Forecasting the Beef and Veal Meat Production in Peninsular Malaysia

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ABSTRACT

This study forecasts beef and veal meat production in Peninsular Malaysia, which is reliant on about 80% of its imports to meet the domestic demand. With Malaysia's aspiration to achieve 50% self-sufficiency by 2030, a seasonal pattern is investigated using a SARIMA model. Due to high reliance on imports and the poor level of self-sufficiency, Malaysia's beef and veal sectors are in an extremely vulnerable position. Precise production projections remain paramount for the three main reasons of resource management, reduction of market volatility, and the realization of food security. These reasons are a few factors affecting the self-sufficiency of beef and veal meat, while this study only focuses on the production of beef and veal meat. The objective of this study is to determine the best models using Box-Jenkins that are suitable for beef and veal meat production and to forecast the production of beef and veal meat in Peninsular Malaysia using the best selected model. This work applies to the SARIMA models in predicting the production of beef and veal. The Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC) will be applied to choose the best model. Based on the results of the analysis, the SARIMA(0,0,1)(0,1,0) fit was the best. Monthly data from January 2016 through December 2023 were used. Forecasted production trends for 2024 included upscaling on religious and cultural occasions. The SARIMA model accurately predicted the future values since it caught the prior pattern. This research will develop a case for the need to have appropriate forecasting in order to improve self-sufficiency and cut overdependence on imports. This is in line with the national policy objectives to enhance local production and to stabilize the beef and veal market. It will contribute to agricultural policies in Malaysia with a robust forecasting tool and policy analyses. The paper points toward the potential that modern farming could have in fulfilling the targets of sustainability and food security.

Keywords: Beef and Veal Meat, Forecasting, Production Trends, SARIMA Model, Box-Jenkins Approach

INTRODUCTION

Beef and veal production are vital to Malaysia's agricultural sector, supporting food security and contributing to economic growth. However, local production remains insufficient to meet the nation's growing demand, with approximately 80% of the supply relying on imports. This dependence exposes Malaysia to vulnerabilities such as price fluctuations, trade restrictions, and supply chain disruptions. Recognizing these challenges, the government has set an ambitious goal of achieving 50% self-sufficiency in beef production by 2030, which requires strategic interventions and accurate forecasting models to stabilize the market and ensure food security.

The demand for beef and veal in Malaysia also sees a significant peak during festive events such as Eid al-Fitr and Eid al-Adha for cultural and religious reasons. This is despite the government's initiatives to enhance local production through modern farming and the employment of technology in farming; these have yet to yield substantial results. These challenges provide an incentive for the integrated approach needed to ensure better domestic production at reduced reliance on imports. Accurate forecasting methods, such as the Seasonal Autoregressive Integrated Moving Average (SARIMA), are very important in resource planning and enhancing production efficiency [1].

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METHODOLOGY

The study aims to determine the best-fit forecasting model using the Box-Jenkins methodology for beef and veal production in Peninsular Malaysia and to forecast production for the next 12 months using the identified model. By achieving these objectives, the research provides critical insights for stakeholders, helping them optimize resource allocation, enhance local production, and reduce dependency on imports.

In carrying out this study, the method will rely on the Seasonal Autoregressive Integrated Moving Average (SARIMA) model, which is widely used in series whose pattern repeats in each seasonal period. Hence, the analysis in this paper is based on monthly data of beef and veal produced in Peninsular Malaysia from January 2016 to December 2023, obtained from the Department of Veterinary Services. The data is divided into two subsets: 72 months of training data and 24 months of testing data, ensuring a robust evaluation of the model's accuracy and generalization.

