

An Empirical Evaluation of Policy Options for Increasing Dairy Production in Indonesia: A System Dynamics Approach

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(received 13-03-2023; revised 17-04-2023; accepted 05-07-2023)

ABSTRAK

Priyono, Nurmalina R, Burhanuddin, Ilham N. 2023. Evaluasi empiris pilihan kebijakan peningkatan produksi susu di Indonesia: pendekatan sistem dinamik. *JITV* 28(3):208-219. DOI:<http://dx.doi.org/10.14334/jitv.v28.i3.3281>.

Produksi susu domestik di Indonesia tumbuh lebih lambat dibandingkan konsumsi, sehingga terjadi kelebihan permintaan yang harus dipenuhi dari impor. Akselerasi peningkatan produksi susu dalam negeri tidak bisa lagi diselesaikan secara parsial, namun diperlukan pendekatan sistem secara holistik. Penelitian ini bertujuan untuk mengevaluasi secara empiris kebijakan akselerasi peningkatan produksi susu di Indonesia. Penelitian menggunakan data sekunder dari Badan Pusat Statistik, Kementerian Pertanian, Kementerian Perdagangan, Kementerian Perindustrian, Kementerian Koordinator Bidang Perekonomian, Kementerian Koperasi dan UMKM, Bank Indonesia, and FAO. Pendekatan sistem dinamik digunakan untuk membangun model dan menggambarkan dampak jangka pendek, menengah, dan panjang berdasarkan opsi skenario kebijakan. Hasil empiris menunjukkan bahwa kebijakan calf rearing pedet, peningkatan impor sapi perah betina dewasa, peningkatan conception rate, dan proteksi tarif impor berdampak positif terhadap pangsa produksi susu domestik terhadap permintaan susu. Di sisi lain, kebijakan peningkatan konsumsi susu yang jika tidak diimbangi dengan peningkatan produksi susu domestik, berdampak negatif terhadap pangsa produksi susu domestik. Semua opsi skenario kebijakan, kecuali kebijakan peningkatan laju konsumsi susu, dalam jangka panjang meningkatkan pangsa produksi susu domestik lebih tinggi dibandingkan jangka pendek dan menengah. Disimpulkan bahwa kebijakan optimis melalui calf rearing, peningkatan impor sapi betina, conception rate, dan mempertahankan tarif impor merupakan kebijakan terbaik yang berdampak pada peningkatan pangsa produksi susu domestik tertinggi dibandingkan kebijakan pesimis dan moderat.

Kata Kunci: Permintaan Susu, Produksi Susu, Analisis Kebijakan, Skenario, Sistem Dinamik

ABSTRACT

Priyono, Nurmalina R, Burhanuddin, Ilham N. 2023. An empirical evaluation of policy options for increasing dairy production in Indonesia: a system dynamics approach. *JITV* 28(3):208-219. DOI:<http://dx.doi.org/10.14334/jitv.v28.i3.3281>.

Domestic dairy production in Indonesia grows slower than consumption, resulting in an excess demand that imports must fulfill. Accelerating dairy production can no longer be solved partially; a holistic system approach is required. This study aims to empirically evaluate the policy options for accelerating dairy production in Indonesia. The data used in this study were secondary data from Badan Pusat Statistik, the Ministry of Agriculture, the Ministry of Trade, the Ministry of Industry, the Coordinating Ministry for Economic Affairs, the Ministry of Cooperatives and SMEs, Bank Indonesia, and FAO. A system dynamics approach was used to construct the model and describe the short-, medium-, and long-term impacts based on policy scenario options. The empirical results showed that the calf rearing program policy, increased female dairy cattle imports, higher conception rates, and import tariffs all positively impacted the share of domestic dairy production to dairy demand. On the other hand, a policy of increasing dairy consumption, if not accompanied by an increase in domestic dairy production, harms the domestic dairy production share. Except for the policy of increasing dairy consumption, all policy scenarios increased the long-term share of domestic dairy production more than the short- and medium-term. It is concluded that an optimistic policy through calf rearing, increased import of female cows, conception rate, and maintaining import tariffs was the best policy with the highest impact on increasing the share of domestic dairy production compared to pessimistic and moderate policies.

Key Words: Dairy Demand, Dairy Production, Policy Analysis, Scenarios, System Dynamics

INTRODUCTION

As one of the potential countries for developing the dairy industry in Southeast Asia, Indonesia is still an

importer of dairy products. Currently, imports are still required to fulfill about 77.26% of dairy consumption, primarily from New Zealand, Australia, the United States, and Europe. Domestic dairy production only

supplies 997.35 thousand tons of the 4,385.73 thousand tons of dairy demand in 2020 (Badan Pusat Statistik 2021). Moreover, the growth rate of domestic dairy production in Indonesia is lower than that of dairy consumption (Pusdatin 2020). Therefore, Indonesia's dairy cow population still needs to be developed because there is still a gap between dairy production and demand.

Indonesia faces challenges and opportunities in accelerating dairy supply from upstream to downstream to reach the target domestic dairy production share to dairy demand. The rise of dairy production depends on dairy cow productivity and population growth. During 1980-2019, the population of dairy cows in Indonesia grew by 3.01%/year, while productivity grew by 1.71%/year, and milk production grew by 4.34%/year (Priyono et al. 2022). On the other hand, the average dairy consumption in Indonesia is predicted to increase along with the increase in income and public awareness of consuming dairy products. Therefore, the gap between domestic dairy production and demand will continue unless domestic dairy production accelerates.

The government has issued several policies to develop the dairy industry in Indonesia. The 2013–2025 Indonesian Dairy Blueprint was launched by the government through the Coordinating Ministry for Economic Affairs in 2014 and then reviewed in 2016. The target share of domestic dairy production reached 60% of dairy demand. Furthermore, the Ministry of Agriculture issued Regulation No. 26/2017 concerning dairy supply and distribution after revoking Presidential Instruction No. 2/1985. Hereafter, the Minister of Agriculture regulation was revised to become No. 33/2018 to respond to World Trade Organization (WTO) policy regulations. The government previously developed a dairy industry roadmap for 2010–2025 through the Ministry of Industry, Republic of Indonesia. The long-term target output in the roadmap includes increasing domestic dairy production to 50–60% through increasing dairy productivity and dairy cow population. Therefore, improving and developing the agribusiness system from upstream to downstream is important in achieving the target share of domestic dairy production, about 60% of dairy demand, while supporting Indonesia's vision as the world's food barn in 2045.

