International Journal of Multidisciplinary Approach and Studies

ISSN NO:: 2348 – 537X

Development of Dynamic System Models for Fulfilling Ras Chicken Availability In Maintaining Stability of Ras Chicken Meat Price In Bali Province, Indonesia

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ABSTRACT

The purpose of this study is to develop a dynamic system model regarding the availability of broiler chicken meat in the province of Bali, Indonesia and simulate various policy scenarios for the availability of broiler chicken meat for the period 2019 to 2035. This research was conducted in Bali Province which consisted of nine districts/cities, namely Badung; Denpasar; Gianyar; Klungkung; Bangli, Karangasem; Buleleng; Jembrana; and Tabanan. This study used the quantitative method supported with qualitative method, from perspective of dynamic model. The research steps were site selection, determination of reviewed objects, selection of respondents (quantitative and qualitative), selection of data type and source, and selection of key variables through prospective analysis. Based on three criteria, namely price stability, the growth of new businesses/breeders, and quality of meat is always fresh, the priority program is obtained, namely policy through increasing broiler chicken production with a weight of 0.75. While the next program is to reduce the demand for broiler chicken with a weight of 0.16; and the smallest value of the weight is the import policy only obtains a weight of 0.09. It was concluded that the dynamic system model approach to the submodel marketing system, showed that the price movement of retail broiler chicken at the consumer level was influenced by the ratio of supply and demand. Changes in the ratio of supply and demand affect the change in retail prices. Thus, through a dynamic system model approach, it can prove that retail prices at the consumer level move according to changes in the ratio of supply and demand.

Keywords: *Dynamic model, price stability, broiler meat consumption, supply-demand*

INTRODUCTION

Community needs for cheap and affordable animal protein is one factor that continues to increase the need for poultry meat. Chicken meat is one of the most popular commodities in the world of livestock agribusiness in Indonesia. Until now, chicken meat has shifted other livestock commodities to meet protein requirements from livestock, because the price is affordable. In addition, broiler meat business is quite prospective, because people's appetite for this commodity is very high in all levels of society (Setyono and Maria, 2011).

Chickens are the most consumed type of meat by the community, and race chicken farms are cultivated in the industry (Pusat Kebijakan Perdagangan Dalam Negeri, 2016). Paying attention to this phenomenon, if it is not anticipated from now for the consumption needs of the population of the next 10 to 30 years, as well as increasing domestic and foreign tourist

visits, it will affect the adequacy of meeting the consumption needs of animal protein sourced from chicken meat.

Although people's chicken meat consumption continues to increase every year, the level of chicken meat consumption in Indonesia is still far behind compared to ASEAN countries, such as Thailand and Malaysia. The consumption of chicken meat per capita for the people of Thailand and Malaysia is 400% higher compared to Indonesia.

The problem of imbalance between the supply and demand of broiler chicken meat in Bali, depends on the ability and independence of the region to meet the market needs of broiler meat derived from the production of self-sufficient regions (Carmona *et al*., 2016). The problem of the availability of broiler chicken is a very complex system that involves various components and variables that interact and interact. The right approach to solving and solving these problems is through a dynamic system approach (Ustriyana, 2015).

The system dynamics approach model, besides being used to model the phenomena that occur, can also be used to simulate alternative policies that can be taken by local governments to overcome the problem of the availability of broiler chicken. Effective policies can be formulated to overcome the problem of price fluctuations, because supply shortages can be overcome (Coyle, 1996). The method with the system dynamics approach is one approach to policy modeling, especially in terms of improving understanding, how (how) and why (why) the dynamic symptoms of a system occur (Tasrif, 1998).

System dynamics modeling is a dynamic system, in which every system actor always interacts by forming a feedback relationship that changes with changes in time. Modeling with a dynamic system approach can present actual conditions, then simulations are carried out to analyze the characteristics of the system (Tasrif, 2004).