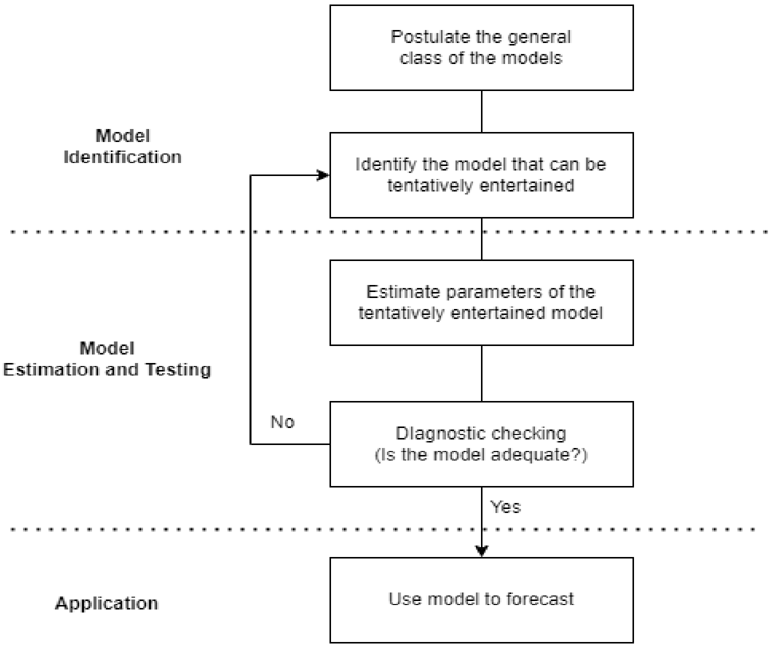

Figure 1: The Box-Jenkins procedure

The SARIMA model follows the Box-Jenkins approach as shown in Figure 1, which consists of three main steps. First, in the model identification stage, stationarity of the time series is confirmed using the Augmented Dickey-Fuller (ADF) unit root test for stationarity and Kwiatkowski-Phillips-Schmidt-Shin (KPSS), which determines whether a time series is stationary around a mean or linear trend, with seasonal differencing applied where necessary.

The Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) plots are then analyzed to determine the appropriate orders of the AR, MA, and seasonal components.

Then, in the second step, which is model estimation, the most appropriate SARIMA model is chosen during the model estimation stage when Akaike's Information Criteria (AIC) and Bayesian Information Criterion (BIC) values are compared. In this regard, minimum AIC and BIC values indicate the best model for a forecast.

Finally, in the last step, model validation, the residual diagnostics will be conducted by using the Ljung-Box Q test, among others, to check that residuals are essentially white noise, which would validate the model for forecasting purposes.

The model identified as the best fit will be used for forecasting beef and veal meat production for the next 12 months. These predictions will then be tested against the testing data to validate the accuracy and viability of the predictions. The approach will ensure that seasonal and holistic production trends have been captured to inform policymakers with relevant insights on how Malaysia's beef and veal production can be further improved.

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SARIMA assumes seasonal and trend patterns in the past will continue into the future. In reality, manufacturing can suddenly change due to new policy, trade bans or disease outbreaks. As an example, Malaysia's meat supply was significantly disrupted during the COVID-19 pandemic. And apart from that, a government subsidy program, importing ban or weather disaster also can immediately rearrange the underlying data pattern. SARIMA does not attempt to detect or react to such breaks and it treats the whole data as though the relationship exists, and this can produce deceptive forecasts following a strong shift. Livestock production is more likely to exhibit non-linear behavior and SARIMA is in its nature linear. Abrupt leaps when new technology is implemented or steep drops amid epidemic outbreaks can challenge the linear models to trace these types of movements since they can depict changes in linear terms only. Even with increasing demand, Malaysia remains largely dependent on imports.

