to a more sustainable breeding system.

The Certainly Equivalent CE values in Table (4) indicates that short time broiler breed duration strategy (Model DF 4) is the most sustainable and risk efficient production system. The analysis also showed that given feed subsidy incentive to the farmers will increase farm net return and shift the NR means to the right and improve net return stability for entire range of risk aversion. The comparison of CE values for Model SD 2 and Model DF 4, shows RO 0.116 per bird need to be given to local farmers to protect them against cheap import poultry price.

Table (4): Ranking Broiler Production and Feed Subsidy Policies by Risk Aversion using CE for NRs (000) RO:

Risk	Risk Neutral		Slightly Risk		Moderate Risk		High Risk	
ARAC	0.00000		0.00000031		0.00000062		0.00000105	
Rank	Model	CE	Model	CE	Model	CE	Model	CE
1	SD (1)	9 691	SD (1)	6 681	SD (2)	3 582	SD (2)	1 243
2	SD (2)	8 510	SD (2)	5 837	SD (1)	2 448	DF (6)	443
3	DF (6)	585	DF (6)	538	DF (6)	496	DF (4)	209
4	DF (4)	241	DF (4)	231	DF (4)	222	SD (1)	-1 429
5	DF (5)	-1 089	DF (5)	-1 334	DF (5)	-1 636	DF (5)	-2 211
6	DF (3)	-1 761	DF (3)	-2 514	DF (3)	-3 623	DF (3)	-5 366

The short time breed duration production system (Model DF 6) and (Model DF 4) are risk efficient alternatives across all the risk aversion range, whereas long time duration models are not sustainable economically and characterized with risk inefficiency. The cold temperature scenarios are only economically sustainable at risk neutral level of ARAC, but are not sustainable at the higher level of risk aversion (ARAC=4.0). The major hypothesis of SERF and CE analysis is that the decision-maker would be risk averse enough to accept a sure lower expected value versus a high unsure expected value.

1.5 Probability Density Function analysis of alternative Broiler Production System

The probability density analysis shows that the long time breed duration production system at cold temperature zone is better than short time breeding practices as birds can capture more gains within the extended breeding period. The long time breed duration at heat stress area has a negative skewed distribution and shows frequent small NR means gains and few large NR loss values. The high probability of extreme net return loss risk of cold temperature scenario could lead to serious business failure and collapse.

The probability density analysis for short time breed duration i.e. (Model DF 4) and (Model DF 6) indicate positively skewed distribution with frequent small gains and few extreme large NR profits. The extreme NR values of short time breeding affect mean and pulled it to the right. The extreme large profit can compensate loses and insurance companies can cover this broiler breed business losses.

