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Dynamic Analysis of Commodity Prices Influence on Broiler Chicken Prices in Malaysia

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Abstract

The poultry industry in Malaysia has been successful to produce more than the domestic demand over the years. Recent hike of animal feeds prices globally is an important issue in developing countries such as Malaysia that affects the cost of broilers production. This study aims to investigate the factors influencing broiler production costs in Malaysia. The factors that are included in this study are the imported ingredient for animal feeds, exchange rate and crude oil prices. This research revealed the strongest positive correlation (0.9504) between soybean meals and corn, followed by wheat and soybean meals (0.8452) in Malaysia. The structural time series model applied in this study shows that the *ex-farm* broiler price can be represented by a basic structural time series model. Hence, the findings from this study suggests a different approach to policy makers to ensure a low dependency on foreign resources and to protect the poultry industry in Malaysia.

1. Introduction

The broiler industry in Malaysia is composed of several key sectors, including breeding farms, hatcheries, and broiler farms that raise chickens for meat production. The breeding process begins with the importation of Grand Parent Stock (GPS), which is used to produce Parent Stock (PS). PS is then utilized to produce hatching eggs. Hatcheries, either owned by breeder farms with integrated facilities or by independent hatcheries dedicated solely to hatching, produce day-old chicks (DOCs). These DOCs are supplied to broiler farms, where they are raised to become table birds. The broiler industry in Malaysia encounters numerous challenges, such as escalating production costs, the effects of free trade, fierce market competition, shifting consumer preferences and purchasing power, the demand for traceability, disease outbreaks, competition for land with other sectors, environmental pollution, and issues related to public nuisance (Jamaludin, 2013). The industry also relies on other critical components such as feed mills, feed ingredient suppliers, pharmaceutical companies, equipment manufacturers, poultry slaughterhouses, and food processing companies. Figure 1 summarized the supply chain sub-sector for broiler in Malaysia.

Fig. 1 *Supply chain sub-sector for broiler in Malaysia*

Chicken plays a vital role in fulfilling the daily protein requirements of people everywhere. Its affordability and absence of cultural or religious taboos has elevated it to the world's favorite protein. Hence, chicken has been the main source of protein in Malaysia. Broiler chicken farming provides significant amount to the Malaysia Growth Domestic Product (GDP). In 2020, the chicken meat consumption per capita is 50.2 kg has increased significantly as compared to in 2000 recorded at 27.3 kg. The production of broiler chicken is considered efficient because it has exceeded the 90% Self Sufficiency Level (SSL) indicating that the domestic supply outperformed the domestic demand. According to the report on special study published by Department of Statistics Malaysia (DOSM) in 2022, the proportion costs of production for a broiler chicken in farm are 98.61% and 1.39% for direct cost and indirect cost respectively. The direct costs cover feeds, utilities, labor, vitamins or vaccines and other expenses for farm. On the other hand, the indirect costs cover the fees, taxes, insurance, and others. On average, the cost to produce a broiler is estimated to be around RM 6.53 where the biggest component to cover the feed cost is about 65%. To produce the chicken feeds, Malaysia had to import almost 100% of the raw materials mainly from Argentina such as corn and soybean meals. Corn and soybean meals are known as the leading raw materials used in broiler rations. In 2020, DOSM reported that Malaysia imported almost RM 4.6 billion or equivalent to 16% of national GDP for animal feeds. Continuous demand and importing products from the global market has raised a concern on food security in Malaysia. The population in Malaysia could exponentially growth over times. Hence, any significant increase in population certainly will result in more demand for food.

Due to the high cost of imported animal feeds from producer country, the production costs of broiler chicken have increased considerably. It is worth to note that most of the international trade between Malaysia and producer country is using the US Dollar or greenbacks. Hence, Malaysia is at a disadvantage side against the competitive producer countries such as Argentina. The depreciating of Malaysian Ringgit against US Dollar resulting to low purchasing power, making the cost of importing thus increasing the production costs. This condition has reduced the profit margin for domestic farmers and eventually making their businesses unable to sustain (Sroka et al., 2023). Previous studies have shown fluctuation in broiler feeds price is the main factor to the final product price in the market. For example, (Çevrimli et al., 2019) showed that the price of broiler feeds and chicken meat are highly correlated and co-integrated in short term. Changes in costs of production are transferred to the final retail prices (Barahona et al., 2014). Recently, the issue of insufficient supply and the hike of broiler price in Malaysia has become a great attention in the media. The short-term solution implemented by the government is to import the chicken meat from other producer countries such as Thailand and India. This problem is a long-standing challenge to the government, feed millers, integrators, farmers, distributors, retailers and eventually consumers who had to purchase the final products at a higher price (Benalywa et al., 2019).

A potential solution to this difficult problem could involve an econometric study considering the dynamic changes in animal feed price is an essential economic risk factor affecting the volume of broiler production. The most recent work in this area is from (Arikan et al., 2022) using boosting regression method shows there is a high correlation between broiler chicken consumer price and variable factors such as broiler feeds, corn, soybean meal, wheat prices, the dollar exchange rate and producer price index in Turkey. However, the work is limited to investigate the factors that affect broiler price in the Turkey market framework. Considering the issue of higher production costs of broiler in Malaysia, this study attempted to evaluate holistically the factors affecting chicken meat prices. First, the aim of this research is to reveal the correlation of factors on the *ex-farm* broiler price in Malaysia from 2018 to 2022. Second, to model and predict the *ex-farm* broiler and commodity prices using structural time series approach.