RESULT AND DISCUSSION

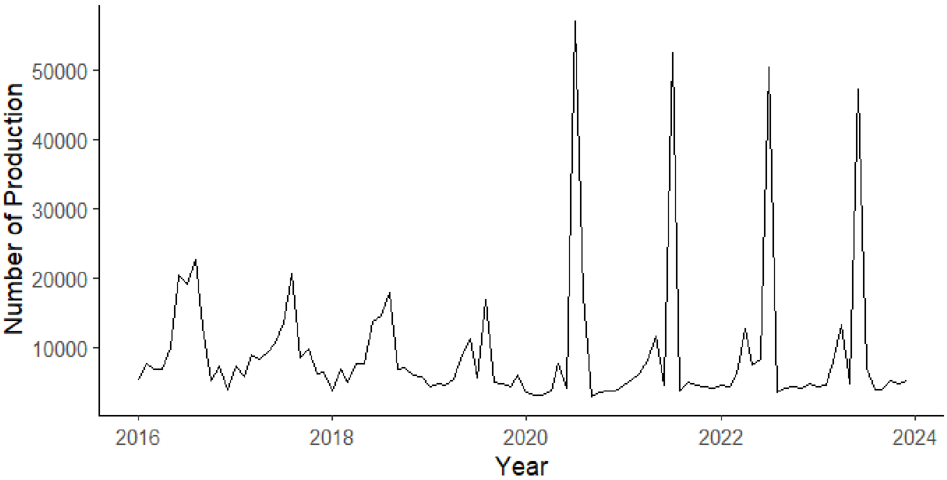

Figure 2: The Trend of Beef and Veal Meat Production

Figure 2 shows the trend of beef and beef meat production for 96 months, which is from January 2016 to December 2023, where it shows a seasonal time series. Based on the trend, it shows a seasonal time series since there are a lot of sharp spikes that are consistent for a period of time. The spikes could be linked to specific cultural or religious events such as Eid al-Fitr or Eid al-Adha. In Islam, these festivals are important because of customs that involve sharing meat with family, friends, and the less fortunate, leading to increased meat intake at these times [2]. For example, it is traditional to perform Qurbani (animal sacrifice) during Eid al-Adha, increasing the demand and production of meat.

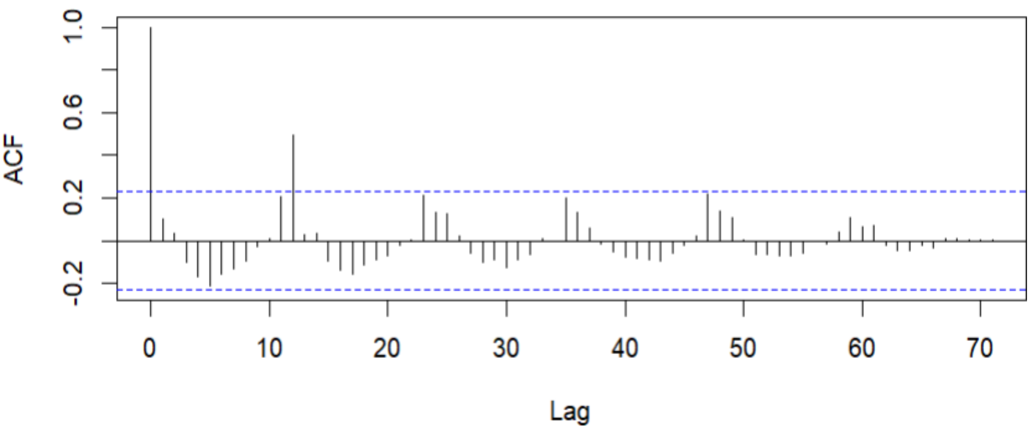

Figure 3: ACF of the time series data

Figure 3 shows the ACF of the data, it can be concluded that the time series data is already stationary and doesn't need differencing. Thus, in the SARIMA model, d in the model can be replaced by 0 indicating no differencing. Since this is seasonal data, seasonal patterns must be eliminated so that the process of Box-Jenkins can be proceed without any problem.

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To confirm the stationarity of the data, the Augmented Dickey-Fuller (ADF) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test are used.

The assumption for the ADF test is that the data series does not have a unit root. The hypothesis for this test is

H_0: The time series has a unit root

H_1: The time series does not have a unit root

Since the p-value for this test is 0.01, which is less than the significance level (0.05), it can be concluded that the data is stationary.

The second test is Kwiatkowski-Phillips-Schmidt-Shin (KPSS). The assumption for this test is that the time series is stationary around a deterministic trend. Thus, the hypothesis for this test is

H_0: Time series is stationary around a deterministic trend

H_1: Time series is not stationary

Based on the analysis, the p-value of this test is 0.1, which is greater than the significance level (0.05). Thus, the conclusion for this test fails to reject H0, and the time series is stationary.