The acceleration of domestic dairy production faces several problems, especially in the upstream and on-farm subsystems. According to Susanty et al. (2019), the productivity of dairy cows in Indonesia has stagnated at 8 to 12 liters/head/day, and cow ownership is 2 to 3 heads per household. Furthermore, the deficit of land-carrying capacity in the dairy cow population centers also needs to be improved to fulfill the required feed (Parmawati et al. 2018). Regarding reproductive performance, a survey on livestock business costs showed that the conception rate of dairy cows in Indonesia is 40.57% (Badan Pusat Statistik 2017). Moreover, the conception rate and the

success of the rearing calf program will significantly affect the increase in the dairy cow population and domestic dairy production. According to Ferguson and Skidmore (2013) and Siddiqui et al. (2013), reproductive management and rearing programs aim to increase fertility and the lactating dairy cows' population. Therefore, based on the existing conditions, conception rates, and rearing programs can be implemented to encourage increased dairy production in Indonesia.

Based on data from the Ministry of Agriculture and Badan Pusat Statistik, the level of dairy consumption in Indonesia in 2000, 2005, 2010, 2015, and 2020 were 6.4, 9.3, 13.2, 15.0, and 16.27 liters/capita/year, respectively. Furthermore, if a rise in domestic dairy production does not accompany an increase in dairy consumption, it will decrease the share of domestic dairy production to dairy demand. Moreover, the government implements an import tariff policy as a trade barrier that can be used as an import protection policy for dairy producers. In addition, these intervention policies aim to protect dairy farmers (Saptati and Priyono 2021) and encourage an increase in domestic production (Salvatore 2013).

Based on the existing conditions, to achieve 60% of the target domestic dairy production share to dairy demand, it is necessary to accelerate the increase in milk production at the farmer level. Most Indonesian dairy producers are smallholder farms, owning less than 4 cows per household (Susanty et al. 2019; Saptati and Priyono 2021). The target of accelerating domestic dairy production can be realized if the development of dairy cows in the upstream and on-farm subsystems can be strengthened. Problems with increasing dairy production in Indonesia could no longer be solved partially; instead, a holistic system approach was required. The system dynamics approach can be used to build an integrated interactive model to increase the availability of dairy supply in Indonesia. Therefore, the empirical evaluation of policy options for accelerating dairy production in Indonesia using a system dynamics approach must be conducted holistically. This study aims to empirically evaluate the policy options proposed for accelerating the increase in the share of domestic dairy production to dairy demand in Indonesia.

MATERIALS AND METHODS

Data collection

This study employed official quantitative data sources from Badan Pusat Statistik, the Ministry of Agriculture, the Ministry of Trade, the Ministry of Industry, the Coordinating Ministry for Economic Affairs, and Ministry of Cooperatives and SMEs Republic of Indonesia, Bank Indonesia, and the Food and Agriculture Organization of the United Nations (FAO).

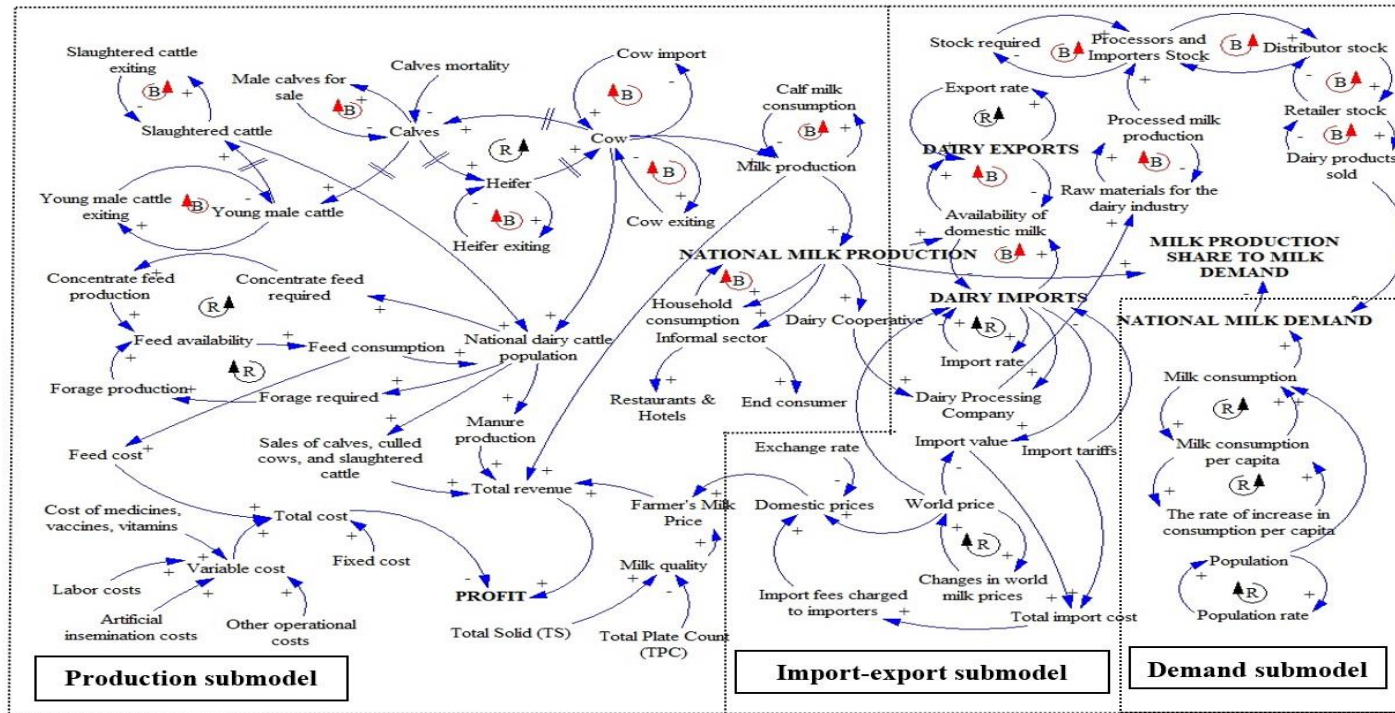


Figure 1. Causal loop diagram of dairy supply model in Indonesia

Table 1. Policy scenario options for accelerating dairy production in Indonesia for the period 2020-2045