The purpose of this study is to develop a dynamic system model of the availability of broiler chicken meat in the province of Bali and simulate various policy scenarios for the availability of broiler chicken during the period 2019 to 2035

METHOD

Dynamic Model Development Method: This paper uses a dynamic model approach, which is built on a "system dynamics" methodology which was originally developed by Jay W. Forrester. The model built with a dynamic system approach allows all socio-economic variables to be incorporated into the system. Dynamic model is an abstraction and simplification of a complex system, but it is attempted to be able to represent the system properly. Furthermore, based on the dynamic model obtained, a policy scenario simulation is based on logically developed assumptions (Sterman, 2000).

Research Site and Schedule: This research was conducted in Bali Province which consisted of nine districts/cities, namely (1) Badung; (2) Denpasar; (3) Gianyar; (4) Klungkung; (5) Bangli, (6) Karangasem; (7) Buleleng; (8) Jembrana; and (9) Tabanan.

Research Design: This study used the quantitative method supported with qualitative method, from perspective of dynamic model. The research steps were site selection, determination of reviewed objects, selection of respondents (quantitative and qualitative), selection of data type and source, and selection of key variables through prospective analysis.

Sampling Method: The sampling method in order to gather information and data from respondents was determined intentionally (purposive sampling) on the basis that respondents had expertise, reputation, and experience in the field under study. For the purpose of identifying dimension factors/attributes in the supply chain of broiler chicken meat and general respondents are academics, Business Actors (GPMT), Animal Husbandry and Animal Health Services, Food Security Services, Department of Trade and Industry of Bali Province, and stakeholders related to broiler cultivation and marketing. For the purposes of collecting needs identification and problem formulation data (for dynamic system analysis), the respondents were determined intentionally (purposive sampling) in nine districts/cities which represented the association of Indonesian poultry people (PINSAR).

Number of Samples: In calculating the amount or number of samples in this study are: the first, if the exact number of population is not known (N), then the *Cochran formula* is used to calculate the number of samples used as respondents (Sugiyono, 2017), as follows:

$$n = \frac{Z^2 p\, q}{e^2}$$

Note:

n = Number of samples
z = The price in the normal curve for a 5% deviation with a value of 1.96
p = 50% correct opportunity
q = Wrong chance 50%
e = The error rate is usually 5%

The second, if the population number (N) is known, then the *Yamane formula* can be used to calculate the number of samples used by respondents using the following formula:

$$n = \frac{N}{1+N\,e^2}$$

Note:

n = Number of samples
N = Total Population
e = The error rate is usually 5%

System Modeling: After finishing building the conceptual system in the form of a causal loop diagram, then the next process is done by pouring the conceptual model of causal diagrams into flow diagrams/model structures (stock and flow diagrams) that can be understood by computer software that will used, so that it can know dynamic behavior caused by assumptions of the simulated model. The results of this modeling are then carried out verification and model validation tests to determine the suitability of the model with the real system.

Software for dynamic system analysis in this study uses *Powersim studio 10* software. Powersim software is used to design the development of dynamic system models. Likewise in the research on the availability of chicken meat in Bali and to be able to meet the needs of chicken meat in the future, use *Powersim studio 10* software. Graphically there are several symbols used in making models in a dynamic system approach.

Level (level) with a four-square box symbol is used to describe the variable state at a certain time. System variables that can be classified into state variables are the parts that remain, if the system is suddenly stopped (frozen). In everyday life, savings in banks and water in a hole in a river are examples of state variables. The source and lubuk (sink) represent the system environment, and flow can occur from source to model and from model to depth without affecting the environment. The symbol flow rate describes the level of flow between parts (components). Auxiliary variables with small circle symbols represent factors that affect flow rates such as inputs and parameters.

Output-Input Analysis: The dynamic model of broiler chicken availability is built by accommodating various related system components. The relationships between system components, inputs, and outputs in the model are expressed in input-output diagrams or black box diagrams. In this analysis there are 6 components in this stage, namely: (1) controlled input components; (2) uncontrolled input components; (3) environmental input components; (4) the desired output component; (5) unwanted component output; and (6) system control components. The input-ouput diagram describes the process of transforming input models into model output. The model uses two types of input, namely input from outside the system and input from inside the system. Endogenous input consists of controlled input and uncontrolled input. Controlled input is a variable that is needed by the system that has an influence in determining the desired system behavior, and can be specified in the system design. Controlled input can be used as a means for engineering the model in achieving the desired goal or output. In this study engineered controlled input is limiting the amount of effort.