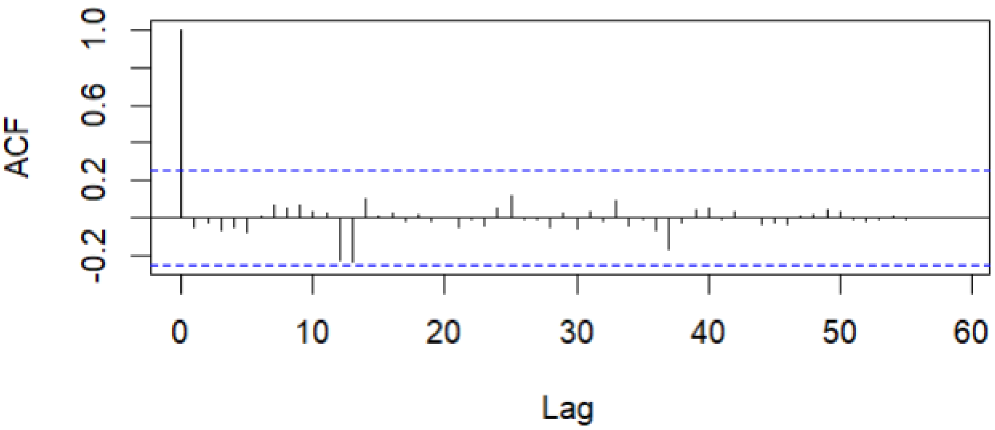

Figure 4: ACF of the time series data after first differencing

After doing the hypothesis testing, it can be confirmed that the data is stationary, and can proceed to the model estimation. Since the model is seasonal, it must remove the seasonality so that the models are accurate. Thus, differencing must be done so that the data is stationary and appropriate for forecasting.

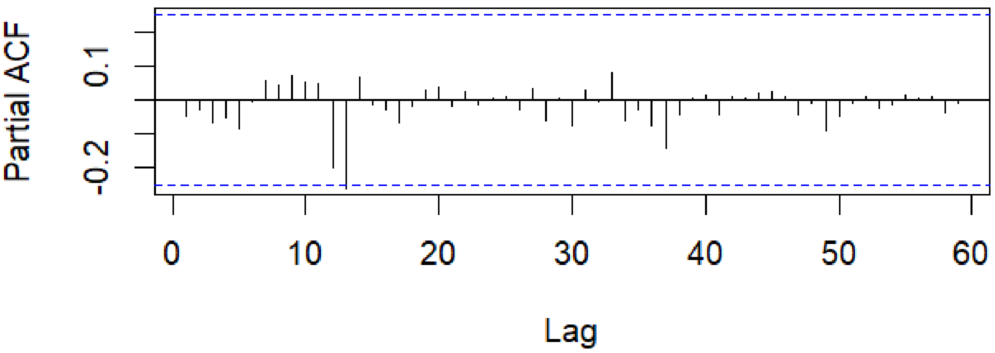

Figure 5: PACF of the time series data after first differencing

After first differencing, Figures 4 and 5 show no spikes for SARIMA models. The ACF correlogram indicates no spikes, suggesting a non-seasonal MA(0) and no seasonal lag spikes. The PACF shows a spike at lag 13, implying a non-seasonal AR(1) and AR(0) for the seasonal component.

The suitable models based on the order of AR and MA are:

1. SARIMA(0,0,1)(0,1,0)
2. SARIMA(1,0,0)(0,1,0)
3. SARIMA(1,0,1)(0,1,0)

The best model is decided on the lowest AIC and BIC value.

TABLE 1 Comparison of AIC and BIC Value of SARIMA Models

Models	Statistics	
	AIC	BIC
SARIMA(0,0,1)(0,1,0)	1047.60	1051.35
SARIMA(1,0,0)(0,1,0)	1047.62	1051.36
SARIMA(1,0,1)(0,1,0)	1048.44	1054.05

Table 1 shows that SARIMA(0,0,1)(0,1,0) is the lowest value from the overall predicted model. It can be interpreted as this model is the most accurate model possible to forecast based on the data set.