The research objectives of this study are:

i. To investigate the strength of relationship between *ex-farm* broiler and commodity prices that contributed to costs production of broiler in Malaysia.
ii. To predict the *ex-farm* broiler and commodity prices based on one-step ahead forecast through the structural time series model.

2. Literature Review

We present an overview of literature that relates to work presented in this section. There is a body of research that has focused extensively on the poultry sector worldwide. Recent research by (Beal et al., 2023) applied a techno-economic analysis (TEA) and life cycle assessment (LCA) to assess the sustainability of the U.S. broiler industry. The study quantified costs, greenhouse gas emissions (GHG), energy use, water consumption, land use, fertilizer inputs, and respiratory impacts across seven broiler production scenarios involving a contract grower, integrator, and a combined control system. The analysis employed a farm-gate to farm-gate approach, considering factors such as capital costs for chicken housing, labor, chick inputs, feed, on-site fuel usage, and emissions. Even though this study provides a comprehensive assessment of resource use and environmental impacts, however its scope is limited to specific production systems and may overlook regional variations or alternative practices that could affect sustainability outcomes.

Similar ideas have been proposed in (Aji et al., 2023) using purposive sampling, data were collected through surveys of broiler farmers engaged in contract farming, and a stochastic frontier cost analysis was employed to estimate the broiler cost function and inefficiency determinants. The results suggest that key cost drivers include labor, day-old chick prices, feed, and harvest output, while inefficiency is influenced by factors such as farmer age, education, household size, experience, and mortality rates (MR). Although reducing MR could enhance yields and cost efficiency, the study overlooks the broader structural issues within CF systems and does not fully address the challenges of implementing training, monitoring, and incentivization measures to improve farmer performance.

(Shokoohi & Saghaian, 2022) examined the impact of oil price shocks on food nutrition prices, revealing differing effects between oil-importing and oil-exporting countries. In oil-importing nations, the effects initially decrease before stabilizing over time, whereas in oil-exporting countries, the effects are consistently significant and increase over time. These findings suggest that crude oil prices, along with income and exchange rate policies, play a critical role in mitigating hunger and enhancing food security, particularly in oil-exporting countries. However, the study's focus on broad economic indicators may overlook more granular factors influencing food security at the local level.

The study conducted by (Kamruzzaman et al., 2021) focused on financial and factor demand analysis of broiler production using survey data from 210 farmers across four key broiler-producing regions in Bangladesh: Dhaka, Rajshahi, Mymensingh, and Chittagong. The findings indicate that operating inputs, particularly feed, constitute the largest portion of production costs. While broiler farming was financially viable across all regions, the Mymensingh division underperformed due to higher unit production costs and lower selling prices compared to other areas. Despite these regional differences, there were no statistically significant variations in variable costs or net returns among the study areas. Although the study provides valuable insights, it focuses primarily on cost and profitability without adequately exploring the broader economic and market dynamics that may influence these outcomes.

An interesting methodology in a paper by (Aji et al., 2023) incorporates a study, conducted in Al-Sharkia and El-Fayoum provinces, aimed to identify profitability factors and challenges for small-scale broiler farms in rural Egypt. The use of a log-linear regression model based on the Cobb-Douglas production function revealed that variables such as experience, education, and access to veterinary services and credit positively affected profitability, while age, feed costs, and mortality rates had negative impacts. However, the study's focus on general factors overlooks deeper structural issues, such as long-term sustainability and broader market dynamics.

In Indonesia, poultry farmers face rising input prices, particularly feed, which constitutes the largest component of broiler production costs, while broiler prices remain volatile. The work of (Sehabudin et al., 2022) analyzed cost structures, unit costs, and income across two partnership patterns: PIR and Makloon, in Sukabumi Regency. However, the study lacks an in-depth exploration of the volatility in broiler prices and the strategies needed to mitigate the financial risks posed by fluctuating input costs, especially feed. Meanwhile, (Bahrun & Zuraida, 2021) examined the economic aspects of broiler chicken farming in Kapuh Village, focusing on costs, income, and profitability for independent farmers who manage all production inputs, from land and equipment to seeds and sales. The findings highlight the full self-reliance of farmers in broiler operations, which increases their exposure to risks related to fluctuating input costs, particularly feed. Similar ideas have been proposed before in focused on the broiler chicken market in PD Pasar Jaya, Pasar Minggu, Jakarta Selatan, with an emphasis on marketing margins. The research identified the marketing channels for broiler chicken, analyzed the margins for retailers, and provided recommendations for improving marketing channel management. The findings highlight that price fluctuations are largely influenced by supply and demand during specific periods, yet the study lacks a deeper exploration of how long-term market dynamics affect these fluctuations. While recommendations for improving marketing efficiency were made, the study fails to adequately address how to create more sustainable solutions to reduce the impact of price volatility on farmers.

Another study conducted by (Utnik-Banaś, 2017) analyzed the impact of overall agricultural progress on changes in unit costs of broiler chicken production in Poland between 1994 and 2015. The results show that the

most significant factor in reducing production costs (22%) was the decrease in feed costs, attributed to improvements in the feed conversion ratio. Other cost reductions, including operational expenses (9%) and the purchase costs of breeding materials and day-old chicks (5%), also contributed to the overall decline. While the study offers valuable insights into cost-saving factors, it overlooks broader market conditions and external economic factors that may have influenced cost structures during the period.