Meanwhile, uncontrolled input is input that directly influences model output, but cannot be fully controlled in changing system behavior. Included in uncontrolled inputs are fish resources, fish prices, socio-cultural conditions, and production quantities.

***Analytic Hierarchy Process (AHP)*:** This AHP method helps solve complex problems by structuring a hierarchy of criteria, the parties that are interested in the results, and by attracting various considerations to develop weight or priority. This method also combines the strengths of the feelings and logic involved in various problems, then synthesizes various diverse considerations into results that match the estimates intuitively as presented at the considerations that have been made (Saaty, 1993).

Model verification and validation: Model verification is done by dimensional checking (unit of measure) on the model variables. Model validation is an attempt to evaluate the model made and conclude whether the model being built is the right representation of the reality being studied, so that it can produce conclusive conclusions (Eriyatno, 1999). Generally, model validation has been carried out according to the purpose of modeling, namely by comparing dynamic behavior with real conditions, if it is considered valid, the model can be used as a representative of a real system (Daalen dan Thissen, 2001).

The statistical test used to measure the deviation between the simulation output and the actual data is mean absolute percentage error (MAPE) to find out the suitability of the forecast data (simulation) with the actual data, with the mathematical formula as follows:

$$\text{MAPE} = \frac{1}{n} \Sigma \left| \frac{Xm - Xd}{Xd} \right| \text{ x } 100\ \%$$

Note:
Xm = simulation data
Xd = actual data
n = period/amount of data

Criteria for the accuracy of the model with the MAPE test (Somantri, 2005) are as follows:
MAPE <5%: very precise
5 <MAPE <10%: right
MAPE> 10%: incorrect

RESULTS AND DISCUSSIONS

The dynamic system approach model in the study of the availability of chicken meat in Bali is very dependent on policy makers, where the period of leadership time is two periods or within a period of 10 years. For this reason, dynamic system models can be sketched with simulations for a minimum of the next 10 years, namely 2020-2030 (Wigine *at al*., 2009). Whereas Ustriyana (2015), in the study of the availability of rice in Bali simulate for the period 2015 to 2030. So that in this study a dynamic system model simulation of broiler chicken availability was also established during an interval of 15 years to see simulation results with several policy scenarios.

The system model of the availability of broiler chicken made is a representation of the real system which is divided into six subsystems, namely the population subsystem, the needs subsystem, the production subsystem, the availability of broiler meat, and the broiler meat marketing subsystem to the consumer level (Hartrisari, 2007).

From the causal loop diagram in Figure 1, the negative loop shows the balancing between production, population, and per capita income. This balance leads to a certain carrying capacity due to the limitations of existing production factors. The balance that is limited by the existing carrying capacity, can shift towards new equilibrium, if there is intervention in terms of production technology, or in terms of population policy. Likewise, in terms of the availability of broiler chicken staples, it is always towards balancing due to people's desire to fulfill their life needs, so that availability is always influenced by a balance between the need and ability to produce within a year, if the deficit will be covered by import between islands.

The population causal loop submodel is constructed from four basic loops. From the four loops, it can be seen that the population will be controlled by birth, death, in-migration, and out-migration. The four loops consist of two positive loops that are affected by birth and incoming migration, and two negative loops that are affected by death and outgoing migration. If you want simplification, outgoing migration and in-migration can be made represented by net migration, that is the difference between incoming migration and outgoing migration, with a fixed migration rate (equal to the normal net migration level).

Naturally, the population model is towards the balance at the threshold of the carrying capacity of the region. But the development of technology, information and investment interventions and sector policies can lead to instability, such as the high pressure of in-migration in regions with high investment power, due to economic growth, ease of business, and security as one of the main attractions economy to develop its business.