| Scenario* | Pessimistic Policy | Moderate Policy | Optimistic Policy |
|--|---------------------------------|---------------------------------|---------------------------------|
| Scenario 1: (Calf rearing and increasing cow imports) | 2.66%/year | 20%/year | 35%/year |
| Scenario 2: (Increasing the conception rate) | 5% | 15% | 25% |
| Scenario 3: (The increasing dairy consumption rate) | 4.5%/year | 5.5%/year | 6.5%/year |
| Scenario 4: (Import Tariff) | 5% | 10% | 10% |
| Scenario 5: (Combination of scenarios 1 and 2) | 2.66%/year & 5% | 20%/year & 15% | 35%/year & 25% |
| Scenario 6: (Combination of scenarios 1, 2, and 3) | 2.66%/year; 5%; & 4.5%/year | 20%/year; 15%; & 5.5%/year | 35%/year; 25%; & 6.5%/year |
| Scenario 7: (Combination of scenarios 1, 2, 3, and 4) | 2.66%/year; 5%; 4.5%/year; & 5% | 20%/year; 15%; 5.5%/year; & 10% | 35%/year; 25%; 6.5%/year; & 10% |

*Policy scenario options will be implemented starting in 2025–2045; Short-term= 2025-2030; Medium-term= 2025-2035; Long-term= 2025-2045

Secondary data were collected at the national level, including the population of dairy cows, dairy production, import and export of dairy products, dairy consumption, domestic dairy prices, imported dairy prices, exchange rates, and related supporting variables. The other quantitative data used in the model development include data from farmers, dairy cooperatives, GKSI, and samples of dairy processing companies obtained from research and development activities at the Indonesian Center for Animal Research and Development, IAARD, Ministry of Agriculture. Primary data were used to confirm the national-level data, which included four dairy cooperatives in West Java, five dairy cooperatives and one milk processing plant in Central Java, and five dairy cooperatives in East Java. The collected quantitative data were used to fill in all the variables in the model, which was developed through a stock and flow diagram. The validation of the model structure involved lecturers, researchers, and practitioners using a purposive sampling technique with the criteria of being experts in developing the dairy industry in Indonesia.

Data analysis method

This paper employed a system dynamics approach to building a dairy supply model. The model was created in three sub-models: production, import-export, and consumption. The stages of system dynamics method analysis consist of problem formulation, system identification, model formulation, model validation, and policy simulation (Forrester 1994; Lie et al. 2018; Susanty et al. 2019; Simões et al. 2020; Azizsafaei et al. 2022). The dairy supply model in this study is described in more detail in a causal loop diagram. According to Sterman (2000), causal loop diagrams provide graphical information about the interrelated relationships between elements in the model. The upstream arrow indicates the cause, and the end of the arrow shows the effect with a positive or negative sign. A causal loop diagram of the dairy supply model in this study can be seen in Figure 1.

Furthermore, causal loop diagrams were developed in stock and flow diagrams. Quantitative data was inputted into stock and flow diagrams on models that passed structural validity testing stages. The validity test of the structure model was conducted to test the model's beliefs and the interaction of causal variables to approach the structure of real-life phenomena. Furthermore, a mean absolute percentage error (MAPE) statistical test was used for output validation. MAPE is a statistical test measuring the simulation output's accuracy. According to Sterman (2000), the mean absolute error (MAE) value between the actual data value and the simulation can be used as an error test tool for simulation results with actual conditions. The formula to calculate MAPE can be seen below:

$$MAPE = \frac{1}{n} \sum_{t=1}^n \left(\frac{|Y_t - \bar{Y}_t|}{Y_t} \right) \times 100$$

Where Y_t is actual data values, \bar{Y}_t is model simulation values, and n is year/time interval.

The model is valid for simulation if the MAPE is small and the deviation between the simulation output and actual data is also small. Furthermore, the model is simulated in compliance with the simulation objectives after being tested for validity (Forrester 1994; Sterman 2000). The causal loop diagram in this study was created using Vensim PLE. Furthermore, stock and flow diagram development, validation testing, and model simulation were performed using Powersim Studio 10. The simulation analysis performed in the 2020–2045 period and the detailed policy scenario options in this model can be seen in Table 1.

RESULTS AND DISCUSSION

Model validation

Model validation was an essential step in system dynamics methodology involving quantitative and qualitative tools. The model validation in this study used dairy cow population, dairy production, and dairy products import variables for the 2015–2019 periods. According to Sterman (2000), mean absolute error (MAE) is used to evaluate models and measure forecast accuracy. The result showed that the mean absolute percentage error of the dairy cow population, dairy production, and dairy product import variables were 3.85%, 3.67%, and 7.16%, respectively. Values of MAPE below 10% designate high accuracy in prediction. As a result, the model in this study met the goodness of fit requirement for policy simulation.

Calf rearing program and higher conception rate policy

Good dairy farming practices, professional farm management, and superior nutrition are required for profitable dairy farming. Dairy farmers frequently suffer profit losses due to delayed sexual maturation and higher age at first calving (Do et al. 2013; Wathes et al. 2014). Therefore, it is critical to manage calves at all stages of growth so that calves grow at the desired rate. Imported superior cows with superior genetics and high productivity should have been included in the program to improve calf-rearing outcomes. Figure 2 shows the impact of the calf rearing program and higher conception rate policy on the dairy cow population. The study found that calf-rearing programs and increased dairy cow imports (scenario 1) positively impacted dairy cow

population growth. Scenario 1 led to a higher dairy cow population than the baseline under pessimistic, moderate, and optimistic policies.