Conceptually similar work has also been carried out by (Abdurofi et al., 2017) in which they assessed the financial status of farmers, the marginal cost of production, total net income, and input-output ratios of broiler production across different regions in Peninsular Malaysia. Utilizing multi-stage sampling, 310 operators were selected from the Southern, Northern, East Coast, and Central regions. The study employed descriptive statistics and farm budget analysis, revealing that feed costs dominate production expenses. While the study highlights regional disparities in profitability, it primarily focuses on cost reduction without thoroughly addressing broader structural issues or external factors that could further impact broiler production sustainability.

Similar work has also been pursued by (Shaban & Alabboodi, 2019) in which the study evaluates the economic viability and financial performance of the broiler farming sector in Peninsular Malaysia. The findings indicate that broiler farms incur significant costs related to operating inputs, particularly feed. However, profitability is maintained due to high demand, industry self-sufficiency, and market stability. Sensitivity analysis reveals that the industry is highly responsive to changes in selling prices and feed costs. While the study suggests that broiler production in Peninsular Malaysia is financially viable and capable of sustaining long-term projects, it overlooks the persistent issue of high production costs.

The reviewed studies consistently highlight the central role of production costs, particularly feed, in broiler chicken farming across various regions, including the U.S., Egypt, Bangladesh, Indonesia, and Malaysia. Feed is identified as the largest component of production expenses, significantly influencing profitability and cost efficiency. Despite variations in regional performance and partnership models, the studies often overlook broader structural issues, such as market volatility and long-term sustainability, while primarily focusing on cost reduction strategies. Most research focuses on strategies to reduce costs without fully addressing the dynamic risks posed by fluctuating feed prices especially from the trading countries. Hence, this is an area that requires further exploration.

3. Data and Methods

Here we present an overview of the methodology employed throughout the research. First, the monthly time series data were collected from January 2018 to December 2022. Table 1 lists the *ex-farm* broiler price and macroeconomic variable prices. Meanwhile, Figure 2 below presented a graphical description of all the procedures used in this study.

Table 1 *List of data used*

Data	Unit	Source
Ex Farm broiler price	Malaysian Ringgit/kg	Department of Veterinary Services
Corn price	US Dollar/ton	https://teseo.clal.it/
Soybean meal price	US Dollar/ton	https://teseo.clal.it/
Wheat price	US Dollar/ton	https://teseo.clal.it/
Exchange rate	Malaysian Ringgit/US Dollar	Refinitiv Datastream
Crude Oil Price (Brent)	US Dollar/barrel	Refinitiv Datastream

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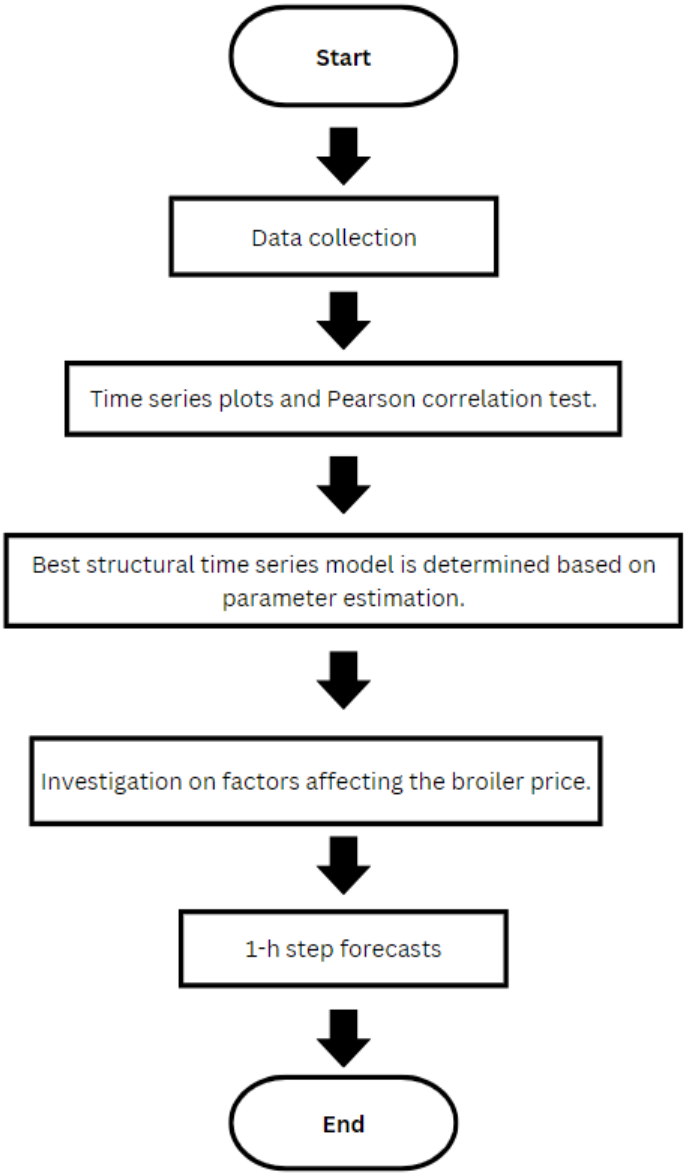

Fig. 2 Flowchart of the procedure for analysing and structural time series model development.

Meanwhile, Figure 2 above presents a flow chart of all the procedures used in this study. This flowchart outlines a systematic approach to analyzing broiler price data, from initial data collection through model selection and forecasting. It combines statistical techniques with time series modeling to predict broiler prices

3.1 Pearson Correlation Test

Second, we used the Pearson correlation analysis to investigate the strength of relationship between *ex-farm* broiler and commodity prices that contributed to costs production of broiler in Malaysia. This test provides information about the magnitude and direction of the relationship. Consider two variables denoted as *X* and *Y*, the Pearson correlation can be formulated by the following formula:

$$\rho_{XY} = \frac{\mathrm{cov}(X,Y)}{\sigma_X.\sigma_Y} \tag{1}$$

where the numerator is the covariance between *X* and *Y*, while the denominator is multiplication of standard deviation of *X* and standard deviation of *Y*. The Pearson correlation coefficient takes value in the closed interval [-1, 1]. This study distinguished the strength of relationship between *X* and *Y* by the following cases as in Table 2.