International Journal of Multidisciplinary Approach and Studies
ISSN NO:: 2348 – 537X

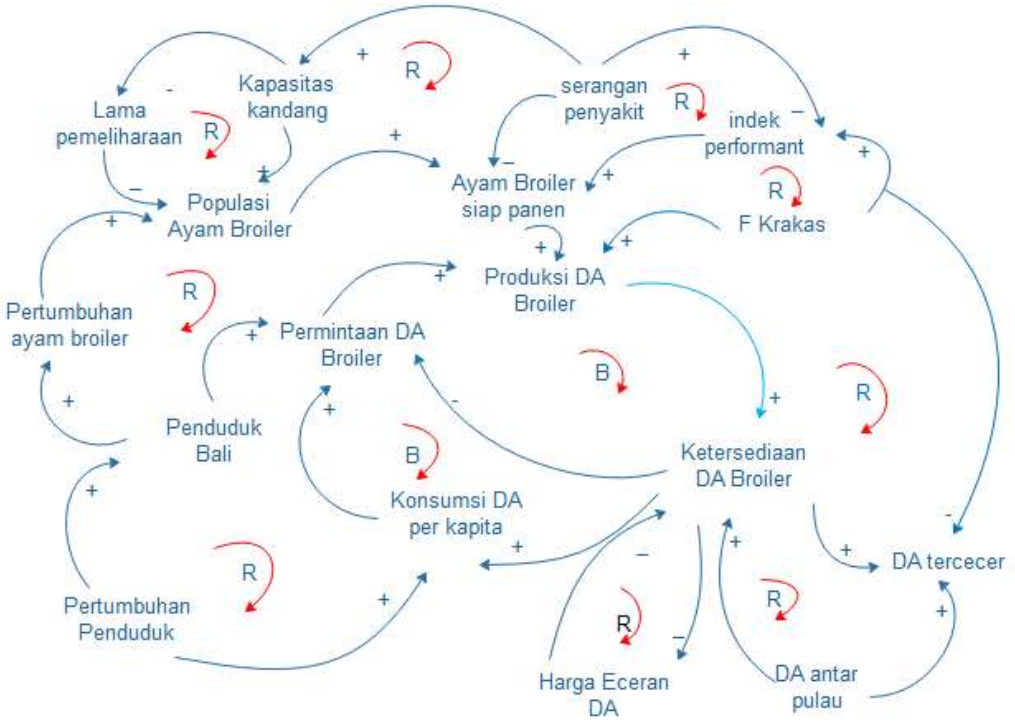

Figure 1. Causal loop diagram system for the availability of broiler chicken meat

The need for broiler chicken is broadly used for direct consumption needs of kg/per capita per year. In addition to direct consumption of broiler chicken meat, it is also needed for processed industrial use with basic ingredients of broiler chicken meat. The amount of demand depends directly on the population and the number of kilograms of broiler chicken consumed per year. Where the population is influenced by the large level of population growth in Bali itself. To calculate the total needs of broiler chicken meat, the damage fraction of meat also affects the total needs of broiler chicken, due to damage because the meat is easily damaged if not stored properly in the freezer. In this calculation, broken meat including scattered meat.

The production sub-model was built through the approach of broiler chicken production originating from the DOC (day-old-chick) into the fattening cage, and during fattening requires a process of 5-6 weeks. During the fattening cycle, some DOCs die so that the harvest time will decrease. The crushing cycle is a causal loop diagram due to the production of broiler chicken meat starting from DOC. In addition to the death of chickens in the fattening process, when broiler chicken is cut its weight becomes reduced, because the innards and feathers or carcass fraction of 72%. In the distribution process to the market or retailer, the meat has a shrinkage or the meat is scattered by 5%, which is called the scattered fraction.

The production sub-model models broiler chicken production which is calculated based on the number of broiler chickens and the average weight per live broiler chicken (live bird). The dynamics of production changes are affected by: (i) DOC supply, (ii) frequency of harvest cycles (5.5 times a year), and (ii) efforts to increase cage productivity.