A good fertility management plan is required to ensure that all actions are directed toward improving reproductive performance. According to Boulton et al. (2017) and Kim and Jeong (2019), the rate of conception and calving will be determined by successful reproductive management, which includes calf and heifer rearing, first mating, pregnancy, and calving. The study also discovered that the conception rate positively impacted the dairy cow population. Higher conception rates (scenario 2) also led to a higher dairy cow population than the baseline, both pessimistic, moderate, and optimistic policies. The conception rate is the percentage of successful inseminations that result in pregnancy. To determine the percentage of conception rate, the insemination date or natural mating date must be collected. The conception rate is affected by the length of the waiting period, heat detection, mating method, body condition score, and feed intake (Siddiqui et al., 2013; Dash et al., 2016; Kim and Jeong, 2019). It is concluded that the policy of the calf rearing program, improved genetics and productivity, and a higher conception rate will lead to a higher dairy cow population.

Dairy import protection policy

The government enacts restrictive trade policies to protect domestic industries. According to Minister of Finance Regulation No. 26 of 2022, the dairy import tariff in Indonesia is fixed at 5%. The study showed that increasing import tariffs from 5% to 10% would reduce the volume of dairy imports (Figure 3). On the other hand, the reduction in import tariffs from 5% to 0% will result in increased import volumes. Based on the simulation results for 2020–2045, the trend for the baseline import rate was 8.26% per year. The 10% import tariff scenario decreased the import volume rate to 5.74% per year. Conversely, a 0% import tariff increased the rate of import volume to 10.42% per year.

The results showed that an increased import tariff of 5% impacted a 6.05% share of domestic dairy production, higher than the baseline. Based on the results, it was indicated that there is a correlation between import tariff, import volume, and dairy production. According to Salvatore (2013); Shagdar and Nyamdaa (2017), import tariffs are restriction policies that protect farmers by creating competitive and profitable domestic agricultural commodity prices. Import tariffs on dairy products have become necessary since the non-tariff policy was abolished in Indonesia. The government implements import tariff protection in the dairy industry by imposing import fees or taxes on dairy products imported from other countries. As a result

of the increase in import tariffs, the total dairy import volume will decrease. Therefore, an import tariff will protect dairy farmers and decrease dairy import volume.

The increase in dairy consumption policy

Increasing dairy consumption is an action plan in the Indonesian dairy blueprint stipulated by the Coordinating Ministry for Economic Affairs. The results showed that household dairy consumption in Indonesia increased positively, with a growth rate of 3.63% per year during 2002–2019. Furthermore, the population growth rate in Indonesia was 1.43% per year (2000–2019), and the gross domestic product increased by 5.07% per year (2010–2019). Dairy consumption has positively increased along with population growth, increased income, and improved socio-economic conditions in consumer households (Akaichi and Revoredo-Giha 2012; Lagrange et al. 2015; Cheng et al. 2015).

Figure 4 shows the impact of policy options in different scenarios on the share of domestic dairy production. The results showed that an increase in higher dairy consumption (optimistic policy) impacted decreasing the higher share of domestic dairy production compared to a pessimistic and moderate policy (scenario 3 in Figure 4). A comparison of the impact of Scenario 5 (without increasing dairy consumption policy) with Scenario 6 (increasing dairy consumption policy) showed that the share of domestic dairy production in Scenario 6 was lower than in Scenario 5. It is clear that the policy of dairy consumption, if not accompanied by an increase in domestic dairy production, harms domestic dairy production.

Impact of pessimistic policy scenario on domestic dairy production

Table 2 shows the changes in domestic dairy production share to dairy demand for pessimistic policy over the short-, medium-, and long-term compared to the baseline. The calf rearing program and increased cow import by 2.66 %/year (Scenario 1) increased the share of domestic dairy production to dairy demand by 2.07% to 5.82% higher than baseline. An increase in the conception rate by 5% (Scenario 2) increased the share of domestic dairy production by 0.11% to 4.87% compared to the baseline. Scenarios 1, 2, 3, and 4 showed that Scenario 1 was the best Scenario, which increased the highest share of domestic dairy production in the long term (Table 2). However, the results of all policy scenario options showed that Scenario 5 led to the highest increase in the share of domestic dairy production by 2.18% to 10.98% in the long term.

In contrast, a program to boost dairy consumption (Scenario 3) has an impact of decreasing the domestic