Table 2 *Strength of the relationship between X and Y based on the range of Pearson correlation coefficient values*

Range	Strength of relationship
ρ_{XY} = -1	The variable *X* and *Y* have a negative perfect correlation.
-0.8 < ρ_{XY} < -1	The variable *X* and *Y* have a strong negative correlation.
-0.3 < ρ_{XY} < -0.6	The variable *X* and *Y* have a moderate negative correlation.
0 < ρ_{XY} < -0.3	The variable *X* and *Y* have a weak negative correlation.
ρ_{XY} = 0	The variable *X* and *Y* has no correlation.
0 < ρ_{XY} < 0.3	The variable *X* and *Y* have a weak positive correlation.
0.3 < ρ_{XY} < 0.6	The variable *X* and *Y* have a moderate positive correlation.
0.8 < ρ_{XY} < 1	The variable *X* and *Y* have a strong positive correlation.
ρ_{XY} = +1	The variable *X* and *Y* have a positive perfect correlation.

3.2 Structural Time Series Model (STSM)

The STSM framework is robust for the analysis of dynamic systems, particularly when unobserved components in time series data are involved. Through STSM, univariate and multivariate ARMA models, linear regression models, and non-linear model can be easily transformed into the state space form (Koopman & Ooms, 2012). Additionally, it is easier to deal with missing values, to test for structural breaks, and to perform forecasting.

The time series can be represented in an additive model; for simplicity, let y_t be univariate time series for a set of observations of $y_1, y_2, \ldots y_t$:

$$y_t = \mu_t + \gamma_t + c_t + \varepsilon_{t,} \tag{2}$$

where t = 1, 2, ..., T; μ_t refers to trend (time component); γ_t refers to the periodic component of a fixed period (seasonal component); c_t denotes a cycle component of a longer period than seasonal component; ε_t denotes an irregular component or error. The behaviour of each component in Equation (2) can be analysed by placing them in a single matrix model or it can be expressed in a unified formula as follows:

$$y_t = \mathbf{Z_t'}\boldsymbol{\alpha_t} + \varepsilon_t, \qquad \varepsilon_t \sim N(0, \sigma_\varepsilon^2) \tag{3}$$

$$\alpha_{t+1} = \mathbf{S}_t\boldsymbol{\alpha}_t + \mathbf{R}_t\xi_t \qquad \xi_t \sim N\left(0, \mathbf{Q}_t\right) \tag{4}$$

where t = 1, 2, ..., T; y_t and ε_t remain as scalar of order of 1×1; Z_t denotes a design vector of size of m×1; S_t denotes a transition matrix of m×m; α_t denotes a state vector of m×1; R_t denotes an identity matrix of order of m×m; m refers to the number of elements in the state vector; the vector Q_t contains m state disturbances with zero means and unknown variances.

The statistical treatment of STSM is based on the state space model form as presented in unified formula in equation (3) or (4). The state space form enables the model to be estimated using Kalman Filter technique (Harvey & Koopman, 2000). The model estimation procedure consists of four steps as depicted in Figure 3.

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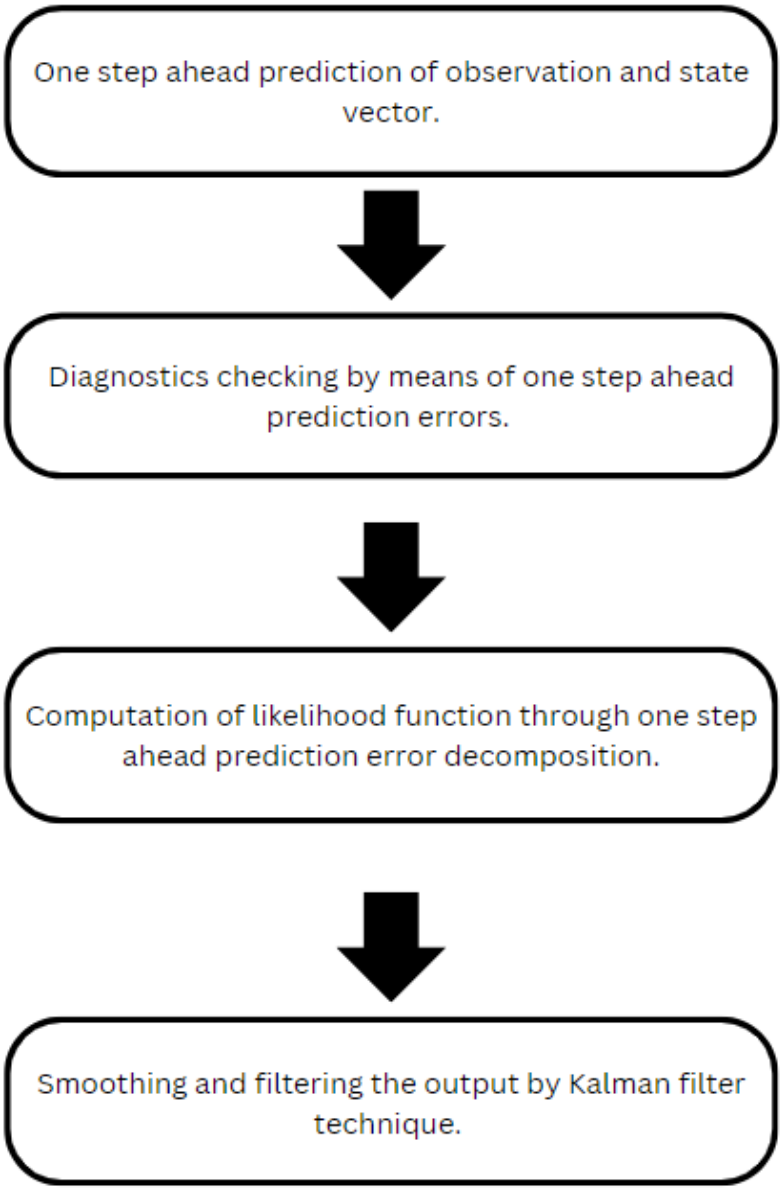