The marketing chain cycle that occurs for each marketing cycle from farmers to retailers is reinforcing. If the basic price of the production of a live bird (HPP) rises, it affects the collector who raises the selling price to the chicken cutter trader (RPA). Furthermore, the RPA will also increase the selling price per unit of kilogram to retailers, as a result of the cost of purchase being increased (HPP). The last cycle is the money paid by consumers to obtain per kilogram of broiler chicken meat also rises. This is due to the multiplayer effect caused by the increase in HPP at the farmer (producer). This efficiency is very fast at the retail level of consumers if there is an increase. Conversely, it can occur if the price at the producer of a live bird drops due to over supply.

The total need for broiler chicken is the consumption needs of the population coupled with industrial needs. Broiler chicken meat produced can be calculated from the average weight of live broiler chickens per head which will be converted from broiler carcass conversion factors. Meanwhile, the number of live broiler chickens to be converted is calculated from the production of broiler chicken minus the fraction of chicken mortality. Between the fraction of broiler chicken scattered with the production of broiler chicken meat will form loop balancing (meaning mutual balancing) and the loop rate of population growth with the population forming a loop reinforcing (mutually reinforcing).

Based on the MAPE value obtained from the variable population number, it can be concluded that the dynamic model of the system of the availability of broiler chicken in Bali that has been built has very high accuracy with an average MAPE of: 0.614% (very appropriate) for the variable development of Bali population . That is, the distance of the simulation results based on the dynamic model of the population subsystem that is built is close to the actual value of the real system.

From the MAPE value obtained from the variables of broiler chicken meat production it can be concluded that the dynamic model of broiler meat production subsystem in Bali that was built has very high accuracy with an average MAPE of: 2.433% (very appropriate) because it is still below 5%, for variable broiler chicken production. The distance of the simulation results is based on the dynamic model of broiler meat production subsystem that is built close to the actual value of the real system. The dynamic model of broiler chicken production subsystem is included as a valid category, meaning that the dynamic model can be continued to predict according to the period of the next few years, due to differences in predictions between the historical data of the last nine years with the simulation results, including categories very precisely, because the results are still below 5 %. In the dynamic model of the system, the availability of broiler chicken in Bali is simulated until the next 2035.

From the survey results it was found that the main causes of instability between supply and demand were: (i) there was a ban on the use of growth-triggering antibiotics (AGP); (ii) disease stress; (ii) cage productivity is still 60% -80% per square meter; and (iv) production costs of 70% of the feed and drug components. The chain effect will continue to occur as a result of soaring meat prices, purchasing power will decrease, and impacting nutritional intake derived from animal protein will also decrease.

There are three schemes of broiler meat market price movements caused by an imbalance between supply and demand, namely:

Dynamic Subsystem Model, Broiler Chicken Meat Marketing Scheme 1.

Model Scheme 1: comparison of demand with supply, if the meat needs are higher than production, then the price of meat will increase upwards from the normal price. This condition is not desired by the government and consumers, because it can cause several impacts, economically, socially and politically. Economically it influences inflation, and socially can cause public health status to decrease, because purchasing power decreases, thereby reducing consumption of chicken meat which is a source of animal protein to fulfill community nutrition (Athanasiou *et al*., 2007).

Broiler chicken at an affordable price, and favored by all walks of life, especially in Bali, which by custom and culture avoids eating beef, because Cows are purified animals, especially for Hindu spiritual aspirants. While politically, with the increase in broiler chicken meat, it can be used as a political commodity by opposition groups, because the government has failed to provide broiler chicken at affordable prices. In marketing scheme 1, graphically is presented in Figure 2. The top garf lines are retail prices at the consumer level (blue), Market Price movements (MPM = ping color) and distribution margins (light yellow). Mathematically, consumer retail prices are the sum of distribution margins with market price movements.