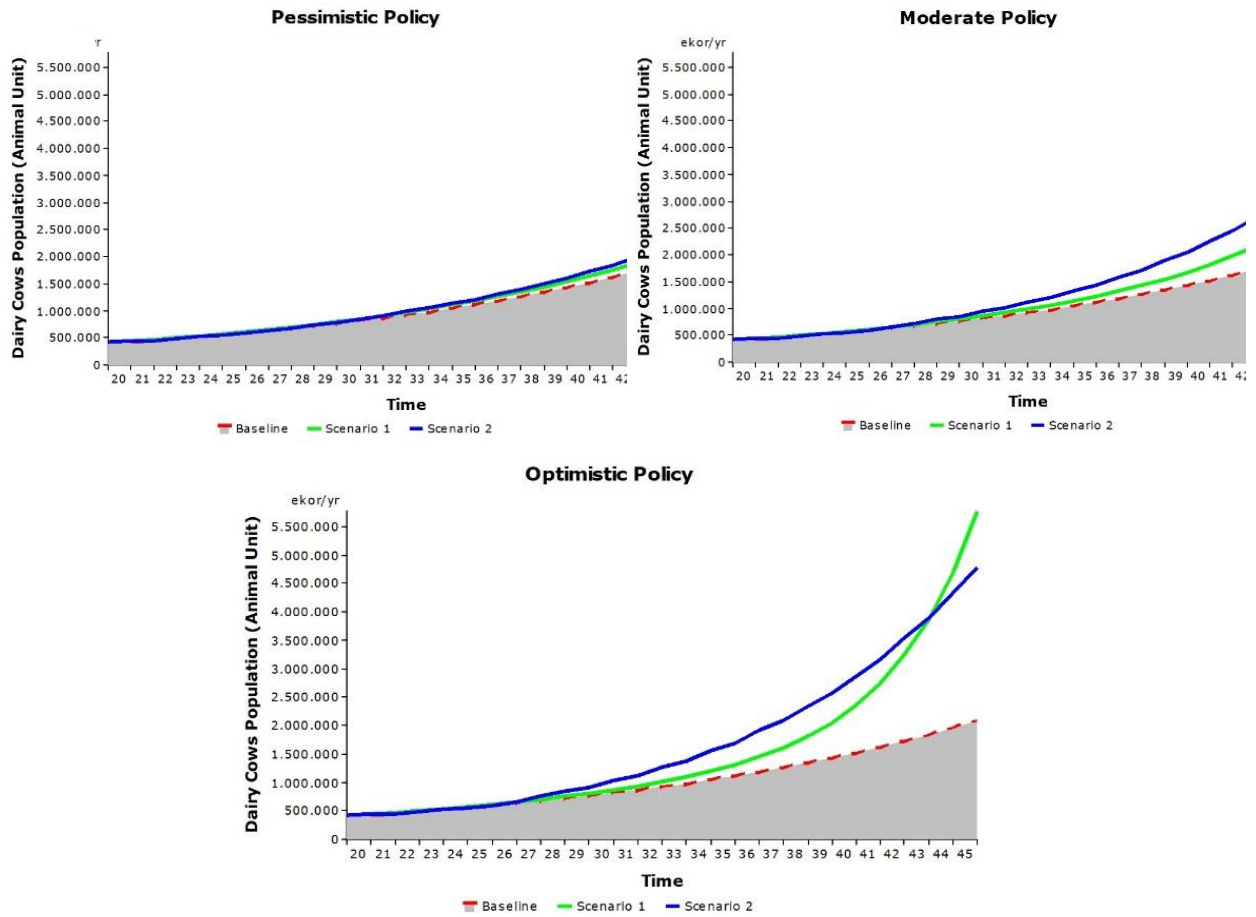


Figure 2. The impact of calf rearing program and higher conception rate policy on dairy cow population in Indonesia for the period 2020–2045

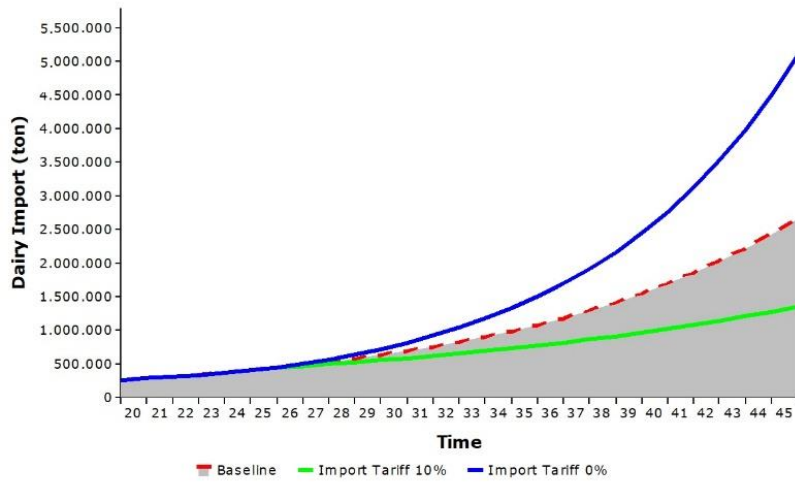


Figure 3. The impact of import tariff on dairy import volume in Indonesia for the period 2020–2045