Fig. 3 *The parameter estimation procedure using Kalman Filter technique*

4. Results

Figure 4 presents six time series plots showing the trends of ex-farm broiler prices and the macroeconomic variables studied. The ex-farm broiler price maintains a stable trend, consistently remaining below RM 7.00 per kg. The price ceiling imposed by the Malaysian government significantly influences chicken meat prices. However, if this condition persists alongside rising production costs, it could reduce the profit margins for local farmers and producers to negative levels.

When the pandemic is under controlled, China as the biggest economic player in the world had purchased a bulk amount of corn and other commodities from Argentina due to less supply from the United States and Ukraine consequence of this approach is that the instability of commodity prices occurred until 2021 (Liu et al., 2023). In addition, the situation worsened when Argentina had taken drastic action to temporarily ban corn exports due to extreme weather from December 2020 to February 2021 (Berger et al., 2021).

Overall, the trends indicate an upward movement for all macroeconomic variables, despite some fluctuations from 2020 to 2023. This observation likely reflects the post-COVID-19 pandemic effect, where there is a robust recovery in consumer spending as the virus spread is controlled. The strong recovery in consumer behavior may be attributed to significant savings accumulated during lockdowns, the absence of travel restrictions, and increased demand during festive seasons (Sattar et al., 2021). The pandemic and travel restrictions disrupted logistics, affecting the import of raw materials into Malaysia. Global trade between

Malaysia and Argentina hit its lowest point when there was a sudden drop of about 200% in corn imports from Argentina in April 2020.