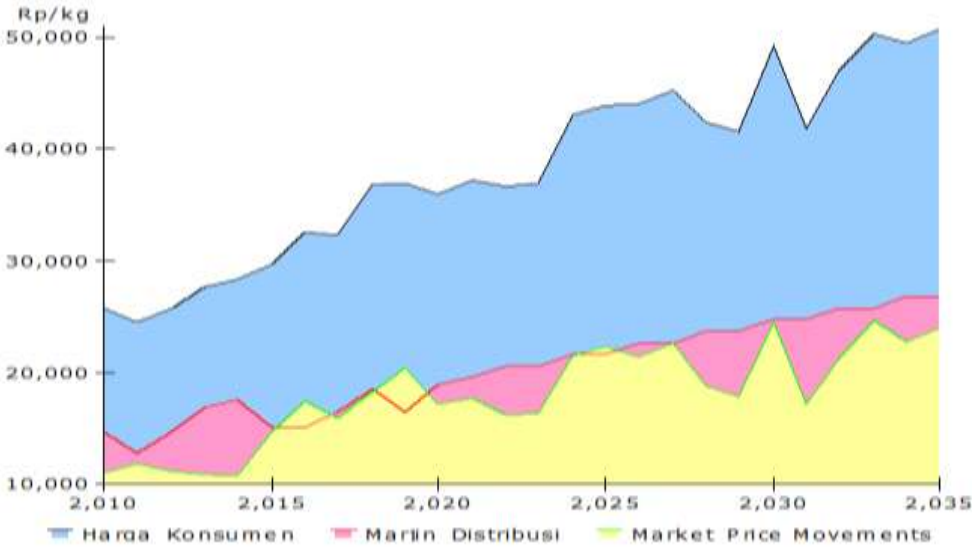

Figure 2. Consumer Retail Prices, Distribution Margin, and Market Price Movements (MPM)

The simulation results of changes in retail prices of meat are presented at the consumer level which are influenced by the level of market price movement (MPM) and distribution schemes in the base year from 2010 to 2018, while for 2019 to 2035 are scenarios for dynamic marketing system model simulations broiler chicken meat and its effect on the stability of the price of broiler chicken meat in the province of Bali.

From the simulation, it was seen that the price of meat at the consumer level continues to fluctuate with the increasing trend following the ratio of demand and supply (D/S). The fluctuating price of broiler chicken meat is influenced by two factors, which are due to changes in the demand-supply ratio which have a direct impact on changes in market price

movements (MPM) and distribution margins. Fluctuations in meat prices are not extreme, because the gap between demand and supply is not a large difference. If the demand-to-supply ratio continues to increase above the number one or the trend rises above the number one, then the MPM figure in rupiah per kilogram will continue to increase along with the increase in the ratio between demand and supply of broiler chicken meat in the market. While the distribution margin is influenced by three sub-variables, namely broker traders, cutting traders, and lapak traders.

Dynamic Model in the Broiler Meat Marketing Subsystem Scheme 2.

The marketing model with Scheme 2 were almost the same as Scheme 1, namely the ratio is the total supply divided by the total demand for broiler meat (demand) in a year. The fluctuations in prices of basic necessities are often temporary, such as the phenomenon of rising chicken prices ahead of the holiday, on the contrary shows symptoms of price declines after Idul Fitri, and are generally temporary, because as a basis for calculations in dynamic system simulations, the average price in a year. The phenomenon of price declines after Idul Fitri or religious holidays and the new year, can decline even far below the cost of production (HPP) at the farmer level, because based on the reference price of Permendag number 96 in 2018, the price is Rp.18000, - per kilograms of live broiler chicken (live bird). While the price of chicken meat in the people's markets which is the monitoring of BPS with the Department of Trade and Industry in Bali Province, the price has remained stable in the range of Rp.33000 and Rp.34000 per kilogram.

In Figure 2, it is presented that the distribution margin of the movement is quite regular or stable even though the trend is rising. While the market price movements (MPM) movements are very volatile, and the movement of retail prices of broiler meat at the consumer level also follows the MPM movement 2010 to 2018 as the base year of simulation calculations using 9-year time series data, and then used for simulating consumer price projections based on the scenario of the dynamic system model of the broiler meat marketing system in the province of Bali. The scenario for calculating consumer price projections starts in 2019 until 2035.
Industry of Bali Province, the price of broiler chicken did not experience a significant decline, even tends to stabilize through the price of Rp.34000 to Rp.35000 per kilogram. Based on the results of the scenario simulation of the broiler meat marketing system in 2020, the retail price of chicken meat at the consumer level can tend to rise to Rp.43000 to Rp.44000. For reasons, when the price of meat goes up between intermediate traders, the turnover falls and gets a very thin profit margin. When prices go down, not lowering meat prices too drastically, it has an impact on sales turnover up to 10-20% compared to ordinary days when the price of chicken is normal.