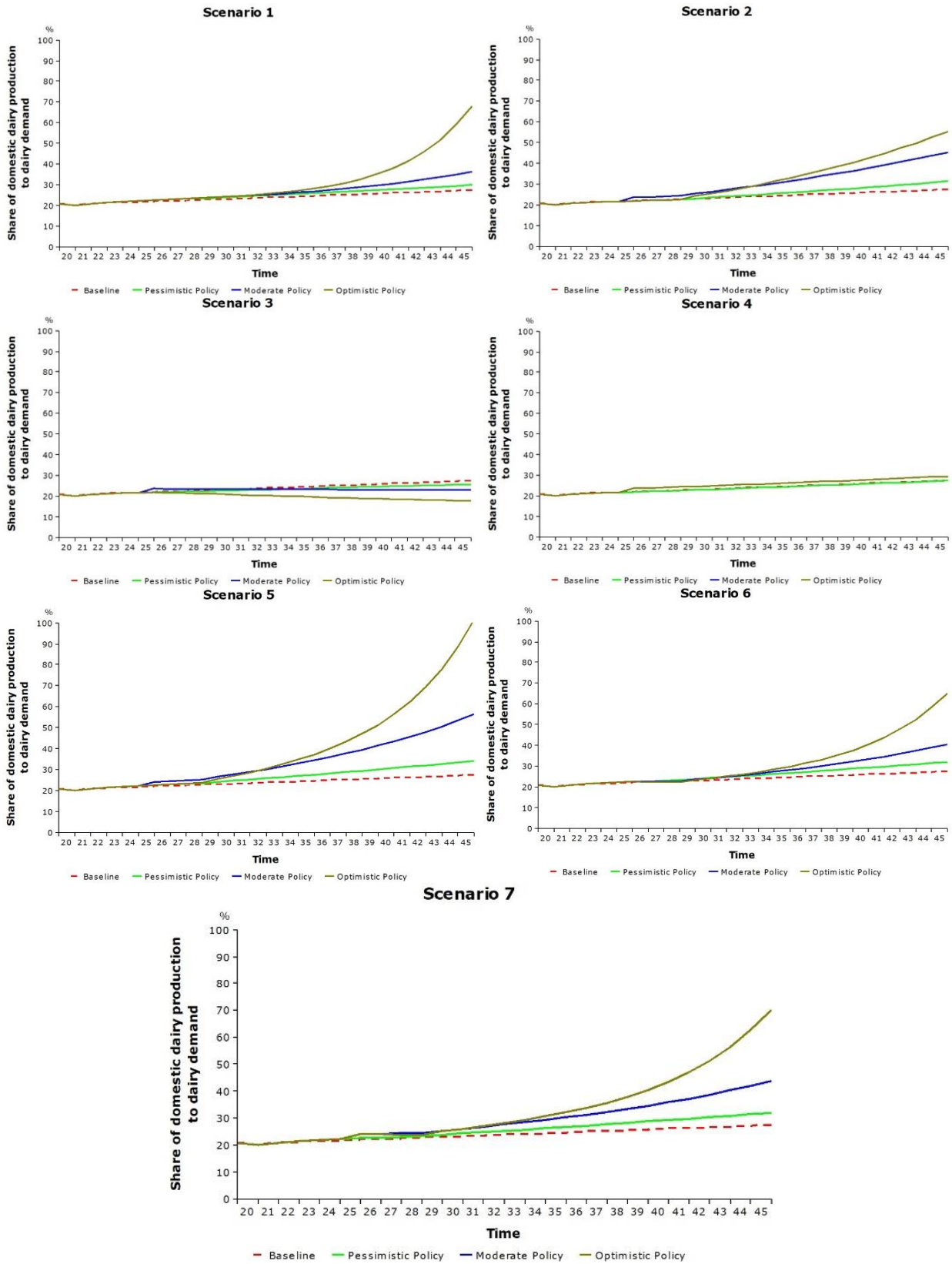


Figure 4. The impact of policy options in different scenarios on the share of domestic dairy production in Indonesia for the period 2020–2045

Table 2. The impact of pessimistic policy options scenario on the share of domestic dairy production in Indonesia for the short, medium, and long-term

| | Short-term | Medium-term | Long-term |
|--|-------------|-------------|-------------|
| | Change (%)* | Change (%)* | Change (%)* |
| Scenario 1: (<i>Calf rearing + increasing cows import by 2.66%/year</i>) | 2.07 | 3.53 | 5.82 |
| Scenario 2: (<i>Increasing the conception rate by 5%</i>) | 0.11 | 1.23 | 4.87 |
| Scenario 3: (<i>The increasing of dairy consumption rate by 4.5%/year</i>) | -0.30 | -0.93 | -2.43 |
| Scenario 4: (<i>Import Tariff by 5%</i>) | 0.00 | 0.00 | 0.00 |
| Scenario 5: (<i>Combination of scenarios 1 and 2</i>) | 2.18 | 4.83 | 10.98 |
| Scenario 6: (<i>Combination of scenarios 1, 2, and 3</i>) | 1.87 | 3.82 | 8.11 |
| Scenario 7: (<i>Combination of scenarios 1, 2, 3, and 4</i>) | 1.87 | 3.82 | 8.11 |

*Percentage change relative to baseline. Short-term = 2025-2030; Medium-term = 2025-2035; Long-term = 2025-2045

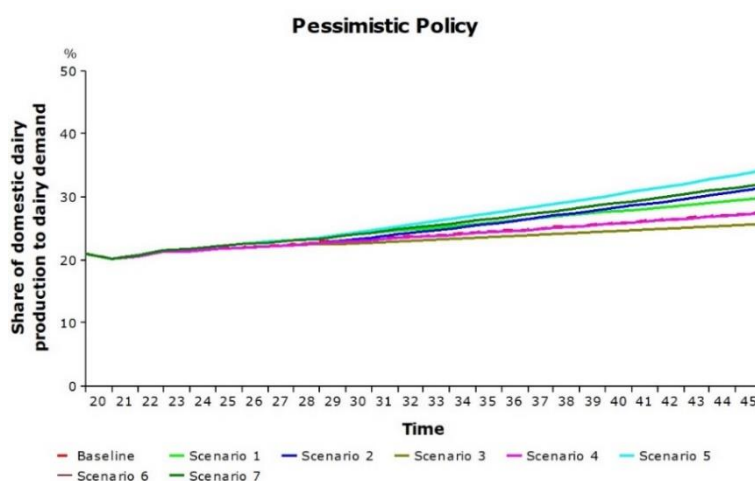


Figure 5. Dynamic simulation result of pessimistic policy scenario in Indonesia for the period 2020–2045

dairy production share by 0.30 to 2.43% in the long term. Under current conditions, the government of Indonesia regulates dairy drinking programs and school milk programs to promote an increase in dairy consumption. According to Rabiei et al. (2021), dairy consumption can be increased by introducing training programs for children, adolescents, and adults, providing more healthy and attractive dairy products, and lowering prices. Modern food marketing methods also effectively increase dairy consumption and build customer trust in milk quality (Cheng et al. 2015).

In the baseline for pessimistic policy, the share of domestic dairy production to dairy demand increased from 20.24% in 2020 to 27.64% in 2045 (Figure 5). Except for scenario 3, the share of domestic dairy production to dairy demand in scenarios 1-7 was higher than the baseline. Based on the simulation result, increasing the conception rate by 5% (Scenario 2) and increasing cow imports by 2.66 %/year (Scenario 1) revealed similar shares of domestic dairy production from 2025–2037. However, beginning in 2038, the share of domestic dairy production for Scenario 2 was higher

than for Scenario 1. However, the combination of Scenarios 1 and 2 (Scenario 5) revealed a higher share of domestic dairy production to dairy demand than the baseline and all policy scenario options. As a result, in the pessimistic policy, the calf rearing program, higher cow imports, and higher conception rates simultaneously positively impact the share of domestic dairy production to dairy demand. According to Russell et al. (2022), implementing calf rearing needs to consider several factors, including calf growth, health, behavior, management practices, the rearing environment, equipment, and external advice. To increase the conception rate, dairy farmers need extensions and training in feed nutrition and reproductive management (Siddiqui et al., 2013).

Impact of moderate policy scenario on domestic dairy production

There is a distinction between pessimistic and moderate policies. In the moderate policy (Table 3), an increase in the conception rate by 15% (Scenario 2)

showed a higher share of domestic dairy production than increasing cow imports by 20% per year (Scenario 1). Scenario 2 showed a lower increase in the short term than scenario 1. However, in the long term, Scenario 2 increased the share of domestic dairy production above Scenario 1. Furthermore, scenario 5 raised the share of domestic dairy production to dairy demand by 2.47% to 29.27%. Therefore, Scenario 5 delivered the best short-, medium-, and long-term performance compared to the baseline and other policy scenario choices. The calf rearing program, followed by an increase in the conception rate and superior cow imports (Scenario 5), aims to increase dairy productivity and domestic dairy production. Genetics and breeding are determinants of milk yield per lactating cow (Lima et al., 2022), and proper nutrition in feeding lactating cows affects milk production significantly (Tramontini et al., 2021). Therefore, the program for calf rearing must be supported by enhancing sound reproduction and rearing management. Costa et al. (2022) state that effective management, milking hygiene practices, and milk storage management determine higher dairy volume.