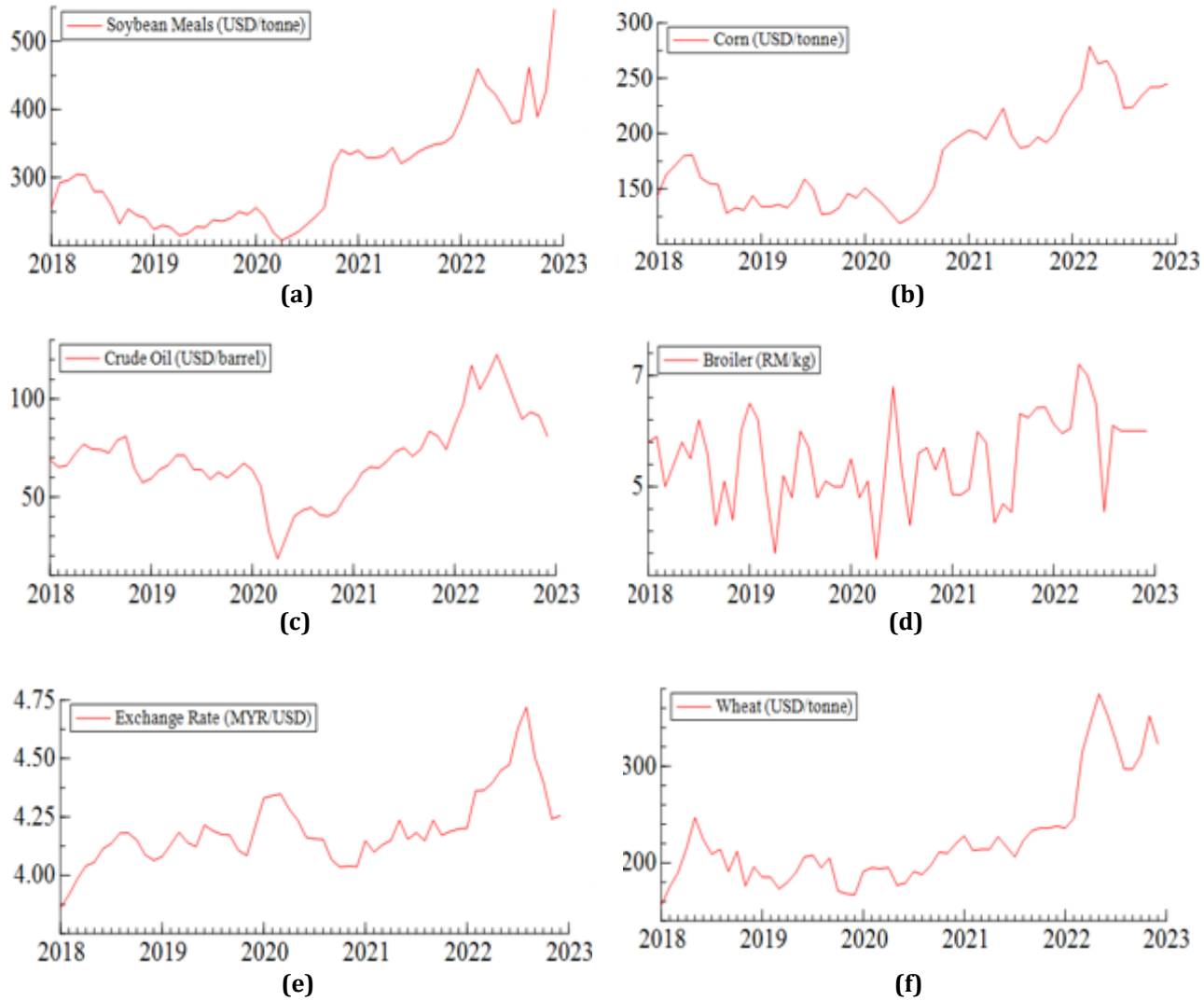

Fig. 4 *(a) Soybean meals price; (b) Corn prices; (c) Crude oil prices; (d) Ex farm broiler prices; (e) Malaysian Ringgit/US Dollar exchange rate; (f) Wheat prices*

Table 3 revealed the strength of association between the variables through an analysis of Pearson correlation coefficient. There appears to be a strong positive correlation between soybean meals price, wheat prices and corn price produce by Argentina. A significant positive association also recorded between Brent crude oil price and the commodity prices from Argentina. This means that any increase in crude oil price will amplify the commodity prices globally. As expected, there is moderate positive correlation recorded between *ex farm* broiler prices and the commodity prices. This result is not surprising since the commodity prices were the main contributor to the costs of production of broilers. It is evident that the currency exchange rate has a positive correlation with the commodity prices. The currency exchange rate plays an important role and is strongly linked with the global trading of commodities.

Table 3 *Pearson correlation coefficient*

	Soybean Meals	Corn	Crude oil	Broiler	Exchange rate	Wheat
Soybean Meals	1					
Corn	0.9504	1				
Crude Oil	0.6852	0.7205	1			
Broiler	0.4579	0.4724	0.4008	1		
Exchange rate	0.4613	0.4986	0.5375	0.1728	1	
Wheat	0.8452	0.8666	0.7616	0.4693	0.6806	1

The model estimation procedure involves three stages. First, the best fitted structural time series model is determined. Second, the factors affecting the ex-farm broiler price are examined. Finally, the forecasting performance is evaluated based on specific performance metrics.

The development of the structural time series model begins with a stepwise procedure. The results of this analysis are summarised in Table 4. It presents the variance disturbance components, which are level, slope, seasonal, and irregular, for various variables estimated using structural time series models. The analysis reveals significant insights into the underlying patterns and volatility of these time series data.

For the ex-farm broiler prices, the Basic Structural Model (BSM) indicates a relatively low-level disturbance (5.3×10^{-4}), suggesting stable underlying mean values. However, the presence of non-zero slope (0.0001) and seasonal (0.0005) disturbances highlights trends and seasonality, likely due to periodic fluctuations in supply and demand. The higher irregular component (0.001) points to significant short-term variability, indicating external shocks or noise affecting the data.

Corn prices, modeled with a Local Level Model (LLM), exhibit a high-level disturbance (3.2×10^{-3}), signifying substantial variability in average price levels. The absence of slope and seasonal disturbances suggests that trends and seasonal patterns are not prominent in this dataset. The highest irregular component among all variables (0.005) indicates a high degree of short-term fluctuations or external shocks affecting corn prices, highlighting the need for robust short-term prediction models.

The soybean meal prices, analyzed with the BSM, show moderate level disturbance (0.0008) with small but notable slope (0.0002) and seasonal (0.0001) disturbances. This suggests the presence of mild trends and seasonal patterns. The relatively low irregular disturbance (0.0003) implies that soybean meal prices are less affected by short-term shocks compared to other commodities, indicating more stable market conditions.

Wheat prices demonstrate significant disturbances in the level (0.0026) and slope (0.0037) components, indicating pronounced variability in mean prices and strong trends over time. The seasonal component (0.0008), although present, is less prominent compared to other disturbances. The high irregular disturbance (0.0075) points to considerable short-term volatility, suggesting frequent external factors or market shocks impacting wheat prices. This necessitates models that can account for both long-term trends and short-term irregularities for accurate forecasting.

The exchange rates, modeled using an LLM, show an extremely low-level disturbance (2.6×10^{-5}), indicating relatively stable mean values. The absence of slope and seasonal disturbances suggests a lack of discernible trends and seasonality in the data. The moderate irregular disturbance (0.0002) points to some short-term variability, likely due to market reactions to economic news or policy changes. This stability makes the exchange rate a predictable variable, suitable for long-term economic planning.

Crude oil prices, analysed with the Local Linear Trend Model (LLTM), exhibit a low-level disturbance (0.0001), indicating stable average price levels. The moderate slope disturbance (0.0006) suggests a discernible trend over time, while the absence of a seasonal component indicates no significant periodic patterns. The moderate irregular disturbance (0.0004) highlights short-term fluctuations influenced by external factors such as geopolitical events or production changes. This understanding is crucial for energy market analysts and policymakers.

Overall, the choice of model varies based on the nature of the data, with BSM applied to variables exhibiting trends and seasonality, LLM for stable series, and LLTM for capturing both level and trend disturbances. The level disturbance is a crucial indicator of long-term variability, with corn and wheat showing the highest values, reflecting their inherent market volatility. The slope and seasonal disturbances highlight the presence of trends and periodicity, essential for accurate forecasting. The irregular disturbance indicates short-term noise or volatility, with high values in corn and wheat suggesting significant external influences.