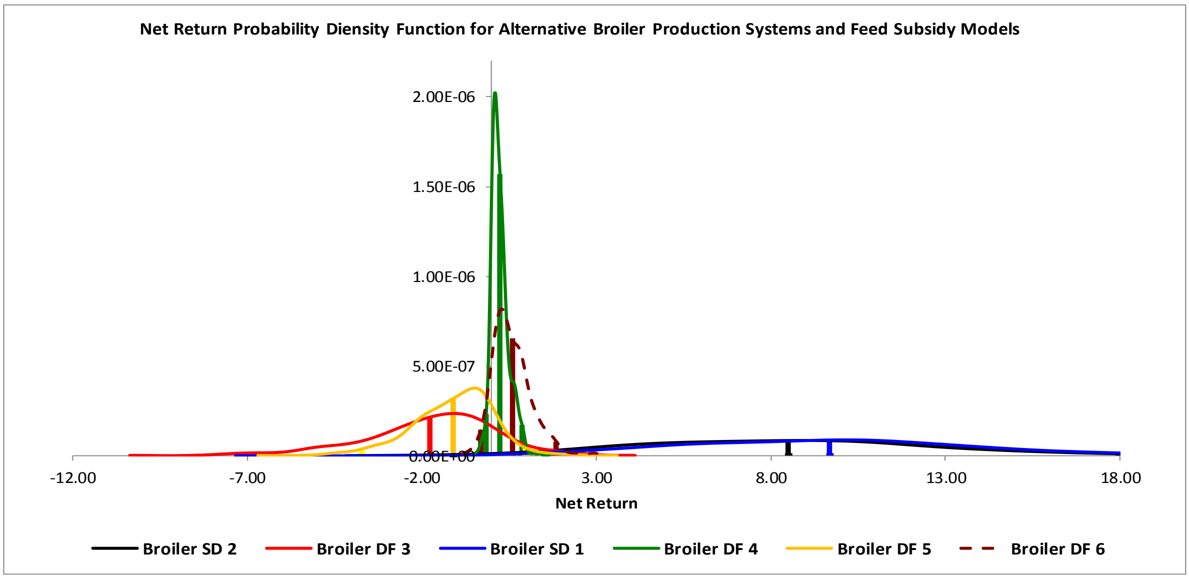


Figure (4) : Farm NR Probability Density Values for Different Broiler Production Systems and feed Subsidy.

1.6 StopLight Analysis and Economic Viability of Broiler Production System

The StopLight Chart analysis is performed to evaluate economic viability of broiler production system and risk management tools. StopLight analysis can be used as good tool for ranking broiler breeding system and alternative feed subsidy policies and indicate the probability of getting favorable Net Return. Assuming each operation practices has risk-averse preferences, the optimal scenario is the one which has the highest probability of target farm net return. The probability of achieving RO 500,000 farm Net Return is presented in green colour, whereas, broiler production system probability of getting Net Return of RO 1,000 and lower is denoted in red colour. Farmers achieving NR between RO 1000 and 500,000 is denoted in yellow, as shown in Figure (5).

Cold temperature scenario i.e. Model (SD 1) and Model (SD 2) can get NR of RO 500,000 or more with a probability of 99% and 97% respectively. The long time breed duration i.e. Model (DF 3) and Model (DF 5) will get loss with a probability of 85% and 86%, respectively. However, the short time breed duration of 35 days and 12 days rest period is a good risk management tool to practice and will reduce loss probability to 10% only. The feed subsidy program can reduce the probability of marginal farmers from 75% to 42% and increase probability of farmers getting RO 500,000 or more from 15% to 48%. The StopLight chart analysis below is a clear evidence of the important of feed subsidy policy to improve broiler farming at rural area and will be good risk management tool to achieve sustainable growth for poultry sector.

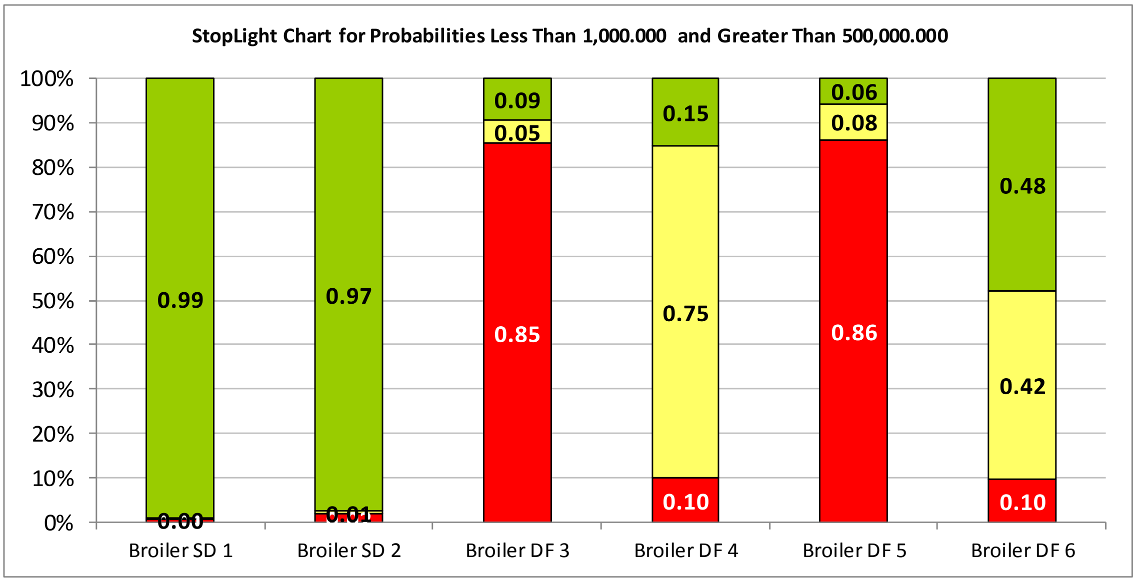


Figure (5) : Probability of Net Return Values for Different Broiler Production Systems and feed Subsidy.