Before forecasting, it is important to identify the white noise of the model. The Ljung-Box statistic is used to validate the assumptions that the residuals for each model possess white noise properties. The hypothesis statement for the Ljung-Box Statistic is

H_0: The errors are random (white noise)

H_1: The errors are non-random (white noise)

TABLE 2 Results of Sarima Model Diagnostics

Statistics	SARIMA (0,0,1)(0,1,0)	SARIMA (1,0,0)(0,1,0)	SARIMA (1,0,1)(0,1,0)
Ljung Value	1.8519	1.8962	1.8937
Degree of Freedom	9	9	8
p-value	0.9936	0.993	0.9841
Decision	Accept H_0	Accept H_0	Accept H_0
Conclusion	The errors are white noise	The errors are white noise	The errors are white noise

Table 2 shows that every SARIMA model is white noise, including the best model, SARIMA(0,0,1)(0,1,0). There shouldn't be any substantial ACF or PACF. Consequently, the stationary condition of the residuals is satisfied, and the forecasting may be done using this model.

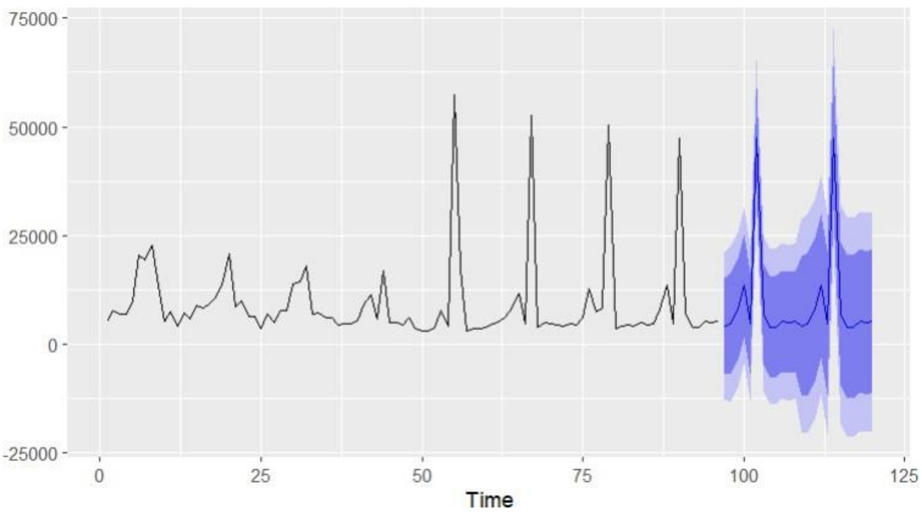

Figure 6: Forecast plot of the SARIMA(0,0,1)(0,1,0)

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Figure 6 shows historical data (black line) with clear seasonality and occasional spikes, likely due to Eid al-Fitr and Eid al-Adha. The forecast (blue line) captures these seasonal patterns well. Shaded regions represent confidence intervals, with wider intervals indicating greater uncertainty. Overall, the prediction aligns well with the historical data, making it suitable for forecasting cyclical events like production and demand.

TABLE 3 Forecast Value for 2024 by Month

Year	Month	Forecast Value
2024	January	4,232.02
	February	4,646.00
	March	7,951.00
	April	13,442.00
	May	4,788.00
	June	47,459.00
	July	7,029.00
	August	3,980.00
	September	3,996.00
	October	5,337.00
	November	4,886.00
	December	5,312.00

Table 3 and Figure 6 show 2024 forecasts using a SARIMA(0,0,1)(0,1,0) model, highlighting seasonal patterns. The graph captures historical data and predictions, with widening confidence intervals over time. The table shows peak values in April (13,442) and June (47,459), while August (3,980) and September (3,996) have the lowest. These forecasts help stakeholders plan resources and manage operations based on seasonal demand.

Malaysia relies heavily on imports for the production of beef and veal, always living with the threats of price and trade disruptions. Resource limitations, inappropriate farming practices, and environmental costs further exacerbate the problem. For subsidy support, improved infrastructure, and modern farming practices, the road ahead will be an improvement in local production, reduction of imports, and the attainment of food security [3]. The COVID-19 pandemic, with its associated global lockdowns and supply chain disruptions, has caused huge variations in production patterns, further underlining the need for domestic stability and resilience [4].