In the moderate policy, the increase in dairy consumption (Scenario 3) lowered the share of domestic dairy production by a higher amount (from -1.19% to -9.18%) than in the pessimistic policy (from -0.30% to -2.43%). On the other hand, an increase in import tariffs (scenario 4) showed an increase in the domestic dairy production share from 3.59% to 6.05%. According to Salvatore (2013), import tariffs on small countries (partial equilibrium) increase domestic production. Forty countries of the World Trade Organization (WTO) have also implemented agricultural tariff-rate quotas. For instance, Mongolia imposes import tariffs on its WTO-bound rates to encourage domestic industries (Shagdar and Nyamdaa 2017). Based on all policy scenarios options in this study, scenario 7 is the best Scenario with the highest impact on increasing domestic

dairy production share to dairy demand in the short- and medium-term. However, in the long term, scenario 5 has the highest increase in the share of domestic dairy production.

Even though scenario 5 was the best Scenario for raising domestic dairy production's share of dairy demand under the moderate policy, the government's commitment to boosting dairy consumption (scenario 6) revealed that the share of domestic dairy production was lower than scenario 5 (Figure 3). Figure 3 further proved that increasing import tariffs (scenario 4) increased the share of domestic dairy production, as indicated by the line in scenario 4 being higher than the baseline line. The result showed that scenario 7 increased the share of domestic dairy production to 43.89% in 2045. The comparison of Figures 5 and 6 also showed that increased dairy consumption impacted the gap line between scenario 3 and the baseline, which was more significant than the gap line for the pessimistic policy.

Impact of optimistic policy scenario on domestic dairy production

In the short term, the optimistic policy resulted in a tremendous increase in domestic dairy production share under Scenario 1 than in Scenario 2. In the medium and long term, however, an increase in the conception rate (scenario 2) impacts dairy production more than an increase in cow imports (scenario 1). Consequently, it is essential to enhance reproductive efficiency. Shaloo et al. (2014) state that inadequate reproductive management contributes to rising dairy farming expenses. In the long term, the combination of scenarios 1 and 2 (scenario 5) increased domestic dairy production by 61.97 %, which was much higher than scenario 1 (30.74%) and scenario 2 (27.73%) (Table 4). Scenario 7 showed an increase in the share of domestic dairy production by 38.03% in the long run.

Table 3. Impact of moderate policy options scenario on the share of domestic dairy production in Indonesia for the short, medium, and long-term

| | Short-term | Medium-term | Long-term |
|---|-------------|-------------|-------------|
| | Change (%)* | Change (%)* | Change (%)* |
| Scenario 1: (Calf rearing + increasing cows import by 20%/year) | 2.10 | 4.07 | 10.96 |
| Scenario 2: (Increasing the conception rate by 15%) | 0.35 | 4.08 | 16.96 |
| Scenario 3: (The increasing of dairy consumption rate by 5.5%/year) | -1.19 | -3.63 | -9.18 |
| Scenario 4: (Import Tariff by 10%) | 3.59 | 4.92 | 6.05 |
| Scenario 5: (Combination of scenarios 1 and 2) | 2.47 | 8.36 | 29.27 |
| Scenario 6: (Combination of scenarios 1, 2, and 3) | 1.21 | 4.08 | 15.37 |
| Scenario 7:(Combination of scenarios 1, 2, 3, and 4) | 4.89 | 9.32 | 22.60 |

*Percentage change relative to baseline. Short-term = 2025-2030; Medium-term = 2025-2035; and Long-term = 2025-2045

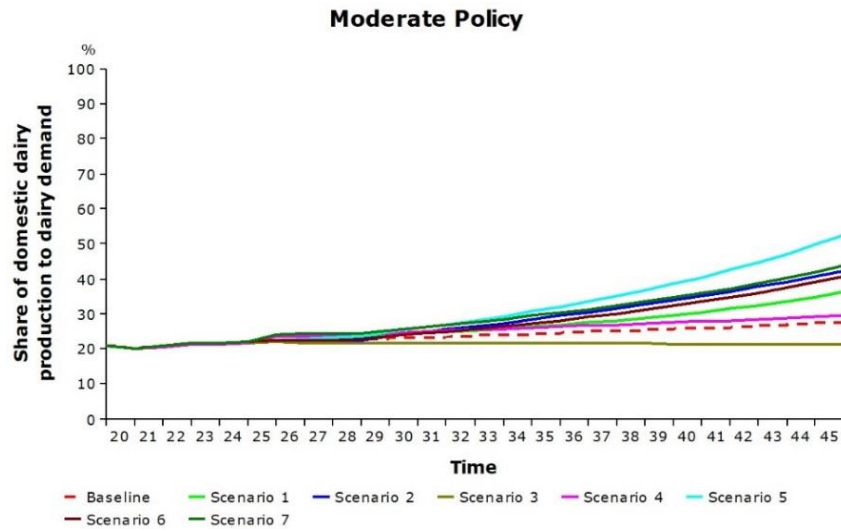


Figure 6. Dynamic simulation result of moderate policy scenario in Indonesia for the period 2020–2045

Table 4. Impact of optimistic policy options scenario on the share of domestic dairy production in Indonesia for the short, medium, and long-term

| | Short-term | Medium-term | Long-term |
|--|-------------|-------------|-------------|
| | Change (%)* | Change (%)* | Change (%)* |
| Scenario 1: (<i>Calf rearing + increasing cows import by 35%/year</i>) | 2.14 | 4.80 | 27.73 |
| Scenario 2: (<i>Increasing the conception rate by 25%</i>) | 0.60 | 7.00 | 30.74 |
| Scenario 3: (<i>The increasing of dairy consumption rate by 6.5%/year</i>) | -2.04 | -6.14 | -15.09 |
| Scenario 4: (<i>Import Tariff by 10%</i>) | 3.59 | 4.92 | 6.05 |
| Scenario 5: (<i>Combination of scenarios 1 and 2</i>) | 2.76 | 12.15 | 61.97 |
| Scenario 6: (<i>Combination of scenarios 1, 2, and 3</i>) | 0.56 | 4.34 | 29.71 |
| Scenario 7: (<i>Combination of scenarios 1, 2, 3, and 4</i>) | 4.20 | 9.60 | 38.03 |