IV. Conclusion

The main task of this paper is to investigate broiler production systems risk efficiency and risk management sustainability at different risk aversion level. Sustainable broiler production systems and risk management instruments sustainability depend on three factors. The first one is identifying sustainable production system which is suitable for broiler breed within farm location area i.e. (heat stress area) and the second is availability of supporting institutes, and finally, Government supporting policies and regulations that understand farmers perception and risk aversion attitude. Accordingly, this paper grouped broiler production systems to three simulated scenarios to represent ideal cold temperature zone, heat stress area and heat stress with feed subsidy program models.

The cold temperature zone broiler production systems have high farm net return with a fat tails distribution, and this refer to relative high probability of extreme net return risk. The probability distribution analysis of long-time breed duration for 42 days (Model SD 1) imply that 90% of the net return distribution are positive and range between 2.87 Mn. and 17.59 Mn. Rials Omani. Whereas short-time breed duration for 35 days (Model SD 2) imply that 90% of the net return distribution range between 1.89 Mn. and 16.30 Mn. Rials Omani. However, this means the long time duration production system in cold temperature is better than short time duration breeding practices as birds can capture more gains within the extended breeding period. The high probability of extreme net return loss risk for cold temperature scenario could lead to serious business failure and collapse.

The heat stress broiler production system have a lower net return farm income compared to cold temperature scenario production system. The long-time breed duration models in heat stress scenario without feed subsidy (Model DF 3) and with feed subsidy (Model DF 5) have a negative skewed net return distribution. It is characterized by many small gains and a few extreme losses and has a long tail on its left side. Risk in this type of broiler breed production systems can be managed and covered by financial institute, cooperatives, minimum revenue guarantee policy and insurance institution support. The feed subsidy policy only reduced the loss range of 90% of NR from R.O. (+0.97 to -5.37) Mn to range of (+0.64 to -3.23) Mn. and could not shift farmers to positive NR zone.

The short-time breed duration models in heat stress scenario without feed subsidy (Model DF 4) and with feed subsidy (Model DF 6) have a positive net return skewed distribution. The PDF analysis indicate that heat stress without feed subsidy (Model DF 4) and with feed subsidy program (Model DF 6) have a probability of positive farm net return of (88.6%) and (88.4%) respectively. The result indicated the effectiveness of short time breed duration practices to NR economic viability and improve farm net return stability at downside risk area and mitigate heat stress risk at hot climate farm location. The feed subsidy strategy implemented by Government Authority will shift farm's NR means to right and increase the range of the profit by 125%. The feed subsidy program increase business stability and risk efficiency and highly recommended for such cases. Appropriate risk perception can be seen as an important factor for choosing an effective risk-coping strategy, because farmer that is not aware of the risks facing his broiler farming clearly will not be able to manage them effectively.

The Government Authority introduce subsidy program in year 2011 and reduce poultry feed price by 12%. The feed subsidy program increased net return per house by 330% for short time breed duration and achieve sustainable risk management goal for this group of the farmers. The feed subsidy policy can also be used to reduce loss for long time breed duration by 38%, but it will not achieve risk management sustainability strategy. However, The Government Authority stopped poultry feed subsidy program by the end of year 2016.

Government policies should encourage small farmers to introduce environment control houses and improve breeding management challenges such as increasing productivities growth at hot climate zone and invest in technology to reduce climate change effect through providing credit facilities and loan to poultry business from Financial Institutions. Co-operative institution also is important to help small farmers to reduce risk and get their required inputs and products marketing facilities.

The study finds that broiler farmers in Oman are increasingly exposed to a wide range of risks while the availability of risk management instruments lags behind. The Government feed subsidy program and availability of cooperatives, insurance and financial institutions are highly required to mitigate net return loss risk and improve poultry business.

Competing interests

The author declared that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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