The SARIMA models facilitate the livestock industry in proper resource management and the optimization of supply chains for exact production forecasts. According to [5], understanding seasonal trends, such as increased demand during Eid, allows producers to allocate resources efficiently and minimize wastage. Forecasts also support Malaysia's goal of reducing reliance on imports, which currently account for 80% of beef consumption. Government initiatives promoting sustainable methods and modern technologies aim to achieve 50% self-sufficiency by 2030 [6]. According to [7], further accurate predictions stabilize market prices, improve food security, and minimize environmental and economic costs.

Countries like Australia and New Zealand have over 70% self-sufficiency because of technology in breeding and favorable policy [8]. It once again gives a clue to the examples of the importance of technology and policy boosting local production. These models, where applicable, should be shared with Malaysia as examples of success to decrease its imports and develop a more stable agricultural system in its beef production to become closer to self-sufficiency and long-term sustainability.

This low level of self-sufficiency is not just brought about by costs of production but also underlying structural issues. One of the issues would be land and resource constraints, where cattle farming in Malaysia has to compete with more economically profitable land uses such as oil palm, rubber or residential development. There are not many specifically allocated grazing pastures, so most of the smallholders use cut-and-carry systems that are less efficient and more labor-intensive. Cut-and-carry method entailed cutting the fresh grass and other forages from a designated area and thereafter carrying the same to a contained or partially contained animal for consumption. Feed is also expensive as much concentrate feed is imported, thereby making production expensive in comparison to the importation of finished meat. Smallholder farmers are not able to afford and obtain affordable

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cheap veterinary services. Artificial insemination (AI) breeding services are not available across the board, especially in remote locations and thus genetic advancement gets delayed.

Inefficient extension services mean that the majority of the farmers don't have the access to best practice in animal health, nutrition, and farm management. Short-run price subsidy programs as opposed to sustained productivity improvement are usually the prevailing subsidy programs. The lack of effective, targeted incentives for farmers renders it difficult for farmers to undertake new technology or invest in breeding and feed manufacturing.

Policies sometimes are diversified by states and ministries and offer unequal support. Australia and New Zealand, for example, have grown largely self-reliant in beef through sustained investment in breeding programs, pasture systems, veterinary and biosecurity services, producer cooperatives, and intense research. Their operations are made possible by large grazing lands, economies of scale and export policies that deserve rigorous traceability and welfare standards. For example, Australia relies on genetic enhancement, feedlot finishing and drought insurance policies, while New Zealand is reliant on pasture efficiency, joint processing and border biosecurity.

These methods construct strong supply chains that strike a balance between productivity, animal welfare and sustainability. Malaysia itself, however, has structural constraints in the shape of limited pasture land, smallholder-based production and heavy reliance on imports (over 70% of beef consumption). Malaysia can nevertheless draw principal lessons by promoting cattle-oil palm integration to meet the land constraint, promoting producer cooperatives to improve bargaining positions and providing mobile veterinary and artificial insemination services to reach out to dispersed smallholders [9].

In addition, forage bank subsidies, genetic improvement and disease resistance would address productivity bottlenecks more effectively than overall price support. Optimization of festive season supply stability, complemented by cold chain infrastructure growth, could relieve import vulnerability during peak demand periods. In this way, Malaysia can learn from self-sufficient countries and convert policies to suit its socio-economic and environmental contexts.

CONCLUSION

Therefore, for food security and reduction of import dependency, the SARIMA model estimation has been estimated by the study in forecasting beef and veal output in Peninsular Malaysia with SARIMA(0,0,1)(0,1,0). This was the best because the lowest AIC and BIC resulted from this model specification, which shows peak output seasonally in the months coinciding with the religious and cultural festivities of Eid al-Fitr and Eid al-Adha. However, the 2024 forecast indicates a slight decline in production compared to 2023, underscoring the insufficiency of current trends to meet growing demand and reduce Malaysia's reliance on imports. The COVID-19 pandemic further disrupted production, emphasizing the importance of accurate forecasting tools like SARIMA in optimizing resource allocation and managing supply chain vulnerabilities. To achieve the government's target of 50% self-sufficiency by 2030, immediate efforts are needed to adopt modern farming techniques, improve feed efficiency, and expand production capacity, ensuring a resilient and sustainable beef and veal industry.

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