Dynamic Model in the Broiler Meat Marketing Subsystem Scheme 3

Marketing patterns such as Scheme 3 were very rare in practice. However, with the simulation of developing a dynamic system model for broiler meat marketing, the system is very easy to explain through simulations using scenarios. In marketing scheme 3, it is a very ideal condition that in economic theory it is said that in equilibrium conditions or equilibrium positions, where the demand and supply are equal. Even though the reality of equilibrium may rarely occur, in order to complete the analysis of the retail price of consumers, it is necessary to explain through the development of a dynamic system model of the marketing of broiler chicken meat as follows.

A condition where the supply and demand are the same size, so the ratio of supply to demand is = 1 (one). This situation lasts until the end of the simulation year, namely in 2035. In other words, the ratio of supply to demand does not affect the fluctuations in retail prices of broiler chicken meat, so the retail price of chicken meat at the consumer level is purely the sum of distribution costs (intermediate traders) and cost of production (HPP) broiler chicken. The simulation scenario of the marketing scheme system 3 dynamic model starts in 2019 and ends in 2035. The graphic form is a sawtooth wave, in line with consumer retail prices, distribution margins, and market price movements (MPM).

The increase is not so drastic that there is even a tendency for 2 years to be stable. This guarantees security for business people, both those in the upstream and downstream sectors. And in the end, with stable meat prices, it will also provide protection for end consumers. Graphically, the shape of the line is not linear, but its wavy shape follows a slightly sloping sawtooth flow and has a straight line with market price movements, distribution margins, and retail prices of consumers. The development of consumer retail prices has a tendency to increase from year to year due to the formation of consumer retail prices, namely market price movements and distribution margins that have the same tendency to increase.

Analytic Hierarchy Process (AHP)

Based on the results of manual calculations with the help of microsoft excel, priority scale is obtained in meeting the increasing needs of broiler chicken meat from three alternatives, namely increasing broiler chicken meat production, suppressing demand for broiler chicken meat, and bringing in imported chicken meat. Based on three criteria, namely price stability, the growth of new businesses/breeders, and quality of meat is always fresh, the priority program is obtained, namely policy through increasing broiler chicken production with a weight of 0.75. While the next program is to reduce the demand for broiler chicken with a weight of 0.16; and the smallest value of the weight is the import policy only obtains a weight of 0.09.

Based on the process hierarchy analysis (AHP) priority scale in meeting the needs of chicken meat until the year 2035, is to increase the production of broiler chicken meat. By using a dynamic system model approach, the findings of the marketing system submodel are obtained, that the price movement of retail broiler chicken at the consumer level is influenced by the ratio of supply and demand. Can be proven by a mathematical formula, that changes in the ratio of supply and demand affect the change in retail prices. Thus, through a dynamic system model approach, it can prove that retail prices at the consumer level move according to changes in the ratio of supply and demand. The availability of broiler chicken in the province of Bali is determined by the total production and the total need for direct consumption as well as processed with basic ingredients of broiler chicken. Broiler chicken production is determined by the population of broiler chickens and the average weight of the broiler chickens. The direct consumption needs of broiler chicken meat is determined by the population and per capita consumption of Balinese people. The greater the population and consumption per capita, the greater the need for broiler chicken meat.

CONCLUSION

It was concluded that the dynamic system model approach to the submodel marketing system, showed that the price movement of retail broiler chicken at the consumer level was influenced by the ratio of supply and demand. Changes in the ratio of supply and demand affect the change in retail prices. Thus, through a dynamic system model approach, it can prove that retail prices at the consumer level move according to changes in the ratio of supply and demand.

ACKNOWLEDGEMENTS

The authors would like to thank to the Dean of Faculty of Animal Science and Rector of Udayana University for their support during this study.

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