Table 4 *Estimation of parameter using structural time series model*

Variables	Variance disturbance				Model
	Level	Slope	Seasonal	Irregular	
Ex Farm Broiler	5.3×10^{-4}	0.0001	0.0005	0.001	BSM
Corn	3.2×10^{-3}	-	-	0.005	LLM
Soybean meal	0.0008	0.0002	0.0001	0.0003	BSM
Wheat	0.0026	0.0037	0.0008	0.0075	BSM
Exchange rate	2.6×10^{-5}	-	-	0.0002	LLM
Crude oil	0.0001	0.0006	-	0.0004	LLTM

*LLM = Local level model, LLTM = Local linear trend model, BSM = Basic structural model

Forecasts are produced from the structural time series model. For forecasting purposes, the out of sample dataset used in forecasting is from January 2023 until December 2023. Figure 5 illustrates the predicted value of

one-step forecast for each variable. Two loss functions, which are root mean square error (RMSE) and mean absolute prediction error (MAPE) were employed to evaluate the performance of structural time series in predicting the *ex-farm* broiler price and other commodity prices.

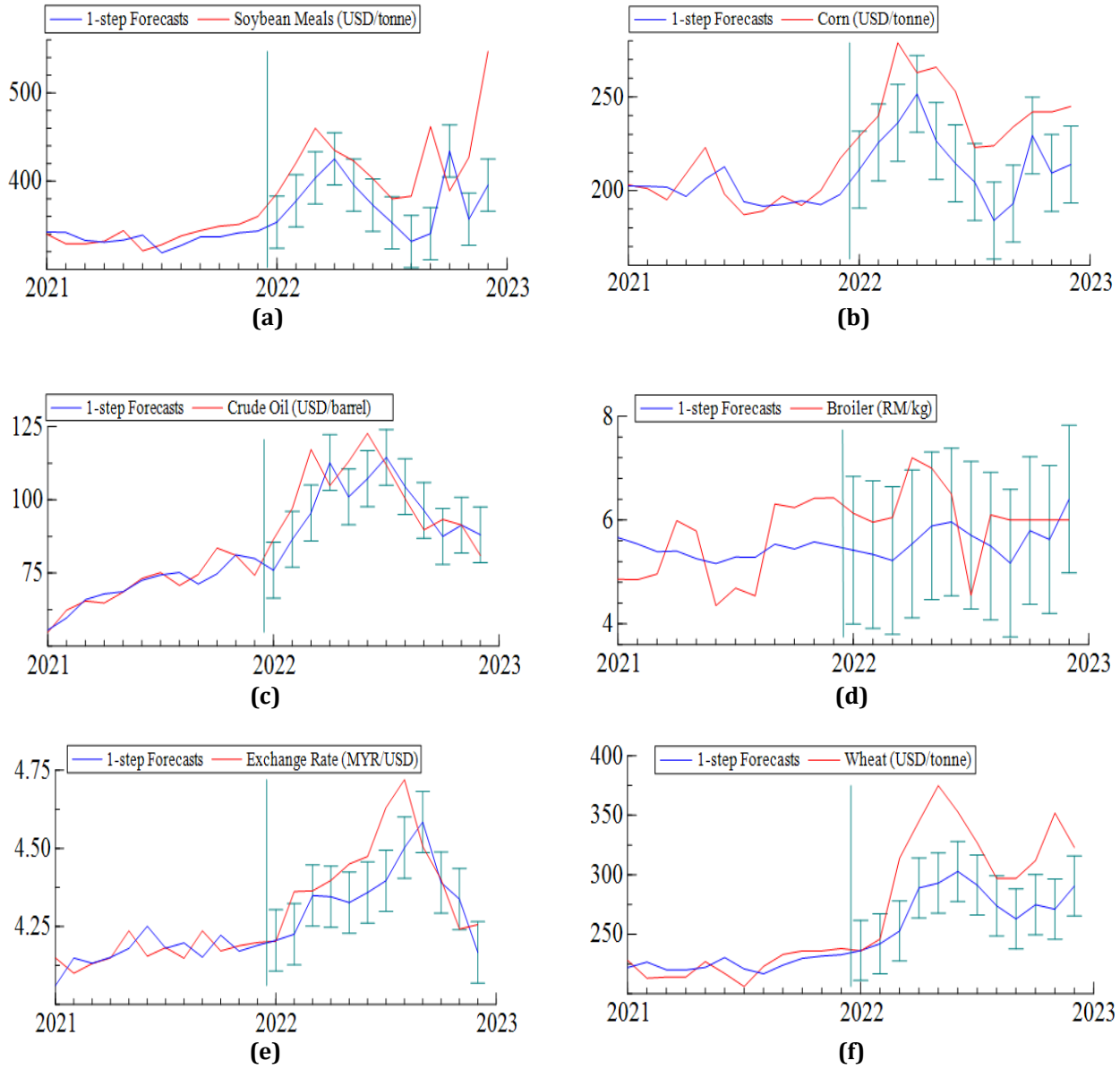

Fig. 5 The 1-step forecasts with ± 2 standard errors

Table 5 tabulated the results of performance metrics as an evaluation of forecast performance. The analysis of the Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) for various variables provides significant insights into the forecast performance of structural time series models. For ex-farm broiler and corn prices, the models demonstrate moderate accuracy with low RMSE values but moderate MAPE percentages, suggesting there is room for improvement in reducing relative forecast errors. Soybean meal and wheat prices exhibit high RMSE and MAPE values, reflecting substantial challenges in accurately predicting these volatile agricultural markets.