*Percentage change relative to baseline. Short-term = 2025-2030; Medium-term = 2025-2035; and Long-term = 2025-2045

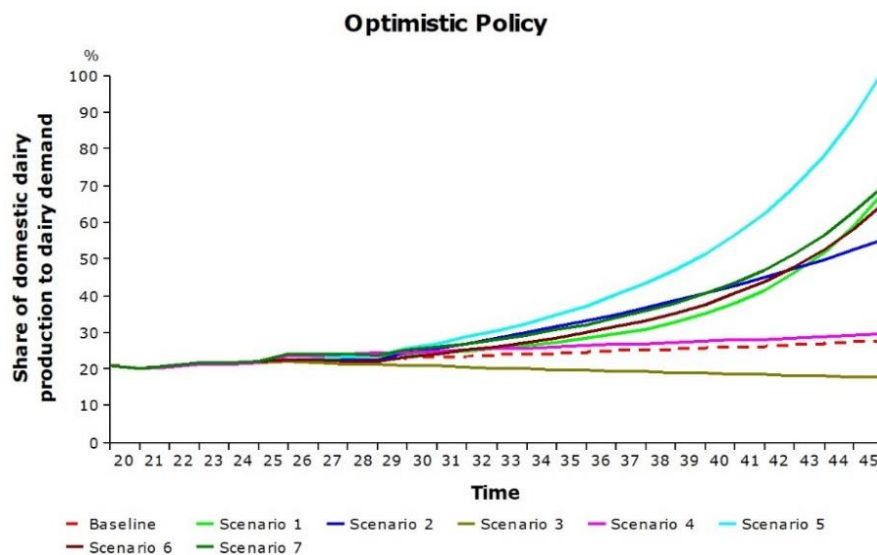


Figure 7. Dynamic simulation result of optimistic policy scenario in Indonesia for the period 2020–2045

The research findings indicated that the increase in dairy consumption combined with other scenarios in Scenario 7 has led to a decrease in the share of domestic dairy production, which was previously at 61.97% in Scenario 5 and has now decreased to 38.03% in Scenario 7. The increase in dairy consumption, assuming a lower growth rate of domestic dairy production than dairy consumption, has reduced the share of domestic dairy production; this indicates that the higher increase in dairy consumption has caused a decline in the share of domestic dairy production in response to dairy demand. As a result of excess demand, higher imports of dairy products are required to meet dairy demand (Salvatore 2013).

Furthermore, the results indicated that scenario 5 raised domestic dairy production in the long term by 17.35 times compared to the short term and in the medium term by 4.9 times compared to the short term. In comparison, scenario 7 showed an increase in domestic dairy production share in the long-term, which was 7.69 times higher than the short-term, and in the medium-term, which was 2.02 times higher than the short-term. It was determined that scenario 5 was more effective in accelerating the share of domestic dairy production to meet dairy demand. However, in the optimistic policy, scenario 7 was the best short-term Scenario, while Scenario 5 was the best medium- and long-term Scenario.

In contrast to the pessimistic and moderate policies, the optimistic policy showed a high share of domestic dairy production to dairy demand. In the optimistic policy, a rise in the conception rate (scenario 2) increased the domestic dairy production share to 53.64% in 2045, while a calf-rearing program accompanied by an increase in cow imports (Scenario 1) increased the domestic dairy production share to 64.39% in 2045. According to Bilkis et al. (2016), the conception rate is determined by the season, breed of cattle, time of insemination, and quality of the semen. In addition, the genetic improvement of dairy cows will determine dairy production and productivity (de Vries and Marcondes, 2020).

The analysis indicated that an increase in higher dairy consumption (scenario 3) resulted in a decrease in the share of domestic dairy production, which was more significant in the optimistic policy than in the pessimistic and moderate policies. Based on simulation results, scenario 5 was the best policy option among all scenarios, as shown by the sharp increase in the scenario 5 line compared to other scenarios (Figure 4). However, implementing a higher consumption policy in the optimistic policy (Scenario 7) decreased the share of domestic dairy production compared to Scenario 5.

It is concluded that the calf rearing program, enhanced female dairy cattle import policy, and higher conception rates positively impacted the share of domestic dairy production in the pessimistic, moderate, and optimistic policies. Maintaining import tariffs as a

restrictive policy to protect the sustainability of domestic dairy production could also be an option to increase the share of domestic dairy production. On the other hand, policies aimed at increasing dairy consumption had the opposite effect on the share of domestic dairy production. The existing condition in Indonesia, in which the growth rate of dairy consumption is higher than that of domestic dairy production, means that implementing Scenario 3 (higher dairy consumption) resulted in a decrease in the share of domestic dairy production. Therefore, the policy of increasing dairy consumption must be balanced with the policy of increasing domestic dairy production.

CONCLUSION

It was found that the calf rearing program, enhanced female dairy cattle import policy, higher conception rates, and import tariff policy have all led to a significant increase in the share of domestic dairy production to dairy demand. The increase in dairy consumption had the opposite effect on the domestic dairy production share. In the long run, an optimistic policy was the best because it increased the highest population of dairy cows and domestic dairy production compared to pessimistic and moderate policies. The findings suggest and recommend that the government and stakeholders can implement calf rearing, enhance reproductive management, maintain import restriction policies, and carefully consider the costs and benefits of different policy options and scenarios to determine policy priorities.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the support of the Director General of the Indonesian Agency for Agricultural Research and Development, Ministry of Agriculture, for funding this research. The authors would also like to thank the Chairman of the National Research and Innovation Agency (BRIN) for supporting the research.

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