Table 5 *Performance metrics for each series*

Variables	RMSE	MAPE
Ex-farm broiler price	0.85	12.36
Corn price	30.76	11.55
Soybean meals price	68.23	12.48
Wheat price	48.37	12.38

Exchange rate	0.12	2.17
Crude oil price	10.39	8.45

The exchange rate model shows superior accuracy with the lowest RMSE (0.12) and MAPE (2.17), highlighting the stability and predictability of the exchange rate data. Crude oil prices also show reasonable forecast accuracy with moderate RMSE and lower MAPE compared to agricultural commodities, indicating that the current models effectively capture the more stable trends in the crude oil market. These results underscore the varying performance of the models across different variables, with exchange rates and crude oil showing more reliable forecasts than agricultural commodities.

To enhance forecast accuracy, future research should incorporate external factors and covariates influencing commodity prices, such as weather patterns and geopolitical events. Refining model parameters and exploring hybrid modeling approaches that combine traditional time series techniques with advanced machine learning algorithms may help reduce forecast errors (Bulut & Hüdaverdi, 2022). Adapting models to the specific characteristics of each variable and incorporating domain-specific knowledge will be crucial for improving forecast accuracy across different markets. This comprehensive analysis emphasizes the importance of tailored modeling strategies to address the unique challenges of each market.

5. Discussions

Over the last decade, the poultry industry in Malaysia has successfully met domestic demand and exported to neighbouring countries such as Singapore. However, reliance on raw materials from other producer countries negatively impacts the development and food sustainability of the poultry sector. This dependency exposes the industry to volatile currency movements and supply chain disruptions in animal feed production (Attia et al., 2022). This section discusses several factors affecting the broiler industry in Malaysia.

Firstly, changes in currency exchange rates significantly impact animal feed prices in broiler production. A study demonstrated that a 10% increase in soybean meal prices resulted in a 3.84% additional cost for broilers in Turkey (Cinar & Keskin, 2018). These findings indicate that the domestic broiler market relies heavily on global commodity markets. Increases in the prices of commodities such as corn, soybean meals, and wheat lead to higher ex-farm broiler prices. It is estimated that approximately 65% of production costs in Malaysia are for chicken feed, while 20% are for day-old chicks (DOSM, 2023). The exchange rate significantly affects the price of poultry feed for local farmers (Jamaludin et al., 2023). If a country's currency depreciates relative to others, the cost of imported feed ingredients, such as soybeans and corn, will rise because the local currency buys less of the imported goods. This increases production costs for local farmers, often passed on to consumers as higher chicken meat prices (Ilyana et al., 2016). Conversely, if a country's currency appreciates, the cost of imported feed ingredients decreases, reducing production costs and benefiting both farmers and consumers by keeping chicken meat prices affordable.

Secondly, global supply chain disruptions and local movement restrictions during the COVID-19 pandemic impacted Malaysia's poultry sector. Suppliers reported that disruptions in global trade hindered the import of raw materials needed to produce feed and medicine. Prolonged border closures prevented the import of essential feed items like corn, wheat, and soybean meals (Al Sattar et al., 2021). Additionally, labor shortages during lockdowns slowed operations in the feed industry. Integrators, feed dealers, and middlemen, who are crucial intermediaries in Malaysia's poultry distribution network, faced significant challenges due to these factors. Although authorities announced that food transport would not be delayed, administrative confusion often led to law enforcement agencies obstructing the movement of livestock and poultry feed vehicles (Food and Agriculture Organization, 2020). These disruptions affected local farmers, making it difficult to distribute their goods due to movement restrictions and higher transport costs, disrupting their standard business practices (Ronaldo, 2020).

Finally, fluctuations in commodity prices and supply chain disruptions have led to asymmetric price transmission to the end product. A recent report by MyCC (2014) statistically confirmed, based on econometric analysis, that changes in ex-farm chicken prices between January 2007 and March 2012 were asymmetrically and positively transmitted to standard broiler prices. Specifically, a 10% increase in the ex-farm price of live chickens resulted in a 7.5% increase in retail broiler prices, ceteris paribus. The research also suggests that other factors may lead to asymmetric price transmission. For example, when input prices rise, all firms tend to increase their product prices. However, when input prices fall, firms avoid reducing their prices to maintain their tacit agreement.

6. Conclusions

The main conclusions of this work are drawn together and presented in this section. First, the results demonstrate the adequacy of the method for measuring the strength of correlation among macroeconomic factors and broiler prices. The Pearson correlation analysis exhibits strongest positive correlative between corn

and soybean meals prices. Second, choice of model varies based on the nature of the data, with BSM applied to variables exhibiting trends and seasonality, LLM for stable series, and LLTM for capturing both level and trend disturbances. The used of structural time series able to describe the ex-farm broiler prices as BSM, corn prices as LLM, soybean meals prices as BSM, wheat prices as BSM, the exchange rates as LLM, and crude oil prices as LLTM. Third, the findings of this study have shown that the dynamic changes in animal feeds prices have significant effect in the cost of production in Malaysia. Besides, the disruption in supply chain also led to the asymmetric price transmission. This study suggests that policy makers should consider different approach to reduce the dependency on foreign resources and protecting the poultry industry in Malaysia. The direction for future research may include other relevant variables such as calendar effect and modelling under the presence of structural breaks.

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Conflict of Interest

All authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Farid Zamani;* ***data collection:*** *Farid Zamani;* ***analysis and interpretation of results:*** *Farid Zamani; Marni Sapar;* ***draft manuscript preparation:*** *Farid Zamani; Marni Sapar. All authors reviewed the results and approved the final version of the manuscript.*

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